Japan International Cooperation Agency (JICA)

Haiphong People's Committee
Socialist Republic of Vietnam

The Study
on
Sanitation Improvement Plan for Haiphong City
in
The Socialist Republic of Vietnam

FINAL REPORT

MAIN REPORT

VOLUME 2: FEASIBILITY STUDIES FOR THE PRIORITY PROJECTS

July 2001

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Note: All the figures shown in the tables of the reports were set or estimated by the JICA Study Team in case data sources are not written.

EXCHANGE RATE FOR COST ESTIMATION

Estimate of Base Cost : As of June 2000 Price Level

Currency Exchange Rate : USD1.0 = VND14,072

THE STUDY ON SANITATION IMPROVEMENT PLAN FOR HAIPHONG CITY

IN THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT

MAIN REPORT

VOLUME 2: FEASIBILITY STUDIES FOR THE PRIORITY PROJECTS

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Abbreviations

Government of Vietnam/Public Institutions

DI	:	Department of Industry
DARD	:	Department of Agriculture and Rural Development
DOC	:	Department of Construction
DOF	:	Department of Finance
DOH	:	Department of Health
DOSTE	:	Department of Science, Technology and Environment
EMD	:	Environmental Management Division
GOV	:	Government of Vietnam
HP	:	Haiphong
HPPC	:	Haiphong People's Committee
MOC	:	Ministry of Construction
MOF	:	Ministry of Finance
MOI	:	Ministry of Industry
MOSTE	:	Ministry of Science, Technology and Environment
MPI	:	Ministry of Planning and Investment
NEA	:	National Environmental Agency
NIED	:	National Institute for Educational Development
NIURP	:	National Institute for Urban and Rural Planning
PMU	:	Project Management Unit
SADCO	:	Sewerage And Drainage Company
SC	:	Steering Committee
SCPE	:	Scientific Center for Population and Environment
TEDI	:	Transportation Engineering Design Institute
TUPWS	:	Transport and Urban Public Works Service
URENCO	:	Urban Environment Company
VIWASE	:	Vietnam Institute for Water and Sanitation Engineering
WSCO	:	Water Supply Company

International / Foreign Organizations

ADB	:	Asian Development Bank
AIT	:	Asian Institute of Technology
ASEAN	:	Association of Southeast Asian Nations
AusAID	:	Australian Agency for International Development
CIDA	:	Canadian International Development Agency
DIDC	:	Department for International Development Cooperation of the Ministry for Foreign Affairs of Finland
EU	:	European Union
FINNIDA	:	Finnish International Development Agency
IBRD (WB)	:	International Bank for Reconstruction and Development (World Bank)

IFC	:	International Finance Agency
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
NGO	:	Non-Government Organization
OECD	:	Organization for Economic Cooperation and Development
SIDA	:	Swedish International Development Agency
UNDP	:	United Nations Development Program
UNICEF	:	United Nations Children's Fund
UNIDO	:	United Nations Industrial Development Organization
WB	:	World Bank
WHO	:	World Health Organization

Peculiar Abbreviations for this Study

City MP	:	Haiphong City Master Plan
DVEZ	:	Dinh Vu Economic zone
NDA	:	New Development Area
NUA	:	New Urban Area
OCC	:	Old City Center
SA	:	Study Area
SMP	:	Sanitation Master Plan
The Study	:	The Study on Sanitation Improvement Plan for Haiphong City
The JICA Study Team	:	The JICA Team for the Study on Sanitation Improvement Plan for Haiphong City

Others

ADWF	:	Average Dry Weather Flow
AIDS	:	Acquired Immuno- Deficiency Syndrome
AJ	:	Aerated Jokaso
AL	:	Aerated Lagoon
AnA	:	Anaerobic Aerobic Process
ARI	:	Average Recurrence Interval
AS	:	Activated Sludge
ASP	:	Activated Sludge Process
BOD	:	Biochemical Oxygen Demand
BOT	:	Built, Operate, Transfer
C	:	Carbon
CAS	:	Conventional Activated Sludge
CCTV	:	Closed Circuit Television
CECS	:	Center for Environmental Chemistry Studies
CEST	:	Center for Environmental Science and Technology
CH_4	:	Methane
Cl	:	Chlorine
CNMS	:	Customer Network Management System

CO_2	:	Carbon dioxide
COD	:	Chemical Oxygen Demand
CPP	:	Contact Purification Process
CRES	:	Center for Regional and Environmental Studies
CSO	:	Combined Sewer Overflow
CW	:	Constructed Wetlands
DID	:	Densely Inhabited District
DO	:	Dissolved Oxygen
EAR	:	Environmental Awareness-Raising
EARET	:	Environmental Awareness-Raising, Education and Training
EE	:	Environmental Education
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Master Plan
ES	:	Executive Seminars
F/S	:	Feasibility Study
FC	:	Fecal Coliform
GDP	:	Gross Domestic Product
GRP	:	Gross Regional Product
H	:	Hydrogen
HCMC	:	Ho Chi Minh City
HDPE	:	High Density Poly-Ethylene
HIV	:	Human Immunodeficiency Virus
HPWSSP	:	Haiphong Water Supply & Sanitation Program
IDF	:	Intensity-Duration-Frequency
IEE	:	Initial Environmental Examinations
IUPM	:	Industrial and Urban Pollution Management
LEP	:	Law on Environmental Protection
LM	:	Laboratory and Monitoring
M/P	:	Master Plan
MEIP	:	Metropolitan Environmental Improvement Program
MT	:	Membrane Technology
MWSP	:	Modified Waste Stabilization Pond
N	:	Nitrogen
NE	:	North East
NH_4	:	Ammonium
NRW	:	Non-Revenue Water
O	:	Oxygen
O&M	:	Operation & Maintenance
OD	:	Oxidation Ditch
ODA	:	Official Development Assistance
P	:	Phosphorous
PDWF	:	Peak Dry Weather Flow
PP	:	Poly Propylene

PS	:	Pumping Station
PVC	:	Poly Vinyl Chloride
RBC	:	Rotating Biological Contactor
SEDS	:	National Socio-Economic Development Strategy
SOE	:	State Owned Enterprises
SOP	:	Standard Operation Procedure
SP	:	Stabilization Pond
SPP		Sewerage Priority Project
SS	:	Suspended Solids
STW	:	Sewage Treatment Works
SW	:	South West
SWM	:	Solid Waste Management
SWS	:	Solid Waste Services
SWTC	:	Solid Waste Treatment Complex
TC	:	Total Coliform
TCVN	:	Vietnam Standard
TEQ	:	Toxic Equivalents
TMS	:	Time and Motion Survey
T-N	:	Total Nitrogen
T-P	:	Total Phosphorous
TSP	:	Total Suspended Particulate
TWAP	:	Treated water from Aeration Pond
TWPP	:	Treated water from Precipitation Pond
UASB	:	Up-flow Anaerobic Sludge Bed (Reactor)
UFW	:	Unaccounted For Water
VAT	:	Vietnam-Australia Training Project
VCEP	:	Vietnam Canada Environment Project
VIP	:	Ventilated Improved Pit (Latrine)
WSP	:	Waste Stabilization Pond
WTP	:	Water Treatment Plant
WWTP	:	Waste Water Treatment Plant
1A	:	Vietnam Three Cities Sanitation Program: Haiphong Component (Water Supply Phase 1)
2A	:	Vietnam Three Cities Sanitation Program: Haiphong Component (Water Supply Phase 2)
1B	:	Vietnam Three Cities Sanitation Program: Haiphong Component (Drainage & Sewerage)

Units of Measurement

T/Y	:	tonnes per year
°C	:	degrees Celsius
g/d	:	grams per day
Gm	:	Gram
ha	:	Hectare
kg	:	kilo gram
km	:	kilo meter
km^2	:	Square kilo meter
lpcd	:	liter per capita per day
m	:	Meter
m^2	:	square meter
m^3	:	cubic meter
m^3/d	:	cubic meter per day
mg/l	:	milligram per liter
Nm^3	:	Normal cubic meter
pg	:	Picogram
t/m^3	:	tonnes per cubic meter
US$	:	United States Dollar
VND	:	Vietnamese Dong
wt%	:	weight percent

PART 1 OUTLINES OF THE SELECTED PRIORITY PROJECT

CHAPTER 1 OUTLINE OF THE PRIORITY PROJECTS

1.1 Selected Priority Projects

From the Sanitation Master Plan, three priority projects are selected to be implemented by 2010. These are:

- Drainage Priority Project
- Sewerage Priority Project
- Solid Waste Management Priority Project

The solid waste management priority project consists of three components, namely,

- Waste collection and transport
- Trang Cat Phase 3 landfill
- Hospital waste management

A brief outline is given in the following and the details are given in subsequent parts. The total capital cost in this section includes the following components: (i) construction/procurement cost, (ii) land acquisition cost, (iii) engineering service cost, (iv) administrative cost, and (v) physical contingency.

1.2 Drainage Priority Project

There are three separate drainage catchments in the priority project area, namely, Southwest, Northeast, and An Kim Hai. The drainage priority project recommends integrating these three to increase the overall drainage performance. To augment the storage capacity, it is recommended to rehabilitate the An Kim Hai Channel and to construct the new Phoung Luu Regulating Lake.

The salient features of the drainage priority project is given below:

- Location: Central area of Class A area
- Area: 1103 ha
- Population: 240,000 (in 2010)
- Rehabilitation: An Kim Hai Channel, 10 km
- Maintenance road along channel: Both sides of An Kim Hai, 5 m wide
- Demolition of tidal gate: One at Cam River
- Construction of tidal gate: Two, at Cam River and Lac Tray River
- Discharge gate: One at Du Hang
- Phoung Luu site development: 28 ha
- Phoung Luu Lake construction: 24 ha
- Maintenance road along lake: 12 m wide
- Connecting channel: 500 m, 15 m wide

- Road from Road No. 5 to lake site 400m, 12 m wide
- Box culvert: 450m, 3 x (3 x 2) m
- Total Capital Cost US$49.1 million
- Implementation Period 2004 to 2009

1.3 Sewerage Priority Project

The sewerage priority project will use all existing combined sewer pipes. It recommends intercepting combined sewer flow before entering into surface water bodies and separate wastewater from rainwater by combined sewer overflow (CSO). Separated wastewater is collected by sewer pipes and transported to central treatment plant. Treatment is to be done by aerated lagoon process satisfying Vietnamese standard. Rainwater separated by CSOs is allowed to bypass into surface water body.

The salient features of the sewerage priority project is given below:

- Location Central area of Class A area
- Area 1103 ha
- Population 240,000 (in 2010)
- Collection System Combined Sewer System
- Estimated Sewage 36,000 m^3/day (in 2010)
- Combined Sewer Overflow 61 nos.
- Sewer pipeline 20 km
- Manhole 190 nos.
- Pumping Station At An Da (30 m^3/min)
- Treatment Plant Near Vinh Niem Tidal Gate
- Treatment process Aerated lagoon
- Treatment capacity 36,000 m^3/day
- Total Capital Cost US$65.5 million
- Implementation Period 2004 to 2010

1.4 Solid Waste Management Priority Project

The solid waste management priority project comprises the 3 components, i.e. 1) waste collection and transport, 2) sanitary landfill, 3) hospital waste management system, each of which is an integral part of the solid waste management system. Salient features of each component are given below.

<u>A. Waste Collection and Transport System</u>

- Location: 4 urban districts and their neighboring areas to be urbanized, as well as Do Son Town
- Beneficiary: 608,000 (in 2005)

• Operators	3 waste management companies, i.e. URENCO, Kien An Urban Works Company, and Do Son Public Works Company
• Collection System	With the implementation of the Priority Project, shift from the existing handcart collection system to the direct collection system with mechanical waste loading into vehicles using bins is planned.
• Waste Collection Capacity	761 ton/day on average (in 2005)
• Equipment to be Procured	• Waste collection vehicles (43 units) • Bins and handcarts (1,234 units) • Workshop equipment (3 sets)
• Total Capital Cost	US$4.6 million
• Procurement Year	2004
• Useful period of equipment	10 years from 2005 to 2014

<u>B. Trang Cat Phase 3 Landfill Site</u>

• Location	A part of Trang Cat Site (60 ha in total) in Trang Cat Commune
• Area	32.7 ha
• Beneficiaries	528,000 (in 2005)
• Disposal System	Sanitary Landfill of Semi-aerobic type
• Total Waste Receiving Capacity	2.6 million ton
• Types of waste to be received	• Solid waste excluding industrial waste, • Incineration residue of medical waste and leachate treatment sludge
• Main Facilities	• Dyke (waste retaining structure) • Leachate collection & treatment system • Gas ventilation system • On-site road • Heavy equipment • Cover soil
• Total Capital Cost	US$10.6 million
• Construction Period	2 years from 2004 to 2005
• Operation Period	10 years from 2005 - 2014

<u>C. Hospital Waste Management System</u>

• System Components	• In-hospital storage room for infectious waste • Waste collection vehicles (1.5 ton/unit x 2 units)

- Incineration (1 unit)
- Landfill for incineration residue (included in Trang Cat Site Plan)

- Direct Beneficiaries: 18 health care organizations (9 hospitals and 9 medical centers, located in the 4 urban districts and Do Son Town, as well as people who may directly contact infectious waste.)
- Indirect Beneficiaries: Whole population of the 4 urban districts including neighboring areas and Do Son Town (704,000 in 2005)
- Outline of Incinerator
  - Location: A place in the existing Trang Cat Phase 1 Landfill Site, in Trang Cat Commune
  - Area required: 200 m^2
  - Capacity: 1.5 ton/day (8 hours operation per day)
  - System: Incinerator with 2combustion chambers: one for solid waste, the other for gases.
  - Dioxin emission: 0.5 ng/Nm^3-TEQ (10 % of the Japanese standard (5 ng/Nm^3-TEQ) for small sized incinerators)
  - Other gases emission: Comply with the Vietnamese standard
  - Service life: 8 years
- Total Capital Cost: US$0.53 million
- Construction/Procurement Year: 2004
- Operation Period: 8 years from 2005 - 2012

The total capital cost for the whole solid waste management priority project is US$15.8 million.

CHAPTER 2 IMPLEMENTATION SCHEDULE AND COST REQUIREMENT

2.1 Construction Plan of Selected Priority Project

2.1.1 Basic Conditions and Assumption for Establishing Construction Plan

The construction plans of selected priority projects are prepared on the basis of following conditions:

(1) Workable Day

Workable days for earth works such as embankment, excavation and hauling, and concrete works are considered to be dominated by the weather conditions, especially rainfall. Therefore, the rainy days in the study area are examined by using the rainfall record at Phu Lien Observation from 1971 to 1997, located on a hilltop at Kien An at an elevation of 113 m. The annual workable days are estimated assuming that the works are to be suspended on Sunday, national holidays and rainy days.

- Rainy season : From May to October
- Dry season : From November to April
- Non- workable day
  - Sunday : 52 days
  - National holiday : 8 days
  - Suspended day due to rainfall, 3.1-5 mm
    - Earthworks : 6.7 days
    - Other works : 0
  - Suspended day due to rainfall, 5.1-10 mm
    - Earthworks : 12.6 days
    - Other works : 0
  - Suspended day due to rainfall, 10.1-20 mm
    - Earthworks : 16 days
    - Other works : 16 days
  - Suspended day due to rainfall, 20.1-50 mm
    - Earthworks : 26.7 days
    - Other works : 26.7 days
  - Suspended day due to rainfall, over 50 mm
    - Earthworks : 20.2 days
    - Other works : 20.2 days
- Average annual workable days
  - Earthworks = 365-52-8-82.2=223 days
  - Other works =365-52-8-62.9=242 days

(2) Working Hours

Daily working hours are assumed to be 8 hours. 1 shift work will be adopted for all works in principle. However the pipe jacking works are applied by 2 shifts due to underground works.

(3) Construction Method and Equipment

To achieve an efficient and qualified construction works, the mechanized system of construction works, which is currently utilized for construction works of the similar projects in Vietnam, is considered for these priority projects. The conventional method and type of equipment will be applied, giving consideration to the local conditions. All the construction equipment to be utilized for the civil works will be provided by the contractor.

2.1.2 Construction Method

(1) Preparatory Works

Some preparatory works and construction facilities are required in the beginning of the implementation. These are access road, temporary buildings, power supply system, water supply system, telecommunication system, assembling and concrete mixing plant, etc.

The construction sites are located in the densely populated and/or outskirts of Haiphong city. Therefore, the planning of preparatory works and construction facilities are made considering the site location, the restriction of rainy season, the magnitude of the construction, and the daily production rate.

The traffic control and temporary road closing are necessitated during these construction works upon the consent of Haiphong Traffic Police Office.

(2) Drainage Priority Project

1) Excavation, Side-slope Lining and Maintenance Road

Total length of the rehabilitation of An Kim Hai channel is about 10 km. The construction of An Kim Hai channel will be made during the dry season from November to April.

The existing channel is situated in the town area and the resident houses are located along both channels. The excavation works will be started after the planned channel land acquisition, and house compensation are settled and the temporary access roads are provided for the service road route.

In case of shallow water depth, the bamboo coffer dikes will be constructed upstream and downstream of the channel manually and then the stagnant water will be dewatered by a 100 mm diameter submersible pump. Meanwhile, the steel sheet piles of type III will be driven by using 30 kW vibration hammer in case of deep water, and then dried by submersible pumps.

The channel excavation works will be carried out by using manpower and a 0.35 m^3 backhoe in the dry area enclosed by bamboo dikes and steel sheet piles. Especially, the muddy sediment material will be handled and loaded into a bucket by manpower. The excavated material will be loaded into 4 ton dump trucks for hauling to the spoil bank in Trang Cat area. At the spoil bank, the material will be dumped and spread by a 10 ton swamp type bulldozer.

The channel section is to be mainly a trapezoidal section with a side-slope lining (wet rubble masonry). The wet rubble masonry works will be carried out in parallel with the excavation in the dry area.

After channel excavation is made, the side-slope of the channel is thoroughly trimmed by manpower. The foundation works of riverbed will first be constructed, then the wet rubble masonry works on the side-slope will be carried out by manpower and equipment.

5 m wide service road will be provided along both sides of the channel. The excavation will be carried out using a 0.35 m^3 backhoe and loaded into a 4 ton dump truck to the spoil bank. The materials for road embankment and shoulder will be obtained from a mountainous site. The road pavement is to be subbase, base and asphalt surface course. The road construction will be performed using a conventional construction method.

2) Tidal Gates and Discharge Gate

Tidal gates are planned at the Lach Tray river and Cam river. The tidal gate located in the confluence of An Kim Hai channel and Lach Tray River is newly constructed adjacent to the existing siphon. The existing tidal gate is located in the confluence of An Kim Hai channel and Cam River with non-operational conditions and has inadequate hydraulic capacity. Thus, the existing tidal gate is necessitated to reconstruct. The discharge gate to Du Hang lake is newly constructed.

The gate civil works will be carried out during dry season. The coffer with double steel sheet piles of type IV with adequate bracing will be provided in the Lach Tray River.

To protect the collapse of existing ground during excavation, the temporary steel sheet pile shoring of type IV with adequate bracing will be provided surrounding the foundation area.

350 × 350 mm precast concrete piles will be driven in designated positions by 2.5 ton diesel pile driver with a 30 ton crawler crane rig and pile follower. The concrete piles will be procured from the pile manufacturer and supplier.

The foundation excavation will be carried out using 0.2 m^3 backhoe, 0.6 m^3 clamshell and 4 ton dump truck, and the excavated material will be hauled to the stockpile area.

After the completion of the foundation excavation, the steel sheet pile type II will be driven by a 30 KW vibration hammer at the gate foundation for the purpose of cut off. Then the treatment of pile cap and capping concrete are carried out. Next, the assembling of form and reinforcement are performed.

The concrete will be hauled by a 3 m^3 agitator truck from the concrete mixing plant provided in the contractor camp area. The concrete will be mainly placed using a 45 m^3/h concrete pump car and vibrator.

The backfill material will be obtained from the stockpile. The backfill will be made by manpower, a 3 ton bulldozer and a 1 ton vibration roller.

3) Puong Luu Regulating Lake

Puong Luu regulating lake is designed to store and control the flood water. Net area of water surface is 24 ha.

The excavation works of lake site will be carried out during dry seasons in principle. The submersible pumps will be provided during the excavation works to secure the excavation site in dry condition.

The excavated material is planned to be utilized as the material of embankment, filling and backfill for other sites. Hence the excavated material is stocked beside the lake site. However, surplus material will be hauled to the spoil bank.

The lake excavation works will be made using a 1.0 m^3 backhoe and the hauling works will be carried out by 10 ton dump trucks.

4) Connecting Channels and Maintenance Roads on Both Sides

A channel with the 15 m width and 500 m length is planned between Puong Luu regulating lake and existing channel.

The excavation works of connecting channel will be performed during dry seasons in principle. The excavation works of connecting channel will be carried out by a combination of a 1.0 m^3 backhoe and 10 ton dump trucks.

A 7 m wide service road will be provided along both sides of the connecting channel. The excavation will be carried out using a 0.35 m^3 backhoe and loaded into a 4 ton dump truck to the spoil bank. The materials for road embankment and shoulder will be obtained from a mountainous site. The road pavement is to be subbase, base and asphalt surface course. The road construction will be performed using a conventional construction method.

5) Box culvert, 3 × (3.0 m × 2.0 m)

3 lanes-3,000mm × 2,000mm with a 450m in total length box culverts are planned in channel between Phuong Luu lake and An Kim Hai channel. The construction of box culvert will require traffic diversion and detour, demolishing existing structures and pavement. To secure the box culvert construction within the scheduled period, several units will be used simultaneously.

Before starting excavation, the steel sheet piles of type III will be driven using a 30-40 KW vibration hammer in both sides of the box culvert as a temporary ground support. Then the coffer dikes and dewatering will be made.

The excavation and hauling will be made by a fleet of 0.6 m^3 backhoe and 10 ton dump trucks. Precast concrete piles with a size of 350 × 350 mm will be driven in designated positions by a 2.5 ton diesel pile driver with a 30 ton crawler crane rig. The concrete piles will be procured from the pile manufacturer and supplier.

After the assembly of form and reinforcement steel bar works, concrete works will be carried out by using conventional equipment such as a 3.0 m^3 agitator truck, 45 m^3/h concrete pump car and vibrators.

6) Bridges

Fifteen (15) bridges are planned to be constructed in An Kim Hai channel and connection channel.

The bridge girders are planned to be a precast type girder with pre-stressed strand and reinforced concrete girder. The post tension type precast girders will be produced at each bridge site due to road and traffic conditions.

Before starting the bridge construction, temporary staging is provided along the planned bridges. After providing temporary staging, steel sheet pile coffers are provided for surrounding piers and abutments.

Precast reinforced concrete piles are driven using a 2.5 ton diesel pile driver. After piling works, the foundation excavation will be made by a 0.35 m^3 backhoe and 4 ton dump trucks. Then, the assembling of form and reinforcement are performed.

The concrete is hauled by a 3 m^3 agitator truck from the concrete mixing plant provided in the contractor camp area. The concrete is mainly placed using a 45 m^3/h concrete pump car and vibrator.

(3) Sewerage Priority Project

1) Trunk Sewer, 100 – 1,200 mm dia., Open Trench Method

The construction of trunk sewer with less than 4 m in depth from the road surface will be carried out by the open trench construction method. In case the banks of the trench are not stable, temporary shoring are required. Total length of the trunk sewer by open trench is 12,260 m.

The construction works will be made by applying conventional method i. e. cutting pavement using a concrete cutter, breaking using a pneumatic hammer, excavation and loading using a 0.35 m^3 backhoe and manpower, and hauling using 4 ton dump truck. After the foundation of the trunk sewer made by bamboo piles, wooden materials and concrete bed is constructed, precast concrete sewer pipes will be transported by a 4 ton flat bed truck equipped with a crane, and laid by using its crane or the 4.5 ton truck crane. After backfill on the sewer pipes, the removal of temporary shoring and re-pavement will be performed.

2) Trunk Sewer, 800 –1,800 mm dia., Pipe Jacking Method

A trunk sewer with more than 4 m in depth from the road surface will be constructed by the pipe jacking method. Total length of this trunk sewer is assumed to be 7,660 m.

Vertical shafts will be firstly constructed every about 40 m intervals for 800 mm dia., 100 m intervals for 900 –1,000 mm dia.,150 m intervals for 1,100 – 1,200 mm dia. and 200 m intervals for 1,650 – 1,800 mm dia. along the trunk sewer line. Those vertical shafts are utilized as the removal of excavated material, operation of jack and supply of precast reinforced concrete jacking pipes.

The excavation of the vertical shafts will be carried out by a 4.5t class truck crane with 0.6 m^3 bucket. For the ground support, the steel sheet pile, type III and its bracing are necessitated.

The precast concrete pipes for jacking must be strong enough to withstand the loads exerted by the jacking procedure. The leading pipe is to equip the leading edge with a cutter or shoe to protect the pipe. Next, lengths of pipes are added between the leading pipe and the jacks. After the pipe jacking, soil is excavated by hand and removed through the pipe. The excavation does not precede the jacking operation. When jacking, it is desirable to coat the outside of the pipe with a lubricant, to reduce the frictional loss. Soil friction may increase with time; it is desirable to continue jacking operations without interruption until completed.

After the completion of works, the vertical shafts will be converted into manholes.

3) Combined Sewer Overflow Control Structure

Two types of overflow control structures are conceived in this area i. e. gate type and orifice type. Required quantity is 20 nos for orifice type and 41 nos for gate type. The gate type consists of 5 types.

When outfall sewer and head structures are partly submerged it is necessary to provide some form of cofferdam during construction. In shallow water, an earth dike or bamboo made dike may be sufficient to maintain a dry pit. In deep water, steel sheet piling cofferdams are desirable. A single wall cofferdam with adequate bracing is sufficient.

The excavation of these structures will be done by a 0.6 m^3 backhoe. After excavation works, the foundation works are performed. Then, form and reinforcement steel bar works are assembled, succeeding concrete works will be carried out by using conventional equipment such as 3.0 m^3 agitator truck, 45 m^3/h concrete pump car and vibrators.

4) Manhole

Six type of manholes are planned along trunk sewer line. Required quantity is 190 nos.

The excavation of these structures will be done by 0.6 m^3 backhoe. After excavation works, the foundation works are performed. Then, assembling of form and reinforcement steel bar works are assembled, succeeding concrete works will be carried out by using conventional equipment such as 3.0 m^3 agitator truck, 45 m^3/h concrete pump car and vibrators.

5) Manhole Type Relay Pumping Station

The submersible pump is installed in the conventional manhole. The pump can be removed from the wet well for servicing without disturbing the discharge piping. The pump can be slid onto the fixed guide rails. In the lowered position, the pump discharge engages the discharge pipe. Four types of manhole type relay pumping station are considered in this area. Required quantity is 5 nos.

The excavation of these structures will be done by a 0.6 m^3 backhoe. After excavation works, the foundation works are performed. Then, form and reinforcement steel bar works are assembled, succeeding concrete works will be carried out by using conventional equipment such as 3.0 m^3 agitator truck, 45 m^3/h concrete pump car and vibrators.

6) Relay Pumping Station

The relay pumping station with a total capacity of 0.535 m^3/s is planned in An Da area. 4 units (1 standby pump) of sewage pumps having a 0.178 m^3/s and 300 mm dia. are selected. The force main (pipe coming out of the pump) is 700 mm.

Pumping station substructures are made by reinforced concrete. The exterior walls below grade and wet-well walls below the maximum high wet-well level will be coated with tar to prevent leakage. Superstructures are made of fireproof construction. The ground floor of the station must be set above the flood to eliminate the possibility of flooding the station. In the pumping station, monorails are provided for equipment handling.

The steel sheet piles type IV and adequate bracing will be provided surrounding the foundation area.

The foundation works of the pumping station comprise the precast concrete piles driving, foundation excavation and capping concrete. The precast concrete piles with 300 x 300 mm will be driven in designated position by a 2.5 ton diesel pile driver with a 30 ton crawler crane rig and pile follower. The concrete piles will be procured from the pile manufacturer and supplier. Next, the foundation excavation is performed by a 0.6 m^3 backhoe, then the treatment of pile cap and capping concrete are carried out.

Reinforced concrete for substructure and superstructure will be placed by using a truck crane and/or concrete pump car. After completion of concrete works, the pump equipment and electrical control equipment will be installed.

7) West Wastewater Treatment Plant

Estimated generation of sewage for Phase I (combined sewer area) until Year 2010 is about 36,000 m^3/day. The capacity of West wastewater treatment plant is to cover this requirement.

The main structure consists of a pumping station, aerated lagoon, settling pond, chlorination tank and sludge drying bed.

The pumping station with a total capacity of 1.059 m^3/s is planned in Thon Niem near Lach Tray river. 3 units (1 standby pump) of sewage pumps having 0.706 m^3/s and 590 mm dia. and 0.353 m^3/s and 420 mm dia. are selected.

Pumping station substructures are made by reinforced concrete. The exterior walls below grade and wet-well walls below the maximum high wet-well level will be coated with tar to prevent leakage. Superstructures blend in with the surroundings and are made of fireproof construction. The ground floor of the station must be set above the flood to eliminate the possibility of flooding the station. In the pumping station, overhead cranes are provided for equipment handling.

The steel sheet piles type IV and adequate bracing will be provided surrounding the foundation area. The foundation works of the pumping station comprise the precast concrete piles driving, foundation excavation and capping concrete. The precast concrete piles 300 x 300 mm in size, will be driven in designated positions by a 2.5 ton diesel pile driver with a 30 ton crawler crane rig and pile follower. The concrete piles will be procured from the pile manufacturer and supplier. Next, the foundation excavation is performed by a 0.6 m^3 backhoe, then the treatment of pile cap and capping concrete are carried out.

Reinforced concrete for substructure and superstructure will be placed by using a truck crane and/or concrete pump car. The construction of outlet structure including excavation, concrete placing, backfill and gate installation will be carried out by applying the conventional construction method. After completion of concrete works, the pump equipment and electrical control equipment will be installed.

4 nos. of 0.9 ha aerated lagoon, 4 nos. of 0.6 ha settling pond, 0.04 ha chlorination tank, 0.5 ha sedimentation pond and 4.55 ha sludge drying bed are made by earth works. Partition and surrounding walls made of earth material are provided in each structure. Those works are carried out during dry season. The sewage flow from the aerated lagoon to the chlorination tank through settling pond is a gravity flow.

The excavation of these structures will be done by a fleet of 1.0 m^3 backhoes and 15 ton bulldozers, and excavated materials are hauled to the earth embankment sites by 10 ton dump trucks, then the unloaded materials are spread and compacted with a thickness of 0.2 m by 11 ton bulldozers. In case the excavated material is anticipated with high moisture content, the excavated material is hauled to stockpiles for moisture control. After moisture control, these materials can be used as the embankment materials.

In total 32 nos of 55 kW surface mechanical aerators with a vertical axis are planned to be provided in the aerated lagoon. The aerators are designed to induce either updraft or downdraft flows through a pumping action. They consist of submerged impellers attached to motors mounted on floats. The works of aerators comprise the procurement and installation.

(4) Solid Waste Management Priority Project

Solid Waste Management Priority Project has 3 components.

1) Waste Collection and Transport System (component 1)

Component 1 procures waste collection and transport equipment: waste collection vehicles, bins, and hand-carts as well as maintenance facilities.

Quantities and specifications of the equipment are as follows:

- 43 units of waste collection vehicles of different loading capacity ranging from 4 – 16 m^3
- 1,010 units of waste bins of 2 different capacities (240 liter and 660 liter)
- 224 units of hand-carts with 500 liter capacity
- 3 sets of maintenance equipment to be used for repair and maintenance of waste collection vehicles by the 3 companies (URENCO, Kien An Public Works Company and Do Son Public Works Company)

2) Trang Cat New Landfill Site (component 2)

The works of component 2 are the construction of Trang Cat new landfill site with a 32.7 ha of area required and the procurement of heavy equipment.

The works of Trang Cat new landfill site include the collection of surcharge soil, transportation to landfill site, placement of surcharge soil, keep that soil to allow compaction of existing soil, remove the surcharge soil, construction of dykes, the construction of leachate collection and treatment comprising the PVC pipe laying, two pumping stations and regulating pond, the construction of road, the construction of vertical gas vents, the construction of fencing, etc. Those works will be carried out by conventional method.

The height of surcharge layer will be 4 m. The total landfill area will be divided into 4 cells. Surcharge soil will be placed in one cell with a trapezoidal shape having a side slope of 1:2.5. This configuration is very stable. The soil will be kept for 10 months. After that the soil ill be moved to next cell. This process will continue till all the landfill area is compacted. Side embankment will be required so that mudflow does not occur to the surrounding area. Surcharge soil will be brought from near by Phu Luu Mountain and a total of around 240,000 m^3 of soil will be required. In case, adverse impact is found due to such soil displacement in course of further study, other alternatives are soil from An Kim Hai Channel rehabilitation and Phound Luu Lake construction.

Synthetic liner is available in sheet roll, each sheet is 5 m wide and 20 m long. A crane will be used for installation. Every sheet’s edge will be overlapped by adjacent sheets by 30 cm. Edge will then be sealed by special heating machine.

The specifications of heavy equipment are 3 units of 15 ton bulldozers, 2 units of 10 ton dump trucks, 1 unit of pick-up truck, etc.

3) Medical Waste Incineration (component 3)

The works of component 3 are the construction of an incineration facilities with its building and the procurement of collection vehicles for medical waste.

The works of incineration facilities include the construction of foundation, the procurement and installation of 1.5 ton/day incineration facilities with a control of flue gas including dioxins and the construction of a 144 m^2 building for incinerator. The incineration facilities are planned to be installed in Trang Cat site. The required area is about 200 m^2. Those building works will be carried out by conventional method.

The specifications of collecting vehicles for medical waste are 2 units of required quantity and 1.5 ton of loading capacity, and made of hard top with a lockable door.

2.2 Basic Conditions of Cost Estimate for the Selected Priority Projects

The basic conditions and assumptions applied for the cost estimate are presented below.

(1) Project Execution Method

All the project works will be executed on a contract basis. The permanent facilities and the temporary construction facilities such as construction equipment, materials, and labors required for the works will be provided by the contractors to be selected through international or local competitive bidding.

The procurement works of waste collection vehicles, bins, hand carts, maintenance facilities, heavy equipment, collection vehicles for medical waste and incineration facilities including installation will also be made by international or local competitive bidding.

(2) Project Cost

The project cost comprises the main construction cost, procurement cost, land acquisition and compensation cost, engineering service cost, administration cost, physical contingency and price contingency. The main construction cost is estimated on the basis of unit price in principle.

(3) Unit Prices

The unit prices for the major work items are prepared by referring to the collected cost data from the on-going projects in Haiphong and Hanoi cities. The unit prices consists of labor cost, material cost, equipment cost and contractor's overhead expenses and profit. All unit prices are given in foreign and local currency portions and expressed in US$. The local currency portion covers the cost of locally available materials including cement, reinforcing bars, fuel and local labors. The costs of pumping equipment, electrical equipment, tidal gate, equipment of solid waste management and depreciation and spare parts cost of construction equipment are allocated into the foreign currency portion. The value added tax is included in the respective unit prices.

(4) Price Level

The construction cost is estimated based on the price level of June 2000.

(5) Exchange Rate

The foreign exchange rate of currencies are US$1.00=VND14,072 in an average of June 2000.

(6) Land Acquisition and Compensation Cost

The land needed for channel improvement, regulating lake, pumping stations, wastewater treatment site, Trang Cat new landfill site, etc. will be acquired by the Government office. Houses located in the land acquired will be compensated.

The summary of land acquisition and compensation cost for each sector is shown below:

- Drainage project (1,300 households and 5 m + 5 m maintenance road): US$3,700,000
- Sewerage project (23 households and 38 ha, pumping station 0.38 ha and relocation of dike): US$2,165,000
- Trang Cat (Land acquisition 32.7 ha and land use right for fishing company): US$602,000
- Total US$6,467,000

(7) Engineering Service Cost

The engineering service cost for detailed design and construction supervision is assumed to be 10 % of total construction cost and land acquisition cost. The engineering service cost for the solid waste management is estimated to be 5 % of total construction and procurement cost.

(8) Administration Cost

The cost for the project administration by the Government office is assumed to be 3 % of the total construction and procurement cost, land acquisition and compensation cost and engineering service cost.

(9) Physical Contingency

The physical contingency is provided to cope with the unforeseen physical conditions. The physical contingency is assumed to be 10 % for the sum of construction and procurement cost, land acquisition and compensation cost, engineering service cost and administration cost.

(10) Price Contingency

The price escalation is given with the rate of 2.0 % per annum for both the foreign and local currency portions considering the consumer price index in industrial countries with the rate of 1.9 % per annum in an average of past 5 years and consumer price index in Vietnam with the rate of 7.8 % per annum in an average of past 8 year

2.3 Implementation Schedule and Cost Estimate for Priority Projects

(1) Implementation Schedule

Pre-construction activities namely the detailed design including preparation of tender documents, the financial arrangement and the land acquisition are necessitated before the commencement of construction works, and it is assumed that 2.0 years for the financial arrangement, 1.0 year for the detailed design for all sectors and 2 years for the land acquisition will be required.

The construction period for selected priority projects are presumed as follows:

- Drainage Priority Project; 5 years
- Sewerage Priority Project; 6 years
- SWM Priority Project (Waste collection and transport, component 1); 1 year
- SWM Priority Project (Trang Cat new landfill site, component 2); 2 years
- SWM Priority Project (Medical waste incineration, component 3); 1 year

All of the construction works will be performed by the contractor to be selected by tendering process and their commencement years are scheduled at the beginning of 2004 for the waste collection and transport system (component 1), Trang Cat landfill site (component 2) and medical waste incineration (component 3) and thereafter, in mid- 2004 for Drainage and Sewerage Priority Projects.

The proposed implementation schedules for selected priority projects are shown in Figures 2.3.1. to 2.3.4.

(2) Construction Cost

Cost estimation has been made based on the final facility plans for the selected priority projects. The breakdown of construction cost for the selected priority projects are shown in Tables 2.3.1 to 2.3.3.

(3) Project Cost

The project cost of the selected priority projects consists of the construction and procurement cost, land acquisition and compensation cost, engineering service cost, administration cost, physical contingency and price contingency.

The estimated total project cost is US$147.3 million comprising foreign currency portion of US$84.9 million and the local currency portion of US$62.4 million. Breakdown of the overall project cost are shown as follows:

Overall Project Cost (unit: 1,000US$)

Description	F.C (US$)	L.C (US$)	Total (US$)
(1)Drainage Priority Project			
Construction and Procurement Cost	18,168.7	17,498.0	35,666.7
Land Acquisition and Compensation	0.0	3,700.0	3,700.0
Engineering Service Cost	1816.9	2,119.8	3,936.7
Administration Cost	0.0	1,299.1	1,299.1
Physical Contingency	1,998.5	2,461.6	4,460.1
Price Contingency	3,167.0	3,508.1	6,675.1
Sub-Total without Price Contingency	21,984.1	27,078.6	49,062.7
Sub-Total	25,151.1	30,586.8	55,737.9
(2) Sewerage Priority Project,			
Construction and Procurement Cost	35,026.4	15,327.3	50,355.1
Land Acquisition and Compensation	0.0	2,165.0	2,165.0
Engineering Service Cost	3,502.6	1,749.2	5,252.0
Administration Cost	0.0	1,733.1	1,733.1
Physical Contingency	3,852.9	2,097.5	5,950.4
Price Contingency	5,918.3	3,106.4	9,024.7
Sub-Total without Price Contingency	42,382.0	23,072.1	65,455.6
Sub-Total	48,300.2	26,178.6	74,478.8
(3) Solid waste management PP			
Construction and Procurement Cost	8,956.8	3,386.0	12,342.8
Land Acquisition and Compensation	0.0	602.0	602.0
Engineering Service Cost	629.4	338.6	968.0
Administration Cost	0.0	417.5	417.5
Physical Contingency	958.6	474.4	1,433.0
Price Contingency	898.5	452.0	1,350.5
Sub-Total without Price Contingency	10,545.2	5,218.4	15,763.6
Sub-Total	11,443.7	5,670.4	17,114.1
Total without Price Contingency	**74,911.2**	**55,369.0**	**130,282.1**
Total	**84,895.0**	**62,435.7**	**147,332.4**

(4) Disbursement Schedule

The annual disbursement schedule of the selected priority project is shown in Tables 2.3.4 to 2.3.7 and summarized below.

Disbursement Schedule of Overall Project Cost (unit: 1,000 US$)

Year	F.C (US$)	L.C (US$)	Total (US$)
2003	1,316.1	5,167.5	6,483.6
2004	15,527.3	10,650.9	26,178.2
2005	15,762.8	10,835.3	26,598.1
2006	14,251.5	9306.0	23,557.5
2007	12,373.9	9,120.8	21,494.7
2008	12,086.4	8,941.2	21,027.6
2009	10,282.3	6,626.3	16,908.6
2010	3,294.2	1,788.2	5,082.4
Total	**84,895.0**	**62,435.7**	**147,332.4**

CHAPTER 3 METHODOLOGY FOR EVALUATING PRIORITY PROJECT FEASIBILITY

The priority projects which are selected should meet the following three basic conditions:

- The project should be essential for solving the currently prevailing problem and should be implemented in the short-term
- The priority project should be in compliance with the long-term sanitation master plan recommended in this JICA Study
- There has been no detailed study nor F/S for the project and therefore F/S should be carried out in this JICA Study (the Study)

Accordingly 3 priority projects are selected, one each for the sectors of drainage improvement, sewerage development and solid waste management. Project evaluation is carried out for these selected priority projects to check the feasibility and viability for implementation.

Firstly, the viability of the priority projects are examined from the following aspects:

- To adequately satisfy the primary objectives of the improvement of the sanitation condition and environment of the Study Area and Haiphong city
- To be economically justifiable through the contribution to economic growth of the Study Area and the city

Secondly, implementabililty and affordability as well as social and environmental acceptance are checked.

If considered to be viable and implementable, the project is evaluated as feasible and recommended for early realization. Evaluation items are explained hereunder.

(1) Objective Achievement (Satisfaction of the sanitation/environment objectives)

Sanitation improvement of the Haiphong City has 2 principle objectives to be satisfied through the implementation of the projects and measures, i.e., a) improvement of sanitary condition of citizens, and b) improvement of ambient environment including surface water quality, cleanliness of the city, etc.

Compliance and degree of satisfaction of Objective Achievement is examined with appropriate indices including area served, number of direct and indirect beneficiaries, reduction of pollution loads into the environment and volume of loads collected and treated or controlled.

(2) Economic Viability

Economic viability of the projects is examined to evaluate the levels of the switching values of the property value and productivity/GRP of the Study Area which offset the project cost. If switching value lies within the reasonable range, the project is considered economically viable. Switching value of the property value is obtained by calculating the percentage of the priority project cost in the property value. Namely, the percentage of increase of the property value which can justify the project implementation, is checked. GRP switching value is checked similarly.

(3) Financial Affordability

Financial requirement of the investment cost and operation and maintenance cost (O&M cost) should be within the affordable range of the Government and people. The annual overall project cost is calculated which comprises the amortized capital cost with 5 % interest rate and 25 year repayment period and O&M cost. Percentage of annual overall project cost in the values of the key indicators are calculated, which include Study Area GRP, HPPC expenditure and disposable income of the residents. If the ratios lie within reasonable range, the project is considered as financially affordable.

Depending on the sector, drainage sector in Haiphong city for example, other urgent projects will also be carried out in parallel with the proposed drainage priority project. Priority project together with these projects will improve the drainage condition in Haiphong city. To keep this improved drainage condition toward the future in sustainable manner, drainage improvement efforts should be continued.

Considering these, master plan cost of each sector is used to check the financial affordability of each priority project instead of the priority project cost. If the financial affordability is proved by this approach, affordability of the priority project is automatically proved.

(4) Technical Feasibility

The technology to be used in the priority project should be a proven and sure one which has already been applied elsewhere in the world or preferably in developing countries in the Southeast Asia. Risk of failure of the project should be low for manufacturing, construction and O&M. Additional skills required for the personnel of the managing organization for O&M should be obtainable with adequate training.

(5) Environmental Acceptability

The adverse social and environmental impacts which will be generated associated with the project implementation, should be in the range acceptable to the affected citizens after taking appropriate counter-measures.

(6) Organizational Capability

The projects should be able to be managed and operated by the responsible organizations after adequate reinforcement of organization, staff and manpower training.

Table 2.3.1 Construction Cost for Drainage Priority Project

No	Description	F.C. Portion(US$)	L.C. Portion(US$)	Total(US$)
		Amount	Amount	
I	Main Component			
0.00	Preparatory Works	1,040,864	1,223,504	2,264,368
1.00	An Kim Hai Channel			
1.10	Channel excavation	1,891,476	852,362	2,743,838
1.20	Revetment works	1,679,246	4,782,896	6,462,141
1.30	Maintenance road	281,888	747,539	1,029,427
1.40	Construction of tidal gate, Lach Tray River	599,670	201,023	800,694
1.50	Construction of tidal gate, Cam River	599,670	201,023	800,694
1.60	Construction of discharge gate to Du Hang Lake	599,670	201,023	800,694
1.70	Demolishing existing outlet gate	906	1,132	2,038
	Total	5,652,527	6,986,999	12,639,525
2.00	Phuong Luu Regulating Lake			
2.10	Phuong luu regulating lake	3,465,416	2,849,731	6,315,147
2.20	Box culvert, 3x(3.0mx2.0m),L=450m	1,290,696	2,398,315	3,689,011
	Total	4,756,112	5,248,046	10,004,157
	Total of I	11,449,502	13,458,549	24,908,051
II	Supplementary Component			
0.00	Preparatory Works	610,833	367,226	978,059
1.00	Supplementary Component, New Sewers	2,275,000	2,275,000	4,550,000
2.00	Supplementary Component, Bridges	1,044,582	1,161,006	2,205,588
3.00	Supplementary Component, Road Ancillary Works	2,788,750	236,250	3,025,000
	Total of II	6,719,165	4,039,482	10,758,647
	Grand Total	18,168,668	17,498,030	35,666,698

Note: Constant price of June 2000
Construction and land acquisition costs

Table 2.3.2 Construction Cost for Sewerage Priority Project (1/2)

No	Description	F.C. Portion(US$)	L.C. Portion(US$)	Total(US$)
		Amount	Amount	
0.00	Preparatory Works	3,184,219	1,393,393	4,577,733
1.00	Trunk Sewer, Open Excavation			
1.10	Steel pipe, 100mm dia.,1-2m covering,L=230m	10,414	22,190	33,806
1.20	Steel pipe, 125mm dia.,1-2m covering,L=260m	18,105	25,686	43,791
1.30	R.C. pipe, 300mm dia.,1-2m covering,L=300m	13,043	30,589	43,632
1.40	R.C. pipe, 300mm dia.,2-3m covering,L=620m	40,479	91,414	131,893
1.50	R.C. pipe, 400mm dia.,1-2m covering,L=620m	29,163	76,563	105,726
1.60	R.C. pipe, 400mm dia.,2-3m covering,L=560m	39,217	94,544	133,761
1.70	R.C. pipe, 400mm dia.,3-4m covering,L=420m	102,654	99,678	202,332
1.80	R.C. pipe, 500mm dia.,2-3m covering,L=1180m	87,808	220,946	308,754
1.90	R.C. pipe, 500mm dia.,3-4m covering,L=600m	162,256	156,592	318,848
1.10	R.C. pipe, 600mm dia.,3-4m covering,L=380m	110,985	104,459	215,444
1.11	R.C. pipe, 700mm dia.,2-3m covering,L=940m	95,559	256,343	351,902
1.12	R.C. pipe, 800mm dia.,2-3m covering,L=550m	58,659	156,515	215,174
1.13	R.C. pipe, 900mm dia.,2-3m covering,L=200m	24,190	60,023	84,213
1.14	R.C. pipe, 900mm dia.,3-4m covering,L=1320m	572,692	544,074	1,116,766
1.15	R.C. pipe, 1000mm dia.,2-3m covering,L=700m	188,333	239,974	428,307
1.16	R.C. pipe, 1000mm dia.,3-4m covering,L=1000m	463,307	434,301	897,608
1.17	R.C. pipe, 1100mm dia.,2-3m covering,L=600m	176,888	223,306	400,194
1.18	R.C. pipe, 1100mm dia.,3-4m covering,L=900m	444,924	419,748	864,673
1.19	R.C. pipe, 1200mm dia.,3-4m covering,L=880m	462,307	432,175	894,482
	Total	3,100,984	3,689,120	6,791,306
2.00	Trunk Sewer, Pipe Jacking Method			
2.10	R.C. pipe for jacking,800mm dia.,L=1300m	1,508,289	346,752	1,855,041
2.20	R.C. pipe for jacking,900mm dia.,L=440m	598,389	172,647	771,036
2.30	R.C. pipe for jacking,1000mm dia.,L=1240m	1,742,282	498,703	2,240,985
2.40	R.C. pipe for jacking,1100mm dia.,L=330m	576,284	240,706	816,990
2.50	R.C. pipe for jacking,1200mm dia.,L=2720m	4,857,545	1,902,156	6,759,701
2.60	R.C. pipe for jacking,1650mm dia.,L=640m	1,537,022	452,291	1,989,313
2.70	R.C. pipe for jacking,1800mm dia.,L=950m	2,492,337	649,796	3,142,133
	Total	13,312,149	4,263,050	17,575,199
3.00	Combined Sewer Overflow Control Structure			
3.10	Orifice type, gate type I, 22nos	456,822	80,898	537,721
3.20	Gate type, type I, 22nos	669,788	105,340	775,129
3.30	Gate type, type II, 12nos	441,482	62,199	503,681
3.40	Gate type, type III, 3 nos	162,102	20,706	182,809
3.50	Gate type, type IV, 2 nos	114,734	14,467	129,202
3.60	Gate type, type V, 2 nos	121,942	15,066	137,007
	Total	1,966,870	298,678	2,265,548
4.00	Manhole			
4.10	Manhole, type 1, 300mm-600mm, 2.5m, 68nos	60,535	39,261	99,796
4.20	Manhole, type 2, 700mm-900mm, 3.0m, 30nos	27,451	25,531	52,982
4.30	Manhole, type 3, 1000mm-1200mm, 3.5m, 33nos	31,044	34,926	65,971
4.40	Manhole, type 3, 800mm-1200mm, 5.0m, 50nos	48,228	66,931	115,158
4.50	Manhole, type 5, 1800mm, 5.0m, 8nos	8,065	12,300	20,365
	Total	175,323	178,948	354,271
5.00	Manhole Type Pump			
5.10	Manhole pump 1	14,573	9,393	23,966
5.20	Manhole pump 2	10,795	5,533	16,328
5.30	Manhole pump 3	10,795	5,533	16,328
5.40	Manhole pump 4	3,919	4,205	8,124
5.50	Manhole pump 5	3,989	4,262	8,252
5.60	Manhole pump 1, mechanical & electrical	47,622	1,474	49,096
5.70	Manhole pump 2, mechanical & electrical	29,985	929	30,914
5.80	Manhole pump 3, mechanical & electrical	29,985	929	30,914
5.90	Manhole pump 4, mechanical & electrical	33,072	1,025	34,097
5.10	Manhole pump 5, mechanical & electrical	39,686	1,230	40,916
5.11	Installation and others	133,669	26,028	159,697
	Total	358,089	60,541	418,631

Table 2.3.2 Construction Cost for Sewerage Priority Project (2/2)

No	Description	F.C. Portion(US$) Amount	L.C. Portion(US$) Amount	Total(US$)
6.00	An Da Relay Pumping Station			
6.10	Pumping house structure	77,246	122,751	199,997
6.20	Pumping house building and others	4,820	14,459	19,278
6.30	Pumping house yard	14,106	24,556	38,662
6.40	Mechanical equipment	307,420	9,494	316,914
6.50	Electrical equipment	117,283	3,629	120,912
6.60	Installation and others	170,583	59,564	230,147
	Total	691,458	234,452	925,910
7.00	West Wastewater Treatment Plant			
7.10	Pumping station	138,457	187,246	325,703
7.20	Aerated lagoon treatment process (AL)	238,788	176,670	415,458
7.30	Settling pond	325,105	161,174	486,279
7.40	Chlorination tank	45,364	217,721	263,086
7.50	Stormwater sedimentation pond	36,803	33,679	70,481
7.60	Sludge drying bed	164,667	497,814	662,481
7.70	Building works	71,623	214,869	286,493
7.80	Splitter chamber	1,039	4,306	5,345
7.90	Gate of outfall	31,273	5,569	36,842
7.10	Wastewater treatment yard	51,367	280,096	331,462
7.11	Operation and maintenance equipment	449,014	13,716	462,730
7.12	Equipment for screenings	1,172,823	36,186	1,209,009
7.13	Equipment for grit chamber	807,396	24,884	832,280
7.14	Equipment for aerated lagoon	3,255,739	100,699	3,356,438
7.15	Equipment for settling pond	63,826	1,974	65,800
7.16	Equipment for chlorination tank	43,210	1,337	44,547
7.17	Piping	493,819	15,273	509,091
7.18	Electrical equipment	651,221	20,148	671,369
7.19	Installation and others	1,960,000	980,000	2,940,000
	Total	10,001,533	2,973,360	12,974,893
8.00	Supplementary works	2,235,785	2,235,785	4,471,570
	Grand Total	35,026,409	15,327,328	50,355,060

Note: Constant price of June 2000
Construction and land acquisition costs

Table 2.3.3 Solid Waste Management Priority Project

No	Description	F.C. Portion(US$)	L.C. Portion(US$)	Total(US$)
		Amount	Amount	
1.00	Waste Collection and Transport System	3907000	0	3907000
2.00	Trang Cat New Landfill Site	4710000	3299000	8009000
3.00	Hospital Waste Treatment	339000	87000	426000
	Total	8956000	3386000	12342000

Note: Constant price of June 2000
Construction and land acquisition costs

Table 2.3.4 Disbursement Schedule of Overall Project Cost of the Priority Projects

US $ 1.00 = VND 14,072 , Unit: 1,000US$

Item	Description	Total (US$)			2003		2004		2005		2006		2007		2008		2009		2010	
No.		F.C	L.C	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
I	**Main Component**																			
1	Construction and Procurement Cost																			
	(1) Drainage Priority Project	11,449.5	13,458.5	24,908.1	0.0	0.0	1,040.9	1,223.5	2,045.1	2,208.2	2,220.2	2,532.3	2,393.5	2,852.3	2,469.6	3,029.3	1,280.3	1,612.9		
	(2) Sewerage Priority Project	35,026.4	15,327.3	50,355.1	0.0	0.0	3,184.2	1,393.4	7,849.8	3,141.5	7,849.8	3,141.5	5,964.9	2,586.0	4,079.4	2,030.2	4,079.4	2,030.2	2,018.9	1,004.5
	(3) Solid Waste Management Priority Project	8,956.8	3,386.0	12,342.8			7,307.3	1,736.5	1,649.5	1,649.5										
	Subtotal	55,432.7	32,171.8	87,606.0	0.0	0.0	11,532.4	4,353.4	11,544.4	6,999.2	10,070.0	5,673.8	8,358.4	5,438.3	6,549.0	5,059.5	5,359.7	3,643.1	2,018.9	1,004.5
2	Land Acquisition and House Compensation																			
		0.0	3,700.0	3,700.0		1,850.0		1,850.0												
		0.0	2,165.0	2,165.0	0.0	1,082.5	0.0	1,082.5												
		0.0	602.0	602.0	0.0	602.0														
	Subtotal	0.0	6,467.0	6,467.0	0.0	3,534.5	0.0	2,932.5												
3	Engineering Service Cost																			
		1,145.0	1,715.9	2,860.8	163.7	245.4	163.7	245.4	163.7	245.4	163.7	245.4	163.7	245.4	163.7	245.4	162.6	243.7		
		3,502.6	1,749.2	5,252.0	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7
	Engineering	629.7	338.6	968.3	429.8	208.7	200.0	129.9	0.0	0.0										
	Subtotal	5,277.3	3,803.7	9,081.1	1,031.3	672.8	801.5	594.0	601.5	464.1	601.5	464.1	601.5	464.1	601.5	464.1	600.4	462.4	437.8	218.7
4	Administration																			
		0.0	944.1	944.1		67.8		135.7		139.9		154.8		169.6		177.2		99.0		
		0.0	1,733.1	1,733.1		52.2		189.5		349.4		349.4		276.2		203.0		203.0		
	Administration	0.0	417.4	417.4	0.0	37.2	0.0	281.2	0.0	99.0										110.4
	Subtotal	0.0	3,094.6	3,094.6	0.0	157.2	0.0	606.4	0.0	588.3	0.0	504.2	0.0	445.8	0.0	380.2	0.0	302.0	0.0	110.4
5	Physical Contingency																			
		1,259.4	1,981.8	3,241.3	16.4	216.3	120.5	345.5	220.9	259.3	238.4	293.2	255.7	326.7	263.3	345.2	144.3	195.6		
		3,852.9	2,097.5	5,950.5	43.8	135.3	362.2	288.4	828.8	371.0	828.8	371.0	640.3	308.1	451.7	245.2	451.7	245.2	245.7	133.4
		958.7	474.4	1,433.1	43.0	84.8	750.7	214.8	165.0	174.8	0.0	0.0								
	Subtotal	6,071.0	4,553.7	10,624.9	103.2	436.4	1,233.4	848.7	1,214.7	805.1	1,067.2	664.2	896.0	634.8	715.0	590.4	596.0	440.8	245.7	133.4
	Total without Price Contingency	66,781.0	50,090.8	116,873.6	1,134.4	4,800.9	13,567.3	9,335.0	13,360.6	8,856.7	11,738.7	7,306.3	9,855.9	6,983.0	7,865.5	6,494.2	6,556.1	4,848.3	2,702.4	1,467.0
6	Price Escalation																			
		1,929.1	2,768.6	4,697.7	11.0	145.6	109.2	313.2	252.9	296.9	330.8	407.0	418.2	534.4	497.2	651.8	309.6	419.7		
		5,918.3	3,106.4	9,024.7	29.5	91.1	328.4	261.5	948.8	424.7	1,150.1	514.8	1,047.2	503.9	853.0	463.0	969.4	526.2	591.8	321.2
		898.5	452.0	1,350.5	28.9	57.1	680.7	194.7	188.8	200.2	0.0	0.0								
	Subtotal	8,745.9	6,327.0	15,072.9	69.4	293.8	1,118.3	769.4	1,390.5	921.8	1,480.9	921.8	1,465.4	1,038.3	1,350.2	1,114.8	1,279.0	945.9	591.8	321.2
	Total of I ＊	75,526.9	56,417.8	131,946.5	1,203.9	5,094.7	14,685.6	10,104.4	14,751.1	9,778.5	13,219.6	8,228.1	11,321.3	8,021.3	9,215.7	7,609.0	7,835.1	5,794.2	3,294.2	1,788.2
II	**Supplementary Component of Drainage PP**																			
	1.0 Preparatory Works	610.8	367.2	978.1			610.8	367.2												
	Subtotal	610.8	367.2	978.1			610.8	367.2												
	1.1 Supplementary Component, New Sewers																			
	1) Main sewers	1,050.0	1,050.0	2,100.0					233.1	233.1	233.1	233.1	233.1	233.1	233.1	233.1	117.6	117.6		
	2) Branch sewers	1,225.0	1,225.0	2,450.0					272.0	272.0	272.0	272.0	272.0	272.0	272.0	272.0	137.2	137.2		
	Subtotal	2,275.0	2,275.0	4,550.0					505.1	505.1	505.1	505.1	505.1	505.1	505.1	505.1	254.8	254.8		
	1.2 Supplementary Component, An Kim Hai Channel																			
	Bridge																			
	1) Bridge, W 7.0 m x L 12.0 m	162.8	180.9	343.7					36.1	40.2	36.1	40.2	36.1	40.2	36.1	40.2	18.2	20.3		
	2) Bridge, W 7.0 m x L 15.0 m	610.5	678.5	1,289.0					135.5	150.6	135.5	150.6	135.5	150.6	135.5	150.6	68.4	76.0		
	3) Bridge, W 7.0 m x L 20.0 m	271.3	301.6	572.9					60.2	66.9	60.2	66.9	60.2	66.9	60.2	66.9	30.4	33.8		
	Subtotal	1,044.6	1,161.0	2,205.6					231.9	257.7	231.9	257.7	231.9	257.7	231.9	257.7	117.0	130.0		
	1.3 Supplementary Component, Road Ancillary Works																			
	1) Lighting	693.6	21.5	715.0											346.8	10.7	346.8	10.7		
	2) Fence	2,095.2	64.8	2,160.0											1,047.6	32.4	1,047.6	32.4		
	3) Plantimg	0.0	150.0	150.0											0.0	75.0	0.0	75.0		
	Subtotal	2,788.8	236.3	3,025.0					0.0	0.0	0.0	0.0	0.0	0.0	1,394.4	118.1	1,394.4	118.1		
	Total	6,719.2	4,039.5	10,758.6			610.8	367.2	736.9	762.8	736.9	762.8	736.9	762.8	2,131.3	880.9	1,766.2	503.0		
	2. Engineering Service Cost	671.9	403.9	1,075.9	96.1	57.8	96.1	57.8	96.1	57.8	96.1	57.8	96.1	57.8	96.1	57.8	95.4	57.4		
	3. Administration	0.0	355.0	355.0		4.6		34.0		49.6		49.6		49.6		95.0		72.7		
	4. Physical Contingency	739.1	479.8	1,219.0	9.6	6.2	70.7	45.9	83.3	87.0	83.3	87.0	83.3	87.0	222.7	103.4	186.2	63.3		
	Total without Price Contingency	8,130.2	5,278.2	13,408.5	105.7	68.6	777.6	504.9	916.3	957.2	916.3	957.2	916.3	957.2	2,450.1	1,137.1	2,047.8	696.4		
	5. Price Contingency	1,237.9	739.5	1,977.4	6.5	4.2	64.1	41.6	95.4	99.6	115.6	120.8	136.2	142.3	420.6	195.2	399.5	135.8		
	Total of II ＊	9,368.1	6,017.9	15,385.9	112.2	72.8	841.7	546.5	1,011.7	1,056.8	1,031.9	1,077.9	1,052.6	1,099.5	2,870.7	1,332.2	2,447.2	832.1		
	Total without Price Contingency	74,911.2	55,369.0	130,282.1	1,240.1	4,869.5	14,344.9	9,839.9	14,276.9	9,813.9	12,655.0	8,263.5	10,772.2	7,940.2	10,315.6	7,631.3	8,603.9	5,544.7	2,702.4	1,467.0
	Total ＊	84,895.0	62,435.7	147,332.4	1,316.1	5,167.5	15,527.3	10,650.9	15,762.8	10,835.3	14,251.5	9,306.0	12,373.9	9,120.8	12,086.4	8,941.2	10,282.3	6,626.3	3,294.2	1,788.2
	Total Recurring Cost	0.0	14883.0	14883.0	0.0	0.0	0.0	0.0	0.0	2147.0	0.0	2185.0	0.0	2538.0	0.0	2566.0	0.0	2709.0	0.0	2738.0

Note: All the amounts are shown in 2000 constant price except for those marked with "＊"

Table 2.3.5 Disbursement Schedule of Project Cost for Drainage Priority Project

US $ 1.00 = VND 14,072 , Unit: 1,000US$

Item	Description	Total (US$)			2003		2004		2005		2006		2007		2008		2009		2010	
No.		F.C	L.C	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1	**Main Component**																			
	1.0 Preparatory Works	1,040.9	1,223.5	2,264.4			1,040.9	1,223.5												
	Subtotal	1,040.9	1,223.5	2,264.4			1,040.9	1,223.5												
	1.1 An Kim Hai Channel																			
	1) Excavation of channel	1,891.5	852.4	2,743.8					419.9	189.2	419.9	189.2	419.9	189.2	419.9	189.2	211.8	95.5		
	2) Revetment works	1,679.2	4,782.9	6,462.1					372.8	1,061.8	372.8	1,061.8	372.8	1,061.8	372.8	1,061.8	188.1	535.7		
	3) Maintenance road	281.9	747.5	1,029.4					62.6	166.0	62.6	166.0	62.6	166.0	62.6	166.0	31.6	83.7		
	4) Construction of tidal gate, Lach Tray river	599.7	201.0	800.7					400.0	134.1	199.7	66.9								
	5) Construction of tidal gate, Cam river	599.7	201.0	800.7							199.7	66.9	400.0	134.1						
	6) Construction of discharge gate to Du Hang lake	599.7	201.0	800.7											400.0	134.1	199.7	66.9		
	7) Demolishing existing outlet gate	0.9	1.1	2.0							0.9	1.1								
	Subtotal	5,652.5	6,987.0	12,639.5					1,255.3	1,551.1	1,255.6	1,552.0	1,255.3	1,551.1	1,255.3	1,551.1	631.2	781.8		
	1.2 Phuong Luu Regulating Lake																			
	1) Excavation of Phuong Luu Regula. Lake	2,998.6	1,396.6	4,395.2					665.7	310.1	665.7	310.1	665.7	310.1	665.7	310.1	335.8	156.4		
	2) Revetment works	192.5	867.1	1,059.6					42.7	192.5	42.7	192.5	42.7	192.5	42.7	192.5	21.6	97.1		
	3) Road works and bridge	136.0	313.5	449.5											68.0	156.7	68.0	156.7		
	4) Excavation of connection channel	46.9	21.8	68.7					31.3	14.5	15.6	7.3								
	5) Revetment works, connection channel	75.2	210.0	285.2					50.1	140.1	25.0	69.9								
	6) Maintenance road	16.3	40.7	57.0											8.2	20.3	8.2	20.3		
	7) Box culvert, 3 x (3.0 m x 2.0 m)	1,290.7	2,398.3	3,689.0							215.5	400.5	429.8	798.6	429.8	798.6	215.5	400.5		
	Subtotal	4,756.1	5,248.0	10,004.2					789.8	657.2	964.6	980.3	1,138.2	1,301.2	1,214.4	1,478.3	649.1	831.1		
	Total	11,449.5	13,458.5	24,908.1	0.0	0.0	1,040.9	1,223.5	2,045.1	2,208.2	2,220.2	2,532.3	2,393.5	2,852.3	2,469.6	3,029.3	1,280.3	1,612.9		
	2. Land Acquisition and House Compensation	0.0	3,700.0	3,700.0		1,850.0		1,850.0												
	3. Engineering Service Cost	1,145.0	1,715.9	2,860.8	163.7	245.4	163.7	245.4	163.7	245.4	163.7	245.4	163.7	245.4	163.7	245.4	162.6	243.7		
	4. Administration	0.0	944.1	944.1		67.8		135.7		139.9		154.8		169.6		177.2		99.0		
	5. Physical Contingency	1,259.4	1,981.8	3,241.3	16.4	216.3	120.5	345.5	220.9	259.3	238.4	293.2	255.7	326.7	263.3	345.2	144.3	195.6		
	Total without Price Contingency	13,853.9	21,800.3	35,654.2	180.1	2,379.5	1,325.1	3,800.0	2,429.7	2,852.8	2,622.3	3,225.7	2,812.9	3,594.0	2,896.7	3,797.1	1,587.2	2,151.1		
	6. Price Contingency	1,929.1	2,768.6	4,697.7	11.0	145.6	109.2	313.2	252.9	296.9	330.8	407.0	418.2	534.4	497.2	651.8	309.6	419.7		
	Total of 1 ＊	15,783.0	24,569.0	40,352.0	191.1	2,525.1	1,434.3	4,113.3	2,682.6	3,149.8	2,953.1	3,632.7	3,231.2	4,128.4	3,394.0	4,448.9	1,896.8	2,570.8		
2	**Supplementary Component**																			
	1.0 Preparatory Works	610.8	367.2	978.1			610.8	367.2												
	Subtotal	610.8	367.2	978.1			610.8	367.2												
	1.1 Supplementary Component, New Sewers																			
	1) Main sewers	1,050.0	1,050.0	2,100.0					233.1	233.1	233.1	233.1	233.1	233.1	233.1	233.1	117.6	117.6		
	2) Branch sewers	1,225.0	1,225.0	2,450.0					272.0	272.0	272.0	272.0	272.0	272.0	272.0	272.0	137.2	137.2		
	Subtotal	2,275.0	2,275.0	4,550.0					505.1	505.1	505.1	505.1	505.1	505.1	505.1	505.1	254.8	254.8		
	1.2 Supplementary Component, An Kim Hai Channel																			
	Bridge																			
	1) Bridge, W 7.0 m x L 12.0 m	162.8	180.9	343.7					36.1	40.2	36.1	40.2	36.1	40.2	36.1	40.2	18.2	20.3		
	2) Bridge, W 7.0 m x L 15.0 m	610.5	678.5	1,289.0					135.5	150.6	135.5	150.6	135.5	150.6	135.5	150.6	68.4	76.0		
	3) Bridge, W 7.0 m x L 20.0 m	271.3	301.6	572.9					60.2	66.9	60.2	66.9	60.2	66.9	60.2	66.9	30.4	33.8		
	Subtotal	1,044.6	1,161.0	2,205.6					231.9	257.7	231.9	257.7	231.9	257.7	231.9	257.7	117.0	130.0		
	1.3 Supplementary Component, Road Ancillary Works																			
	1) Lighting	693.6	21.5	715.0											346.8	10.7	346.8	10.7		
	2) Fence	2,095.2	64.8	2,160.0											1,047.6	32.4	1,047.6	32.4		
	3) Plantimg	0.0	150.0	150.0											0.0	75.0	0.0	75.0		
	Subtotal	2,788.8	236.3	3,025.0					0.0	0.0	0.0	0.0	0.0	0.0	1,394.4	118.1	1,394.4	118.1		
	Total	6,719.2	4,039.5	10,758.6			610.8	367.2	736.9	762.8	736.9	762.8	736.9	762.8	2,131.3	880.9	1,766.2	503.0		
	2. Engineering Service Cost	671.9	403.9	1,075.9	96.1	57.8	96.1	57.8	96.1	57.8	96.1	57.8	96.1	57.8	96.1	57.8	95.4	57.4		
	3. Administration	0.0	355.0	355.0		4.6		34.0		49.6		49.6		49.6		95.0		72.7		
	4. Physical Contingency	739.1	479.8	1,219.0	9.6	6.2	70.7	45.9	83.3	87.0	83.3	87.0	83.3	87.0	222.7	103.4	186.2	63.3		
	Total without Price Contingency	8,130.2	5,278.3	13,408.5	105.7	68.6	777.6	504.8	916.3	957.2	916.3	957.2	916.3	957.2	2,450.1	1,137.0	2,047.7	696.3		
	5. Price Contingency	1,237.9	739.5	1,977.4	6.5	4.2	64.1	41.6	95.4	99.6	115.6	120.8	136.2	142.3	420.6	195.2	399.5	135.8		
	Total of 2 ＊	9,368.1	6,017.9	15,385.9	112.2	72.8	841.7	546.5	1,011.7	1,056.8	1,031.9	1,077.9	1,052.6	1,099.5	2,870.7	1,332.2	2,447.2	832.1		
	Total without Price Contingency	21,984.1	27,078.6	49,062.7	285.8	2,448.1	2,102.7	4,304.9	3,346.0	3,810.0	3,538.6	4,182.9	3,729.3	4,551.2	5,346.9	4,934.2	3,634.9	2,847.4		
	Total ＊	25,151.1	30,586.8	55,737.9	303.3	2,597.9	2,276.0	4,659.7	3,694.3	4,206.6	3,985.1	4,710.6	4,283.7	5,227.9	6,264.7	5,781.2	4,344.0	3,402.9		
	Recurring Cost		75.0	75.0				0.0		0.0		0.0		16.0		18.0		20.0		21.0

Note: All the amounts are shown in 2000 constant price except for those marked with "＊"

Table 2.3.6 Disbursement Schedule of Project Cost for Sewerage Priority Project

US $ 1.00 = VND 14,072 , Unit: 1,000US$

Item	Description	Total (US$)			2003		2004		2005		2006		2007		2008		2009		2010	
No.		F.C	L.C	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1	Construction and Procurement Cost																			
	1.0 Preparatory Works	3,184.2	1,393.4	4,577.7			3,184.2	1,393.4												
	1.1 Trunk Sewer, Open Excavation	3,101.0	3,689.1	6,791.3					564.4	671.4	564.4	671.4	564.4	671.4	564.4	671.4	564.4	671.4	279.1	332.0
	1.2 Trunk Sewer, Pipe Jacking	13,312.1	4,263.1	17,575.2					2,422.8	775.9	2,422.8	775.9	2,422.8	775.9	2,422.8	775.9	2,422.8	775.9	1,198.1	383.7
	1.3 Combined Sewer Overflow Control	1,966.9	298.7	2,265.5					358.0	54.4	358.0	54.4	358.0	54.4	358.0	54.4	358.0	54.4	177.0	26.9
	1.4 Manhole	175.3	178.9	354.3					31.9	32.6	31.9	32.6	31.9	32.6	31.9	32.6	31.9	32.6	15.8	16.1
	1.5 Manhole type pump	358.1	60.5	418.6					65.2	11.0	65.2	11.0	65.2	11.0	65.2	11.0	65.2	11.0	32.2	5.4
	1.6 An Da Relay Pumping Station	691.5	234.5	925.9									115.5	39.2	230.3	78.1	230.3	78.1	115.5	39.2
	1.7 West Wastewater Treatment Plant	10,001.5	2,973.4	12,974.9					4,000.6	1,189.3	4,000.6	1,189.3	2,000.3	594.7						
	1.8 Supplementary Works	2,235.8	2,235.8	4,471.6					406.9	406.9	406.9	406.9	406.9	406.9	406.9	406.9	406.9	406.9	201.2	201.2
	Subtotal	35,026.4	15,327.3	50,355.1	0.0	0.0	3,184.2	1,393.4	7,849.8	3,141.5	7,849.8	3,141.5	5,964.9	2,586.0	4,079.4	2,030.2	4,079.4	2,030.2	2,018.9	1,004.5
2	Land Acquisition and Compensation	0.0	2,165.0	2,165.0	0.0	1,082.5	0.0	1,082.5												
3	Engineering Service Cost	3,502.6	1,749.2	5,252.0	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7	437.8	218.7
4	Administration	0.0	1,733.1	1,733.1		52.2		189.5		349.4		349.4		276.2		203.0		203.0		110.4
5	Physical Contingency	3,852.9	2,097.5	5,950.4	43.8	135.3	362.2	288.4	828.8	371.0	828.8	371.0	640.3	308.1	451.7	245.2	451.7	245.2	245.7	133.4
	Total without Price Contingency	42,382.0	23,072.1	65,455.6	481.6	1,488.7	3,984.3	3,172.4	9,116.4	4,080.5	9,116.4	4,080.5	7,043.0	3,388.9	4,969.0	2,697.1	4,969.0	2,697.1	2,702.4	1,466.9
6	Price Contingency	5,918.3	3,106.4	9,024.7	29.5	91.1	328.4	261.5	948.8	424.7	1,150.1	514.8	1,047.2	503.9	853.0	463.0	969.4	526.2	591.8	321.2
	Total ＊	48,300.2	26,178.6	74,478.8	511.1	1,579.8	4,312.7	3,434.0	10,065.2	4,505.2	10,266.5	4,595.4	8,090.2	3,892.8	5,821.9	3,160.0	5,938.4	3,223.2	3,294.2	1,788.2
	Recurring Cost		1,470.0	1,470.0										309.0		309.0		426.0		426.0

Note: All the amounts are shown in 2000 constant price except for those marked with "＊"

Table 2.3.7 Disbursement Schedule of Project Cost for Solid Waste Management Priority Project

US $ 1.00 = VND 14,072 , Unit: 1,000US$

Item	Description	Total (US$)			2003		2004		2005		2006		2007		2008		2009		2010	
No.		F.C	L.C	Total	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C	F.C	L.C
1	**Waste collection and transport system**																			
	(1) Procurement of collection vehicles, bins, handcarts and work shop equipment	3,907.0	0.0	3,907.0			3,907.0	0.0												
	Subtotal	3,907.0	0.0	3,907.0			3,907.0	0.0												
	(2) Land Acquisition and Compensation	0.0	0.0	0.0	0.0	0.0														
	(3) Engineering Service Cost	195.4	0.0	195.4	195.4	0.0	0.0	0.0												
	(4) Administration	0.0	123.1	123.1		5.9		117.2		0.0										
	(5) Physical Contingency	410.2	12.3	422.5	19.5	0.6	390.7	11.7	0.0	0.0										
	Total without Price Contingency	4,512.6	135.4	4,648.0	214.9	6.4	4,297.7	128.9	0.0	0.0										
	(6) Price Contingency	367.4	11.0	378.4	13.2	0.4	354.3	10.6	0.0	0.0										
	Total *	4,880.0	146.4	5,026.4	228.0	6.8	4,652.0	139.6	0.0	0.0										
	Recurring cost	0.0	10,464.0	10,464.0		0.0		0.0		1,744.0		1,744.0		1,744.0		1,744.0		1,744.0		1,744.0
2	**Trang Cat new landfill site**																			
	(1) Civil works of Trang Cat new landfill site	3,299.0	3,299.0	6,598.0			1,649.5	1,649.5	1,649.5	1,649.5										
	(2) Procurement of heavy equipment	1,411.8	0.0	1,411.8			1,411.8	0.0												
	Subtotal	4,710.8	3,299.0	8,009.8			3,061.3	1,649.5	1,649.5	1,649.5										
	(3) Land Acquisition and Compensation	0.0	602.0	602.0	0.0	602.0														
	(4) Engineering Service Cost	400.5	329.9	730.4	200.5	200.0	200.0	129.9	0.0	0.0										
	(5) Administration	0.0	280.3	280.3		30.1		151.2		99.0										
	(6) Physical Contingency	511.1	451.1	962.2	20.1	83.2	326.1	193.1	165.0	174.8										
	Total without Price Contingency	5,622.4	4,962.3	10,584.7	220.6	915.3	3,587.4	2,123.7	1,814.5	1,923.3										
	(7) Price Contingency	498.1	431.3	929.3	13.5	56.0	295.7	175.1	188.8	200.2										
	Total *	6,120.5	5,393.5	11,514.0	234.0	971.3	3,883.1	2,298.7	2,003.3	2,123.5										
	Recurring cost	0.0	2,592.0	2,592.0		0.0		0.0		356.0		394.0		422.0		448.0		472.0		500.0
3	**Hospital waste treatment**																			
	(1) Procurement of incineration plant	263.0	0.0	263.0			263.0	0.0												
	(2) Site preparation and building	0.0	87.0	87.0			0.0	87.0												
	(3) Procurement of medical waste collection vehicles	76.0	0.0	76.0			76.0	0.0												
	Subtotal	339.00	87.00	426.00			339.00	87.00												
	(4) Land Acquisition and Compensation	0	0	0	0	0														
	(5) Engineering Service Cost	33.9	8.7	42.6	33.9	8.7	0.0	0.0												
	(6) Administration	0.0	14.1	14.1		1.3		12.8												
	(7) Physical Contingency	37.3	11.0	48.3	3.4	1.0	33.9	10.0												
	Total without Price Contingency	410.2	120.7	530.9	37.3	11.0	372.9	109.8												
	(8) Price Contingency	33.0	9.7	42.7	2.3	0.7	30.7	9.0												
	Total *	443.2	130.5	573.7	39.6	11.6	403.6	118.8												
	Recurring cost	0.0	282.0	282.0		0.0		0.0		47.0		47.0		47.0		47.0		47.0		47.0
	Total without Price Contingency	10,545.2	5,218.4	15,763.6	472.7	932.7	8,258.0	2,362.4	1,814.5	1,923.3										
	Total *	11,443.7	5,670.4	17,114.1	501.7	989.8	8,938.7	2,557.1	2,003.3	2,123.5										
	Total Recurring Cost	0.0	13,338.0	13,338.0	0.0	0.0	0.0	0.0	0.0	2,147.0		2,185.0		2,213.0		2,239.0		2,263.0		2,291.0

Note: All the amounts are shown in 2000 constant price except for those marked with "*"

Figure 2.3.1 Overall Implementation Schedule for Selected Priority Project

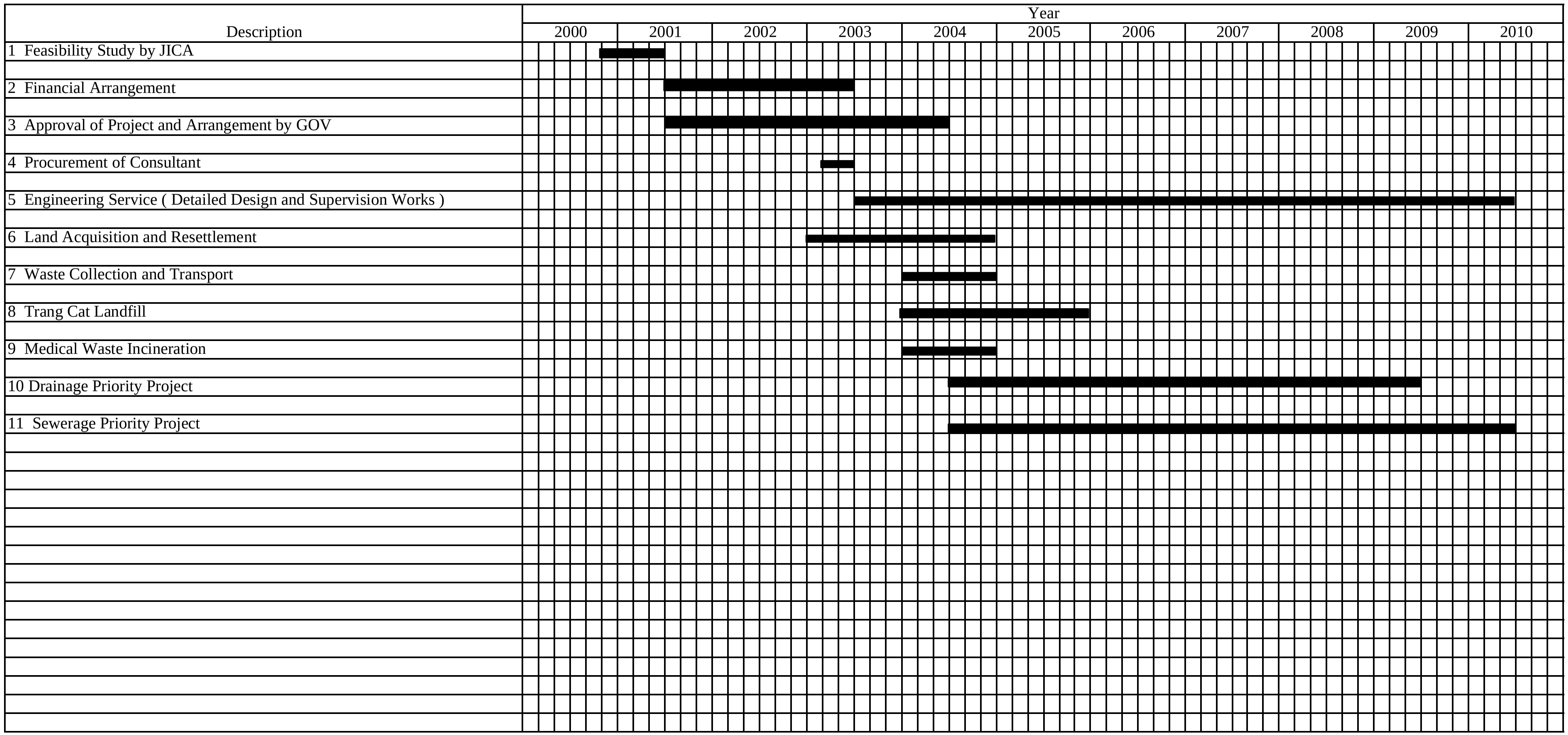


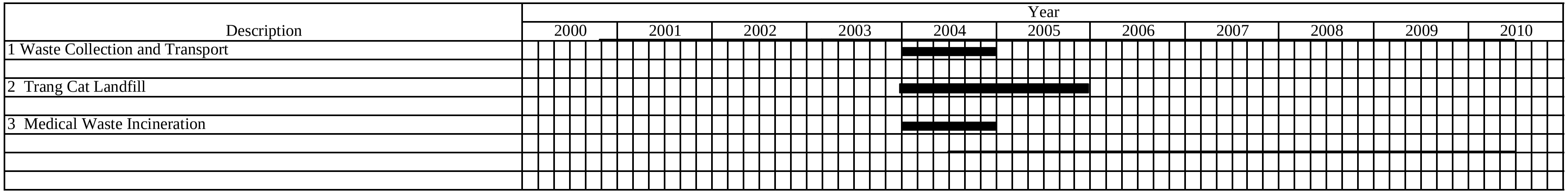
Figure 2.3.2 Implementation Schedule for Drainage Priority Project

Description	Quantity	Year: 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
An Kim Hai Channel and Phuong Luu Regulating Lake												
0 Preparatory Works	L.S											
1 An Kim Hai Channel												
1) Excavation of channel	164,500 m3											
2) Revetment works	53,200 m3											
3) Maintenance road	20,000 m2											
4) Construction of tidal gate, Lach Tray river	L.S											
5) Construction of tidal gate, Cam river	L.S											
6) Construction of discharge gate to Du Hang lake	L.S											
7) Demolishing existing outlet gate	L.S											
2 Phuong Luu Regulating Lake												
1) Excavation of Phuong Luu Regulating Lake	672,000 m3											
2) Revetment works	8,200 m3											
3) Road works and bridge	1,400 m2											
4) Excavation of connection channel	10,900 m3											
5) Revetment works, connection channel	2,660 m3											
6) Maintenance road	1,000 m2											
7) Box culvert, 3 x (3.0 m x 2.0 m)	450 m											
3 Construction of New Sewers												
1) Trunk sewers	3,000 m											
2) Lateral sewers	7,000 m											
4 Supplementary Component, An Kim Hai Channel Bridge												
1) Bridge, W 7.0 m x L 12.0 m	3 nos											
2) Bridge, W 7.0 m x L 15.0 m	9 nos											
3) Bridge, W 7.0 m x L 20.0 m	3 nos											
5 Road Ancillary Works												
1) Lighting	650nos											
2) Fence	24000m											
3) Planting	L.S											

Figure2.3.3 Implementation Schedule for Sewerage Priority Project

Description	Quantity	Year 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
West Wastewater Treatment Plant, Phase I, Combined Sewer Area												
0 Preparatory Works	L.S											
1 Trunk Sewer, Open Excavation, 100-1200 mm dia.	12,260 m											
2 Trunk Sewer, Pipe Jacking, 800-1800 mm dia.	7,660 m											
3 Combined Sewer Overflow Control Structure	63 nos											
4 Manholes	189 nos											
5 Manhole Type Pump												
1) Civil Works	5 nos											
2) Pumping facilities	5 nos											
6 An Da Relay Pumping Station												
6.1 Pumping House Structure												
1) Excavation of common soil	3,110 m3											
2) Embankment	5,270 m3											
3) Concrete pile	336 m											
4) Soil improvement	924 m3											
5) Concrete works	447 m3											
6.2 Pumping Facilities												
1) Pump, 300 mm dia., 11 m3/min, 18.5 kw	4 sets											
2) Electrical equipment	L.S											
7 West Wastewater Treatment Plant												
7.1 Pumping House Structure												
1) Excavation of common soil	5,150 m3											
2) Backfilling	5,200 m3											
3) Concrete pile, 300mmx300mm	540 m											
4) Soil improvement	1,520 m3											
5) Concrete works	594 m3											
7.2 Aerated Lagoon Treatment Process												
1) Excavation of common soil	12,800 m3											
2) Soil stabilization	12,800 m3											
3) Aerators, 55 kw	32 sets											
7.3 Settling Pond												
1) Excavation of common soil	49,000 m3											
2) Soil stabilization	8,200 m3											
7.4 Chlorination Tank												
1) Excavation of common soil	500 m3											
2) Concrete	620 m3											
7.5 Stormwater sedimentation pond												
1) Excavation of common soil	4,700 m3											
2) Soil stabilization	1,400 m3											
7.6 Sludge Drying Bed												
1) Excavation of common soil	1,600 m3											
2) Soil stabilization	6,800 m3											
3) Concrete	1,530 m3											
7.7 Building Works												
1) Operation building	640 m2											
2) Other building	430 m2											
7.8 Pumping Facilities												
1) Rack rake	4 sets											
2) Pump, 400 mm dia., 22.5 m3/min, 55 kw	2 sets											
3) Pump, 600 mm dia., 45.1 m3/min, 110 kw	1 set											
4) Dredge pump, 1.3 m3/min, 7.5 kw	1 set											
5) Electrical equipment	L.S											
8.0 Supplementary works												
1) Construction of precast R.C. pipe, 300 mm	10,000 m											
2) Construction of precast R.C. pipe, 400 mm	5,000 m											
3) Construction of precast R.C. pipe, 500 mm	3,000 m											
4) Construction of precast R.C. pipe, 700 mm	2,000 m											
5) Manhole	270 nos											
6) Manhole type pump	5 nos											

Figure 2.3.4 Implementation Schedule for Solid Waste Management Priority Project



PART 2 FEASIBILITY STUDY OF DRAINAGE PRIORITY PROJECT

CHAPTER 1 BACKGROUND

1.1 Drainage Improvement Master Plan

1.1.1 Class A Areas

(1) Need for Storm Water Drainage Improvements

Class A Areas comprise existing urbanized areas in the Haiphong City area with high population densities. Because of the high degree of land development, a properly developed storm water drainage system is needed in Class A Areas.

Flooding occurs regularly in the three urban districts of Class A Areas. Because of urbanized conditions the amount of storm water runoff is high and accumulates in low areas, causing flooding of significant magnitude and duration.

(2) Target Planning Areas

Three target planning areas were defined in the Drainage Improvement Master Plan for Class A Areas. Definition of the target planning areas was based on the following considerations:

- Current and future planned population densities
- Natural conditions related to drainage, including land levels, number of outlets connected with tidal rivers, channels, and lakes
- Whether combined sewers presently exist or not

The target planning areas are located in Le Chan District, Ngo Quyen District, Old City Center within the Hong Bang District, 2 communes located outside and south of Le Chan District, and 4 communes located outside and east of Ngo Quyen District. The total coverage area is 5,240 ha.

After selection of the Drainage Priority Project and during preliminary design, the target planning areas were slightly modified. Land area of 172 ha was removed from the Central Area and included in the New Urban Area. Purpose of the modification was to have consistency with the target planning areas of the selected Sewerage Priority Project. It was assessed that the modification did not affect the preliminary designs of Phase I and Phase II Projects.

The locations of the modified target planning areas are presented in Figure 2.1.1. Characteristics of each planning area is presented in the following table.

Target Planning Areas in Class A Areas

Planning Area	Area	Beneficiary (2020)
Old City Center	856 ha	121,452
Central Area	1,103 ha	229,286
New Urban Area	3,262 ha	193,939
TOTAL	5,241 ha	574,671

The six non-urban communes are included in the target area because of their high present population density and strong possibility of including in the urban district in near future.

(3) Alternatives for Drainage Improvement Plan

Four alternatives were formulated for the target planning areas. The basis of the four alternatives are different drainage target levels for the areas. Three different drainage target levels were defined. These levels were based on the frequency of high tide conditions and the frequency of expected storms and rainfall magnitudes.

High tide conditions with a frequency of a 10 year average recurrence interval (ARI) was selected for all three drainage target levels. However, the frequency of the expected storms and rainfall magnitudes were different for each drainage target level and system element and are defined as follows:

- Level A: Storm with a frequency of 10 year ARI
- Level B: Storm with a frequency of 5 year ARI
- Level C: Storm with a frequency of 2 year ARI

Target drainage levels are also defined for different elements of the drainage system. The levels of the different elements of the drainage system are defined as follows:

- Grade A: Storage lakes, drainage channels, and pumping stations
- Grade B: Main and branch combined sewers
- Grade C: Tertiary sewers

Based on these target drainage levels, the four alternatives for storm water drainage improvements were formulated as shown in the following table.

Planning Alternatives for Drainage Improvement Master Plan in Class A Areas

	Target Area	Target Drainage Level	
		Lakes and Channels	Sewers
Alternative D1	Central Area New Urban Area Old City Center	5 Year ARI Storm 5 Year ARI Storm No Action	2 Year ARI Storm 2 Year ARI Storm No Action
Alternative D2	Central Area New Urban Area Old City Center	5 Year ARI Storm 5 Year ARI Storm 2 Year ARI Storm	2 Year ARI Storm 2 Year ARI Storm 2 Year ARI Storm
Alternative D3	Central Area New Urban Area Old City Center	10 Year ARI Storm 10 Year ARI Storm 2 Year ARI Storm	5 Year ARI Storm 5 Year ARI Storm 2 Year ARI Storm
Alternative D4	Central Area New Urban Area Old City Center	10 Year ARI Storm 10 Year ARI Storm 2 Year ARI Storm	5 Year ARI Storm 5 Year ARI Storm 5 Year ARI Storm

For the alternative formulation, the Old City Center is considered as relatively low priority when considering the present high degree of drainage development. In Alternative D1, this area is not included. However, in the other three alternatives this area is included, because of the high population density and economic importance of the area.

Furthermore, all alternatives were divided into two implementation phases. The Central Area was selected to be covered in Phase I. As the Old City Center is considered to have relatively low priority from further development needs, this area is included in Phase II, except for Alternative D1, where this area is not included in either phase. New Urban Area is not yet developed, so this area is included in Phase II for all four alternatives.

(4) Selection of Alternative for Drainage Improvement Plan

The formulated alternatives were compared from the following major points:

- Inclusion or exclusion of the Old City Center
- Selection of the most appropriate target drainage level for each area based on average recurrence interval of expected tide conditions and storms
- Phasing of implementation of the drainage improvements for each area

Alternative D2 was selected as the optimum measure for Class A Areas. The basis for this selection included the following:

- Complete coverage of the target planning area
- Target drainage levels are adequate when considering high tide conditions
- Most cost effective for largest coverage of target planning area

As a summary the drainage improvement plan for Class A Areas have target drainage levels for the different grade facilities and a phased implementation schedule as presented in the following table.

Planning Criteria for Drainage Improvement Plan for Class A Areas

Target Area	Target Drainage Level			Implementation
	Grade A	Grade B	High Tide	
Central Area	5 year ARI Storm	2 year ARI Storm	10 year ARI	Phase I
Old City Center	2 year ARI Storm	2 year ARI Storm	10 year ARI	Phase II
New Urban Area	5 year ARI Storm	2 year ARI Storm	10 year ARI	Phase II

1.1.2 Class B Areas

(1) Need for Storm Water Drainage Improvements in Class B Areas

Class B Areas include Kien An District, Do Son Town, and Quan Toan Area. These areas are characterized as areas under urbanization with medium population density and tourism areas.

For Class B Areas, the degree of developed land is great enough that it requires a properly developed and functioning storm water drainage system. At present there are 12 km of existing combined sewers, 10 km of drainage channels, and 8 tidal gates in Kien An.

For the other sub-areas the degree of developed land is not great, and natural drainage is sufficient. Investments in storm water drainage improvements are then needed only for Kien An in Class B Areas.

(2) Drainage Improvement Plan for Class B Areas

The components of the proposed drainage improvement plan for Kien An are presented in the following table.

Proposed Drainage Improvement Plan for Kien Anh

Item	Unit	Amount
Rehabilitation of existing sewer	km	10.0
Construction of new sewer	km	17.2
Construction of main drainage channel	km	5.0
Rehabilitation of tidal gate	nos.	7

Planning criteria is as follows:

- Grade A facilities: 5 year ARI storm, 10 year ARI tide conditions
- Grade B facilities: 2 year ARI storm, 10 year ARI tide conditions

1.1.3 Class C Areas

Class C Areas include Minh Duc, New Development Area, and Dinh Vu. These areas are characterized as rural or undeveloped areas with low population density where agricultural land use is dominating.

For all areas in Class C Areas the degree of developed land is not great, and natural drainage is sufficient. Investments in storm water drainage improvements are therefore not needed in Class C Areas.

1.1.4 Related On-Going Projects

At present there are two related on-going projects in Class A Areas: World Bank Sanitation Project and FINNIDA Project. These projects are included in the Drainage Improvement Master Plan.

Both projects include measures for drainage improvements in both the Old City Center and the Central Area. However, both projects do not achieve the target drainage levels of 10 year ARI high tide conditions formulated in the Drainage Improvement Master Plan for these areas.

General aspects of these two projects are summarized in the following sections.

(1) World Bank Sanitation Project

In the Old City Center and Central Area, the existing combined sewers are to be cleaned and inspected. Sewers needing rehabilitation will then be identified, and these sewers will either be repaired or replaced. In addition about 7 km of new combined sewers are to be constructed to reduce flooding in prioritized flood areas.

In the Central Area, the Northeast and Southwest Channels are to be rehabilitated by dredging the channels and constructing embankment works and maintenance roads. May Den and Vinh Niem Tidal Gates at the outlets of these channels are also to be rehabilitated.

In the Central Area, Tien Nga, Sen, Lam Tuong and Du Hang Lakes are to be rehabilitated by dredging the lakes and constructing embankment works and maintenance roads.

For the Old City Center and Central Area, vehicles and equipment are procured for cleaning, inspecting and maintaining the combined sewer network.

Also, treatment facilities at Trang Cat Landfill are provided for treating and disposing the sludge which is dredged from the channels.

(2) FINNIDA Projects

In the Central Area, two storm water pumping stations are to be constructed. The pumping stations are located at May Den and Vinh Niem Tidal Gates. Total capacity of each pumping station is 9 m^3/s.

1.1.5 Implementation and Costs Estimates

Implementation of Phase I for Class A Areas is targeted for completion by the Year 2010 and Phase II by the Year 2020. Time frame for the implementation of the proposed project in Kien Anh is proposed for Phase II.

The total direct costs of the Drainage Improvement Master Plan is estimated at about US$179 million.

1.2 Selection of Drainage Priority Project

Phase I of the proposed Drainage Improvement Master Plan in Class A Areas is selected as the Drainage Priority Project. The project consists of two main components as follows:

- Rehabilitation of An Kim Hai Channel
- Construction of Phuong Luu Lake

The selection was based on the following justifications.

(1) Need for New Detailed Study

Although the World Bank and FINNIDA Projects include project components both for the Central Area and the Old City Center, they are limited in degree. For the Central Area, the anticipated drainage improvements are not considered as sufficiently comprehensive and do not achieve the target drainage levels.

(2) Urgency

The Central Area to be covered by the Drainage Priority Project is seriously affected by flooding. The area experiences different degrees of flooding almost every year, and sometimes several times in a year.

(3) Satisfaction of the Project Objectives

Sanitation conditions will be improved by avoiding frequent flooding. Furthermore, pollution in An Kim Hai Channel would be reduced. The rehabilitated channel could also be used for flushing the existing lakes in the Central Area with cleaner water. The improved sanitation conditions from the reduced pollution in the water bodies would provide a more healthy living environment.

(4) Economic Viability

The Central Area is the most densely populated area in Haiphong City with the expected population density of 235 persons per ha in the year 2020. The number of beneficiaries will total about 240,000 persons in 2010 and 260,000 persons in 2020. Drainage conditions will be improved for about 1,100 ha.

Investment cost per beneficiary is the smallest among all the drainage alternatives formulated in the JICA Study for the Central Area.

(5) Financial Affordability

Investment cost is the lowest among the alternatives which completely cover the target planning areas in the Class A Areas.

(6) Technical Feasibility

Proposed plan will mainly consist of ordinary civil works and no special technology will be needed both for construction and operation and maintenance.

(7) Meeting Time Requirement

Physical works will not require a long time for completion. However, careful consideration will be needed for the time needed for possible relocation of the inhabitants associated with rehabilitation of An Kim Hai Channel.

(8) Coordination and Being Complementary with Other Plans

The World Bank and FINNIDA Projects cover the Central Area, except for the drainage zones of An Kim Hai Channel. However, the improvements are directed to drainage zones which are not integrated. The Drainage Priority Project would include the An Kim Hai Channel Drainage Zone and integrate the three drainage zones. The Priority Project would then increase the effectiveness of these projects, as well as providing additional needed improvements.

(9) Complement of with the Long-Term Sanitation Master Plan

The Drainage Priority Project forms an integral part of the long-term Sanitation Improvement Master Plan to be implemented in Phase I.

(10) Small Negative Impacts

Since it will include the rehabilitation of the An Kim Hai channel of 10 km length, relocation of inhabitants along the channel will be unavoidable. Careful consideration is taken to minimize the relocation.

CHAPTER 2 RECOMMENDED DRAINAGE PRIORITY PROJECT

2.1 System Concept of Priority Project

2.1.1 Background

The Priority Project consists of rehabilitating of an existing channel and construction of a new lake. The Priority Project is based on the Haiphong Sewerage and Drainage Master Plan prepared by Haiphong City and is consistent with development plans for the city.

The main components of the Drainage Priority Project consist of the following:

- Rehabilitation of An Kim Hai Channel
- Construction of Phuong Luu Lake

The main project components and given conditions are presented in Figure 2.2.1.

The existing length of An Kim Hai Channel in the Priority Project area is 10 km. An existing tidal gate (Nam Dong Tidal Gate) is located at the discharge point of the channel to Cam River. A siphon structure is located at the west end of the channel and crosses under the Lach Tray River to connect with the upstream part of the channel outside the Priority Project area. A flow gate is connected to the siphon structure on the west side of the Lach Tray River.

There are seven main lakes used for drainage and storm water storage in the Priority Project area. The Priority Project proposes to construct a new lake (Phuong Luu Lake). Phuong Luu Lake would be connected to the Northeast Channel and An Kim Hai Channel.

2.1.2 Development Approach

The drainage system for the area of the Drainage Priority Project is based on a trunk system consisting of drainage channels, storage lakes, and tidal gates.

The channels are needed because of the low land levels and the long distances to the receiving rivers. Combined sewers discharge storm water to the channels, from where the storm water is then discharged to rivers and lakes.

The storage lakes are needed because the land levels are lower than the highest tide levels. Storm water must then be discharged and stored in the lakes during high tide conditions.

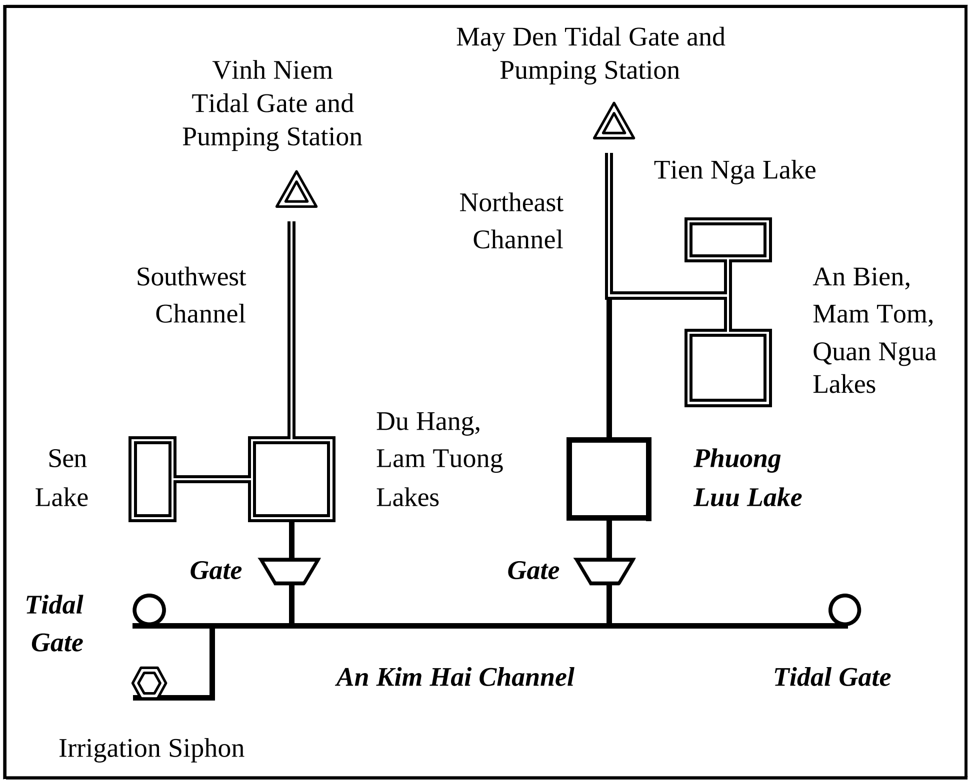
Tidal gates are used at the discharge points of the channels to the rivers. During high tide the tidal gates are closed and storm water is stored in the lakes. The storm water is stored in the lakes until the tide decreases to a level where the tidal gates can be opened and the stored water can be discharged through the channels to the rivers. Construction of storm water pumping stations (FINNIDA Project) are planned to discharge some of the storm water stored during high tide.

The area of the Drainage Priority Project consists of three main drainage zones as shown in Figure 2.2.2 and as follows:

- Northeast Drainage Zone
- Southwest Drainage Zone
- An Kim Hai Channel Drainage Zone

In addition, as shown in Figure 2.2.2, An Kim Hai Channel Drainage Zone is divided into 5 sub-zones for the purpose of preliminary design.

The development approach is to integrate the three drainage zones by rehabilitating An Kim Hai Channel and constructing Phuong Luu Lake to connect the three drainage zones. The new Phuong Luu Lake will also provide additional storage capacity for the integrated drainage zones. The following figure presents a schematic diagram of the development approach.



Development Approach of Drainage Priority Project

The integrated drainage zones will provide benefits both in avoided flood incidences as well as favorable urban development in the Central Area, both of which can not be obtained without a suitable and properly functioning trunk drainage system.

2.1.3 Planning Criteria

Development of the drainage system in the Central Area is based on the planning criteria in the Drainage Improvement Master Plan. The target drainage level is a storm with a frequency of 5 year ARI for Grade A facilities (channels and lakes) and 2 year ARI for Grade B facilities (main and branch sewers), and high tide conditions at the river discharge outlets with a frequency of 10 year ARI.

2.1.4 Inclusion of Areas in New Urban Area in Priority Project

As shown in Figure 2.1.1 and Figure 2.2.2, there are parts of the areas of the An Kim Hai Channel Draiage Zone which are located in the New Urban Area. These areas are outside the Central Area, which is the target planning area for Phase I implementation of the Drainage Improvement Master Plan.

It is necessary to include these areas of the New Urban Area for planning and design of the main components of the Priority Project. These areas will contribute rainfall runoff into the drainage system to be developed. The runoff will discharge into the system through connecting ditches and channels in these areas.

However, for the Year 2010 the projected degree of land and economic development for these areas in the New Urban Area is not great enough to justify inclusion of these areas into the target planning area.

Though drainage improvements will occur in these areas of the New Urban Area after implementation of Phase I, the positive impacts will be an indirect benefit which will not be fully realized until implementation of Phase II.

2.2 Compatibility with Other Projects

Given conditions are adopted for development of the Priority Project. These given conditions consist of the existing drainage system in the Priority Project area and implementation of the World Bank and FINNIDA Projects.

2.2.1 Compatibility with World Bank Sanitation Project

(1) Rehabilitation of Combined Sewers

A major component of the World Bank Project is comprehensive rehabilitation of the existing combined sewer network, comprising cleaning, inspection and possible repair or replacement of existing sewers. The project allows the possibility of rehabilitating about 50 % of the existing sewer lengths. This amount anticipates the rehabilitation needs of the combined sewer network and is based on estimates of the present structural conditions of the sewers.

Rehabilitation of the combined sewer network includes provision for possible replacement of combined sewers by either (1) sewers of the same size for sewers in very poor structural condition, or (2) sewers of a larger size, where repair of the sewer is not considered cost effective because the hydraulic capacity of the existing sewer can be increased to provide more effective performance.

Estimates for the rehabilitation needs of the World Bank Project is considered as appropriate. Consequently, the Priority Project does not include provision for additional repair or replacement of sewers which are to be cleaned and inspected within the World Bank Project.

However, the World Bank Project does not include cleaning and inspecting of sewers for some areas of the Priority Project area as follows:

- Tertiary sewers are not included in the project for Lam Son, An Duong and Niem Nghia Phuongs in Le Chan District and May Chai Phuong in Ngo Quyen District
- Neither main, lateral nor tertiary sewers are included in the project for Dong Khe and Dang Giang Phuongs in Ngo Quyen District and Du Hang Kenh Commune in An Hai District

Nonetheless, the World Bank Project provides procurement of sewer cleaning and inspection equipment to SADCO. In this case SADCO will have the capability, especially with the experience gained from the World Bank Project, to clean and inspect the main, branch and tertiary sewers not included in the World Bank Project. Therefore, this task is not included in the Priority Project.

The amount of sewers which SADCO would need to clean and inspect in these areas is small, estimated as about 12 km. Consequently, based on the estimations from the World Bank Project, the amount of sewers needing possible repairs would be small. Any repairs can then be financed through the present budget of SADCO.

However, for sewers needing possible replacement because of poor condition or inadequate hydraulic capacity, the Priority Project includes the construction of new sewers to replace these sewers as a supplementary component.

(2) Construction of New Combined Sewers

The World Bank Sanitation Project includes construction of new combined sewers in both the Old City Center and the Central Area. The construction of the new sewers is needed to replace existing sewers which have inadequate hydraulic capacity and which are needed to reduce flooding in prioritized flooding areas.

Also, construction of new sewers is included in the sewer rehabilitation component, when after inspection, it is determined that repair of the sewer is not cost effective, because the hydraulic capacity of the existing sewer can be increased to provide more effective performance.

For the Old City Center, the design criteria is a storm with a 2 year ARI for a maximum tide level of +2.5 m (the north Vietnam Datum). Because the Priority Project is focused on the Central Area, the two projects are compatible.

For the Central Area the design criteria is a storm with a 2 year ARI for a maximum water level of +2.2 m in the lake and channel systems. This approach is consistent with the Priority Project, and the two projects are compatible.

At present the amount of existing combined sewers is considered to be too small in some of the areas in the Priority Project area. These areas comprise the following:

- Dong Khe Phuong in Ngo Quyen District
- Du Hang Kenh Commune in An Hai District

Based on urban development plans of Haiphong City, new roads are planned for construction in these areas: Sen Road in Du Hang Kenh Commune and Cat Bi Road in Dong Khe Phuong. Locating new main combined sewers at these new roads would provide much more cost effective drainage than attempting to plan and construct new sewers based on the existing conditions.

It is expected that the budget of the roads project would include construction of new main sewers for the roads. Therefore, the Priority Project does not include provision of new main sewers for these roads

However, the Priority Project includes provision for branch sewers as a supplementary component. These branch sewers would then connect to the new main sewers of the new roads construction project. This approach avoids potential problems with coordination between these two very different projects.

(3) Rehabilitation of Channels and Lakes

The World Bank Sanitation Project includes rehabilitation of the Northeast and Southwest Channels and four lakes in the Central Area. The rehabilitation is needed to increase the hydraulic and storage capacities of these drainage systems.

The channels and lakes were designed for storms with a frequency of 10 year ARI for rising and falling tide conditions without the use of pumping stations.

For the Priority Project these channels and lakes are integrated, and the integrated system is designed to achieve the drainage target levels. In addition, the design of the integrated system is also checked to ensure that the design criteria of the World Bank Project is also satisfied. Consequently, the two projects are compatible.

2.2.2 Compatibility with FINNIDA Projects

The FINNIDA Haiphong Stormwater Pumping Stations Project consists of constructing pumping stations at May Den and Vinh Niem Tidal Gates. Total capacity of each pumping station is 9 m^3/s.

Though the design capacities of the pumping stations were selected without considering any addition storm water discharges which may occur from the An Kim Hai Channel Drainage Zone into the existing storage lakes, this additional storm water load would be compensated by the additional storage capacity provided by Phuong Luu Lake.

For the Priority Project, the integrated system is designed to achieve the drainage target levels. In addition, the design of the integrated system is also checked to ensure that the design criteria of both the World Bank Project and FINNIDA Project are also satisfied. Consequently, all three projects are compatible.

2.3 Main Project Components

Rehabilitation of An Kim Hai Channel consists of the following:

- Excavation and embankment works of existing channel
- Construction of maintenance roads along both sides of the channel
- Demolition of one existing tidal gate at river outlet
- Construction of two tidal gates at river outlets
- Construction of discharge gate at lake outlet

Construction of Phuong Luu Lake consists of the following:

- Excavation and embankment works of new lake
- Construction of roads and margins along the sides of the lakes
- Construction of connecting channel to Northeast Channel
- Construction of road connecting the lake site area to Highway No. 5
- Construction of closed conduit to An Kim Hai Channel and discharge gates

2.4 Planning and Design Methodology

2.4.1 Computer Modeling of Drainage System

Planning and design of the Drainage Priority Project is based on computer modeling of the drainage system by using the computer program MOUSE 2000 developed by the Danish Hydraulic Institute. Development of the computer model is presented in the flowchart in Figure 2.2.3. The layout of the computer model with a background map of the Priority Project area is presented in Figure 2.2.4. The layout of the computer model with node labels for An Kim Hai Channel are presented in Figure 2.2.5.

(1) Hydrological Modeling

Hydrological modeling was achieved by using a time/area method. Routing of the rain water in the runoff model, reduced by a constant hydrological amount, is determined by the catchment shape and by time of concentration. Rectangular catchment areas were selected for developing the model.

(2) Hydrodynamic Modeling

Hydrodynamic modeling was based on computations using the complete St. Venant (dynamic flow) equations. The method allows for time variable hydrodynamic modeling which includes backwater effects, flow reversal, surcharging in manholes, free-surface and pressure flow, tidal outfalls, storage basins, open channels, and pumping stations.

2.4.2 Computer Simulation and Performance Analysis

(1) Hydrological Design Conditions

Hydrological design conditions are based on rainfall intensity, duration and frequency data obtained from the Phu Lien Meteorological Station near Haiphong.

The applied hydrological data is presented in Figure 2.2.6. The figure also includes numerical data for rainfall intensities and durations for storms with average recurrence intervals (ARI) of 5 years and 10 years.

Design storm hyetographs are developed using rainfall data for storms with 5 year ARI and 10 year ARI and a total rainfall duration of 12 hours.

The hyetographs are developed using a "Balanced Storm Approach". In this method the storm depth at any duration of the storm is equal to the depth from the Intensity-Duration-Frequency (IDF) curves.

(2) Hydrographic Design Conditions

Hydrographic design conditions are based on tide level data measured at the Cam River near Haiphong.

Representative data of tide levels is presented in Figure 2.2.7. The figure includes numerical data for high tide levels and tide durations with a 10 year ARI.

Design tide levels are developed using data for tide levels with a 10 year ARI. Based on this data the maximum water level is +4.1 m and the minimum water level is +1.0 m. The complete tide cycle is 24 hours. The duration of water levels above +2.5 m is approximately 12 hours.

(3) System Performance Analysis

Computer simulations of the drainage system are done to check the following design conditions:

- 5 year ARI storm during 10 year ARI high tide conditions

In addition, computer simulations of the drainage system are done to assess the following conditions to ensure compatibility with the World Bank Project:

- 10 year ARI storm during 10 year ARI rising tide conditions
- 10 year ARI storm during 10 year ARI falling tide conditions

The three design conditions are presented in Figures 2.2.8, 2.2.9 and 2.2.10. For the storm with 5 year ARI, the moment of greatest rainfall was set to occur when the tide level is +4.1 m. For the storms with 10 year ARI, the moment of greatest rainfall was set to occur when the tide level was +2.2 m.

In the simulations the pumps at the May Den and Vinh Niem Pumping Stations are operated when the water levels at the stations exceed +1.8 m and stopped when the water levels fall below +1.5 m. From +1.8 m to +2.0 m, only one pump (3 m^3/s) is used. From +2.0 m and higher, all three pumps (9 m^3/s) are used.

2.5 Methodology for Assessing Flood Reductions

2.5.1 Basic Approach

The methodology for assessing the flood reductions in the Priority Project Area after implementation of the Priority Project is based on the following:

- Use of existing flood data from previous studies and projects
- Computer simulation of flooding for the present conditions of An Kim Hai Channel using the developed computer model

Figure 2.2.11 presents the adopted methodology. The methodology consists of the following approach and assumptions:

- Data from the World Bank Project for the present flooding conditions is verified by reviewing the flood data from SADCO
- Quantitative data from the World Bank Project provides the basis for determining the incremental reductions in flooding for all three projects
- Quantitative data from the World Bank Project for the reductions in flooding after implementation of the project is a given condition

- Quantitative data from the FINNIDA Project for the reductions in flooding after implementation of the project is a given condition
- Computer simulation of flooding for the present conditions of An Kim Hai Channel is used to provide quantitative data for the reductions in flooding after implementation of the Priority Project
- Quantitative data from the computer simulations are compared with the quantitative data from the World Bank and FINNIDA Projects to assess and verify the consistency of the data
- After verification of the data, delineation of the flood reductions for the Priority Project and for the other areas is achieved for each project

2.5.2 Use of Risk Factors

Quantitative data on the degree of flooding is based on the following conditions:

- Actual degree of flooding which occurs for a storm and tide conditions
- Expected annual degree of flooding

The actual degree of flooding is based on storm with a rainfall magnitude which is based on the frequency of the storm. In addition, the actual degree of flooding is based on whether the storm occurs during low or high tide conditions.

The expected annual degree of flooding represents a annual amount of flooding which is expected to occur during a significantly long period of time, for example, 20 years, and which represents a yearly average. Although this approach is not based on a physical basis, it does provide a common benchmark for assessing the degree of flood reductions for projects implemented to reduce flooding.

Risk factors are used for determining the expected annual degree of flooding. There are two types of risk factors:

- Risk factor of a storm occurring
- Risk factor of high tide occurring

The two risk factors are independent of each other and can be multiplied to provide a joint risk factor.

For the frequencies of storms and associated rainfall magnitudes, the following risk factors are used:

- 0.5 year ARI: risk factor = 100 %
- 0.25 year ARI: risk factor = 100 %
- 1 year ARI: risk factor = 100 %
- 2 year ARI: risk factor = 50 %

- 5 year ARI: risk factor = 20 %

High tide conditions are defined as the risk of a storm with a four duration occurring when the tide level is +2.5 m or greater for the entire duration of the four hour storm. Based on information from the World Bank and FINNIDA Projects, this risk factor is 25 %.

For storms with a 1 year ARI or less, the probabilities that these storms would occur during a 1 year period is 100 %. However, for storms with a 0.25 year ARI and 0.5 ARI, the joint risk factor is multiplied by 4 and 2, respectively. The basis for this approach is that for a storm with 0.25 year ARI, there would then be storms of this magnitude four times during any one year period. Because the risk factor of high tide is 25 %, there is then a yearly 100 % probability that high tide would occur during one of the four storms.

The following example is presented to illustrate these principles. A storm occurs with a frequency of 5 year ARI during low tide conditions, and the area of flooding is 100 ha. The expected annual degree of flooding from this storm is then 20 % of this value or 20 ha. This result means that during any five year period, the area of flooding associated with this storm is a yearly average of 20 ha.

If a storm with a frequency of 5 year ARI would occur during high tide conditions, and the area of flooding is 200 ha, the expected annual degree of flooding is then 20 % times 25 %, which is 5 %, therefore 10 ha. This result means that during any twenty year period, four storms with frequencies of 5 year ARI would occur, and one of these storms would occur during high tide conditions. The area of flooding associated with these conditions during the twenty year period is a yearly average of 10 ha.

2.5.3 Present Flooding Conditions

(1) Sources of Quantitative Data

Quantitative data on the present flooding conditions in Class A Areas have been collected from the following sources:

- Summary Report of the Study of Flood Investigations, SADCO, April 2000
- Vietnam: Sanitation Project, Haiphong Component, Preliminary Design Report, May 1999

The flooding data in three sources consist of quantitative estimates for annual flood areas, flood depths, and flood durations for storms of different frequencies and rainfall area of different intensities and durations.

The data in the Study of Flood Investigations consists of quantitative estimates for the present flood conditions. The study and quantitative data was prepared by Haiphong SADCO.

The data in the Preliminary Design Report consists of quantitative estimates for both the present flooding conditions and the flooding conditions after implementation of the World Bank Project.

(2) Present Flood Conditions from Data of SADCO Study

Assessments of the present flood conditions, as reported in the Study of Flood Investigations by SADCO, is summarized in the following table.

Present Degree of Flooding Assessed by SADCO

Approximate Frequency	Rainfall	Maximum Rainfall Intensity	Tide Conditions	% of Total Area
2 year ARI	60-65 mm	30-40 mm/hr	Low tide	30% of street areas
	65-80 mm	30-40 mm/hr	Rising/Falling	39% of street areas
	60-80 mm	30-40 mm/hr	Low tide	13% of alley areas
	60-80 mm	30-40 mm/hr	Rising/Falling	15% of alley areas
5 year ARI	180-190 mm	40-60 mm/hr	Low tide	49% of street areas
	120-150 mm	40-60 mm/hr	Rising/Falling	63% of street areas
	180 mm	40-50 mm/hr	Low tide	46% of alley areas
	130-150 mm	40-60 mm/hr	High tide	56% of alley areas

For the storms with a frequency of 2 year ARI, the flooding magnitudes in the street and alley areas was reported as 20-40 cm with a 4-6 hour duration. For the storms with a frequency of 5 year ARI, the flooding magnitudes in the street and alley areas was reported as 30-50 cm with 1-3 hour duration.

(3) Present Flood Conditions from Data of World Bank Project

Quantitative data on the present flood conditions has been obtained from the World Bank Project. For the interpretation of the data, it is assumed that flood areas are associated with streets, alleys, and open public spaces, since flooding cannot occur where land is occupied by buildings. Therefore it is assumed that flooding would occur in 20 % of the total land area. This value was also adopted in the flooding and economic evaluation in the FINNIDA Project.

Based on reported flood locations, the data from the World Bank Project includes flooding in the three drainage zones in the Priority Project Area, the Old City Center, and the Cat Bi Ward in the New Urban Area. The potential flood areas are included in these land areas, except for the drainage sub-zones of AKH-4 and AKH-5 in the An Kim Hai Channel Drainage Zone, since these land areas are mostly undeveloped. The total land area is then 2,340 ha and the potential flood area is 20 % of this value, or about 470 ha.

Based on this approach, the following table assesses the interpreted data from the World Bank Project.

Present Degree of Flooding in Priority Project Area, Old City Center and Cat Bi Ward

Frequency	Potential Flood Area	Reported Flood Area	% of Potential Area
0.25 years	470 ha	140 ha	29.7%
0.5 years	470 ha	180 ha	38.3%
1 year	470 ha	250 ha	53.2%
2 year	470 ha	280 ha	59.6%
5 year	470 ha	320 ha	68.1%

The data for the flood areas in the World Bank Project includes flood areas where the flood magnitudes are 10-30 cm. These magnitudes are less than the flood magnitudes reported by the SADCO. However, the interpreted data of the World Bank is considered as consistent with the assessments of SADCO, and is used in the flood reductions assessment.

2.5.4 Assessed Flood Reductions from World Bank Project

Quantitative data on the assessed flood reductions after implementation of the World Bank Project has been obtained from the World Bank Project. The quantitative data is interpreted and assessed using the same approach as for the quantitative data on the present flooding conditions.

Figure 2.2.12 presents the interpreted data for the reductions in flooding after implementation of the World Bank Project. For a storm with a frequency of 2 year ARI, about 98 ha of flooding would still occur. Based on a 25 % risk that this expected annual flooding would occur during high tide conditions, the actual flood areas would then be 392 ha, or 83.4 % of the potential flood areas. This figure appears reasonable when considering the following:

- Sewers in the Old City Center are designed for a storm with a 2 year ARI, but for a maximum water level of +2.5 m, where the high tide level is +4.1 m
- No storm water pumping stations exist in the Central Area
- An Kim Hai Drainage Zone does not include any storage lakes

For a storm with a frequency of 5 year ARI, when using the risk factor, the actual flood areas would be 600 ha, which is greater than 470 ha, which represents the potential flood areas. This figure suggests that flood areas in the An Kim Hai Drainage Zone are associated with overflow of the channel, where the potential flood area would extend over a greater land area than streets, alleys, and open public spaces.

2.5.5 Assessed Flood Reductions from FINNIDA Project

Quantitative flood data for flood reductions from implementation of the FINNIDA Project has been collected from the Haiphong Stormwater Pumping Stations Project, Feasibility Study, April 2000. The data consists of quantitative estimates for the flooding conditions during high tide after implementation of the World Bank Project and the flooding conditions during high tide after implementation of the World Bank Sanitation Project and the FINNIDA Project.

In the World Bank Project the Northeast and Southwest Channels were designed for a storm with a 10 year ARI during falling tide conditions. Consequently, the degree of flooding in the Central Area is expected to decrease significantly for storms with frequencies of 5 year ARI or less. However, the risk of flooding remains for storms which would occur during high tide conditions.

The FINNIDA Project was developed to construct pumping stations for these two channels in the Central Area. An assessment of flood reductions after project implementation, and including implementation of the World Bank Project, was provided in the project documentation. The approach for the assessment was based on quantitative data, which was verified by results of computer simulations of flooding in the Central Area.

The quantitative data consisted of flood areas during high tide conditions with and without the project for storms of different frequency. The assessed flood areas were then multiplied by the risk factor of 25 % to determine the expected flood areas which would occur for storms of different frequency.

The quantitative data on the assessed flood reductions, based on data from the FINNIDA Project, is presented in Figure 2.2.13. As shown in the figure, the actual flood areas are significant, even after project implementation, if high tide would occur during the duration of the storm. The data is also consistent with the assessments from the World Bank Project.

2.5.6 Present Flood Areas in the An Kim Hai Channel Drainage Zone

Assessment of flood reductions from implementation of the Drainage Priority Project is based on assessing and estimating the present amount of flood areas which can be attributed to the present inadequate hydraulic capacity of An Kim Hai Channel without any connections to existing storage lakes.

The assessment of the flood areas is based on computer simulation of the hydraulic performance of An Kim Hai Channel for its present conditions, with one discharge location at the Cam River.

The basis of the computer simulations comprise the following:

- Utilization and modification of computer model developed for technical design of An Kim Hai Channel
- Use of channel survey data from Field Study No. 1 and Field Study No. 2
- Use of hydrological data based on present catchment area characteristics in An Kim Hai Channel Drainage Zone
- Use of rainfall data for storms with frequencies of 2 year ARI, 5 year ARI and 10 Year ARI and twelve hour rainfall duration
- Use of data for high tide levels with frequency of 10 year ARI for falling tide conditions

Simulation of flooding was achieved by using modeled weirs and artificial basins in the modified model. Weirs were located at each inlet node. The weir level at each inlet node was set to the same level as the ground level of the inlet node. When the hydraulic grade exceeds the level of the weir, water is then routed to an artificial basin associated with each weir. When the hydraulic grade is less than the level of the weir, water is then routed from the storage basis back to the inlet node.

For the model runoff coefficients are based on the amounts of developed and undeveloped land in the catchment areas, using the criteria presented in the following table.

Criteria for Calculating Composite Design Runoff Coefficients

Degree of Land Development	Runoff Coefficient	
	Developed Land	Undeveloped Land
90% - 100%	0.60	0.30
80% - 90%	0.55	0.25
70% - 80%	0.50	0.20
50% - 70%	0.45	0.15
30% - 50%	0.40	0.10
10% - 30%	0.30	0.05

Based on this criteria, composite runoff coefficients are calculated using the following formula.

$$C_{COMPOSITE} = \frac{\sum \left(C_{SUB-AREA} * AREA_{SUB-AREA} \right)}{\sum AREA_{SUB-AREA}}$$

For the model, times of concentration are needed as input data. Times of concentration are defined as the time for overland, ditch or sewer flow of rainfall runoff to reach a channel inlet point. It is assumed that it is correlated with the runoff coefficient. For developed land areas, 30 minutes is used as a benchmark value and increases as the amount of developed land is less.

Land development data is presented in Table 2.2.1 for the five sub-basins. Based on the data for the amounts of developed and undeveloped land in the Year 2000, the needed model input data are presented in the following table.

Runoff Coefficients and Times of Concentration of Drainage Sub-Basins

Sub-Basin	Land Area (ha)	Runoff Coefficient	Time of Concentration
Sub-Basin AK-1	70	0.58	30
Sub-Basin AK-2	160	0.37	60
Sub-Basin AK-3	120	0.44	45
Sub-Basin AK-4	310	0.20	90
Sub-Basin AK-5	180	0.11	90

Because of the present varying channel cross-sections and top widths, as well as the present excessive vegetation growth in the channel, and the variation in degree for different sections, the following energy loss coefficients in the Manning Equation are used for the channel sections in the drainage sub-zones as follows:

- Sub-Zones AKH-1 to AKH-3: Manning coefficient = 0.040
- Sub-Zones AKH-4 to AKH-5: Manning coefficient = 0.035

Storm hyetographs are developed using rainfall data for storms with frequencies of 2 year ARI, 5 year ARI and 10 year ARI and a total rainfall duration of 12 hours. The approach and developed hyetographs are identical to hyetographs used for technical design for rehabilitating An Kim Hai Channel and constructing Phuong Luu Lake. Based on the hyetographs, the total rainfall amounts for each storm are 112 mm (2 year ARI), 175 cm (5 year ARI), and 227 mm (10 year ARI).

From the simulations, flooding only occurs in the sub-zones of AKH-1, AKH-2 and AKH-3. Table 2.2.2 presents the results from the computer simulations. The results consists of the volumes of storm water which are associated with flooding for each node of the computer model for An Kim Hai Channel.

For the storm with a 2 year ARI the amount of flood areas was calculated using an average flood magnitude of 25 cm. For storms with 5 year ARI and 10 year ARI, an average flood magnitude of 35 cm was used.

When estimating the amount of flooding in the Central Area (target planning area for Phase I), and outside the Central Area, but in the An Kim Hai Channel Drainage

Basin, the following assumptions are applied for sub-zones AKH-2 and AKH-3, which include areas in both the Central Area and New Urban Area:

- 75 % of the flooding for sub-zone AKH-2 occurs in the Central Area
- 50 % of the flooding for sub-zone AKH-3 occurs in the Central Area

Based on the results of the computer simulations and the above assumptions, the estimated amount of flood areas in the An Kim Hai Drainage Zone is presented in the following table.

Present Flooding Areas (ha) in the An Kim Hai Channel Drainage Zone

Sub-Zone	Central Area			New Urban Area			Total		
	2 yr	5 yr	10 yr	2 yr	5 yr	10 yr	2 yr	5 yr	10 yr
SC-1	13.4	18.1	24.2	0	0	0	13.4	18.1	24.3
SC-2	10.2	15.7	24.0	3.4	5.2	8.0	13.6	20.9	32.0
SC-3	3.0	7.1	11.8	3.0	7.1	11.8	5.9	14.2	23.5
TOTAL	26.6	40.9	60.0	6.4	12.3	19.8	32.9	53.2	79.8

In general, sub-zone AKH-1 experiences the worst flooding, because it is located at the farthest end of the channel from the discharge point.

CHAPTER 3 REHABILITATION OF AN KIM HAI CHANNEL

3.1 Planning Issues and Design Criteria

3.1.1 Planning Issues

An Kim Hai Channel was originally developed for the purpose of irrigation. However, the channel also functions for drainage. Storm water sewers for Highway No. 5 discharge into the channel as well as drainage ditches and other channels connected to the channel.

The present channel top widths and cross-sections vary considerably along the entire length of the channel. The present hydraulic layout of the channel is not defined, and system performance is very poor.

Maintenance roads do not exist along the channel banks preventing effective maintenance of the channel. Sludge has accumulated on the bottoms of the channel, requiring dredging. Encroachment of illegal housing has occurred along the channel banks preventing maintenance as well as reducing the hydraulic capacity of the channel.

The existing channel side-slopes are not protected. Vegetation growth is prevalent in the channel, increasing the flow resistance in the channel. The present hydraulic capacity is very insufficient.

Consequently, the main planning issues for rehabilitation of An Kim Hai Channel comprise the following:

- Primary and secondary functions of the channel
- Hydraulic layout of the channel
- Maintenance roads and margins
- Channel cross-sections

Alternatives for each planning issue are identified, and the optimum alternative is selected for design.

3.1.2 Design Criteria

The purpose of rehabilitating An Kim Hai Channel is to provide sufficient hydraulic capacity in the channel to achieve the following:

- Prevent flooding of sewers discharging into the channel
- Prevent flooding of the lakes discharging into the channel during low tide conditions when the tidal gates are opened

- Prevent flooding of the channel when water is being discharged from the channel to the lakes during high tide conditions and to the rivers during low tide conditions

The hydraulic capacity of the rehabilitated channel is considered as sufficient, if the maximum water levels are lower than 0.5 m from the design levels of the channel banks for the design storms and tide conditions.

Achievement of the design criteria is determined by calculating the maximum water levels for the three design conditions. The calculations are done using the developed computer model.

3.2 Alternative Study

3.2.1 Primary and Secondary Functions of Channel

(1) Alternative Approaches

At present An Kim Hai Channel can function for both the purpose of irrigation and also for drainage. There are then four alternative approaches associated with the future function of An Kim Hai Channel:

- IR-1: Channel used only for irrigation
- IR-2: Channel used only for drainage
- IR-3: Primary function for irrigation and secondary function for drainage
- IR-4: Primary function for drainage and secondary function for irrigation

IR-1 is not a viable alternative, because the channel already is used for drainage, most notably for urban areas immediately adjacent to the channel and also for Highway No. 5 with locations parallel to the channel.

Furthermore, the channel represents an existing trunk drainage corridor in the part of the city in which it is located. This part of the city is expected to further urbanize in the immediate future. No viable drainage system can be developed for this area without a functioning drainage channel in this part of the city.

IR-2 can be considered as an appropriate alternative. However, the dual use also for irrigation would require the construction and use of gates at drainage discharge points. Investment costs for these measures are not great. Economic benefits from irrigation are expected to be greater than these investment costs. Consequently, dual use for irrigation is considered as more beneficial and viable than singular use only for drainage.

IR-3 is not a viable alternative, because the necessary hydraulic capacity for drainage is greater than the needed hydraulic capacity for irrigation.

(2) Selected Approach

Alternative IR-4 is selected because the channel is needed for drainage in the part of the city in which it is located. However, the channel can also be used for irrigation, providing additional economic benefits. Selection of the primary function of the channel for drainage is based on the needed hydraulic capacity.

3.2.2 Hydraulic Layout of Channel

(1) Alternative Approaches

The hydraulic layout of the channel depends on the amounts and locations of storm water discharges into the channel as well as the number and locations of discharge outlets of the channel to receiving lakes and rivers.

At present there exists only one discharge outlet of the channel, which is located at the east end of the channel at the Cam River. However, possibilities exist to construct new discharge outlets at other river locations as well as at storage lakes in the drainage basin of the channel.

There then exists five alternatives for defining the hydraulic layout of the rehabilitated channel:

- HL-1: Discharge at one outlet to a river
- HL-2: Discharge at one outlet to a storage lake
- HL-3: Discharge at multiple outlets to the nearest rivers
- HL-4: Discharge at multiple outlets to the nearest storage lakes
- HL-5: Discharge at multiple outlets to the nearest rivers and storage lakes

HL-1 and HL-2 would require channels with greater hydraulic capacity than the three remaining alternatives, and would therefore require more investment costs.

HL-3 is not a viable alternative, because tidal gates at the ends of the channel would need to be closed during high tide. The channel would then not be able to discharge storm water to a receiving water body during high tide, and flooding would then occur in the drainage zone.

HL-4 can be considered as an appropriate alternative. However, a discharge outlet to the Cam River already exists. Also, a discharge outlet to the Lach Tray River can be constructed without great costs. During low tide the channel can discharge directly to the receiving water bodies at these locations, thus bypassing discharge to storage lakes in the drainage basin.

(2) Selected Approach

Alternative HL-5 is selected because it allows the channel to be constructed at minimal costs, because the needed hydraulic capacity is less than the other four alternatives. Also, the alternative allows the channel to be used for drainage during both high tide and low tide conditions.

3.2.3 Maintenance Roads and Margins

(1) Alternative Approaches

Maintenance roads and margins are needed along the channel banks for accessing the channel for maintenance and for preventing further encroachment on the channel. However, implementing maintenance roads and margins will result in resettlement of Project affected population.

There are two alternative approaches for locating maintenance roads and margins along the channel banks:

- MR-1: Maintenance road on one side of the channel
- MR-2: Maintenance roads on both sides of the channel

Illegal encroachment on the channel has occurred and is considered as a major problem which must be controlled. Construction of maintenance roads on both sides of the channel is the most effective measure to prevent encroachment on the channel on both sides.

Rehabilitation of the channel will require site clearing on the sides of the channel. This may require demolition of houses and other structures located along the sides of the channels. Without maintenance roads some households may be able to relocate and rebuild their houses at their previous sites. However, compensation to these households would still be needed and would be comparable to the compensation if the households would be required to relocate to a new area.

(2) Selected Approach

MR-2 is the selected alternative. Maintenance roads on both sides of the channels is the most effective measure to prevent illegal encroachment on the channel.

Furthermore, households located immediately along the sides of the channel would be affected by site clearing during the rehabilitation works of the channel, whether or not maintenance roads would be constructed.

3.2.4 Channel Cross-Sections

(1) Alternative Approaches

Rehabilitation of the channel includes embankment works and dimensioning the channel cross-sections. The following alternative approaches can be considered:

- CH-1: Reformation of the banks with grass or sod slope protection. This alternative is most applicable when the existing hydraulic capacity is sufficient for discharging the design storms
- CH-2: Trapezoidal shapes with side-slope from 1:3 to 1:2 lined with grass or sod. This alternative is most applicable for suburban areas where land acquisition is not needed
- CH-3: Trapezoidal shape with side-slopes from 1:2 to 1:1 with slope lining of stone masonry revetment. This alternative is most applicable for urbanized areas where land acquisition is needed
- CH-4: Stone masonry retaining walls. This alternative is most applicable for urbanized areas where land acquisition is restricted

CH-1 and CH-2 are not viable alternatives, because the existing channel is located predominantly in urban areas. Also, slope lining with rubble masonry is considered as a more effective measure to prevent illegal encroachment along the sides of the channel than grass or sod lining.

CH-4 can be considered as an appropriate alternative. However, it represents the most expensive alternative, requiring the most excavation or filling of the channel. Also, land acquisition is needed for constructing the maintenance roads along the sides of the channel. Adoption of this alternative would not reduce the need for resettlement of project affected population.

(2) Selected Approach

CH-3 is the preferred approach, although CH-4 can also be considered, because these represent the most cost effective measures for rehabilitating the channel, which is located predominantly in urban areas, and for also preventing illegal encroachment along the sides of the channel.

3.3 Technical Design

3.3.1 Site and Soil Conditions

Total length of An Kim Hai Channel is about 10 km. The channel starts from Thuong Ly River close to An Duong Water Treatment Plant. Between An Duong Water Treatment Plant and Tran Ngyen Han Street the width of the channel varies between 6 m to more than 14 m. There is a narrow lane with a width of 2 m on one side of the channel.

From Tran Nguyen Han Street forward until the southern end of Du Hang Lake the channel is in an average only 5 m to 9 m wide and full of waste. There are small houses at the both sides but not any roads along the shore.

After Du Hang Lake the channel becomes wider (10 – 20 m) and is less polluted. There are also less houses along the channel. Along Highway No. 5 the channel is about 20 m wide. The surroundings are mainly rice fields until Hang Kenh Street.

Between Hang Kenh Street and An Da Street the width varies mainly from 10 m to 15 m. There are some houses on both sides of the channel and in places a narrow land with a width of 2.0 m along the shore. The rest of the channel up to Cam River is about 20 m or more wide. The surroundings are mostly rice fields. There is also a margin of 3 – 4 m wide on both sides of the channel.

The soil conditions along An Kim Hai Channel have not been investigated in this study. Nonetheless, the soil conditions along Du Hang Lake have been estimated on the basis of old boreholes from previous projects and for the other parts according to general geological conditions of Haiphong City area.

The area is in general flat and ground surface level is in average from +3.0 to +3.5 m. The top layer on the shore is backfill soil, with a thickness of 1.0 m to 1.7 m. Backfill soil is mainly composed of sandy clay and silt. The bottom of the channel is covered by 0.1 m – 2.3 m thick sludge layer (average about 0.5 m).

Natural soil under the backfill soil is from very soft to soft sandy and clayey silt (N-values of SPT tests N= 0.5 - 2.4). Close to Du Hang Lake firm sandy silt layer has been encountered at the depth of 9 m. In places there is about 1.0 m stiffer layer just under the backfill soil (N = 2 - 4). Ground water (perched water) is about 1.0 – 1.8 m from ground surface.

3.3.2 Preliminary Hydraulic Design

(1) Methodology for Determination of Hydraulic Layout

Layout design of the channel is determined as follows:

- Discharge locations of the channel to lakes and rivers are selected
- Based on the discharge locations different alternatives for the channel top widths and cross-sections for different lengths of the channels are identified
- The different alternatives are then compared to the existing conditions to ensure that the existing hydraulic capacity of the channel is not further reduced by filling in the channel

- Preliminary calculations are then done to assess and compare the hydraulic capacities of the alternatives

The selected hydraulic layout must also satisfy the planning requirement for dual function of the channel for drainage and irrigation.

(2) Discharge Locations of Channel

Four discharge locations of the channel were selected as follows:

- Discharge to Lach Tray River
- Discharge to Du Hang Lake
- Discharge to Phuong Luu Lake
- Discharge to Cam River

1) Discharge Location at Lach Tray River

At present the channel is connected to a siphon structure located under the Lach Tray River which connects the channel part in the Priority Project area to the part of the channel located upstream. The siphon is used for delivering water for irrigation. In the project, gates are located on the siphon on the west side of the Lach Tray River. The siphon system will remain. A new tidal gate is constructed on the east side of the Lach Tray River and on the north side of the siphon structure. The tidal gate allows discharge from the channel to Lach Tray River during low tide conditions when the siphon gate is closed.

2) Discharge Location at Du Hang Lake

One purpose of rehabilitating the channel is to integrate the Southwest and Northeast Drainage Zones. This objective is partially achieved by constructing a discharge gate to Du Hang Lake in the Southwest Drainage Zone. Location of the discharge gate is selected at mid-point along the length of the lake, because it represents the shortest distance for discharge to the Lach Tray River during low tide conditions with the lowest amount of housing density along the lake. When the channel is used for irrigation, the discharge gates are closed.

3) Discharge Location at Phuong Luu Lake

The Northeast Drainage Zone is integrated by connecting An Kim Hai Channel to the new Phuong Luu Lake. Discharge gates are included in the works for Phuong Luu Lake for connection with An Kim Hai Channel. When the channel is used for irrigation, the discharge gates are closed.

4) Discharge Location at Cam River

An existing tidal gate is located at the east end of the channel at the Cam River. Two gates and gate openings presently exist. The width of the two openings is 3 m each. However, the tidal gate is not totally functional and needs rehabilitation. Also, the present discharge capacity is low and three openings are considered as minimum to allow discharge for drainage. Therefore, it is needed to demolish the existing tidal gate and to replace it with a new tidal gate which has three openings of 3 m each (Figure 2.3.8).

(3) Selected Hydraulic Layout of the Channel

1) Alternative Hydraulic Layouts

Four alternative channel layouts are identified. Each alternative is based on five channel sections with the following characteristics.

Locations and Lengths of Channel Design Sections

Section	Location	Length
SC-1	From Lach Tray Tidal Gate to Du Hang Lake Gate	1,900 m
SC-2	From Du Hang Discharge Gate to Lach Tray Street	2,900 m
SC-3	From Lach Tray Street to Phuong Luu Lake Gate	1,650 m
SC-4	From Phuong Luu Lake Gate to Ha Doan Road	2,000 m
SC-5	From Ha Doan Road to Cam River Tidal Gate	1,700 m

The four alternative channel layouts are based on different channel top widths, slopes and walls as presented in the following table and in Figure 2.3.1.

For all alternatives the bottom of the channel is at a level of +0.5 m and the banks of the channel are at levels of +3.8 m on both sides of the channel.

As shown in the table each alternative has the same channel top widths and side-slopes for sections SC-4 and SC-5.

For both Alternatives LY-1 and LY-2 rubble masonry retaining walls are selected for Sections SC-1 with channel top widths of 7 m.

For Alternative LY-1 rubble masonry retaining walls are also used for Section SC-2 with a channel top width of 10 m, but for Alternative LY-2 rubble masonry revetment is used with a top width of 12 m. As benchmark design alternatives these channel cross-section designs are presented in Figure 2.3.2. In the figure, maintenance margins of total 5 m width on both sides of the channel are also presented.

The remaining alternatives are based on rubble masonry revetment, but with different top widths at different locations.

Channel Top Widths, Side-Slopes and Walls for Alternative Channel Layouts

Alternative	SC-1	SC-2	SC-3	SC-4	SC-5
LY-1	7 m	10 m	12 m	15 m	15 m
LY-2	12 m	12 m	12 m	15 m	15 m
LY-3	7 m	12 m	15 m	15 m	15 m
LY-4	12 m	15 m	15 m	15 m	15 m
LY-1	1:0.3	1:0.3	1:1.25	1:1.25	1:1.25
LY-2	1:1.25	1:1.25	1:1.25	1:1.25	1:1.25
LY-3	1:0.3	1:1.25	1:1.25	1:1.25	1:1.25
LY-4	1:1.25	1:1.25	1:1.25	1:1.25	1:1.25
LY-1	RMRW (top width:7m) RMR (others)	RMRW (top width:10m) RMR (others)	RMR	RMR	RMR
LY-2	RMRW (top width:7m) RMR (others)	RMR	RMR	RMR	RMR
LY-3	RMR	RMR	RMR	RMR	RMR
LY-4	RMR	RMR	RMR	RMR	RMR

Note: RMRW: Rubble Masonry Retaining Walls, RMR: Rubble Masonry Revetment

2) Selection of Optimum Hydraulic Layout

Based on computer simulations, all of the alternatives were able to satisfy the hydraulic design criteria. Alternative LY-4 provided the best hydraulic performance, but the results for the three other alternatives suggest that from the aspect of hydraulic performance, each of the alternatives can be considered as viable.

Based on existing conditions the most critical section is Section SC-2. This channel is wide in most of the section length. Except for Alternative LY-4, the remaining alternatives would result in filling in parts of this section, especially for Alternative LY-1. This aspect is considered as costly and unnecessary considering that the housing density on both sides of the channel is very low, except for the part near Lach Tray Street.

Also, maximization of the hydraulic capacity of Section SC-2 of the channel is considered as beneficial because it increases the available storage capacity in the Southeast Drainage Zone, which has the lowest storage capacity in the system. This result is achieved because more hydraulic capacity in this section allows more storm water to be conveyed from this drainage zone to Phuong Luu Lake, which has four times as much storage capacity as Du Hang and Lam Tuong Lakes.

Based on existing conditions Alternatives LY-1 and LY-3 would also result in filling of the channel. These alternatives also use rubble masonry retaining walls. Both of these measures are costly. Although the housing density on both sides of this channel is high in this section, using a top width of 7 m instead of 12 m would not significantly reduce the amount of households to be resettled, because of the locations of the maintenance roads on both sides of the channel.

Also, maximization of the hydraulic capacity of Section SC-1 of the channel is considered as beneficial because it allows more effective discharge of Du Hang Lake, which has low storage capacity, to the Lach Tray River during low tide conditions.

Based on these aspects Alternative LY-4 is selected because it provides the most cost effective hydraulic performance. The amount of households to be resettled for this alternative is not considered to be significantly greater than for the other four alternatives.

(4) Design Calculations

1) Design Catchment Areas

Based on existing conditions, the integrated drainage system consists of the following drainage basins and associated land surface areas:

- Northeast Drainage Basin 600 ha surface area
- Southwest Drainage Basin 400 ha surface area
- An Kim Hai Channel Drainage Basin 840 ha surface area

For the World Bank Project, the rehabilitation design of Northeast and Southwest Channels were based on inclusion of two catchment areas, each of size 50 ha, of the An Kim Hai Channel Drainage Basin in each of the two basins. However, these catchment areas are proposed to remain in the An Kim Hai Channel Basin for preliminary design of the system.

2) Design Runoff Coefficients

Design runoff coefficients are based on the amounts of developed and undeveloped land in the catchment areas, using the criteria presented in the following table.

Criteria for Calculating Composite Design Runoff Coefficients

Degree of Land Development	Runoff Coefficient	
	Developed Land	Undeveloped Land
90% - 100%	0.60	0.30
80% - 90%	0.55	0.25
70% - 80%	0.50	0.20
50% - 70%	0.45	0.15
30% - 50%	0.40	0.10
10% - 30%	0.30	0.05

Based on this criteria composite runoff coefficients are calculated using the following formula.

$$C_{COMPOSITE} = \frac{\sum (C_{SUB-AREA} * AREA_{SUB-AREA})}{\sum AREA_{SUB-AREA}}$$

For the model, times of concentration are needed as input data. Times of concentration are defined as the time for overland, ditch or sewer flow of rainfall runoff to reach a channel inlet point. It is assumed that it is correlated with the runoff coefficient. For developed land areas, 30 minutes is used as a benchmark value and increases as the amount of developed land is less.

Land development data for the Year 2010 is presented in Table 2.3.1 for the Northeast and Southwest Drainage Basins. Runoff coefficients for each node in the computer model are based on this data

Except for the following exceptions, a time of concentration of 30 minutes was selected for the sewer inlet nodes. The exceptions were for nodes associated with channels and lakes without direct sewer connections in suburban areas, with a time of concentration of 60 minutes. For nodes associated with channels and lakes without direct sewer connections in agricultural areas, a time of concentration of 90 minutes was used.

Land development data is presented in Table 2.2.1 for the five sub-basins. Based on the data for the amounts of developed and undeveloped land in the Year 2010, the needed model input data are presented in the following table.

Runoff Coefficients and Times of Concentration of Drainage Sub-Basins

Sub-Basin	Land Area (ha)	Runoff Coefficient	Time of Concentration
Sub-Basin AK-1	70	0.58	30
Sub-Basin AK-2	160	0.52	45
Sub-Basin AK-3	120	0.50	45
Sub-Basin AK-4	310	0.27	90
Sub-Basin AK-5	180	0.13	90

Based on the calculations the overall composite runoff coefficient for the total integrated drainage basin of 1,840 ha is 0.414.

The Manning equation was used to model energy losses in the channel. An energy loss coefficient of 0.030 was used, which is appropriate for channels with rubble masonry revetment.

3) Results from Design Calculations

Figures 2.3.3, 2.3.4 and 2.3.5 present simulated water levels for the selected channel layout designed for the three design conditions. In each figure the highest and lowest water levels are presented. Also, the water level during maximum discharge is presented.

As shown in the figures, the selected channel layout design satisfies the design criteria, where the maximum water levels are lower than 0.5 m from the levels of the channel banks.

Also, the maximum water levels are lower than 0.9 m from the levels of the channel banks, so that additional hydraulic capacity is also available when implementing Phase II of the Drainage Improvement Master Plan.

3.3.3 Preliminary Civil Works Design

(1) Summary of Construction Works

The preliminary layout design of An Kim Hai Channel is presented in Figure 2.3.6. Rehabilitation of An Kim Hai Channel consists of the following works:

- Dredging and excavation of the channel of total length of about 10 km
- Construction of embankment works of rubble masonry revetment for the channel with side slopes of 1:1.25
- Construction of maintenance roads and margins along the sides of the channel each with total width of 5 m
- Construction of Lach Tray Tidal Gate at Lach Tray River with three openings of width 3 m and three gates
- Demolition of existing Nam Dong Tidal Gate at Cam River and construction of new tidal gate with three openings of width 3 m and three gates
- Construction of Du Hang Flow Gate at Du Hang Lake with three openings of width 3 m and three gates

The channel will be rehabilitated according to the following criteria:

- Top width of 12 m for a length of 1,900 m
- Top width of 15 m for a length of 6,550 m
- Top width of 20 m for a length of 1,700 m

The maintenance roads and margins will be located on both sides of the channel for the entire length of the channel.

(2) Channel Embankment Works

Preliminary design of the channel embankment works is based on levels of the channel banks and channel bottom which remain constant for the entire length of the channel. The following levels have been selected:

- Levels of channel banks on both sides: +3.8 m
- Level of channel bottom: +0.5 m

Channel side-slopes have been selected as 1:1.25. Selection of this value was based on previous studies. However, during detailed design geotechnical investigations are needed to confirm the geotechnical stability of this channel side-slope.

Figure 2.3.7 presents the preliminary design of the channel embankment works. The works consist of an upper layer of wet masonry with an intermediate layer of base concrete and a bottom layer of gravel bedding. A footing beam is located at the base of the revetment. Bamboo piles with a density of 25 piles per m^2 are located below the beam to provide an adequate foundation.

(3) Maintenance Road Works

Preliminary design of the maintenance road works is based on a road surface width of 3.5 m and a margin of 1.0 m on the channel side and 0.5 m on the other side. The total margin width is then 5.0 m.

Figure 2.3.8 presents the preliminary design of the maintenance road works. The works consist of an upper layer of asphalt concrete with an intermediate layer of base course and a bottom layer of sub-base course. Precast concrete curbs are located on the side edges of the sub-surface works.

(4) Tidal Gate and Discharge Gate Works

Preliminary design of the tidal gates at Lach Tray River and Cam River and the discharge gate at Du Hang Lake is based on a common design for the three structures. Three conduits are used in the structure with gates on the river and lake sides of the structure. The width and height of each conduit is both 3 m. The conduits can be isolated with stop logs.

Figure 2.3.8 presents the preliminary design of the structural works. The invert level of the conduits is +0.0 m. A road is located on the top of the structure at the level of +4.5 m. The structure has a facade covering of wet masonry with an intermediate layer of coarse sand and internal fill of compacted soil. The civil works design of the road is identical to the design of the maintenance road of the channel. Precast reinforced concrete piles are located on the bottom of the structure to provide an adequate foundation.

The gates are opened and closed by using three electric motor driven spindles. The motors are rated as 5.5 kW, 380 V, and 50 Hz. The motors are located on frames constructed of reinforced concrete. Access to the motors is by a steel ladder. Steel hand rails are located on the sides of the working floor.

Gabions are located on the upstream side of the structure on the channel bottom and also on the downstream side on the river and lake bottoms for erosion control and protection.

CHAPTER 4 CONSTRUCTION OF PHUONG LUU LAKE

4.1 Planning Issues and Design Criteria

(1) Planning Issues

The main planning objective for construction of Phuong Luu Lake is to integrate the Northeast, Southwest and An Kim Hai Drainage Zones and to provide adequate storage capacity for storing storm water during high tide conditions. The drainage zone with the greatest need for storage capacity is the An Kim Hai Channel Drainage Zone, which presently does not have any major lakes. Additional storage capacity is also needed for the Southwest Drainage Basin.

The location of the new lake is based on the Haiphong Sewerage and Drainage Master Plan. Land for the construction of Phuong Luu Lake is available at the proposed location as the area consists mostly of agricultural land.

The primary function of Phuong Luu Lake is for drainage. During high tide conditions water will be discharged from An Kim Hai Channel and Northeast Channel to the lake. During the subsequent low tide conditions the stored storm water will then be discharged through An Kim Hai Channel and Northeast Channel to the Cam River.

However, the lake will also have a secondary function for recreation. The site layout will include margins along the lake which will provide a recreational environment.

The most important planning issue for construction of Phuong Luu Lake is the surface area of the lake which defines the storage capacity of the lake. A minimum volume of water will be allowed in the lake to obtain the benefits from the secondary function for recreation.

Selection of the bottom level of the lake is based on providing a minimum depth of water, and is not directly related to providing adequate storage capacity. The storage capacity is then defined as the amount of storm water which can be stored at the design minimum and maximum water levels.

Consequently, the main planning issues for construction of Phuong Luu Lake comprise the following:

- Site layout of the lake
- Maintenance roads and margins
- Embankment works

Alternatives for each planning issue are identified, and the optimum alternative is selected for design.

(2) Design Criteria

The design criteria for construction of Phuong Luu Lake comprise calculating the maximum water levels in all of the lakes in the integrated drainage zones during the three design conditions as described in Section 2.3.2. The calculations are done using the developed computer model. The surface area of Phuong Luu Lake is considered as sufficient, if the calculated maximum water levels in all of the lakes in the integrated drainage zone are less than the design maximum levels for each of the three design conditions.

The maximum water levels for the lakes comprise the following design criteria:

- Phuong Luu Lake: +2.7 m
- An Bien, Mam Tom, Quan Ngua and Tien Nga Lakes: +2.9 m
- Du Hang and Lam Tuong Lakes: +2.9 m
- Sen Lake: +3.2 m

The maximum water level for Phuong Luu Lake is based on the Haiphong Sewerage and Drainage Master Plan prepared by Haiphong City. The maximum water level for the existing lakes (An Bien, Mam Tom, Quan Ngua, Du Hang, Lam Tuong and Sen Lakes) are based on the rehabilitation design criteria from the World Bank Sanitation Project for these lakes.

The minimum water levels in the lakes are +1.5 m. This design criteria is based on the Haiphong Sewerage and Drainage Master Plan prepared by Haiphong City.

4.2 Alternative Study

4.2.1 Site Layout of Lake

(1) Alternative Approaches

The site layout for Phuong Luu Lake must consider the following issues associated with the proposed site for the lake:

- Location of electricity lines and towers in the site area
- Location of future Cat Bi Road
- Relocation of graveyards in the site area
- Possibilities for connections to An Kim Hai Channel

Four alternative layout designs have been identified which are based on the above issues. The four alternatives are as follows:

- PL-1: Center of site area with parallel orientation with future Cat Bi Road
- PL-2: Center of site area with parallel orientation with electricity lines

- PL-3: Location which is west of the electricity lines
- PL-4: Location which is east of the electricity lines

Alternative PL-1 is located in the center of the site area with a parallel orientation to the future planned Cat Bi Road. The alternative is presented in Figure 2.4.1. The main disadvantage with this alternative is that the high power voltage tower and lines in the site area would need to be relocated. Also, connections to An Kim Hai Channel would require removal of buildings adjacent to Highway No. 5.

Alternative PL-2 is located in the center of the site area and consists of two separate parts, where the power towers and lines would be located in the margin between the two parts. The alternative is presented in Figure 2.4.2. The main disadvantage with this alternative is that the costs would be higher than an alternative with only one part. Also, this alternative may have less recreational value because of the presence of the electricity towers and lines in the middle of the lake area.

Alternative PL-3 is located on the west side of the electricity towers and lines. The alternative is presented in Figure 2.4.3. The main disadvantage with this alternative is that amount of relocation of graveyards would be greater than the three other alternatives. Also, this alternative may interfere with the plans and location for the future Cat Bi Road.

Alternative PL-4 is located on the east side of the electricity towers and lines. The alternative is presented in Figure 2.4.4. There are no major disadvantages to this alternative, although one of the electricity lines may need to be moved a short distance to the west of its present location.

(2) Selected Alternative

Alternative PL-4 is adopted because there would be no major interference with the electricity lines or towers in the site area nor interference with the planned future Cat Bi Road. Also, the area of graveyards to be relocated is low and there are more accessible connections to An Kim Hai Channel.

4.2.2 Connections to Channels

(1) Alternative Approaches

The new lake is to be connected to the Northeast Channel and to the rehabilitated An Kim Hai Channel. Alternative approaches for the channel connections comprise the following:

- CN-1: Direct connection
- CN-2: Open channel connection

- CN-3: Closed conduit connection

Alternative CN-1 represents the least cost alternative. However, the site conditions of the location of the lake does not allow direct connections. The area near the Northeast Channel contains residential housing, so that the surface of the lake cannot be extended to the channel, without major resettlement of Project affected population. Highway No. 5 is located between the lake and An Kim Hai Channel, so it is not possible to construct a direct connection to An Kim Hai Channel. Consequently, Alternative CN-1 is not viable.

Alternative CN-2 represents the next least cost alternative. However, selection of this alternative depends on available land in the area.

Alternative CN-3 represents the most costly alternative. Furthermore, the hydraulic capacity of the closed conduits would be less than using an open channel of relatively similar margin dimensions.

(2) Selected Alternative

Land is available in the area near the Northeast Channel to select Alternative CN-2 for connecting Phuong Luu Lake to the Northeast Channel. Some houses are located at the connection to the channel and need to be removed requiring some resettlement of Project affected population.

Land is not available in the area near An Kim Hai Channel for constructing an open channel connection, with Highway No. 5 causing the greatest restriction. Selection of Alternative CN-3 is then required for connecting Phuong Luu Lake to An Kim Hai Channel.

4.3 Technical Design

4.3.1 Site and Soil Conditions

The area of the planned Phuong Luu Regulation Lake is mainly flat vegetable and rice fields. Ground level is in general about + 2.8 m to +3.1 m. There are some aquaculture and fishing ponds and graveyards in the area. Electricity lines and a telephone line as well as some ditches and irrigation channels cross the site in the middle. In the north the area borders the Northeast Channel and Highway No. 5 in the south. At the western and eastern sides there are residential areas.

Natural soil is from very soft to soft sandy and clayey silt (N-values of SPT tests of N = 0.5 - 2). These soft layers reach at least to the depth of 10 m. The shearing strength of the soil is low. Ground water (perched water) is about 0.5 to 1.0 m from ground surface .

4.3.2 Preliminary Hydraulic Design

(1) Surface Area of Lake

Based on the given conditions, the lake can be developed using a total site area of 28 ha and a lake surface area of 24 ha without restrictions from existing housing in the area.

There is then 4 ha of land available around the lake for the lake road and recreational areas. The lake surface area of 24 ha is consistent with the surface area calculated in the Drainage Improvement Master Plan. The value is checked using a more detailed design methodology adopted for the Feasibility Study.

(2) Design Calculations

Design calculations were done using the same developed computer model and design data as for An Kim Hai Channel. The selected design of An Kim Hai Channel is also included in the developed computer model.

Figures 2.4.5, 2.4.6, 2.4.7 and 2.4.8 present simulated water levels for the three design conditions for Phuong Luu, An Bien, Du Hang and Sen Lakes. The water levels at the beginning of the computer simulations were +1.5 m, which represents the minimum water levels for the lakes.

As shown in the figures, the selected storage capacity of Phuong Luu Lake satisfies the design criteria, where the maximum water levels in the lakes in the integrated drainage zone are less than or approximately equal to the design maximum water levels for the lakes.

4.3.3 Preliminary Civil Works Design

(1) Summary of Construction Works

The preliminary layout design of Phuong Luu Lake is presented in Figure 2.4.9. Construction of Phuong Luu Lake consists of the following construction works:

- Excavation of the lake with surface area of 24 ha and bottom level +0.0 m
- Construction of embankment works of rubble masonry revetment along the lake edges with side-slopes of 1:1.5
- Construction of roads and margins along the sides of the lakes with a total width of 12 m and road level of +3.8 m
- Construction of recreational areas at locations along the lake with a total site area of 28 ha for the lake, roads and recreational areas

- Construction of connecting channel to Northeast Channel with a length of 500 m, top width of 15 m, rubble masonry revetment with side-slopes 1:1.25, and maintenance roads and margins on both sides each with a total width of 7 m
- Construction of roads and margins with a total width of 12 m and length of 400 m connecting the lake site area to Highway No. 5
- Construction of concrete box culvert of 3 x (3.0 m x 2.0 m) dimensions of the length of 450 m located under road connecting site area to Highway No. 5 and discharging to An Kim Hai Channel
- Construction of three flow gates at the discharge location of the box culvert to An Kim Hai Channel each with a width of 3 m

The lake site area is also located to allow urban development to occur at the edges of the lake site area.

(2) Lake Road and Embankment Works

Preliminary design of the lake road and embankment works is based on a bottom level of +0.0 m and the design minimum water level of +1.5 m. The level of the road is selected as +3.8 m which is the same as the levels of the channel banks for rehabilitating An Kim Hai Channel.

Figure 2.4.10 presents the preliminary design of the lake embankment and road works. The embankment works consist of rubble masonry revetment. The total width of the maintenance roads plus margins on each side is selected as 12 m. The road will consist of two lanes, each with a width of 3.5 m. Sidewalk margins with a width of 2.5 m will be located on both sides of the road.

The designs of the embankment and road works are similar as the designs for An Kim Hai Channel. A side-slope of 1:1.5 is selected for the embankment works.

(3) Connecting Channel Works

Preliminary design of the connecting channel is identical to the channel designs for rehabilitating An Kim Hai Channel. However, the total width of the maintenance road margin is 7 m, with a 2 m wide margin on the channel side and a 1.5 m wide margin on the other side. This condition is applied because land is available to implement these dimensions. A bridge is constructed over the channel where it connects to the lake. The length of the bridge is 15 m with a width of 12 m.

(4) Closed Conduit Structure Works

The closed conduit connection to An Kim Hai Channel consists of a box culvert with three conduits. The width of each conduit is 3 m and the height is 2 m. The invert level of the conduits is +0.8 m.

The road connecting the lake area to Highway No. 5 is located above the box culvert. The total width of the roads plus margins on each side is selected as 12 m. The road will consist of two lanes, each with a width of 3.5 m. Sidewalk margins of width 2.5 m will be located on both sides of the road.

Figure 2.4.11 presents the preliminary design of the culvert and road works. The culvert is constructed of reinforced concrete. Precast reinforced concrete piles are located on the bottom of the structure to provide an adequate foundation. The road works consist of a top layer of asphalt concrete and a base layer of crushed stone. Precast concrete curbs are located on the side edges of the sub-surface works of the road.

Gate structures are to be located at the connection to An Kim Hai Channel. The conceptual design of the gate works is identical to the conceptual designs of the gate works for the tidal gates for Lach Tray and Cam River and the discharge gate for Du Hang Lake.

CHAPTER 5 SUPPLEMENTARY COMPONENTS

5.1 New Combined Sewers

(1) Construction of Replacement Sewers

Rehabilitation of the existing combined sewer network is a given condition considering that sewer rehabilitation works are included in the World Bank Sanitation Project. However, the World Bank Project does not include cleaning and inspecting of sewers for some areas of the Priority Project area as follows:

- Tertiary sewers are not included in the project for Lam Son, An Duong and Niem Nghia Phuongs in Le Chan District and May Chai Phuong in Ngo Quyen District
- Neither main, lateral nor tertiary sewers are included in the project for Dong Khe and Dang Giang Phuongs in Ngo Quyen District and Du Hang Kenh Commune in An Hai District

To ensure compatibility between the Priority Project and World Bank Project, an approach is adopted where SADCO would assume this responsibility by using the sewer cleaning and inspection equipment procured in the World Bank Project to cover this area. It is expected that the amount of sewers which would need repair is small, and that repair works can be financed by the budget of SADCO.

However, for sewers needing possible replacement because of poor condition or inadequate hydraulic capacity, provision of 3 km of new main sewers is provided in the Priority Project as a supplementary component.

(2) Construction of New Sewers

At present the amount of existing combined sewers is considered to be too small in some of the areas in the Priority Project area. These areas comprise the following:

- Dong Khe Phuong in Ngo Quyen District
- Du Hang Kenh Commune in An Hai District

Based on urban development plans of Haiphong City new roads are planned for construction in these areas: Sen Road in Du Hang Kenh Commune and Cat Bi Road in Dong Khe Phuong. Locating new main combined sewers at these new roads would provide much more cost effective drainage than attempting to plan and construct new sewers based on the existing conditions.

The adopted approach for the Priority Project is that new main combined sewers would be provided in these road construction projects separately from the Priority Project, but the Priority Project would include provision for 7 km of lateral sewers as a supplementary component. These branch sewers would then connect to the new main sewers of the new roads construction project.

5.2 Channel Road Bridges

At present there are 10 road bridges and 21 small wooden and bamboo bridges which cross over An Kim Hai Channel. The small foot bridges will need to be removed. However, the main road bridges do not need to be removed.

Consequently, the Drainage Priority Project includes the construction of new bridges crossing over An Kim Hai Channel as a supplementary component. The amount of new bridges would be located at the following channel sections:

- Section SC-1: Construction of 3 new bridges, length 12 m
- Section SC-2: Construction of 4 new bridges, length 15 m
- Section SC-3: Construction of 2 new bridges, length 15 m
- Section SC-4: Construction of 3 new bridges, length 15 m
- Section SC-5: Construction of 3 new bridges, length 20 m

The total amount provided as a supplementary component is 15 new bridges. The width of the new bridges is 7 m.

5.3 Ancillary Works

Ancillary works are also included in the Drainage Priority Project as a supplementary component for the maintenance roads and margins along An Kim Hai Channel and the road and margin areas around Phuong Luu Lake.

The ancillary works consist of the following:

- Lighting of the channel and lake roads and margin areas provided by light poles and lamps at intervals of 40 m
- Metal fences along the edges of the channel and lake roads along both sides of the channel and around the entire lake
- Trees and other plantings in the margin areas of the channels and lake

These works would enhance the value of the living environment of the road and margin areas along the channels and lake.

CHAPTER 6 COSTS ESTIMATES

6.1 Investment Costs

Investment cost includes direct construction cost and land acquisition cost.

Direct construction cost is estimated based on bill of quantities given in tables for this chapter and the unit prices presented in Chapter 3, Part 1 of Volume 2. Details of the cost estimation can be found in the Supporting Report. A summary is given in the following table.

Summary of Direct Costs of Drainage Priority Project

Item	Cost (US$1000)
1. Preparatory Works	2,264
2. Rehabilitation of An Kim Hai Channel	12,640
3. Construction of Phuong Luu Lake	10,004
Total	**24,908**

The cost of supplementary components is also estimated. Total cost is US$10.8 million (of which, costs for preparatory works is US$1.0 million, for new sewers is US$4.6 million, for bridges is US$2.2 million, and for ancillary works is US$3.0 million).

Cost of land acquisition and compensation is estimated based on actual field condition and details is given in Supporting Report. Total cost is US$3.7 million.

The total investment cost for the Drainage Priority Project is US$39.4 million.

6.2 O&M Costs

New staff is required to operate the new facilities proposed in the Priority Project. The estimation is based on the work performance of the existing staff, expected work load, available working hour, available equipment, and other factors. Total number of new staff is 6.

Unit cost for various levels of labor is given in Chapter 3 of Part 1, Volume 2.

Estimations for O&M costs is based on the following approach and assumptions:

- Annual operation costs is considered as constant and comprise vehicle and equipment costs, and office and communication costs. These costs are associated with daily monitoring of the system, and occasional operational activities during dry weather and wet weather (storm) conditions
- Annual maintenance costs is considered as variable and increase in the future, when the need for minor upkeep and repairs increase as the physical condition

of the civil works begin to deteriorate. These comprise vehicle and equipment costs, and costs for maintenance and repair materials

It is estimated that the maintenance costs for minor upkeep and repair is US$5.1 thousand in the year 2010 and will increase to US$17 thousand by the year 2015 and US$42.5 thousand by the year 2020.

Based on this approach and assumptions, the following table presents the O&M costs for the Priority Project by the year 2020.

O&M Costs for Drainage Priority Project in Year 2020

	COST ITEM	Amount (nr)	Unit Cost US$/nr	Cost US$
1	**Annual Staff Costs**			
1.1	Technicians and Operators	4	2 000	8 000
1.2	Indirect Support Staff	2	2 000	4 000
				12 000
2	**Annual Operation Costs**			
2.1	Vehicle and Equipment Costs	1	3 000	3 000
2.2	Office and Communication Costs	1	1 200	1 200
				4 200
3	**Year 2020 Maintenance Costs**			
3.1	Vehicle and Equipment Costs	1	7 000	17 500
3.2	Maintenance and Repair Materials	1	10 000	25 000
				42 500

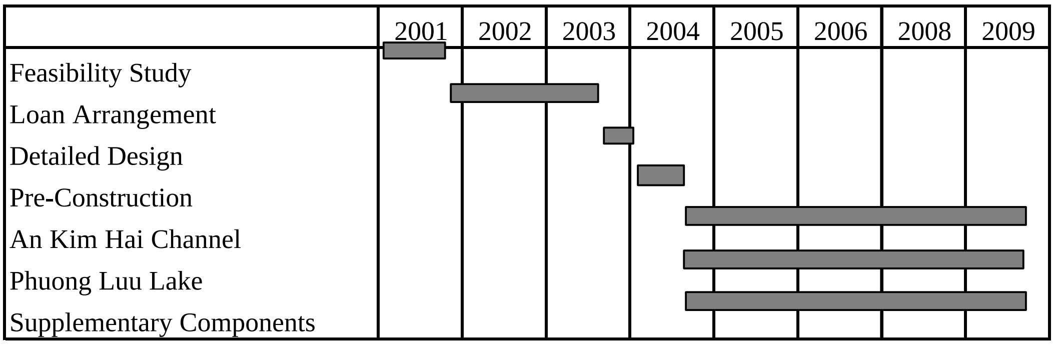
As shown in the table, total O&M costs is estimated to be US$58.7 thousand by the year 2020.

CHAPTER 7 PROJECT IMPLEMENTATION PLAN

7.1 Implementation Schedule

The implementation of the Drainage Priority Project is proposed to start from mid 2004 and to be completed by mid 2009. Loan arrangement is to be completed by mid 2003. Detail design and pre-construction will take about one year to complete. An Kim Hai Channel will be rehabilitated over a 5 year period and be completed by mid 2009. Phuong Luu Lake will be constructed over a 5 year period and be completed by mid 2009. Supplementary components will be constructed gradually over the entire five year implementation period.

The implementation schedule is summarized in the following figure.



7.2 Operational and Organization Plan

The Priority Project includes operation of two tidal gates and two discharge gates.

The two tidal gates are closed during normal dry weather conditions. If storms occur during high tide conditions, then the tidal gates remain closed until the tide levels are decreasing and water level in the channel increase to a level which is greater than the tide level. If storms occur during low tide conditions, then the tidal gates are opened immediately after the storm has begun, and the water levels in the channels and lakes are regulated at the minimum water level of +1.5 m.

The two discharge gates are closed when the channel is used for irrigation. When the channel is used for drainage, then the two gates are opened, and the gate at the siphon at Lach Tray River is closed.

The new staff comprises 4 operators and technicians. This O&M organization structure then allows the possibility that the two tidal gates and two discharge gates can be operated at any single moment.

7.2.1 Project Management in SADCO

This section focuses on the evaluation of the readiness of the key organizations to implement the priority projects. It assumed that TUPWS will assign the project construction management and supervision of the drainage project to SADCO.

Prior to the implementation of the proposed project drainage improvement, the existing PMU in SADCO will have had the experience with the World Bank 1B Project. The PMU is being strengthened along with the overall capacity building efforts of the FINNIDA funded Water Supply, Drainage, Sewerage, and Sanitation Management Program, 2001-2004 (WSDSSMP).

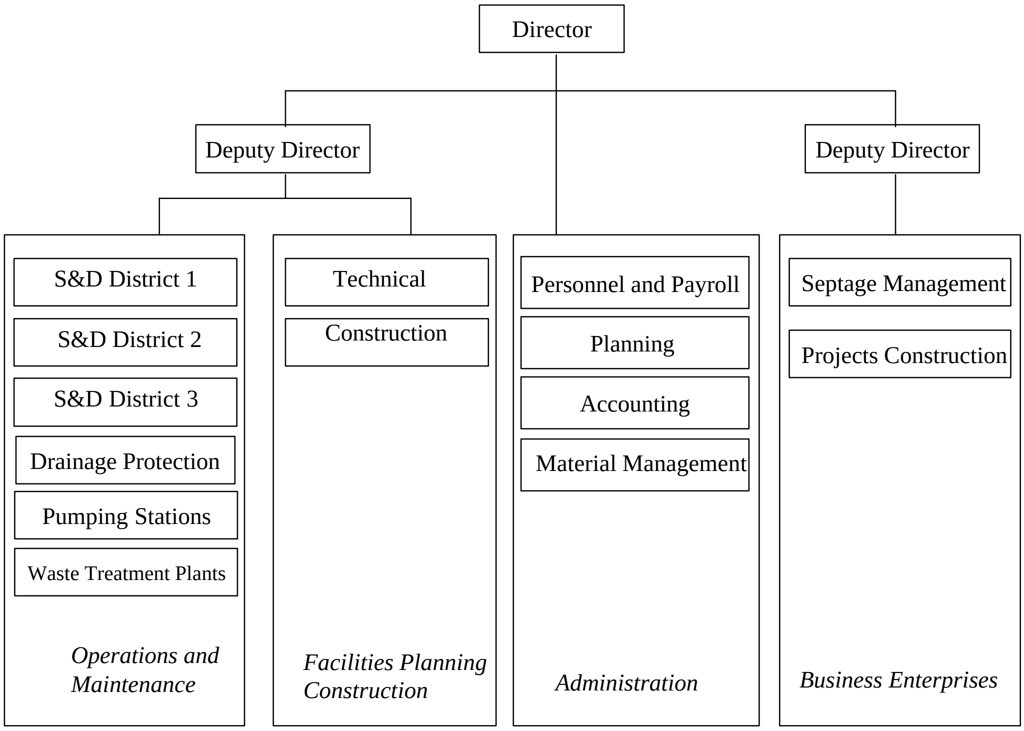
To date progress in developing the staff in SADCO has been slow. However, by the time the Drainage Priority Project is ready for implementation, it is expected that the capability of the PMU to effectively execute and manage the priority projects will be improved.

However, for planning purposes, it should be assumed that:

- The PMU unit will require further technical assistance to facilitate their participation in the implementation of the Priority Project
- International advisors will need to participate directly in the bidding, procurement and construction supervision

7.2.2 Prior Reorganization of SADCO

SADCO will need to be reorganized to successfully implement the Priority Project. It is proposed that the overall organizational structure will be as in the following figure.



Organizational Structure of SADCO prior to implementation of the Drainage Priority Projects.

7.2.3 Institutional Changes

Currently, the responsibility for management of An Kim Hai Channel belongs to the Department of Agriculture and Rural Development. SADCO will need to be assigned specific authorities to perform the following:

- Regulation of hydrological performance of drainage system
- Prohibition of construction within specified buffer zones around all drainage facilities and works
- Restriction of discharges of sewage, dumping of solid waste, or industrial effluent to the drainage system

The main institutional consequences of the priority project on drainage are summarized in the following table.

Main Institutional Consequences of Priority Project on Drainage

Priority Project Element	Institutional Consequences
Rehabilitation of An Kim Hai Channel and Construction of Phuong Luu Lake	• Assignment of responsibility for management of An Kim Hai Channel to TUPWS/SADCO • Assignment for Responsibility for Control of Hydrological Regime in Phuong Luu Lake • Increased O&M

7.2.4 Manpower Training

Training and technical assistance should be undertaken to achieve the following objectives:

- Strengthen the capacity of the project management unit (PMU) to ensure that it can effectively implement the drainage project
- Increase the technical competence of the drainage team

The following set of specific courses must be developed and delivered.

Unit	Specific Courses
Project Management Units	• Project management systems • Bidding and Contract Management • Engineering skills • Foreign Languages
Drainage	• Channel Cleaning, Rehabilitation and Maintenance • Operation of Facilities for Channels and Lakes

Specific measures for manpower training are proposed as follows:

(1) To learn from the preceding projects and experience in the cities in Vietnam

In Vietnam, large-scale drainage projects are currently underway or will be implemented soon in the cities of Hanoi and Ho Chi Minh. Their experience and knowledge can be learnt and transferred to the PMU to be established for Haiphong drainage priority project as well as to SADCO in the similar manner as mentioned above for the cooperation between WSC and SADCO. In the case of Ho Chi Minh drainage project, about 7,000 households must be resettled for which detailed plan has been worked out. This plan should carefully be referred to and studied when detailed resettlement will be formulated for Haiphong project.

(2) To study in appropriate academic organizations

In Haiphong, the Haiphong Private university has an Environment Faculty and can offer the educational opportunities for sanitation and environmental subjects. Marine university can also offer opportunities for related subjects. In Hanoi located only 2 hours distance from Haiphong, several universities are established which can offer courses related to sanitation management including the followings:

- Hanoi University of Civil Engineering (Center for Environmental Engineering for Towns and Industrial Area)
- Hanoi University of Technology (Center for Environmental Science and Technology)
- Hanoi National University

- Hanoi Architecture University
- Hanoi Politechnique University
- Dong Do Private University
- Asian Institute of Technology, Hanoi Branch

The offered courses by Hanoi University of Technology, which is closely related sanitation management, for example, include Environmental Chemistry, Environmental Pollution Control, Water Pollution and Treatment Technologies, Design and Management of Wastewater Treatment Plant, Collection and Treatment of Solid Waste and Sewerage Network for Urban Areas.

These courses would provide good training opportunities.

(3) Training by means of the technical assistance by overseas public sector organizations

Ministries and municipal governments of the advanced countries have long experience in the drainage management and their cooperation should be sought.

7.2.5 Cost Estimate for Training and Technical Assistance

The estimate total cost for training is US$4,000 and for technical assistance for a drainage advisor to project management unit is US$300,000. The details are given in the following table.

Estimate Cost for Training and Technical Assistance – Drainage Project

I. Training	1	2	3	4	5	6
	Trainee	Course Units	Days/ Unit	Trainer Days	Cost/ Day	Total Cost
1. Sewerage and Drainage Units						
Cleaning, Rehabilitation, and Maintenance	30	3	5	15	100	$ 1,500
2. Project Management Unit						
Project Management Systems	10	1	5	5	100	$ 500
Bidding and Contract Management	5	1	10	10	100	$ 1,000
3. Drainage Protection Unit						
New Regulation and Inspection Procedures	15	1	10	10	100	$ 1,000
TOTAL TRAINING COSTS						$ 4,000

II. Technical Assistance - Priority Projects	Man Months	Cost/ Month	Total Cost
1. Drainage Advisor - Project Management	12	25,000	$ 300,000
TOTAL TECHNICAL ASSISTANCE COST			$ 300,000

Training and technical assistance will be provided over a two-year period from 2005 to 2006. It may be mentioned here that cost for training and technical assistance is not included in the Priority Project cost estimates.

CHAPTER 8 PROJECT EVALUATION

8.1 Objective Achievement

(1) Project Objectives

The Implementation of the Drainage Priority Project has 3 major objectives as follows:

- Improvement of public health
- Improvement of the quality of ambient water bodies
- Reinforcement of the economic activities and upgrade of the environment for future economic growth

Public health improvement objective will be achieved by Drainage Priority Project implementation through the reduction of inundation area, depth and frequency as well as duration. Sanitation conditions of the project area which is located at the central part of the city will be improved and water-borne diseases of the city will be reduced.

Sweeping of the pollution load and flowing into the surface water during storm will be reduced which will contribute to the quality improvement of ambient water bodies.

With the lowered risk of flooding, land value will be enhanced and economic growth will be stimulated. These economic benefit will be discussed in the following section of this chapter.

(2) Objective Achievement Evaluation

1) Evaluation by Means of Impact Indicators

(a) Public Health Improvement

The central part of the city which is most densely populated and where flooding or inundation has been occurring most frequently, will be protected from flooding up to the storm water recurrence period of 5 years. Under bigger storms, the degree of flooding will be lessened. Duration and degree of unsanitary conditions will be shortened as well as water-borne diseases including the infectious ones. The overall public health condition will be improved which will have beneficial impacts on the whole city population which will be 1.909 million by the year 2010 and 2.121 million by the year 2020.

2) Evaluation by Means of Development Indicators

Drainage Priority Project will directly protect the central city area of about 11 km^2 where 240 million residents will be living in the year 2010 and 286 million in the year 2020. They living environment will be upgraded in this directly affected area. Economic potential of this area will also be enlarged.

The incremental flood reductions in the Central Area which is the target area for the Project, are assessed assuming the implentation of the World Bank Project and FINNIDA Project prior to the Project based on the following data:

- Flood reduction data for Class A Areas from World Bank Project
- Expected annual flood reductions in Central Area from FINNIDA Project
- Flood data for Central Area from computer simulations for Priority Project

The assessments of the incremental flood areas in Class A Areas (total amount) and inside and outside the Central Area are presented in the following table.

Based on the adopted methodology, the incremental flood reductions in the Central Area after implementation of each of project is presented in Figure 2.8.1 and the following table.

Incremental Flood Reductions in Central Area After Project Implementation

Frequency	Potential Flood Area	World Bank Project	FINNIDA Project	Priority Project
0.25 year ARI	140 ha	46 ha	3 ha	4 ha
0.5 year ARI	180 ha	58 ha	8 ha	11 ha
1 year ARI	250 ha	76 ha	13 ha	19 ha
2 year ARI	280 ha	88 ha	18 ha	31 ha
5 year ARI	320 ha	92 ha	23 ha	46 ha

Note: Potential area is the maximum calculated flood area. Actual flood area with 5 year ARI is less than 161 ha.

Under the 5 year ARI storm condition, Drainage Priority Project alone will reduce flooding area in Central Area by 46 ha. Besides the project target area of the Central Area, Drainage Priority Project will also reduce the flooding area in New Urban Area by 12 ha. In the Central Area, out of the potential flooding area of 320 ha, half of it is the built-up area, being occupied the buildings and other structures and the area of the flood-prone site is 161 ha area. Together with the other two project implementation, flooding area will be reduced by 161 ha or no flooding will occur under the 5 year ARI condition. Flood reduction effect of the Drainage Priority Project and the other 2 drainage projects are shown in Figure 2.8.1 together with present flood areas.

For assessing the incremental flood reductions, the amount attributed to the Project also includes flood areas determined from data from the FINNIDA Project, but not included in flood areas determined from the computer simulations for flooding for the Priority Project. Reductions in flood for these areas can be expected after implementation of the Priority Project, because the defined total catchment area for the Northeast and Southwest

Drainage Basins was 100 ha less for the Priority Project than for the FINNIDA Project. This situation occurs because these catchment areas will be developed as part of the An Kim Hai Channel Basin after implementation of the Priority Project, rather than as part of the Northeast and Southwest Drainage Basins, as planned in the World Bank and FINNIDA Projects.

3) Evaluation by Means of Operation Indicators

(a) Total Storage Capacity of An Kim Hai Channel

This data refers to the storage capacity of AKH Channel when the channel would be empty until the channel would be completely full (i.e. from bottom to top). This data is considered as only indicative, because it does not consider minimum and maximum regulated water levels in the channel.

Before rehab: total storage capacity = 192,000 m^3

After rehab: total storage capacity = 375,000 m^3

Thus, after rehab the total storage capacity is about 95 % greater than the total storage capacity before rehab.

(b) Hydraulic Conveyance of An Kim Hai Channel

This data is based on the Manning Equation and is defined mathematically as follows:

Conveyance = (1/n)*A*R^(2/3)

where A is the flow area, R is the hydraulic radius, and n is the Manning energy loss coefficient.

Hydraulic conveyance is a good comparative indicator for the increase in hydraulic capacity, because when it is assumed that the energy losses are equivalent in the comparison, then the hydraulic conveyance represents the flowrate (Q) in the channel.

For the following data, the hydraulic conveyance is based on the total flow area in the channel (i.e. the channel is flowing full). Also, because of different channel conditions, the data represents the "composite" hydraulic conveyance of the channel, when considering the representative channel cross-section for a length of the channel.

Before rehab: composite hydraulic conveyance = 641

After rehab: composite hydraulic conveyance = 2013

Thus, the composite hydraulic conveyance after rehab is 215 % greater than the composite hydraulic conveyance before rehab.

(c) Effective Storage Capacity of Lake System

The effective storage capacity of the lake system is defined as the storage capacity available in the lakes where the water levels in the lakes are regulated according to the minimum and maximum water levels (i.e. the effective storage capacity is the volume of water which can be stored between the minimum and maximum water levels).

For Phuong Luu Lake, the minimum and maximum water levels are +1.5 m and +2.7 m, respectively. For the other lakes, similar data is used given in previous sections.

Before: effective storage capacity of lakes = 500,000 m^3
After: effective storage capacity of lakes = 790,000 m^3

Thus, after construction of PL Lake, the effective storage capacity of the lakes in the PP target planning area is 58 % greater than the effective storage capacity of the lakes before construction of PL Lake.

(d) Combined storage capacity of the lake and channel

After the rehabilitation of An Kim Hai Channel and Phuong Luu Lake, increase in the combined storage capacity is 183,000 m^3 from AKH Channel and 290,000 from PL Lake, with a total increase of 473,000 m^3.

8.2. Economic Evaluation

8.2.1 General Principles

The drainage and sewerage priority projects are closely interrelated, and form part of a comprehensive program of environmental improvement in Haiphong, which is being developed with the financial assistance of several external agencies. Due to their close physical interrelationship, and to the nature of their impacts and objectives, it is appropriate for the purpose of project evaluation first of all to analyze the two projects individually, and also to present them as a combined project. This second approach is contained in Part 5 Chapter 2, below.

It is not possible to estimate the economic benefits of the priority drainage project with any accuracy due to inadequacy of data on the various influences on measures such as property values, human health, etc. Justification essentially rests upon qualitative analysis of benefits and engineering cost-effective solutions, combined with affordability tests. In this case it will not be possible to check the cost-effectiveness of the project by comparing costs per beneficiary or other unit cost indicators with international experience, or with that of other Vietnamese cities, due to their essentially location-specific nature.

One reason why economic justification is not easy to demonstrate is the existence of very imperfect markets, which do not permit an effective willingness to pay for housing, utility services etc. The ability to make informed investment decisions will thus depend to a large extent on the pace of economic policy reform, which will allow greater expression of willingness to pay on the part of ultimate beneficiaries of the services concerned.

The main impact of the selected priority project will be in 1,103 ha. of the Phase 1 Area, although the longer-term impact is likely to extend well beyond this boundary.

Economic evaluation of the project must be assessed in light of its contribution to the long-term development of Haiphong City. This city has been identified as a major growth area by the Vietnamese government, and is expected to grow at a rate substantially greater than that for the country as a whole.

Haiphong City's unique position as the major port area for Hanoi and the Red River Delta area makes its development of primary national importance. As such, it requires a significant improvement in the basic infrastructure, such as roads, water supply, sewerage, and drainage. All these facilities must be upgraded if Haiphong's potential is to be fully realized.

The drainage project, as described above, is essentially a public good, the benefits of which are not clearly related to any individual household, consumer or street. Rather, they improve the overall environment throughout the Phase 1 area, by reducing the incidence of flooding, providing adequate drainage for normal rainfall conditions, and by reducing environmental pollution and groundwater contamination of the whole area. These improvements are over and above those provided by on-going projects of other external agencies such as the World Bank and FINNIDA. For example, the drainage project will reduce the frequency of flooding from a two year ARI (to be achieved by the World Bank project) to a five-year ARI flood.

It is clear that high-density, high-value economic development in the Study Area will be greatly assisted by the proposed project, which will effectively increase the availability of usable land, create a recreational lake, and regulate the quantity and quality of waste water and normal runoff.

Although the drainage project will reduce the incidence of flooding of households and commercial establishments and roadways, this is not thought to be the major objective, and avoided damage to existing properties from flooding is believed to be relatively small. The major contribution of the drainage project, in association with the sewerage project, will be to allow the affected area to develop as a modern economic residential and commercial area in a systematic way. For example, it is proposed to build a new medical university at the southern end of the Phase 1 Area. This will be at a location that is currently occupied by a lake that will be drained as part of the project.

If adequate data were available, the economic justification of the projects would as a minimum be revealed by an increase in property values in the affected area, or by an increase in the economic productivity of the affected area, that result from the projects. However, data are not available to predict precisely what these impacts would be.

The method employed in this study is therefore to estimate, as two alternative approaches:

- the percentage increase in property values in the affected area that would be required to offset the costs of the projects
- the percentage increase in the productivity of land in the affected area that would be required to offset the costs of the projects

A judgment can then be made as to whether such percentage increases can reasonably be expected. This is known as the “switching value” method.

It is considered that both of the approaches would yield a minimum estimate of the economic benefits of the projects, as their impacts would no doubt extend well beyond the specific areas concerned, where the direct beneficiaries are located. However it will not be possible to estimate the city-wide, or region-wide, impacts.

In estimating the base (without-project) case for property values and productivity, two alternative assumptions are made, i.e. (a) that there is no economic growth in the Study Area after year 2001, and (b) that economic growth will correspond to the Average Scenario referred to in the Environmental Master Plan Report.

Results of the economic analysis are as follows.

8.2.2 Least-Cost Solution

For the preparation of the long-term plan for drainage improvement as an integral part of SMP, 4 alternatives are formulated; D1, D2, D3 and D4. These alternatives are compared from various aspects including the scope of beneficial impact, technical feasibility and cost-effectiveness. Consequently, D2 has been selected. The proposed Drainage Priority Project is the phase 1 or the first phase of the proposed D2 alternative.

Among the 4 alternatives, target area of D1 is smaller, not covering the old city center while the other 3 have the same target area. Out of the 3 alternatives excluding D1, D2 has the smallest investment cost per beneficiary or about 72 % of the second least-costly. The conclusion will not be affected when comparison is made in terms of the overall cost including O&M cost because O&M cost is small compared with the investment cost and its ratio to the investment cost is about the same for all of the alternatives.

8.2.3 Economic Feasibility

The following describes the method used to determine the base case property value and productivity indicators, and alternative assumptions about these indicators in future years. Details of the calculations, as well as of the results of the "switching value" exercise, are presented in Tables 2.8.1 and 2.8.2, attached.

(1) Base Case Property Values and Urban Productivity

1) Property Values: "No Growth" Scenario

Property values in Phase 1 area are derived from Study Team estimates of land values, based upon data supplied by the Haiphong City Finance Department, and updated to year 2000 prices, and which total US$403.7 million. To this is added estimates of the value of buildings and movable property which might be threatened by flooding, which are based upon a survey conducted for the World Bank Three Cities Sanitation Project, and applicable to the Phase 1 area. Updating to 2000 prices, the present value of these properties is estimated at US$480.4 million. (Underlying data and assumptions for this calculation: population of Phase 1 area 238,425; average number of persons per household 4.5; average size per house including commercial areas property 55 m^2; value of property US$157 per m^2).

Total current value of properties in the Phase 1 area, assumed to be the same in the 2003 base year for the "No Growth" case, is therefore US$884.1 million.

It is considered that as soon as the project is started, property values would start to increase in anticipation of the benefits it would bring. Property values therefore date from the 2003 base year in these calculations.

2) Property Values: "Average Growth" Scenario

It is probable that property values in Haiphong will increase in real terms in the future, as urbanization expands. It is assumed here that property values will increase at the same rate as Haiphong's overall GRP, under the "Average Growth" scenario presented in the Sanitation Master Plan Report.

Under the Average Growth scenario, the present value of properties in the Phase 1 area (at 10 %, with a 2003 base year) is estimated at US$1,864.3 million.

3) Urban Productivity: "No Growth" Scenario

Current (year 2000) productivity, or value added, or GRP, per capita in the Phase 1 area is assumed to be the same as that for the non-agricultural population in the Study Area as a whole, i.e. US$742 in 2000 prices. With a current potential beneficiary population of 238,425, the total productivity of the area is US$176.9 million (corresponding to about US$160,000/ha). This is the base case figure for the "No Growth" scenario. The present value of GRP in Phase 1 over the 20-year period 2003-2023, using a 10 % discount rate, and with 2003 as the base year, is estimated at US$1,346 million. The calculations relating to productivity assume that benefits will begin to accrue halfway through total project completion, i.e. 2006.

4) Productivity Per Hectare: "Average Growth" Scenario

Average growth of productivity per hectare is assumed to be at the same rate as that presented in the Sanitation Master Plan Report. Under this assumption, the present value of GRP in Phase 1 over the 20-year period 2003-2023, using a 10 % discount rate, and with 2003 as the base year, is estimated at US$3,133 million. (As before, productivity benefits are assumed to begin to accrue in 2006).

(2) Economic Feasibility of the Priority Drainage Project: Impact on Property Values and Productivity

The costs of the drainage project as shown above are now compared with the two selected indicators to test if the impact required to demonstrate economic justification is in fact likely to be met. The table below shows the costs of the project in relation to the two indicators, i.e. property values and productivity. In each case, present values at a 10 % discount rate, a 20-year time horizon, and a 2003 base year are used.

Cost of Drainage Project as Percentage of Property Values and Productivity in the Project Area

	Present Value of the Property or GRP as of 2023 with 2003 as the Base Year (US$ million)	Present Worth of Project Cost (US$ 32.874 million) as % of Values in Column (b)
(a)	(b)	(c)
Property value – under No Growth case	884	3.7 %
Property value - under Average Growth case	1,864	1.8 %
Project Area GRP value –under No Growth case	1,346	2.5 %
Project Area GRP value– under Average Growth case	3,133	1.1 %

These results appear to provide a reasonable justification for the drainage project, taken in isolation, particularly if the Average Growth scenario is realized. Under the "No Growth" scenario, which is quite conservative, a 3.7 % increase in property values or 2.5 % increase in productivity would be required to indicate project justification. Under the more realistic Average Growth scenario, these percentages fall to 1.8 % and 1.1 % respectively.

The various assumptions and estimates used to address project impacts are adequate as sensitivity tests on the benefit side. Sensitivity of the results to variations in cost estimates is also tested. The following table shows the percentage increases required to demonstrate project justification under three assumptions, namely the base case (as in the preceding table) and where project costs are increased by 10 % and 20 % respectively.

Even with a 20 % cost increase, the increases in property values or productivity required to demonstrate justification continue to be reasonable.

Cost of Drainage Project as Percentage of Property Values and Productivity in the Project Area: Sensitivity to Cost Estimates

	Base Case	Costs + 10 %	Costs + 20 %
Property value – under No Growth case	3.7 %	4.1 %	4.4 %
Property value - under Average Growth case	1.8 %	1.9 %	2.2 %
Project Area GRP value – under No Growth case	2.5 %	2.8 %	3.0 %
Project Area GRP value – under Average Growth case	1.1 %	1.2 %	1.3 %

In order to check whether or not the proposed Drainage Priority Project is affordable for HPPC for financing, reference was made to the drainage project that is under construction in the Hanoi city. Comparison between the 2 cases (Hanoi and Haiphong) was made from the viewpoints as shown in the table below:

- Ratio of the total project investment cost to the annual city expenditure.
- Ratio of the counterpart fund out of the total investment cost to the annual city expenditure
- Ratio of the annual counterpart fund out of the total investment cost to the annual city expenditure

It is noted that majority (about 85 %) of the fund requirement for the Hanoi project has been financed by external ODA loan of concessionary conditions, and for Haiphong project similar loan was assumed to be extended. As shown in Item g in the table, financial burden on HPPC to meet the investment cost that is not covered by the loan, is less than half of the Hanoi case in terms of the whole requirement (see Item g below) and about half in terms of annual requirement (see Item h below).

The Drainage Priority project cost is therefore considered affordable to HPPC

Comparison of Hanoi Drainage Project and Haiphong Drainage Project

	Hanoi	**Haiphong**
a. Implementation Period	9 years (1995 – 2003)	7 years (2003 – 2009)
b. Total Project Investment	US$200.0 million	US$55.7 million
c. Counterpart fund financed by the City	US$31.2 million	US$8.4 million
d. Annual average counterpart fund (c/a)	US$3.5 million	US$1.2 million
e. City's Total Expenditure in the mid year of construction period	US$164.5 million in 2000	US$102.4 million in 2006
f. Ratio of Item b to Item e	**121 %**	**54 %**
g. Ratio of Item c to Item e	**19.0 %**	**8.2 %**
h. Ratio of Item d to Item e	**2.1 %**	**1.2 %**

Notes:

1. Hanoi city's total expenditure in 2000 was estimated assuming an exponential expenditure growth between two years of which data were available to the JICA Study Team (US$156.7 million in 1999, and 172.1 million in 2001) Original amount was indicated in Japanese yen. Yen amounts were converted into US$ using an exchange rate of 110 yen/US$ which seems to be average and dominant rate considering that the rates have ranged from 100 yen/US$ to 120 yen/US$ since 1995 up to present.
2. All other data were obtained by the JICA Study Team

8.3 Financial Evaluation and Affordability

8.3.1 Affordability: General Principles

Even if a project may pass cost-benefit tests, indicating that the present worth of costs over the lifetime of the project may exceed the benefits, it does not necessarily mean that it is financially feasible, or affordable, particularly in the short to medium term. This applies to each of the components of the Sanitary Master Plan individually, the relevant analysis becoming even more important when an investment package, comprising in this case of drainage, sewerage, and solid waste, is considered. Thus while each component of the proposed package of priority projects may be affordable individually, the whole program may not be.

Affordability of the environmental program for Haiphong City as a whole, of which the priority projects are an integral part, has been estimated in the Sanitary Master Plan Report, in which general assumptions were made about loan conditions (25 years, 5% interest). This represented the general financial opportunity costs of the program to the country as a whole, and related to possible concessionary and non-concessionary lending from a variety of sources, which have not been identified.

Results of the Master Plan study suggested that the proposed program would satisfy affordability criteria on an aggregate basis, as long as the basic assumptions about economic growth and cost estimates are realized. In particular, the viability of the program is extremely dependent upon the rate of economic growth in Haiphong. Analysis in this volume more precisely relates costs of individual programs to the capacity to pay of specific beneficiary groups, rather than the Study Area as a whole.

Because the priority drainage project is part of a comprehensive on-going program of drainage investments, financed by other donors as well, affordability of the priority drainage project in isolation is not meaningful. Rather, affordability must be judged in light of the costs of the overall drainage program for the city. Similar estimates will be made subsequently for the priority sewerage and solid waste projects.

Key economic and population indicators for this purpose are presented in Table 2.8.3. The population indicators refer to the whole of Haiphong City, or the Study Area, as defined in the Environmental Master Plan report, Volume 1.

Relevant indicators for judging affordability with regard to the whole population of the Study Area, and for Haiphong City, which are applicable not only to drainage, but also sewerage and solid waste, are as follows:

<u>Per capita GRP in areas benefiting from the program</u>. This provides an indicator of the feasibility of the programs in terms of the overall economic capacity of the concerned community to pay for the services.

<u>Per capita disposable income of direct beneficiaries</u>. This provides an indicator of the financial feasibility of direct beneficiaries to pay, out of their discretionary household incomes, for the services provided. This information is important in a strategic policy sense. Thus, even though costs of certain services may be low when compared with GRP, this may not be so when household disposable incomes are concerned. This applies in particular to services which should ideally be financed by recovery of costs from actual beneficiaries. (As noted below, this applies primarily to sewerage and solid waste rather than to drainage). If the proportion of GRP that is received as disposable income is low, this may frustrate the objective of decentralization. The relationship between the costs of the environmental program and disposable incomes thus provides some indication as to how realistic the prospects are for the effective autonomy of the utilities concerned.

<u>Total HPPC expenditures</u>. This provides an indication of the fiscal feasibility of the proposed programs for Haiphong City government. This is important for solid waste and for sewerage and drainage, even though an increasing proportion of costs is to be recovered in the form of user charges or fees.

Growth rates for the economic indicators listed above correspond to the Average Growth scenario described in Volume 1 of this report.

8.3.2 Affordability of Drainage Program

Results for the drainage program are summarized in the following two tables. In column (2) of the first table, investment costs are amortized, thereby showing how much it will cost, year by year, to repay loans required to finance the program. It is assumed here that funds will be borrowed on terms that correspond on average to a 25-year loan at a 5 % interest rate. Note that even if funds are provided in grant form, or on a more favorable basis than the above, they may still represent financial opportunities foregone, and will thus typically involve real economic costs to the recipient.

Drainage program costs, populations of the Study Area and Haiphong City, and costs per capita are shown below:

Drainage Program Costs and Study Area and Haiphong Population, 2001-2020

Costs in 2000 prices

Year	Capital Costs (US$'000)	Amort. Val of (1) (US$'000)	Cumulative Val of (2) (US$'000)	Recurrent Costs (US$'000)	Total Costs (US$'000)	Study Area Population	Cost Per Capita Study Area (US$)	Cost Per Capita Haiphong (US$)
2001	151	11	11	208	219	567,387	0.39	0.13
2002	14,825	1,052	1,063	208	1,271	573,785	2.22	0.73
2003	17,559	1,246	2,308	208	2,516	580,183	4.34	1.43
2004	21,233	1,507	3,815	299	4,114	586,581	7.01	2.31
2005	7,156	508	4,323	308	4,631	592,579	7.81	2.58
2006	7,722	548	4,871	318	5,189	599,245	8.66	2.85
2007	8,281	588	5,458	328	5,786	605,911	9.55	3.14
2008	10,281	729	6,188	342	6,530	612,576	10.66	3.50
2009	7,322	520	6,707	350	7,057	619,242	11.40	3.74
2010	2,116	150	6,857	350	7,207	625,908	11.51	3.77
2011	15,869	1,126	7,983	381	8,364	632,517	13.22	4.33
2012	15,964	1,133	9,116	416	9,532	639,126	14.91	4.88
2013	13,848	983	10,098	453	10,551	645,735	16.34	5.35
2014	13,753	976	11,074	489	11,563	652,344	17.73	5.80
2015	13,753	976	12,050	523	12,573	658,953	19.08	6.24
2016	13,753	976	13,026	557	13,583	665,556	20.41	6.67
2017	13,753	976	14,002	592	14,594	672,160	21.71	7.09
2018	13,753	976	14,977	626	15,603	678,763	22.99	7.51
2019	13,753	976	15,953	660	16,613	685,367	24.24	7.91
2020	13,753	976	16,929	694	17,623	691,970	25.47	8.31

Affordability of the proposed program can be assessed in light of the information provided in the following table:

Affordability of the Drainage Program, 2001-20:
Costs as Percentage of Key Indicators

values in 2000 prices

Year	Total Cost (US$'000)	Total Cost as % of Study Area GRP (%)	Total Cost as % of Haiphong GRP (%)	Total Cost as % of HPPC Exp. (%)	Total Cost as % of Study Area Disp. Inc. (%)	Annual Per Cap. Cost in Study Area (US$)
2001	219	0.05	0.03	0.34	0.10	0.39
2002	1,271	0.27	0.17	1.87	0.54	2.22
2003	2,516	0.50	0.31	3.46	1.00	4.34
2004	4,114	0.76	0.48	5.33	1.53	7.01
2005	4,631	0.81	0.51	5.66	1.61	7.81
2006	5,189	0.80	0.51	5.70	1.59	8.66
2007	5,786	0.79	0.52	5.78	1.59	9.55
2008	6,530	0.81	0.54	5.97	1.62	10.66
2009	7,057	0.80	0.54	5.95	1.59	11.40
2010	7,207	0.75	0.51	5.64	1.50	11.51
2011	8,364	0.82	0.55	6.16	1.63	13.22
2012	9,532	0.88	0.60	6.62	1.76	14.91
2013	10,551	0.92	0.63	6.94	1.84	16.34
2014	11,563	0.96	0.65	7.23	1.92	17.73
2015	12,573	0.99	0.67	7.48	1.99	19.08
2016	13,583	1.02	0.69	7.71	2.05	20.41
2017	14,594	1.05	0.71	7.93	2.11	21.71
2018	15,603	1.08	0.73	8.12	2.16	22.99
2019	16,613	1.10	0.75	8.30	2.20	24.24
2020	17,623	1.12	0.76	8.46	2.25	25.47

Note: Investment costs on amortized basis.

This table suggests that the drainage program satisfies the affordability criteria. Since the drainage program is essentially a public good, the most relevant indicators for affordability are GRP per capita of actual beneficiaries (i.e. those living in the Study Area), per capita for Haiphong City as a whole, or HPPC expenditure.

The results are sensitive to the assumptions made about economic growth. Table 2.8.4 shows the results of the foregoing type of analysis if economic growth is half of that estimated above, and costs increase by 10 % and 20 %. Under these conditions, the cost of the program would increase from 0.75 % to 1.33 % of Study Area GRP in 2010, and from 5.6 % to 9 % of HPPC expenditures in that year. Continual monitoring of key economic indicators will be required in order to assess affordability as the program is developed.

8.3.3 Funding Requirements and Financing Plan

In practice, the issue of affordability is eased by the prospect of loans from external development agencies at subsidized rates. If these can be obtained, costs per beneficiary and as a proportion of various income measures would fall significantly. It is therefore proposed that external assistance should be obtained for the priority project. It is assumed that funding will be available on the following terms:

- Interest rate for construction and procurement 1.3 %, and for engineering 0.75 %
- Funding available for 85 % of project costs, repayable over 30 years after a 10-year grace period, during which time interest only is paid

Table 2.8.5 shows the repayment schedule and total financial burden under these conditions. The Average Growth Scenario and base case project costs (in current prices) are assumed.

It is also assumed that the responsibility for repayment of loans for the selected priority projects ultimately rests with HPPC. If so, Table 2.8.5 shows the percentage of HPPC expenditure that would be required to repay the loan, plus the associated recurrent costs of the projects. In addition, HPPC would have to fund the 15 % of project costs not financed by the external lender.

The table shows that during the project construction period, when 15 % of project costs must be found in cash terms, the financial burden for HPPC is relatively high, with maximum cash payment of US$2.6 million in 2004, corresponding to 3.1 % of predicted HPPC expenditures in the same year. These funds might be obtained from increased user charges, or at the expense of other HPPC programs, or possibly by support from the national government. When actual loan repayment begins, i.e. in 2013, the financial burden peaks again, rising to about 1.5 % at its maximum.

8.4 Technical Evaluation

Drainage Priority Project mainly comprises the rehabilitation of An Kim Hai channel, construction of Phuong Luu lake, construction of a connecting channel between the lake and Northeast Channel, construction of a box culvert between the lake and An Kim Hai channel, construction of two tidal gates, and construction of two discharge gates.

Construction of the Drainage Priority Project will be by means of the traditional method and require no peculiar and advance technology. O&M of the project facility themselves will not accompany any advanced skills.

The project facility has dual functions of storm water drainage and irrigation. Tidal influence to the An Kim Hai Channel must be avoided. To serve these objectives, the recommended gates must be controlled, i.e., closing and opening properly and timely. An appropriate instruction manual is essential for the operation of these project facility together with other related facility including 2 drainage pumping stations, one at the Cam River and the other at Lach Tray River. The established operation rules should duly be observed.

Together with these efforts, the Drainage Priority Project is considered to be technically feasible.

8.5 Environmental Impact Assessment

8.5.1 Environmental Impacts of Drainage Project

The main impacts of the proposed project are described for the design phase, construction phase and operation phase. An alternative without the project implementation has also been described. Details of the EIA and mitigating measures are described in the Supporting Report, Part C.

The proposed drainage project is expected to have the following positive impacts: (i) improvement of drainage system, (ii) reduction of flood problems, (iii) improvement of public health condition, and (iv) improvement of landscape.

The biggest adverse impacts during the project implementation are: (i) land acquisition and resettlement of about 1300 households, (ii) transportation and disposal of dredged material, and (iii) general nuisance during dredging, excavation and transportation, including dust, noise and offensive odor.

Assessment of Advantages and Disadvantage of Project to Living Environment

Cause			**Time Scale**	**Need for mitigation**
	Positive	**Negative**		
Land acquisition and resettlement		- - -	Long-term	Yes
Odor during dredging and sludge disposal site		- - -	Temporary	Yes
Noise during construction		- -	Temporary	Yes
Dust during construction work		- -	Temporary	Yes
Traffic jam during construction		- -	Temporary	Yes
Relocation of structures (power lines, underground pipes etc)		-	Temporary	Yes
Risk of soil and groundwater contamination during construction and sludge disposal		-	Temporary	Yes
Safety for worker		-	Temporary	Yes
Influences on spiritual and cultural values	+	-	Temporary	No
Sludge recycle and reuse for landscaping	+		Temporary	No
Usage of sludge as fertilizer	+		Temporary	No
Employment creation	+		Temporary	No
Reduction of pollution to water supply system	+		Long-term	No
Enhancement of storage capacity of regulation lake	+ +		Long-term	No
Aesthetic improvement	+ +		Long-term	No
Reduction of water related diseases	+ +		Long-term	No
Health improvement	+ +		Long-term	No
Reduction of losses due to flood	+ +		Long-term	No
Improvement of hydraulic condition in the channel	+ + +		Long-term	No
Reduction of flood	+ + +		Long-term	No

Legend:
- - - Very negative   - - Negative   - Less negative
+ Less positive   + + Positive   + + + Very Positive

The table above shows that the positive aspects of the project exceed the negative ones. Most of the negative impacts are temporary and short time while the positive impacts are long-term.

The major environmental impacts from dredging of An Kim Hai Channel and construction of Phuong Luu Lake are presented in more detail in Table 2.8.6.

The Without-Project alternative is to leave the project unimplemented (i.e., do-nothing alternative). In that case, the current environmental pollution will increase as follows:

- No changes or even increase of frequent floods along the upper parts of An Kim Hai Channel will create more and more human and infrastructure losses such as degradation of roads, houses, water supply system etc.
- Increase of solid waste and sedimentation in the channel will further obstruct the water flow, increase the current pollution in the channel, increase offensive odors and insects, and increase possibility of disperse water related diseases

8.5.2 Mitigation Measures for Drainage Project

(1) General Instructions

Environmental matters have to be integrated in all the design work and planning of the project. The designing has to be done by minimizing the adverse impacts on environment using as much as possible existing facilities and selecting the location of new facilities in areas where the disturbance to environment, people and existing structures is the smallest. Where possible, existing rights-of-way has to be used rather than create new ones.

Mitigation measures are given separately for design phase, construction phase and operation phase. The most important activity is to arrange land acquisition, resettlement and site-clearance during design and pre-construction phase. During construction phase special attention should be paid to minimize the adverse impacts from dredging, transportation and disposal of dredged material from An Kim Hai Channel. More detailed information is presented in Table 2.8.6.

(2) Mitigation Measures during Design Phase

1) Land Acquisition and Resettlement Sites

A detailed measurement survey has to be conducted and the exact number and type of houses and infrastructure to be relocated has to be identified. Land acquisition and resettlement has to be done according to the approved resettlement procedures described in Resettlement Action Plan (RAP) to be prepared during or before the detailed design phase of the project. The RAP should include a public relation program, and the affected residents should be informed about the potential need for resettlement in the earliest possible stage of the project. The Study Team strongly recommends that RAP should be undertaken as early as possible.

The preliminary estimation for the needed resettlement area is 5 – 8 ha depending on the type of houses to be constructed. In accordance with the SADCO’s plan, two resettlement sites are proposed, one along Highway No. 5 and one south of Phuong Luu Lake. The third possible option is development of resettlement area around the proposed Phuong Luu Lake. Yet another option is to develop area along the An Kim Hai Channel in the southeast, that is along the down stream reach of the channel. This area is not yet developed much. Location and size of resettlement areas has to be decided during the detailed design phase, and design the necessary infrastructure and other structures.

2) Channel Dredging Design

The channel dredging has to be designed so that the need of site clearance and resettlement is minimized, therefore the widest option was not selected. However, the width of the maintenance roads (margins) along the channel should be wide enough to allow efficient maintenance of the channel and to control encroachment.

In the selection of the dredging method, special attention has to be paid to constraints imposed by the wide range of channel cross-sections, the access limitations for conventional plant and machinery, the availability of suitable sites for sludge disposal, and the operational procedures required for Employer, to improve the situation.

The hydraulic capacity of the existing channel is not adequate, the channel will be widened to achieve an adequate flow transmission capacity. The channel banks will be lined with revetment and some new crossing bridges will be provided under the project as supporting components.

(3) Mitigation Measures during Construction Phase

1) General Instructions

The general instructions concerning working conditions, prevention of noise, odor, litter and dust during works, protection of water and sediment, health and safety, and public relations mentioned in the project documents have to be followed.

2) Dredging, Transportation and Disposal of Sludge

The drainage channel should be dredged during the dry season. The release of heavy metals, possible organic micro-pollutants and loose sediments to the downstream during dredging works has to be minimized by preventing water discharge into the channels.

Sludge disposal can be done in temporary disposal sites located on wasteland or agricultural land downstream of An Kim Hai Channel in section 5. According to the analyzing results there is no need of special treatment of sludge. To minimize odor, mixing with other material is recommended. Protection strips have to be designed around sludge disposal area to separate it from the surroundings.

(4) Mitigation Measures during Operation Phase

The environmental impacts will be minor during operation phase and no special mitigation measures are needed.

(5) Summary of Mitigation Measures for Drainage Project

Phase	Main mitigation measures	Responsible organization
Design	International and Vietnamese design criteria and standards to be used Maintenance roads designed so that need for resettlement is minimized Works designed to implemented during dry season	Design Consultant
Construction	Minimize dust, odor, litter, noise and traffic emissions by good operation management and site supervision Appropriate working methods have to be followed Sites have to be kept clean and safe during and after the work Safety and health regulations have to be strictly followed Protective clothing and operational training for workers is essential Sludge disposal on a wasteland downstream of An Kim Hai Channel or other appropriate site should be arranged Transportation has to be minimized and routes selected to avoid public nuisance Transportation during rush hours and night has to be avoided Tight and proper equipment to transport sludge has to be used to avoid accidental spills and odor nuisances Construction sites and time have to be informed to the local people in advance	Contractor
O&M	Minimize dust, odor, litter, noise and traffic emissions by good operation management and site supervision Appropriate working methods have to be followed Sites have to be kept clean and safe during and after the work Safety and health regulations have to be strictly followed Protective clothing and operational training for workers is essential Sludge should be disposed of in an environmentally-sound manner at a designated disposal site Transportation has to be minimized and routes should be selected to avoid public nuisance	PIO

8.5.3 Evaluation of the Impacts with the Counter-Measures

Impacts of the project will be monitored in every phase according to the monitoring program (see Supporting Report).

Implementation of smooth land acquisition and resettlement will need good co-operation between local authorities and project affected people. However, the Vietnamese resettlement procedures give good basis to minimize the problems.

Environmental impacts caused by dredging, transportation and disposal of dredged sludge can be minimized to the acceptable levels with good site management and using proper equipment and working methods.

8.6 Organizational Setup and Capability of the Implementing and Managing Bodies

8.6.1 Recommended Organizational Setup

In the Study, the following implementation setup is recommended for the efficient implementation of the Drainage Priority Project.

(1) One Project Management Unit (PMU) should be set up which will be responsible for the 2 priority projects of Sewerage Priority Project and Drainage Priority Project, considering:

- Same regulatory and supervising body, i.e., TUPWS and same managing and O&M body is responsible for both priority projects
- Facility and function of both are closely related and dependant on each other
- Timing of the implementation is expected to be about the same

The PMU will assume the prime responsibility of the project implementation including tendering, construction supervision and other related works. TUPWS will be responsible for giving necessary instruction to PMU for smooth implementation when deemed necessary. SADCO will extend assistance for daily works of PMU when deemed necessary.

Drainage Priority Project will involve a sizable amount of resettlement of people for the rehabilitation of An Kim Hai channel. Land Acquisition and resettlement will be carried out in accordance with Decree No.22/1998/ND-CP (1998) and other relevant regulations. A Resettlement Committee will be established in Haiphong PC. The committee will be chaired by a Vice Chairman of the Haiphong PC, and committee members will comprise representatives from Project Implementing Organization (PIO), district and/or phuong-level PCs, Land Administration Dept., Finance Dept., Dept. Construction, DPI, other relevant organizations as well as representatives from Project Affected People (PAP). Under the city-level Resettlement Committee, district/phuong-level Resettlement Committees will also be established. It is the district/phuong-level Resettlement Committees and PIO that work closely with PAPs, while city-level Resettlement Committee will serve as the guiding and decision-making body. In order to ensure smooth land acquisition/resettlement, a detailed Resettlement Action Plan (RAP) should be developed in the early stage of the Detailed Design.

After entering the O&M stage, SADCO will manage the project including all the O&M works.

8.6.2 Capability of the Implementing Body

Sizable scale projects has been implemented in the recent years in the field of sanitation improvement, i.e., water supply (1A) and drainage (1B). In the latter case, the same implementation setup was adopted, i.e., PMU, TUPWS and SADCO and the project is successfully being implemented. Before the start of the Priority Projects, a few more projects are expected to be implemented in the same manner.

Haiphong PC has already carried out the land acquisition/resettlement for HWY 5 Project, and is about to undertake the land acquisition/resettlement for Rehabilitation of NE and SW Channel (World Bank 1B Project), which is very similar to the proposed drainage project.

Assuming strenuous efforts to be made together with the experience to be accumulated, it is expected that HPPC will develop adequate capability to carry out the land acquisition and resettlement by the time of implementation.

Considering the above, it is considered that the Drainage Priority Project can successfully be implemented by the recommended implementation setup.

8.6.3 Capability of the Managing Body

To date, SADCO has experience in managing the drainage system of combined sewers. The Drainage Priority Project, however, is a more comprehensive project comprising various facility including combined sewers, An Kim Hai channel with dual functions of drainage and irrigation, regulating lake, gates and others. It is recommended in the Study that new sections should be created within SADCO for O&M of the drainage facility together with the increase of staffs and provision of adequate manpower training. Before the implementation of Drainage Priority Project, 1B project is scheduled to be implemented which mainly comprises cleaning and rehabilitation as well as new construction of combined sewers and some experience is expected to be obtained. In Hanoi and Ho Chi Minh city, large scale drainage projects are under implementation. These experience and knowledge will be valuable for the implementation of the Drainage Priority Project in Haiphong.

If all the recommended organizational reinforcement and manpower training as well as other efforts to strengthen their capability are realized, SADCO is considered to be capable of managing the Drainage Priority Project.

8.7 Overall Project Evaluation

The Drainage Priority Project will meet the primary objective of the sanitation and environment improvement for the project area as well as for the city by reducing the flood incidence in the central part of the city. Public health will be enhanced through the reduction of the water-borne diseases. Pollution load inflow into the water bodies will be decreased, resulting in the water quality improvement of the ambient waters.

From an economic point of view, the expected contribution of Drainage Priority Project to the economic growth in the future in terms of GRP growth and property value increase can justify the investment cost incurred to implement the project. The project cost is considered within the affordable range of the HPPC/Government in terms of the annual equivalent cost of the project assuming sinking fund with the condition of 5 % annual interest rate and 25 year repayment period. From a financial viewpoint, the assumed concessionary loan is repayable by HPPC/Government.

From a technical feasibility viewpoint, no difficulty is expected in the construction and manufacturing of the project facility. Assuming the recommended organizational strengthening including the setting up of new sections for drainage control as well as adequate training of the staff, operation and maintenance can effectively be carried out by SADCO.

Vigorous efforts of HPPC will be required to implement the resettlement project needed for the An Kim Hai rehabilitation project. Resettlement Action Program should be formulated to alleviate the negative social impact and secure the cooperation of the project affected people. Dredged sludge should be disposed of in an environmentally sound manner. Assuming these efforts, Drainage Priority Project is considered as socially acceptable.

In conclusion, Drainage Priority Project is evaluated to be feasible for implementation.

Table 2.2.1 Land Area (km2) and Developed Area Projections for An Kim Hai Channel Drainage Basin

No.	Administrative division	Area	Developed Area Ratio			Area Rati	Area	Developed Area		
		1999	2000	2010	2020		1999	2000	2010	2020
	Sub-Basin AKH-1									
5.07	Lam Son Ward	0.49	87%	87%	87%	21%	0.10	0.089	0.089	0.089
5.09	An Duong Ward	0.21	100%	100%	100%	41%	0.09	0.102	0.102	0.102
5.11	Tran Nguyen Han Ward	0.27	100%	100%	100%	48%	0.13	0.102	0.102	0.102
5.23	Niem Nghia Ward	1.12	93%	93%	93%	34%	0.38	0.095	0.095	0.095
	Sub-Basin AKH-2									
6.01	Du Hang Kenh Commune	2.69	54%	88%	88%	46%	1.23	0.055	0.089	0.089
6.03	Dong Hai Ward	0.36	93%	93%	93%	56%	0.20	0.095	0.095	0.095
3.19	Lach Tray Ward	2.32	76%	76%	76%	3%	0.08	0.078	0.078	0.078
5.21	Dong Hai Ward	0.36	93%	93%	93%	5%	0.02	0.095	0.095	0.095
3.25	Dong Quac Bing Ward	0.23	97%	97%	100%	33%	0.08	0.099	0.099	0.102
	Sub-Basin AKH-3									
3.19	Lach Tray Ward	0.15	100%	100%	100%	35%	0.1	0.102	0.102	0.102
3.25	Dong Quac Bing Ward	0.23	97%	97%	100%	59%	0.13	0.099	0.099	0.102
3.21	Dang Giang Ward	1.82	73%	85%	96%	26%	0.48	0.075	0.086	0.098
5.21	Dong Hai Ward	0.39	97%	98%	98%	46%	0.18	0.099	0.100	0.100
6.04	Dang Lam Commune	4.62	65%	79%	87%	6%	0.28	0.066	0.081	0.089
6.05	Dang Hai Commune	2.98	21%	35%	50%	2%	0.07	0.020	0.036	0.051
	Sub-Basin AKH-4									
6.05	Dang Hai Commune	2.98	21%	35%	50%	52%	1.54	0.020	0.036	0.051
6.03	Dong Hai Commune	9.52	51%	58%	65%	16%	1.56	0.051	0.059	0.066
	Sub-Basin AKH-5									
6.03	Dong Hai Commune	9.52	51%	58%	65%	1%	0.13	0.051	0.059	0.066
6.06	Nam Hai Commune	18.96	17%	25%	32%	9%	1.67	0.017	0.025	0.033

Table 2.2.2 Results from Computer Simulations (Flood Volume) and Calculated Flood Areas (ha)

		STORM WITH 2 YEAR ARI			STORM WITH 5 YEAR ARI			STORM WITH 10 YEAR ARI		
Drainage Sub-Zone	**Model Node**	**Node Area (ha)**	**Flood Volume (m3)**	**Flood Area (ha)**	**Node Area (ha)**	**Flood Volume (m3)**	**Flood Area (ha)**	**Node Area (ha)**	**Flood Volume (m3)**	**Flood Area (ha)**
AKH-1	AH1	15	7 382	3.0	15	14 073	4.0	15	18 861	5.4
	AH2	20	9 624	3.8	20	18 347	5.2	20	24 589	7.0
	AH3	20	9 406	3.8	20	17 937	5.1	20	24 033	6.9
	AH4	15	6 892	2.8	15	13 135	3.8	15	17 604	5.0
	AHDH	0	0	0.0	0	0	0.0	0	0	0.0
	AH5	0	0	0.0	0	0	0.0	0	0	0.0
Sub-Total		**70**	**33 302**	**13.4**	**70**	**63 485**	**18.1**	**70**	**85 084**	**24.3**
AKH-2	AH6	10	2 312	0.9	10	4 991	1.4	10	7 636	2.2
	AH7	30	6 752	2.7	30	14 571	4.2	30	22 296	6.4
	AH8	30	6 562	2.6	30	14 165	4.0	30	21 671	6.2
	AH9	15	3 182	1.3	15	6 883	2.0	15	10 526	3.0
	AH10	30	6 187	2.5	30	13 356	3.8	30	20 432	5.8
	AH11	30	6 003	2.4	30	12 951	3.7	30	19 813	5.7
	AH12	15	2 906	1.2	15	6 273	1.8	15	9 597	2.7
Sub-Total		**160**	**33 904**	**13.6**	**160**	**73 186**	**20.9**	**160**	**111 965**	**32.0**
AKH-3	AH12	15	1 969	0.8	15	6 696	1.9	15	11 069	3.2
	AH13	30	3 797	1.5	30	12 914	3.7	30	21 347	6.1
	AH14	30	3 656	1.5	30	12 436	3.6	30	20 557	5.9
	AH15	30	3 515	1.4	30	11 957	3.4	30	19 766	5.6
	AHPL	15	1 688	0.7	15	5 749	1.6	15	9 488	2.7
Sub-Total		**120**	**14 625**	**5.9**	**120**	**49 743**	**14.2**	**120**	**82 227**	**23.5**

Table 2.3.1 Land Area (km2) and Developed Area Projections for Northeast and Southwest Drainage Basins

No.	Administrative division	Area	Developed Area Ratio			Area Rati	Area	Developed Area		
		1999	2000	2010	2020		1999	2000	2010	2020
	Ngo Quyen District									
3.01	May To Ward	1.48	74%	74%	74%	17%	0.26	0.188	0.188	0.188
3.03	May Chai Ward	2.32	76%	76%	76%	19%	0.45	0.339	0.339	0.339
3.05	Van My Ward	1.08	88%	90%	90%	100%	1.08	0.951	0.975	0.975
3.07	Lac Vien Ward	0.38	96%	96%	96%	100%	0.38	0.365	0.365	0.366
3.09	Cau Tre Ward	0.45	100%	100%	100%	100%	0.45	0.450	0.450	0.450
3.13	Gia Vien Ward	0.25	100%	100%	100%	100%	0.25	0.251	0.251	0.251
3.15	Cau Dat Ward	0.15	100%	100%	100%	14%	0.02	0.022	0.022	0.022
3.17	Le Loi Ward	0.23	87%	87%	87%	100%	0.23	0.200	0.200	0.200
3.19	Lach Tray Ward	0.67	95%	95%	95%	62%	0.41	0.395	0.395	0.395
3.21	Dang Giang Ward	1.82	73%	85%	96%	25%	0.45	0.329	0.381	0.432
3.23	Dong Khe Ward	1.76	54%	78%	94%	100%	1.76	0.948	1.374	1.650
	Le Chan District									
5.07	Lam Son Ward	0.49	87%	87%	87%	0%	0.00	0.000	0.000	0.000
5.09	An Duong Ward	0.21	100%	100%	100%	0%	0.00	0.000	0.000	0.000
5.11	Tran Nguyen Han Ward	0.27	100%	100%	100%	52%	0.14	0.140	0.140	0.140
5.13	Ho Nam Ward	0.36	93%	93%	93%	100%	0.36	0.335	0.335	0.335
5.15	Trai Cau Ward	0.30	97%	97%	97%	100%	0.30	0.292	0.292	0.292
5.17	Du Hang Ward	0.27	100%	100%	100%	100%	0.27	0.270	0.270	0.270
5.19	Hang Kenh Ward	0.37	100%	100%	100%	100%	0.37	0.370	0.370	0.370
5.21	Dong Hai Ward	0.39	97%	98%	98%	54%	0.21	0.205	0.207	0.207
5.23	Niem Nghia Ward	1.12	93%	93%	93%	0%	0.00	0.000	0.000	0.000
	An Hai Rural District									
6.01	Du Hang Kenh Com.	2.69	54%	88%	88%	29%	0.77	0.417	0.680	0.680
6.02	Vinh Niem Com.	5.63	21%	45%	69%	33%	1.84	0.388	0.827	1.266

Table 2.8.1 Property Values: Drainage Project

Year	Total Value (Land plus Bldgs, Property) ($mill) (1)	Annual equiv of (1) (No Growth) ($mill) (2)	Annual Value (Avge. Growth)* ($mill) (3)	Present Value (PV) of (3) (2003 base Yr) ($mill) (4)	Annual Project Costs ($1,000) (5)	PV of Project Costs 2003 base Yr ($mill) (6)	Cost as % of Property Value (No Growth) (7)	Cost as % of Property Value (Avge. Growth) (8)
2001	884.1	104	104					
2		104	112					
3		104	121	1,864.3	2,734	32.9	**3.7**	**1.8**
4		104	129		6,408			
5		104	138		7,156			
6		104	156		7,722			
7		104	174		8,296			
8		104	193		10,299			
9		104	211		6,502			
10		104	229		21			
11		104	243		23			
12		104	257		25			
13		104	270		26			
14		104	284		30			
15		104	298		33			
16		104	311		38			
17		104	325		43			
18		104	338		49			
19		104	352		54			
20		104	365		59			
21		104	365		64			
22		104	365		69			
23		104	365		74			

Table 2.8.2 Urban Productivity: Drainage Project

Year	Value-Added (No Growth) ($mill) (1)	Present Value (PV) Of (1) 2003 Base yr* ($mill) (2)	Total Value-Added (Avge. Growth after 2001) ($mill) (3)	PV of (3) 2003 base yr ($mill) (4)	PV of Project Costs 2003 base yr ($mill) (5)	Proj cost as % of Value Added (No Growth) (6)	Proj cost as % of Value (Avge. Growth after 2001) (7)
2001	177		177				
2	177		191				
3	177	1,346	206	3,132.8	32.9	**2.45**	**1.05**
4	177		220				
5	177		235				
6	177		266				
7	177		297				
8	177		328				
9	177		359				
10	177		390				
11	177		414				
12	177		437				
13	177		461				
14	177		484				
15	177		507				
16	177		531				
17	177		554				
18	177		577				
19	177		600				
20	177		623				
21	177		654				
22	177		687				
23	177		721				

Table 2.8.3 Key Economic Indicators and Population, Study Area and Haiphong

$US '000, 2000 prices)

Year	GRP in Study Area	GRP in Haiphong	HPPC Expenditure	Disposable Income in Study Area	Study Area Population	Haiphong Population
2001	432,050	705,042	63,493	216,025	567,387	1,717,491
2002	467,528	755,728	68,057	233,764	573,785	1,737,503
2003	503,007	806,413	72,621	251,503	580,183	1,757,516
2004	538,485	857,099	77,186	269,243	586,581	1,777,529
2005	573,999	907,785	81,750	287,000	592,579	1,797,542
2006	651,992	1,009,928	90,957	325,996	599,245	1,819,898
2007	729,985	1,112,070	100,164	364,992	605,911	1,842,254
2008	807,978	1,214,213	109,371	403,989	612,576	1,864,610
2009	885,971	1,316,356	118,578	442,985	619,242	1,886,966
2010	963,928	1,418,570	127,786	481,964	625,908	1,909,322
2011	1,024,310	1,507,938	135,836	512,155	632,517	1,930,587
2012	1,084,692	1,597,306	143,886	542,346	639,126	1,951,853
2013	1,145,074	1,686,673	151,936	572,537	645,735	1,973,118
2014	1,205,456	1,776,041	159,986	602,728	652,344	1,994,384
2015	1,265,838	1,865,409	168,036	632,919	658,953	2,015,649
2016	1,326,220	1,954,777	176,086	663,110	665,556	2,036,658
2017	1,386,602	2,044,144	184,136	693,301	672,160	2,057,666
2018	1,446,984	2,133,512	192,186	723,492	678,763	2,078,675
2019	1,507,366	2,222,880	200,236	753,683	685,367	2,099,683
2020	1,567,713	2,312,212	208,286	783,856	691,970	2,120,692

Table 2.8.4 Drainage Program Costs in Relation to Key Indicators: Sensitivity to Key Assumptions

(20% increase in estimated costs, half the predicted economic growth rate)

values in 2000 prices

Year	Total Cost ($US'000)	Cost as % of GRP in Study Area (%)	Cost as % of GRP in Haiphong (%)	Cost as % of HPPC Exp. (%)	Cost as % of Disp. Inc. Study Area (%)	Per Capita Cost in Study Area ($)
2001	263	0.06	0.04	0.41	0.12	0.46
2002	1,525	0.34	0.21	2.31	0.68	2.66
2003	3,019	0.65	0.40	4.40	1.29	5.20
2004	4,937	1.02	0.63	6.95	2.04	8.42
2005	5,557	1.11	0.68	7.57	2.23	9.38
2006	6,227	1.17	0.72	7.95	2.34	10.39
2007	6,943	1.23	0.75	8.36	2.46	11.46
2008	7,836	1.32	0.81	8.96	2.63	12.79
2009	8,468	1.36	0.83	9.24	2.71	13.68
2010	8,648	1.33	0.81	9.03	2.66	13.82
2011	10,037	1.49	0.92	10.17	2.99	15.87
2012	11,438	1.65	1.01	11.25	3.31	17.90
2013	12,661	1.78	1.09	12.12	3.56	19.61
2014	13,876	1.90	1.17	12.94	3.80	21.27
2015	15,088	2.02	1.24	13.73	4.03	22.90
2016	16,300	2.13	1.30	14.48	4.26	24.49
2017	17,513	2.24	1.37	15.22	4.47	26.05
2018	18,724	2.34	1.43	15.92	4.68	27.58
2019	19,936	2.44	1.50	16.61	4.88	29.09
2020	21,148	2.54	1.56	17.27	5.08	30.56

Table 2.8.5. Drainage Priority Project: Loan Repayment Schedule and Costs as Percentage of HPPC's Expenditure

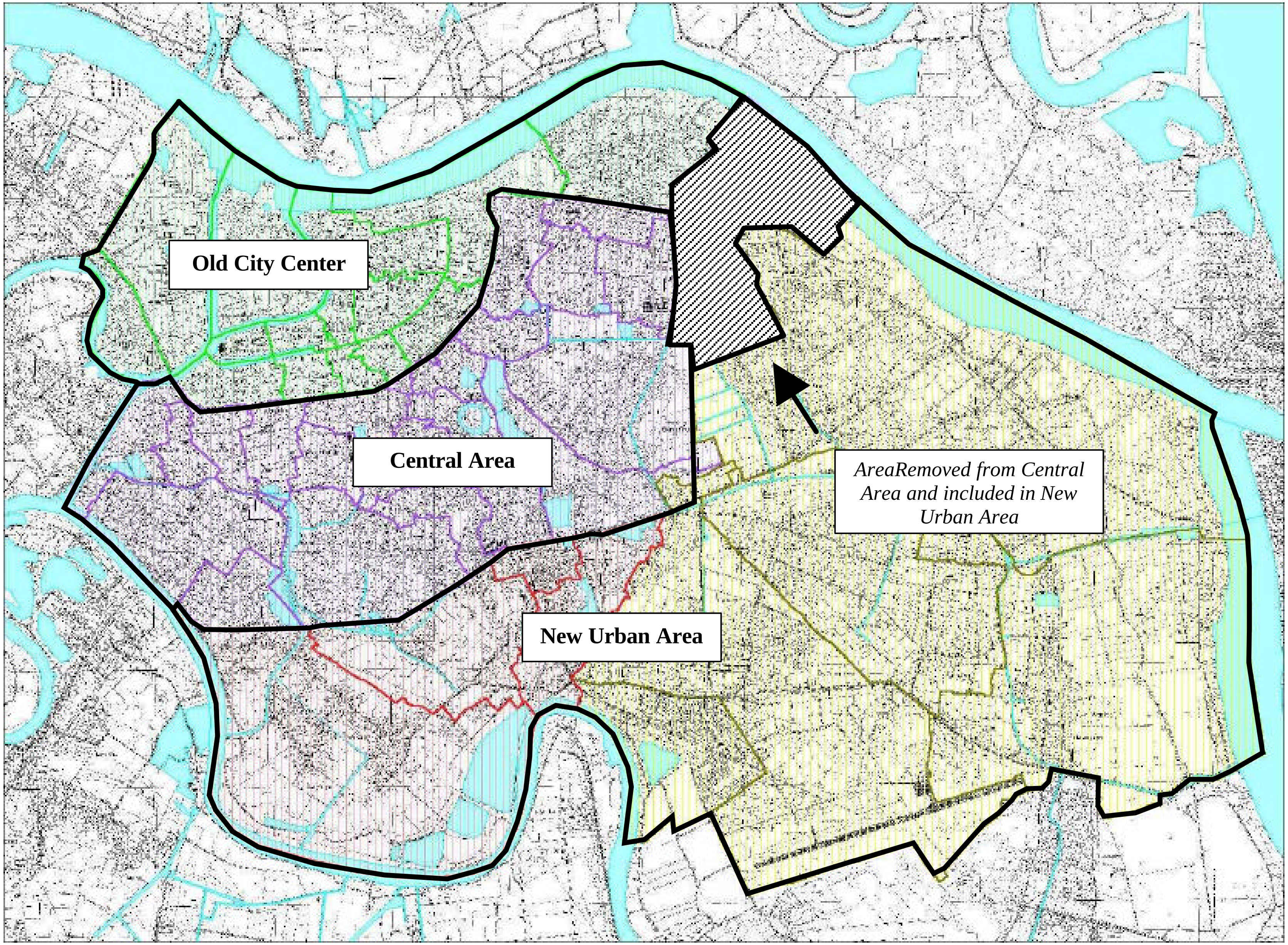
Unit: 1,000 dollar in current price

	Borrowing (85% of Total Investment)												
	Construction & Procurement (1.3%/year)	Engineering (0.75%/year)	Total	Repayment of Principal	Payment of Interest	Total Repayment	15% of Total Investment (Not Covered by Loan)	Recurring Cost	Total Project Cash Expenditure	HPPC's Expenditure	Raito of Repayment to HPPC Exp.	Ratio of Sum of the 15% & Recurring Cost to HPPC Exp.	Ratio of Total Project Expenditure to HPPC Exp.
a	b	c	d = b+c	e	f	g = e+f	h	I	j = g+h+I	k	l =g/k	m = (h+I)/k	n = j/k
2003	0	657	657	0	0	0	2,244	0	2,244	77,066	0.0%	2.9%	2.9%
2004	3,656	670	4,327	0	5	5	2,609	0	2,614	83,548	0.0%	3.1%	3.1%
2005	6,617	684	7,301	0	57	57	600	0	657	90,259	0.1%	0.7%	0.7%
2006	7,335	697	8,032	0	149	149	663	0	812	102,432	0.1%	0.6%	0.8%
2007	8,072	711	8,783	0	249	249	728	19	996	115,057	0.2%	0.6%	0.9%
2008	10,389	726	11,114	0	359	359	931	21	1,311	128,146	0.3%	0.7%	1.0%
2009	6,427	735	7,162	0	500	500	585	23	1,107	141,712	0.4%	0.4%	0.8%
2010	0	0	0	0	589	589	0	24	614	155,770	0.4%	0.0%	0.4%
2011	0	0	0	0	589	589	0	26	615	168,894	0.3%	0.0%	0.4%
2012	0	0	0	0	589	589	0	28	617	182,482	0.3%	0.0%	0.3%
2013	0	0	0	2,288	589	2,877	0	30	2,907	196,545	1.5%	0.0%	1.5%
2014	0	0	0	2,288	560	2,848	0	34	2,882	211,098	1.3%	0.0%	1.4%
2015	0	0	0	2,288	531	2,819	0	38	2,857	226,154	1.2%	0.0%	1.3%
2016	0	0	0	2,288	503	2,790	0	44	2,834	241,728	1.2%	0.0%	1.2%
2017	0	0	0	2,288	474	2,761	0	50	2,811	257,834	1.1%	0.0%	1.1%
2018	0	0	0	2,288	445	2,732	0	56	2,788	274,488	1.0%	0.0%	1.0%
2019	0	0	0	2,288	416	2,704	0	62	2,765	291,705	0.9%	0.0%	0.9%
2020	0	0	0	2,288	387	2,675	0	67	2,742	309,501	0.9%	0.0%	0.9%
2021	0	0	0	2,288	358	2,646	0	73	2,719	328,319	0.8%	0.0%	0.8%
2022	0	0	0	2,288	329	2,617	0	79	2,696	348,281	0.8%	0.0%	0.8%
2023	0	0	0	2,288	301	2,588	0	85	2,673	369,456	0.7%	0.0%	0.7%
2024	0	0	0	2,288	272	2,559	0	91	2,651	391,919	0.7%	0.0%	0.7%
2025	0	0	0	2,288	243	2,530	0	98	2,629	415,748	0.6%	0.0%	0.6%
2026	0	0	0	2,288	214	2,502	0	105	2,607	441,025	0.6%	0.0%	0.6%
2027	0	0	0	2,288	185	2,473	0	113	2,586	467,840	0.5%	0.0%	0.6%
2028	0	0	0	2,288	156	2,444	0	121	2,565	496,284	0.5%	0.0%	0.5%
2029	0	0	0	2,288	128	2,415	0	130	2,546	526,458	0.5%	0.0%	0.5%
2030	0	0	0	2,288	99	2,386	0	140	2,526	558,467	0.4%	0.0%	0.5%
2031	0	0	0	2,288	70	2,357	0	150	2,508	592,422	0.4%	0.0%	0.4%
2032	0	0	0	2,288	41	2,329	0	162	2,490	628,441	0.4%	0.0%	0.4%
2033	0	0	0	163	12	175	0	174	348	666,650	0.0%	0.0%	0.1%
2034	0	0	0	163	11	174	0	186	360	707,183	0.0%	0.0%	0.1%
2035	0	0	0	163	10	172	0	200	373	750,179	0.0%	0.0%	0.0%
2036	0	0	0	163	9	171	0	215	386	795,790	0.0%	0.0%	0.0%
2037	0	0	0	163	7	170	0	231	401	844,174	0.0%	0.0%	0.0%
2038	0	0	0	163	6	169	0	248	417	895,500	0.0%	0.0%	0.0%
2039	0	0	0	163	5	168	0	266	434	949,947	0.0%	0.0%	0.0%
2040	0	0	0	163	4	166	0	286	453	1,007,703	0.0%	0.0%	0.0%
2041	0	0	0	163	2	165	0	307	472	1,068,972	0.0%	0.0%	0.0%
2042	0	0	0	163	1	164	0	330	494	1,133,965	0.0%	0.0%	0.0%
Total	42,497	4,880	47,377	47,377	9,455	56,832	8,361	4,316	69,509	9,917,709	0.6%	0.1%	0.7%

Note: A 2% annual inflation in terms of dollar is assumed.

Table 2.8.6 Summary of the Major Impacts and Mitigation Measures for Drainage Project

Issue	Location	Major Impacts	Mitigation Measures	Net Effects	Monitoring
Pre-Construction					
Land acquisition and Compensation	An Kim Hai Channel	About 1300 households, 14 high voltage electric poles, 115 low voltage power pole, 70 tombs and other structures have to be relocated. Exact number will be clarified during Detailed Measurement Survey.	The resettlement action plan has to be done outlining principles and regulations for compensation and resettlement of the project affected people. Resettlement sites are proposed along highway No.5, in Phuong Luu area and downstream An Kim Hai channel.	Long-term effect on relocated households. Influence to the spiritual life of those who have tombs to be removed.	Detailed measurement survey, monitoring of resettlement and informing project affected people.
	Phuong Luu Lake	24 ha of agricultural land, 1,000 tombs	Appropriate compensation according to law Tombs are proposed to relocated in the same area.	Long-term impact	Monitoring of relocation and compensation
Construction					
Water and Soil Pollution	Along the channel	Water pollution, soil contamination, noise, offensive odor, traffic disruption	Contamination of surface and groundwater has to be prevented by managing wastewater from the construction site.	Short-term impact	Monitoring of water and sediment quality
Dredging Works	Along the channel	Noise, offensive odor, traffic disruption and other nuisance	Contractor should minimize construction-related nuisance. The local residents should be informed about the schedule and work plan.	Short-term impact	Nuisance level, complaints from residents
Disposal of dredged sludge	Along An Kim Hai Channel	Disposal of dredged materials and construction waste from demolished houses	Proper disposal and treatment has to be arranged on proposed temporary disposal sites on wasteland downstream An Kim Hai channel or Trang Cat landfill Excavated soil from Phuong Luu Lake area can be used as construction materials.	Long-term impact along channel if mitigation measures are not adopted	Monitoring of transportation, disposal and treatment



North
Not To Scale

PLANNING CRITERIA

PHASE I

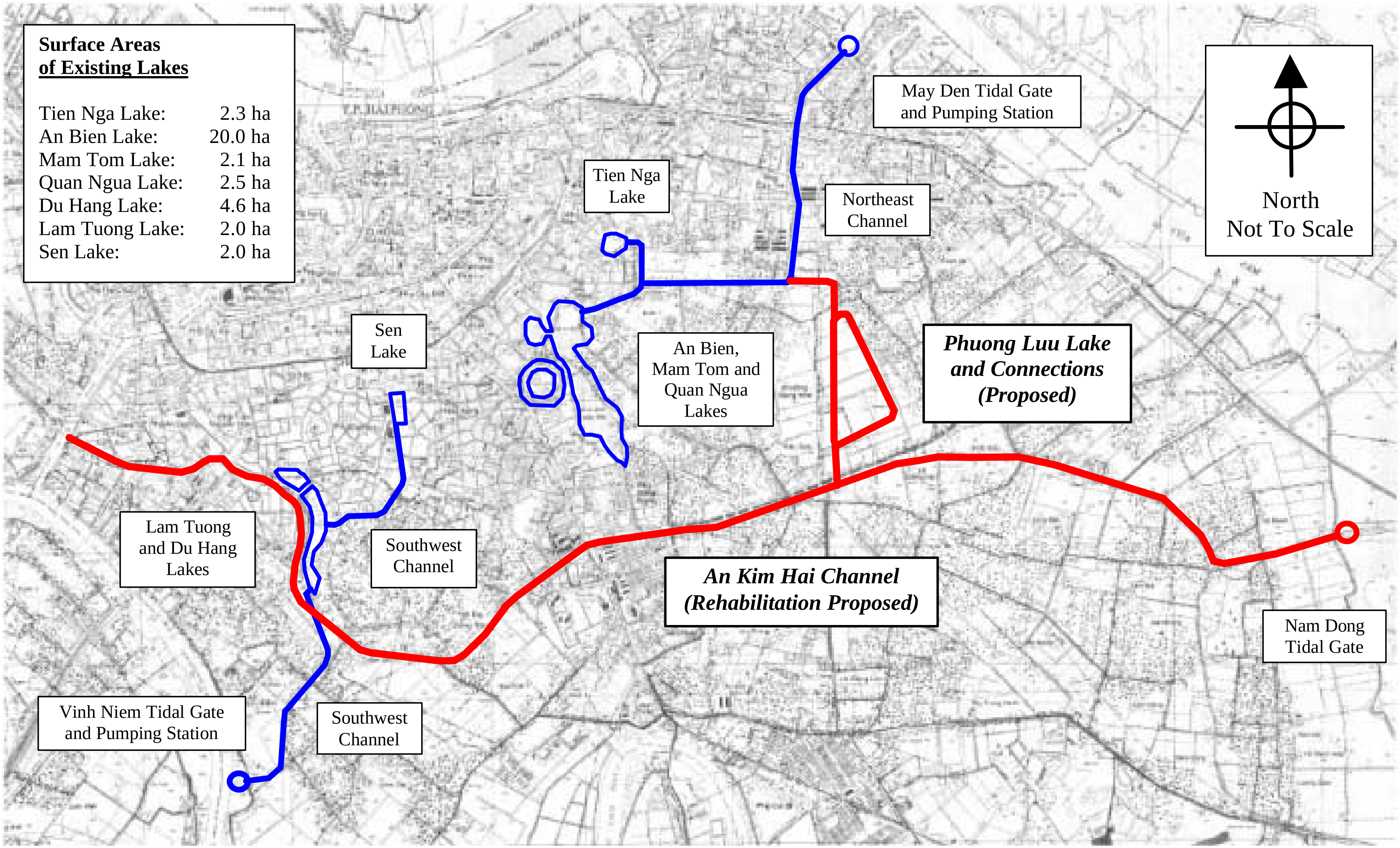
Central Area
Surface Area: 1,103 ha
Grade A: 5 Year ARI Storm
Grade B: 2 Year ARI Storm
10 Year ARI High Tide

PHASE II

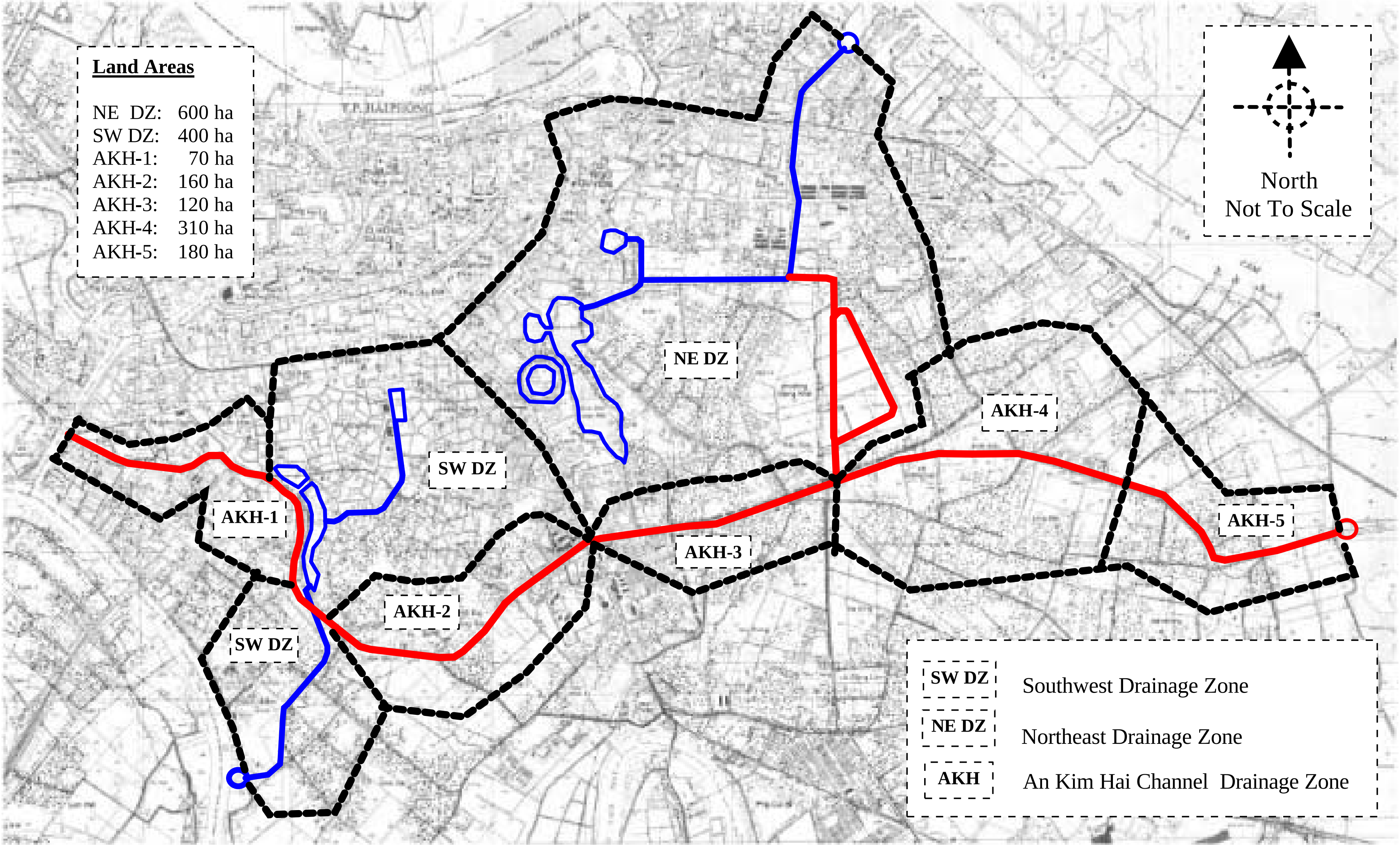
Old City Center
Surface Area: 856 ha
Grade A: 2 Year ARI Storm
Grade B: 2 Year ARI Storm
10 Year ARI High Tide

New Urban Area
Surface Area: 3,282 ha
Grade A: 5 Year ARI Storm
Grade B: 2 Year ARI Storm
10 Year ARI High Tide

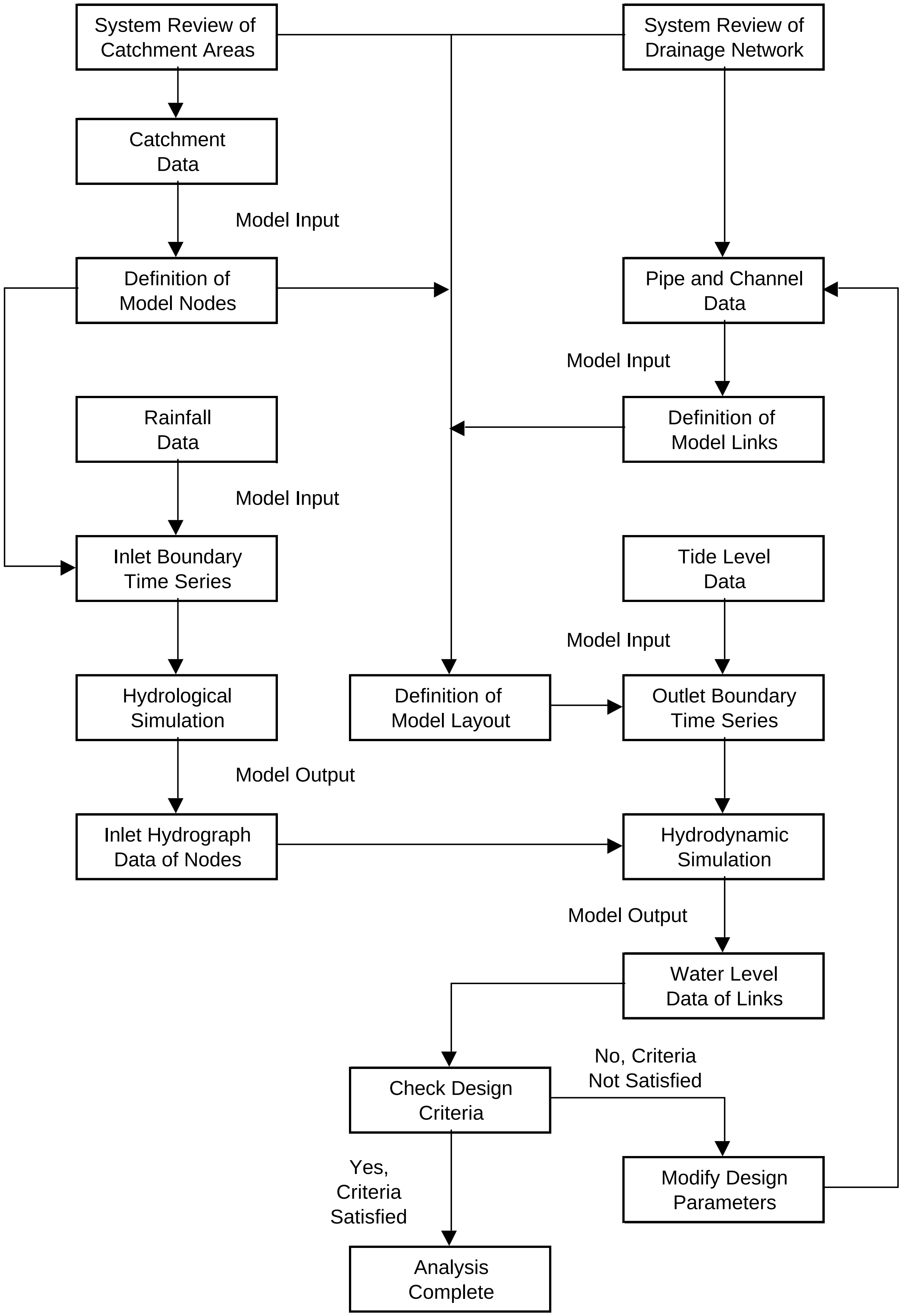
Figure 2.1.1 Modified Target Planning Areas in Class A Areas and Planning Criteria for Drainage Improvement Plan



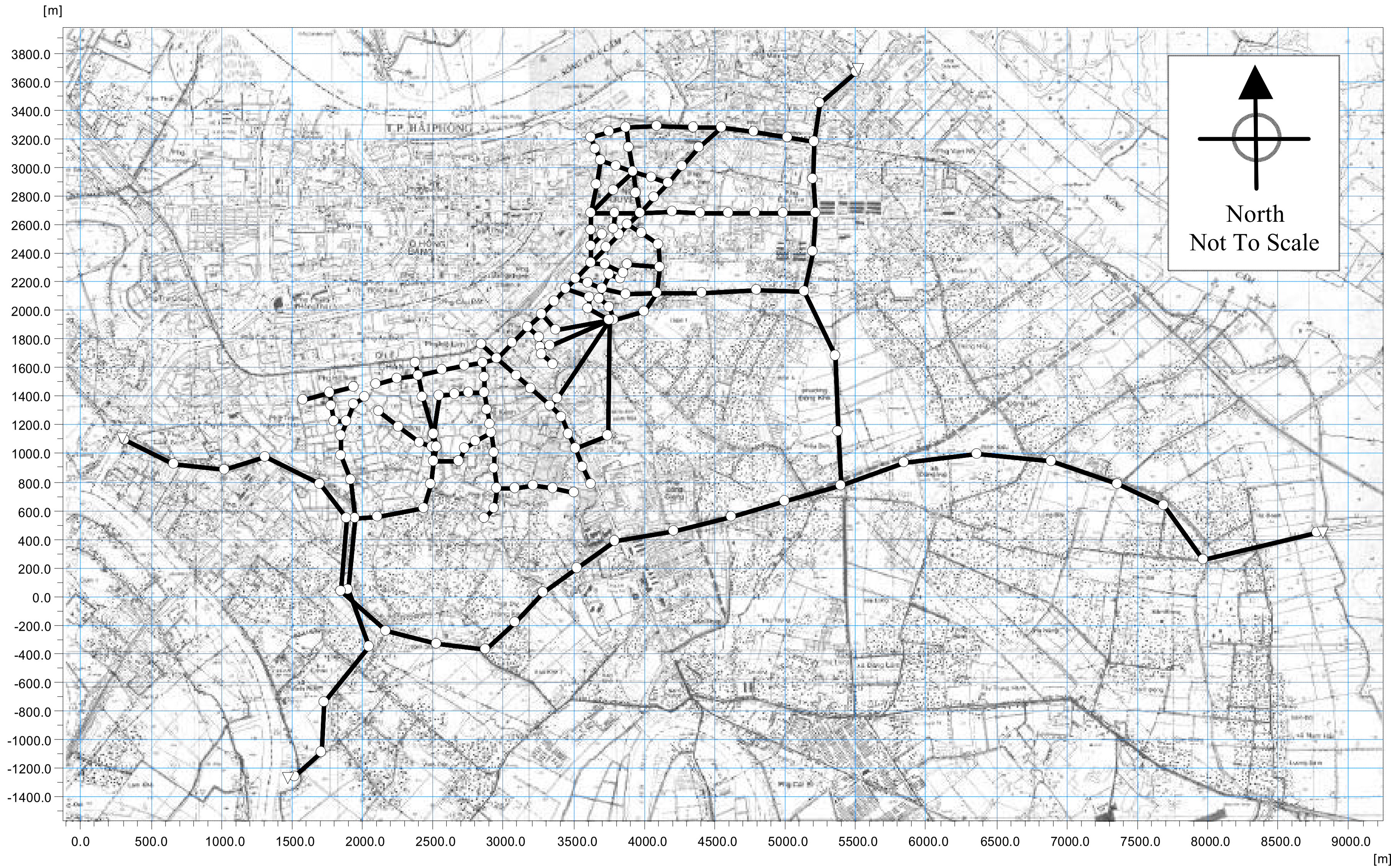
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.1 Given Conditions and Main Project Components of Drainage Priority Project
Japan International Cooperation Agency	



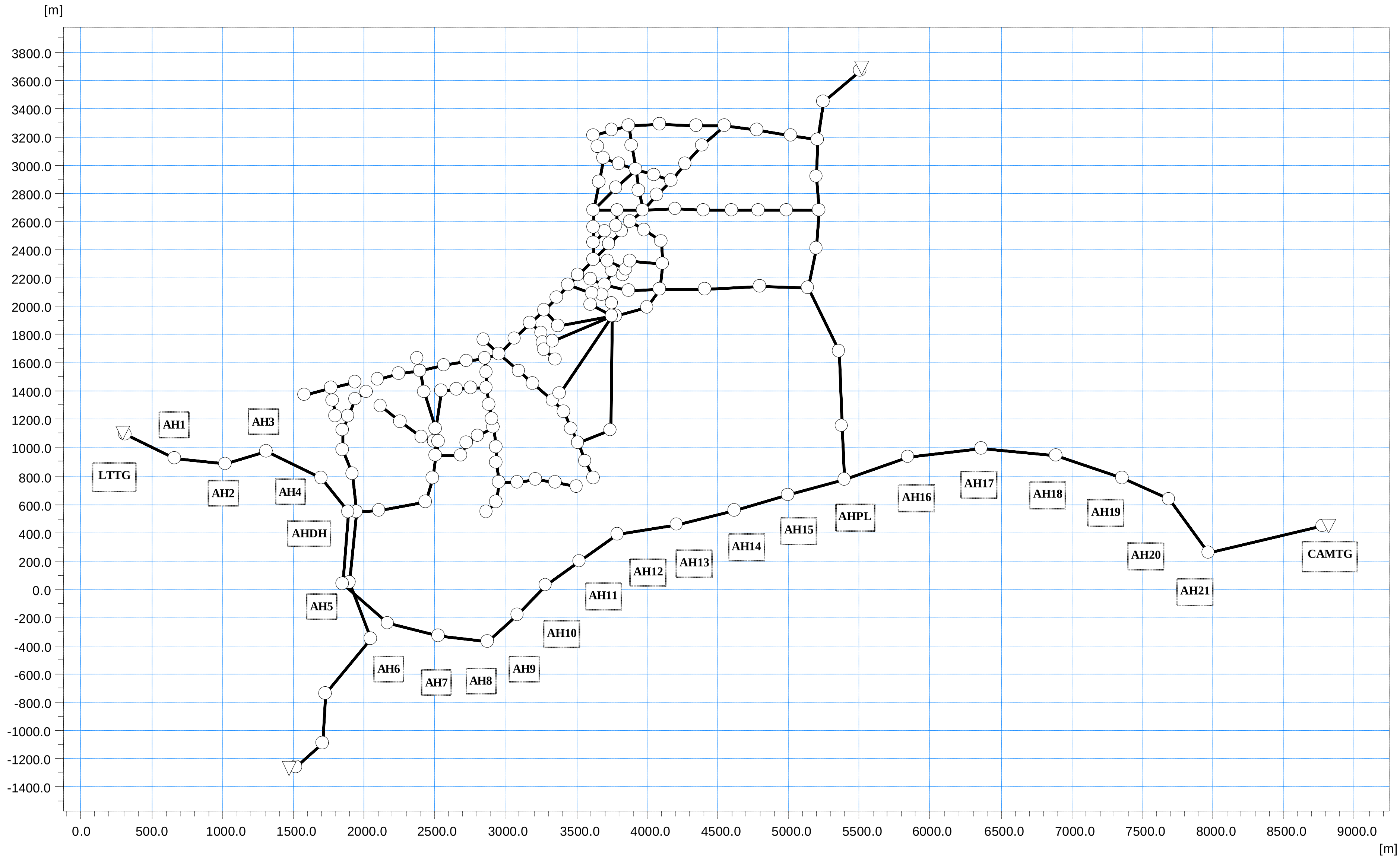
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.2 Drainage Zone Areas of Drainage Priority Project
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.3 Flowchart of Computer Model Development, Simulation and System Analysis
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.4 Computer Model Layout With Background Map
Japan International Cooperation Agency	

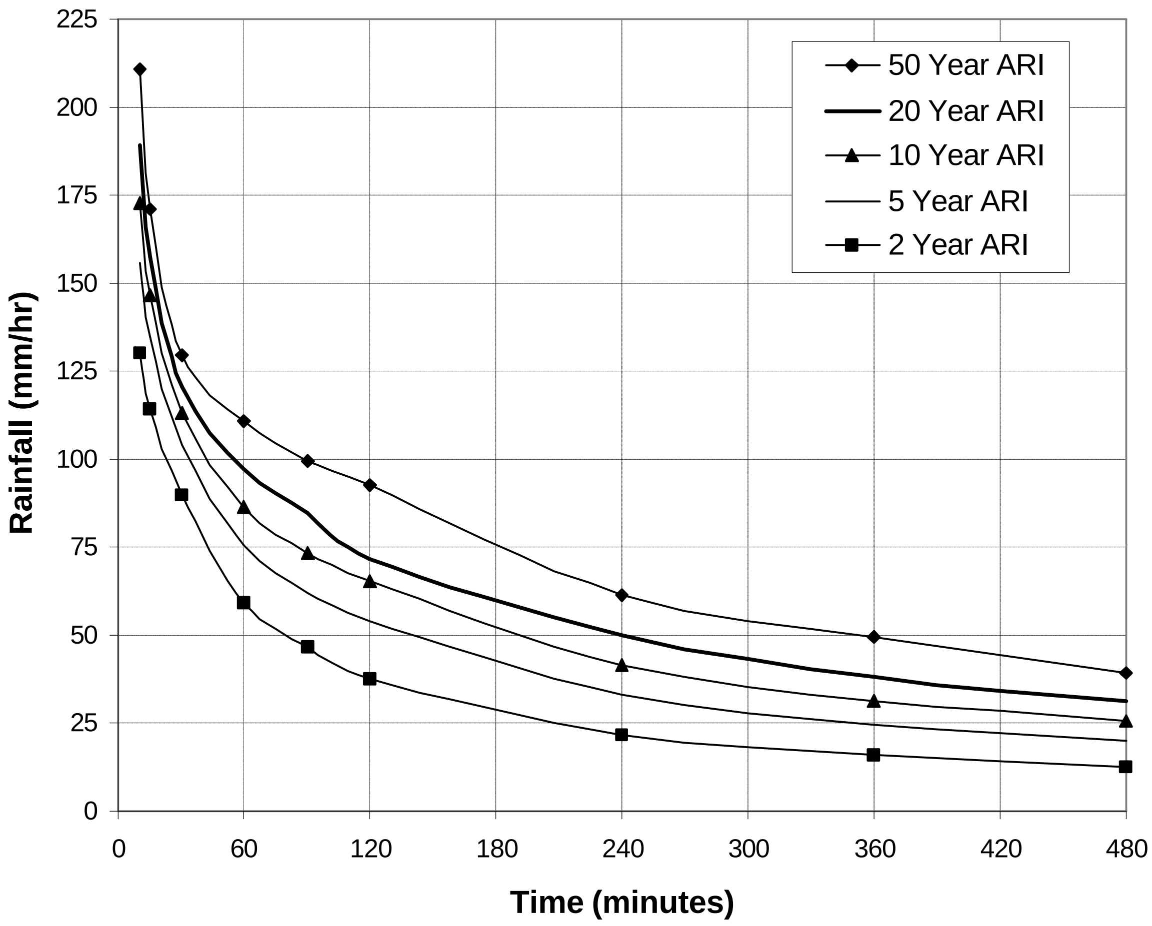


The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

Figure 2.2.5 Computer Model Layout With Node Labels

Time (minutes)	Rainfall Intensity (mm/hr)	
	5 Year ARI	10 Year ARI
10	155.4	172.8
15	134.8	146.8
30	104.2	112.8
60	75.4	86.5
90	62.1	73.5
120	53.8	65.6
240	32.7	41.3
360	24.6	31.2
480	19.9	25.6
720	14.6	18.9
1440	8.7	11.3

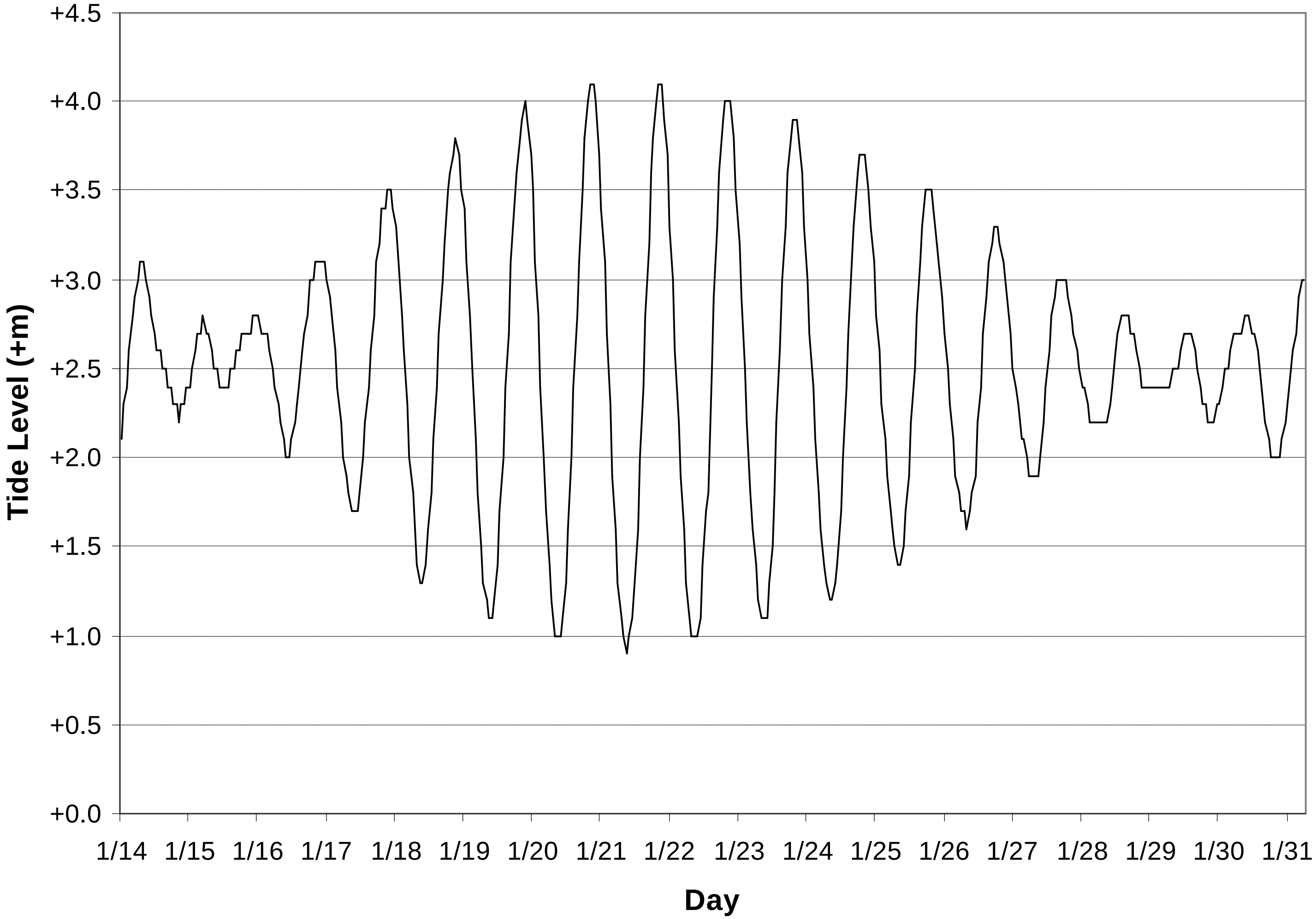


The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

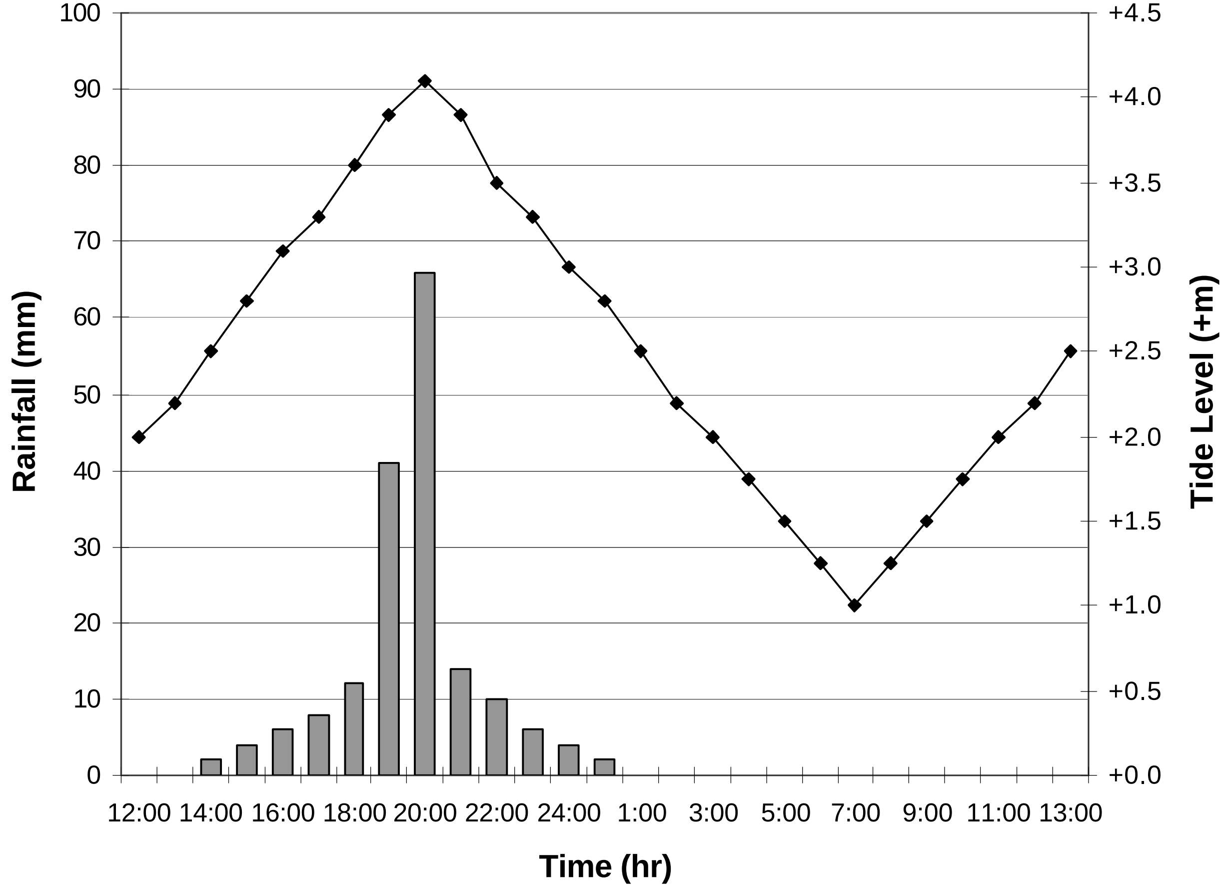
Figure 2.2.6 Rainfall Intensity, Duration and Frequency Data Used for Design of Drainage Priority Projects

Time (hr)	Tide Level (+m)
3:00	+1.0
4:00	+1.3
5:00	+1.5
6:00	+1.8
7:00	+2.0
8:00	+2.2
9:00	+2.5
10:00	+2.8
11:00	+3.1
12:00	+3.3
13:00	+3.6
14:00	+3.9
15:00	+4.1
16:00	+3.9
17:00	+3.5
18:00	+3.3
19:00	+3.0
20:00	+2.8
21:00	+2.5
22:00	+2.2
23:00	+2.0
24:00	+1.8
1:00	+1.5
2:00	+1.3
3:00	+1.0



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.7 Tide Level Data with Frequency of 10 Year ARI and High Tide Conditions
Japan International Cooperation Agency	

Time (hr)	Rainfall (mm)	Tide Level (+m)
12:00	0	+2.0
13:00	0	+2.2
14:00	2	+2.5
15:00	4	+2.8
16:00	6	+3.1
17:00	8	+3.3
18:00	12	+3.6
19:00	41	+3.9
20:00	66	+4.1
21:00	14	+3.9
22:00	10	+3.5
23:00	6	+3.3
24:00	4	+3.0
0:00	2	+2.8
1:00	0	+2.5
2:00	0	+2.2
3:00	0	+2.0
4:00	0	+1.8
5:00	0	+1.5
6:00	0	+1.3
7:00	0	+1.0
8:00	0	+1.3
9:00	0	+1.5
10:00	0	+1.8
11:00	0	+2.0
12:00	0	+2.2
13:00	0	+2.5

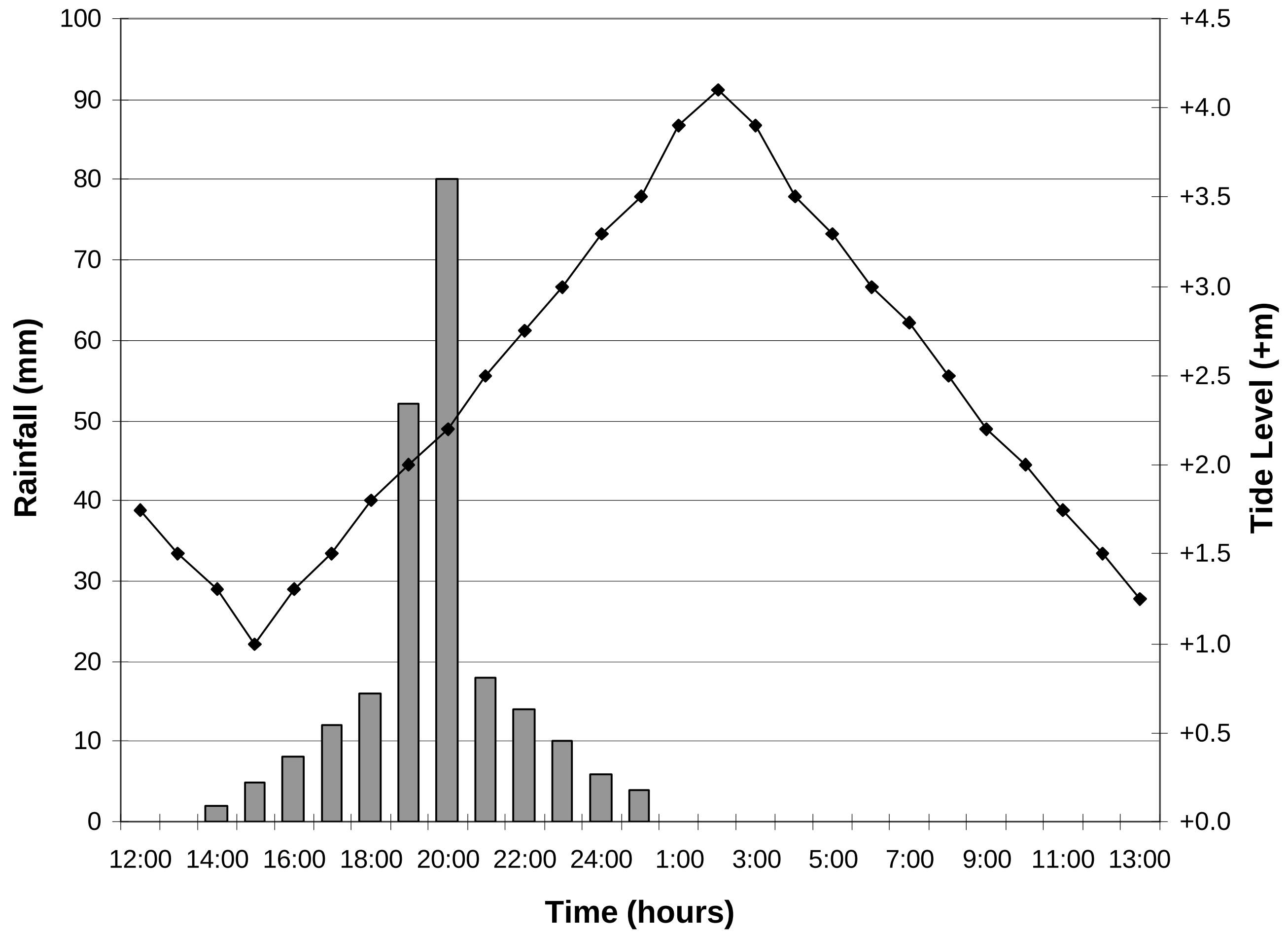


The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

Figure 2.2.8 Design Storm Hyetograph with Frequency of 5 Year ARI during High Tide Conditions

Time (hr)	Rainfall (mm)	Tide Level (+m)
12:00	0	+1.8
13:00	0	+1.5
14:00	2	+1.3
15:00	5	+1.0
16:00	8	+1.3
17:00	12	+1.5
18:00	16	+1.8
19:00	52	+2.0
20:00	80	+2.2
21:00	18	+2.5
22:00	14	+2.8
23:00	10	+3.0
24:00	6	+3.3
0:00	4	+3.5
1:00	0	+3.9
2:00	0	+4.1
3:00	0	+3.9
4:00	0	+3.5
5:00	0	+3.3
6:00	0	+3.0
7:00	0	+2.8
8:00	0	+2.5
9:00	0	+2.2
10:00	0	+2.0
11:00	0	+1.8
12:00	0	+1.5
13:00	0	+1.3



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.9 Design Storm Hyetograph with Frequency of 10 Year ARI during Rising Tide Conditions
Japan International Cooperation Agency	

Time (hr)	Rainfall (mm)	Tide Level (+m)
12:00	0	+3.9
13:00	0	+4.1
14:00	2	+3.9
15:00	5	+3.5
16:00	8	+3.3
17:00	12	+3.0
18:00	16	+2.8
19:00	52	+2.5
20:00	80	+2.2
21:00	18	+2.0
22:00	14	+1.8
23:00	10	+1.5
24:00	6	+1.3
0:00	4	+1.0
1:00	0	+1.3
2:00	0	+1.5
3:00	0	+1.8
4:00	0	+2.0
5:00	0	+2.2
6:00	0	+2.5
7:00	0	+2.8
8:00	0	+3.0
9:00	0	+3.3
10:00	0	+3.5
11:00	0	+3.9
12:00	0	+4.1
13:00	0	+3.9

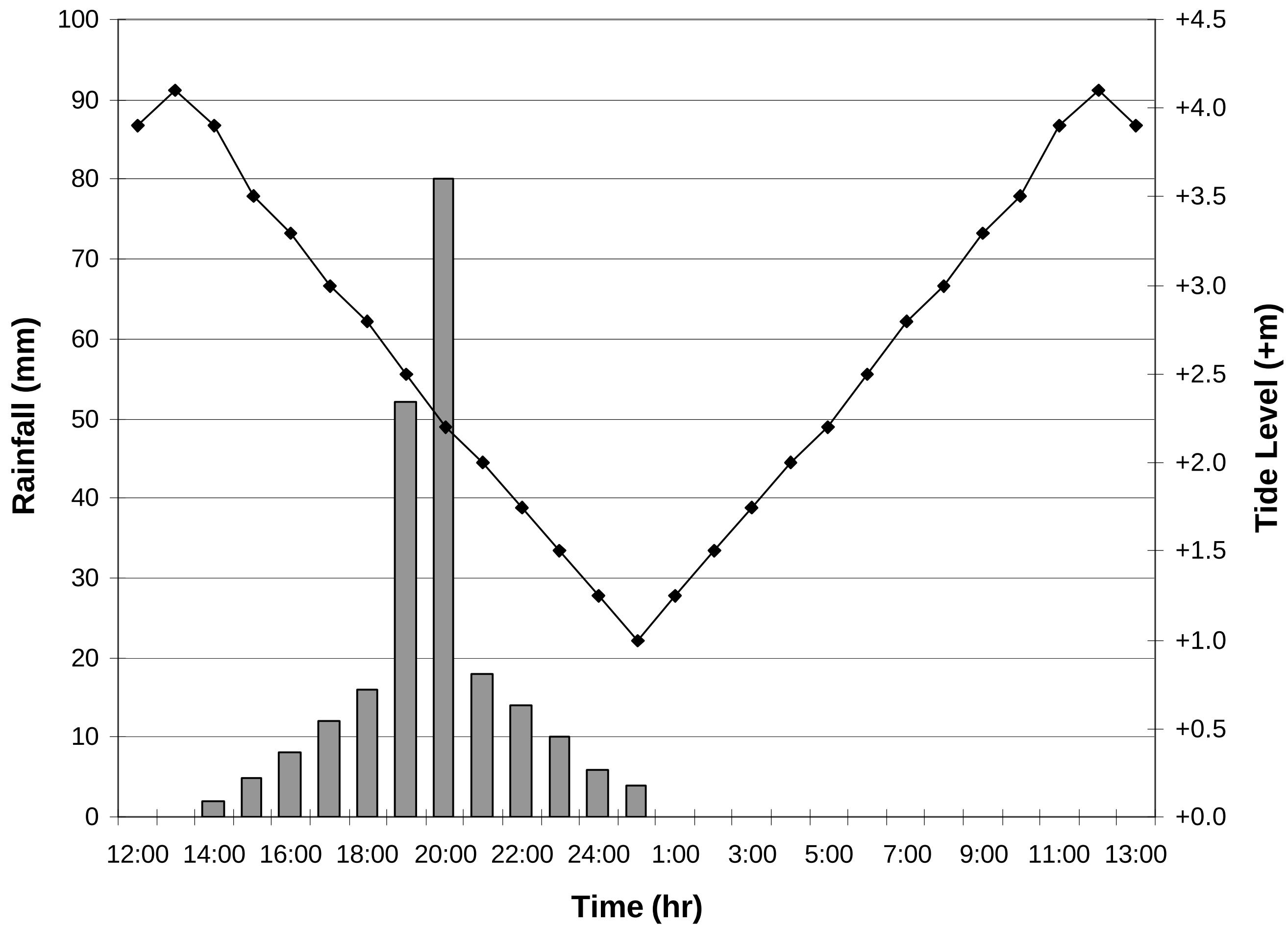
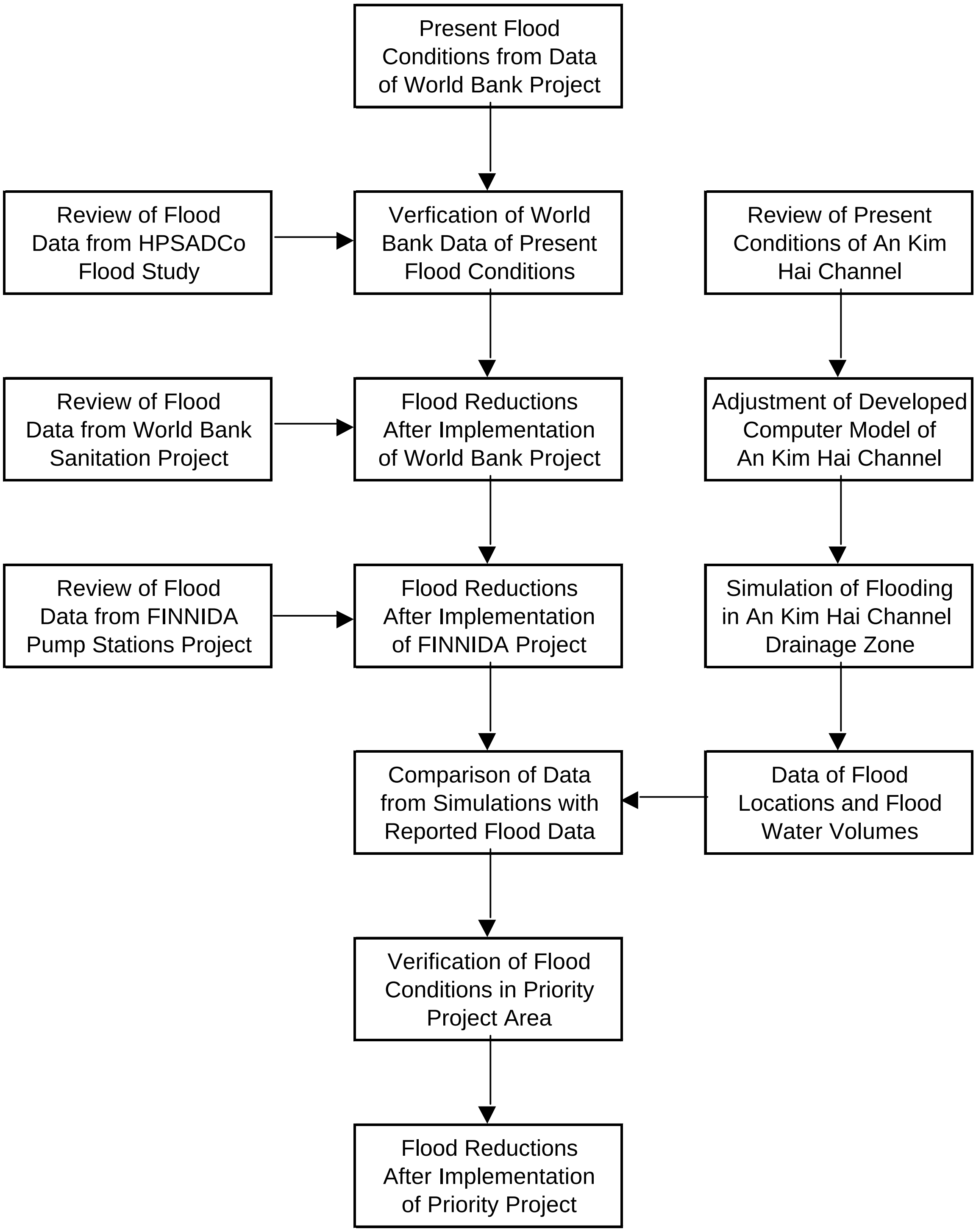
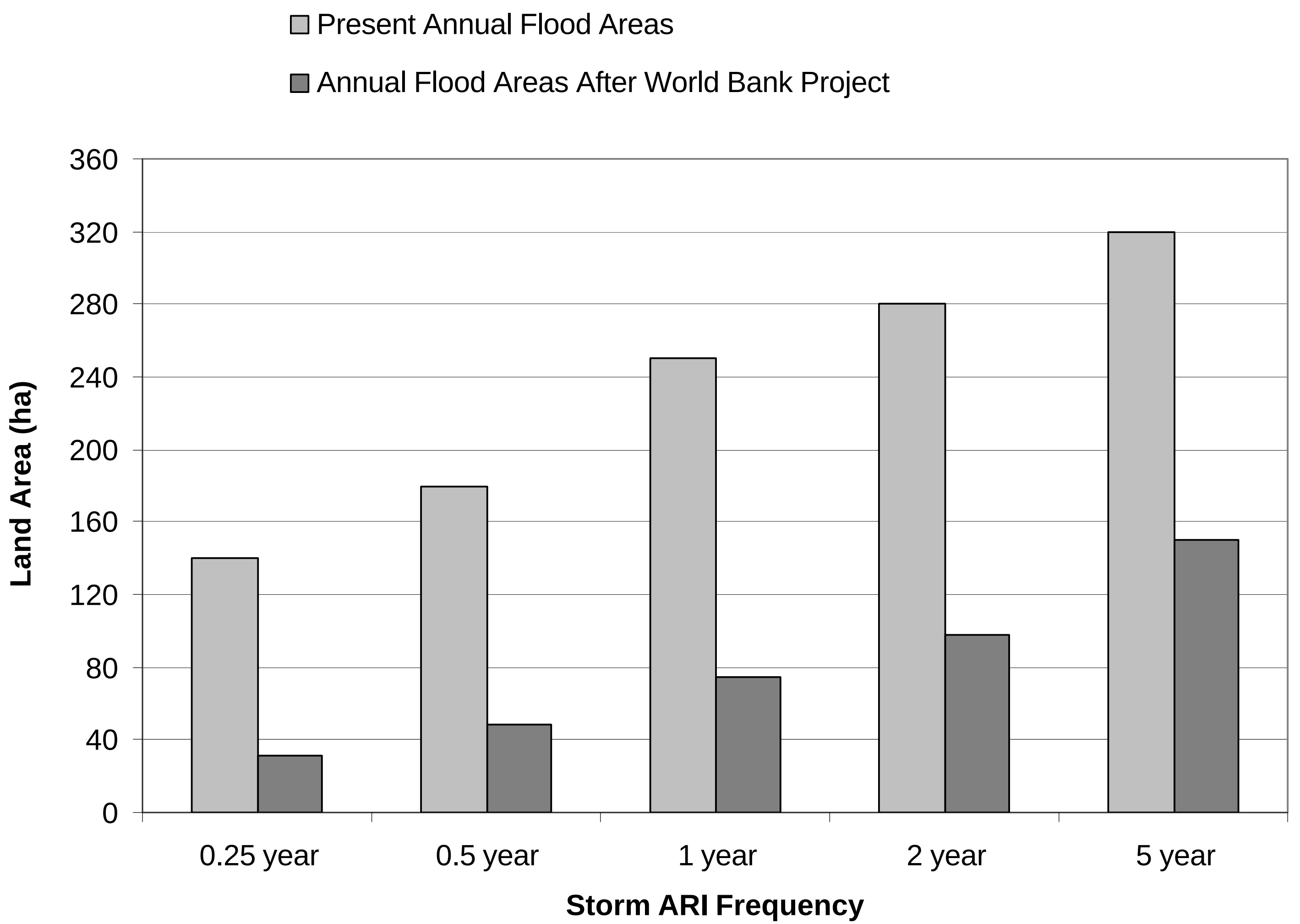


Figure 2.2.10 Design Storm Hyetograph with Frequency of 10 Year ARI during Falling Tide Conditions



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.11 Flowchart of Methodology for Assessing Flood Reductions
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.2.12 Assessed Flood Reductions in Class A Areas After World Bank Project
Japan International Cooperation Agency	

Actual Flood Areas In Central Area During High Tide

	With World Bank Project	
	Without FINNIDA Project	With FINNIDA Project
Frequency	Flood Areas (ha)	Flood Areas (ha)
0.25 Year ARI	12	0
0.5 Year ARI	33	0
1 Year ARI	56	4
2 Year ARI	88	15
5 Year ARI	128	34

Expected Annual Flood Areas in Central Area

	With World Bank Project	
	Without FINNIDA Project	With FINNIDA Project
Frequency	Flood Areas (ha)	Flood Areas (ha)
0.25 Year ARI	3	0
0.5 Year ARI	8	0
1 Year ARI	14	1
2 Year ARI	22	4
5 Year ARI	32	9

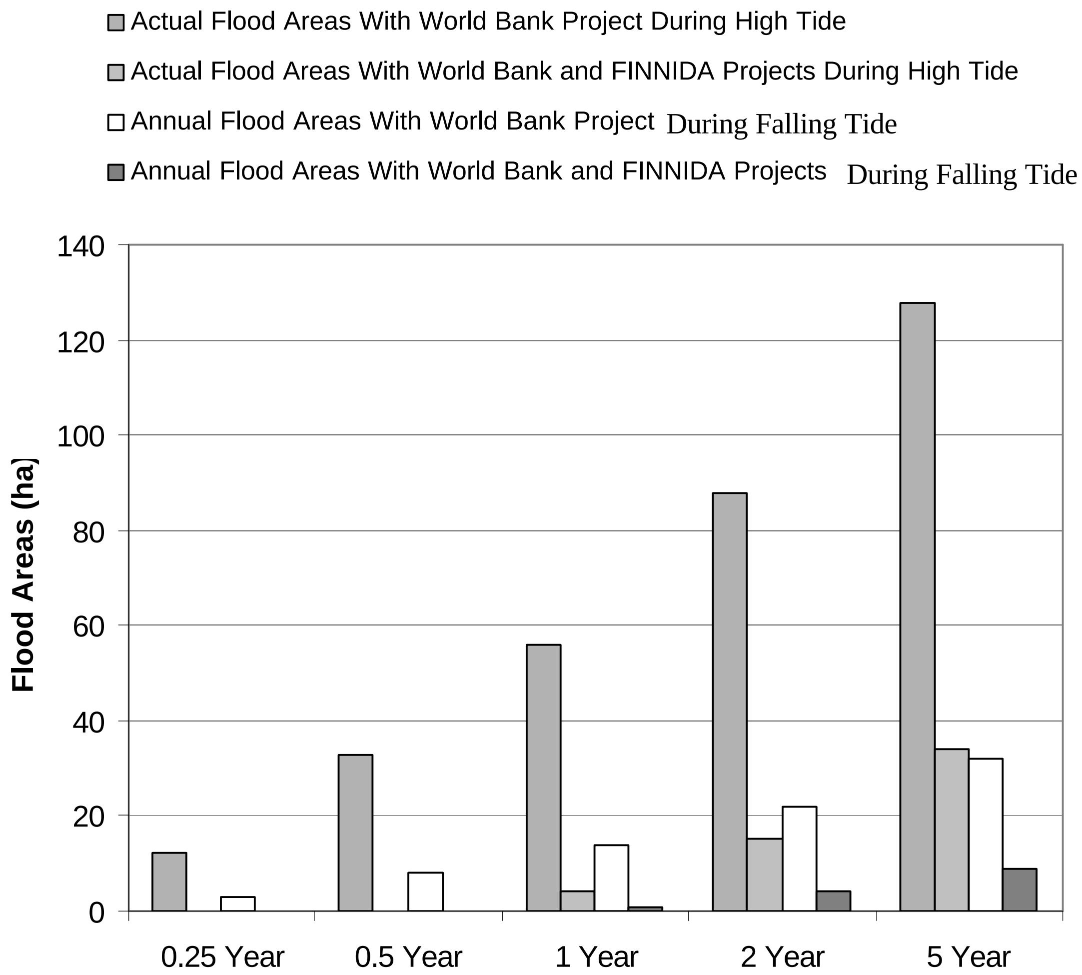
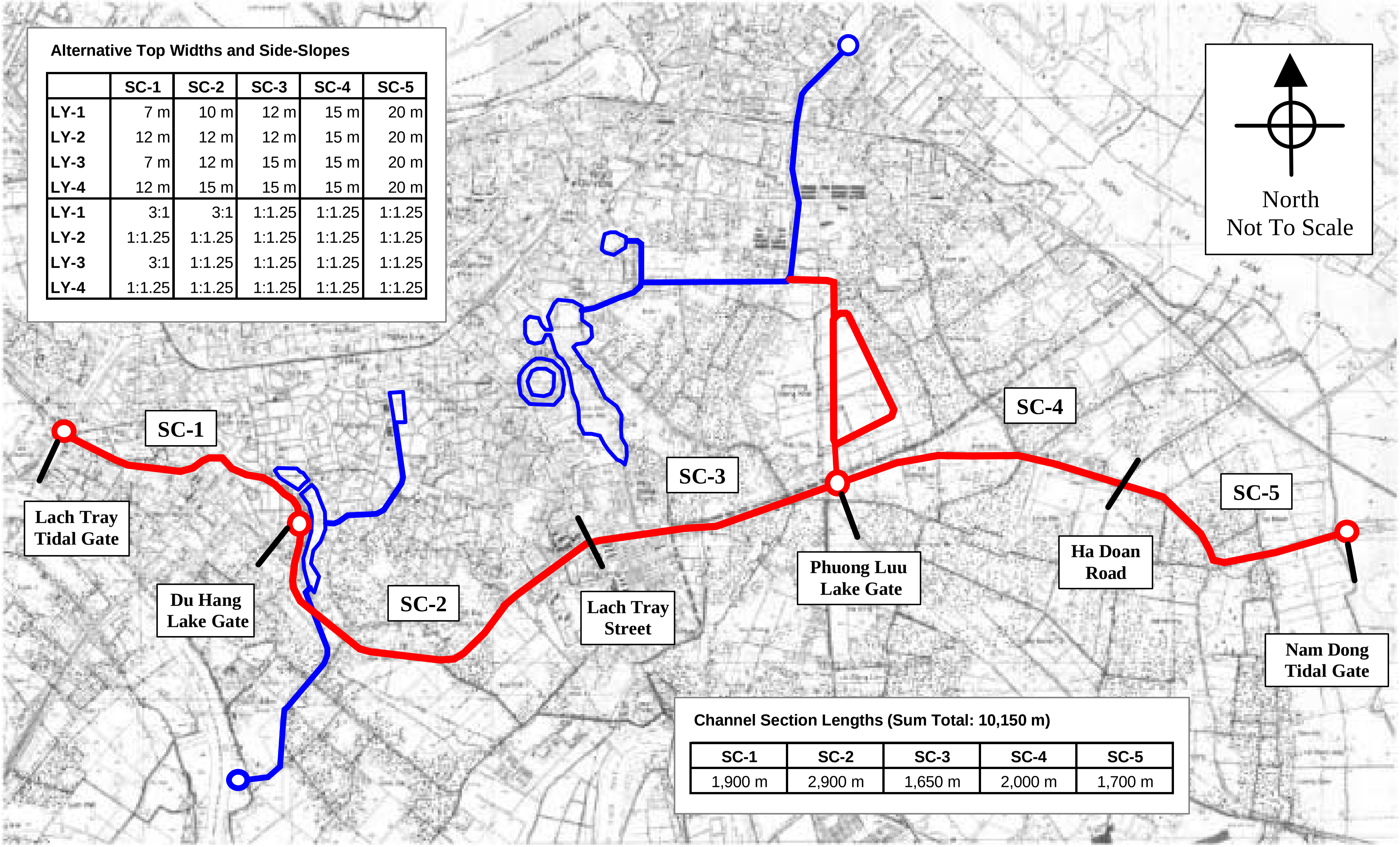


Figure 2.2.13 Assessed Flood Reductions of World Bank and FINNIDA Projects



Alternative Top Widths and Side-Slopes

	SC-1	SC-2	SC-3	SC-4	SC-5
LY-1	7 m	10 m	12 m	15 m	20 m
LY-2	12 m	12 m	12 m	15 m	20 m
LY-3	7 m	12 m	15 m	15 m	20 m
LY-4	12 m	15 m	15 m	15 m	20 m
LY-1	3:1	3:1	1:1.25	1:1.25	1:1.25
LY-2	1:1.25	1:1.25	1:1.25	1:1.25	1:1.25
LY-3	3:1	1:1.25	1:1.25	1:1.25	1:1.25
LY-4	1:1.25	1:1.25	1:1.25	1:1.25	1:1.25

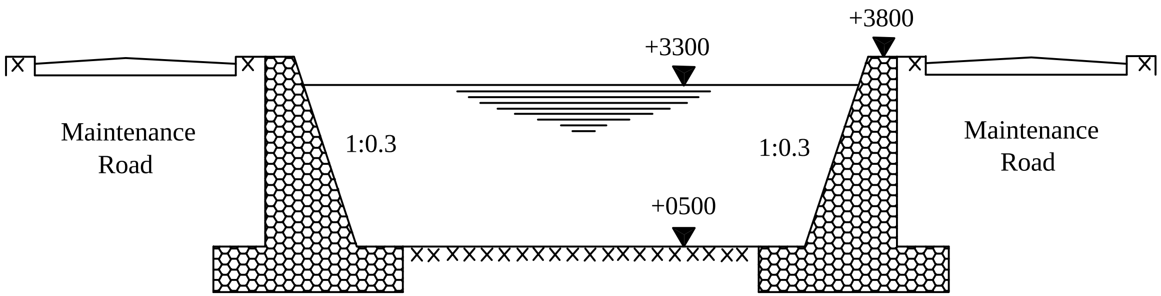
Channel Section Lengths (Sum Total: 10,150 m)

SC-1	SC-2	SC-3	SC-4	SC-5
1,900 m	2,900 m	1,650 m	2,000 m	1,700 m

The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

Figure 2.3.1 Alternative Channel Layouts (Top Widths and Side-Slopes)

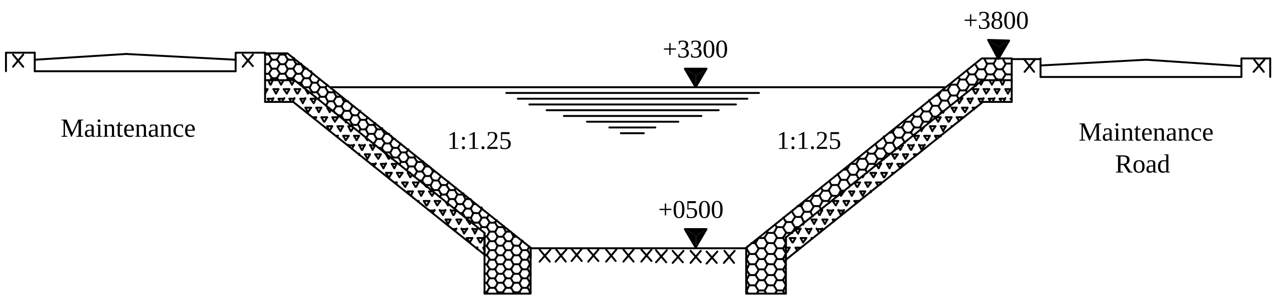


ALTERNATIVE LY-1

Channel Section SC-2

Rubble Masonry Retaining Wall

Side-Slope = 1:0.3



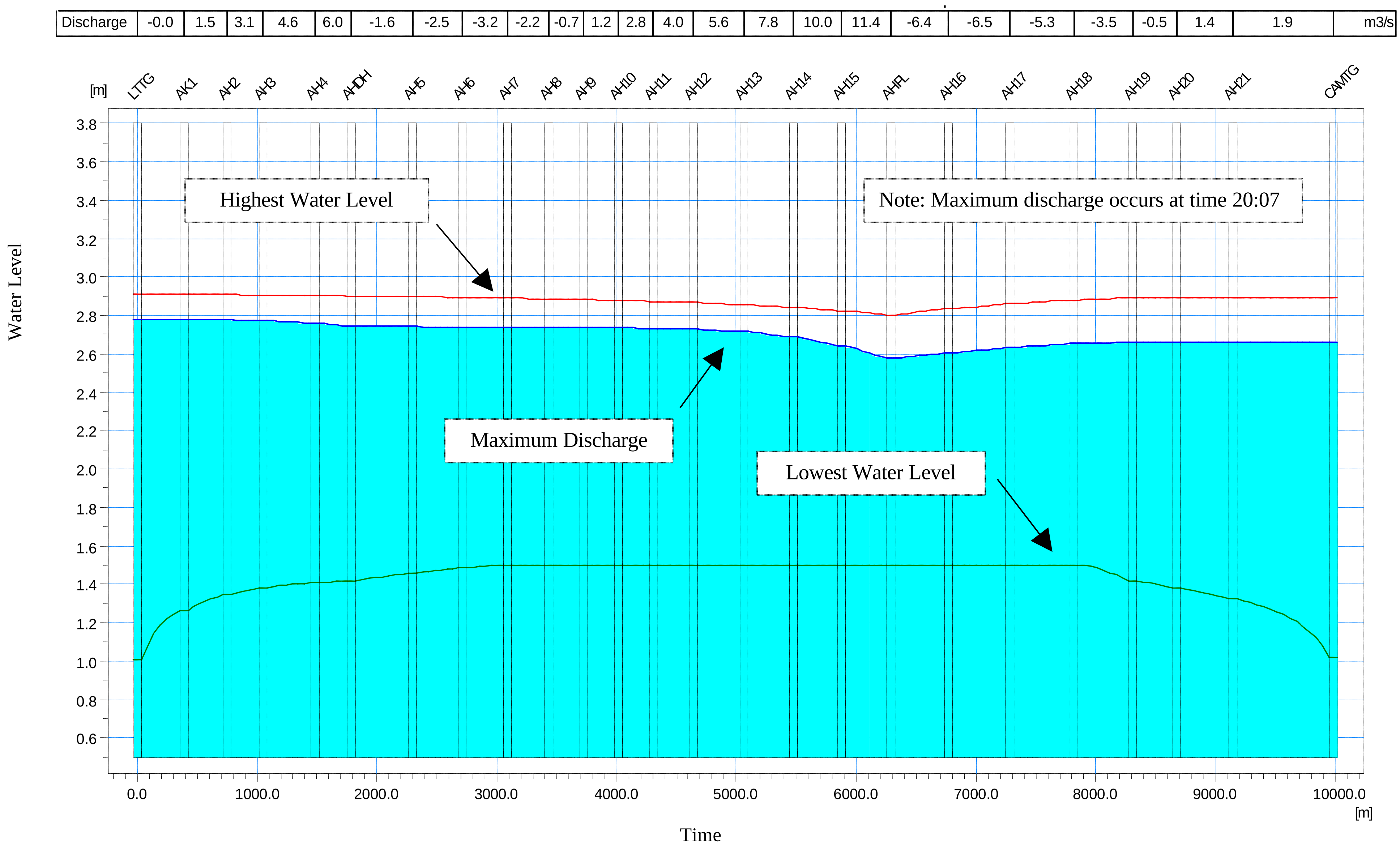
ALTERNATIVE LY-2

Channel Section SC-2

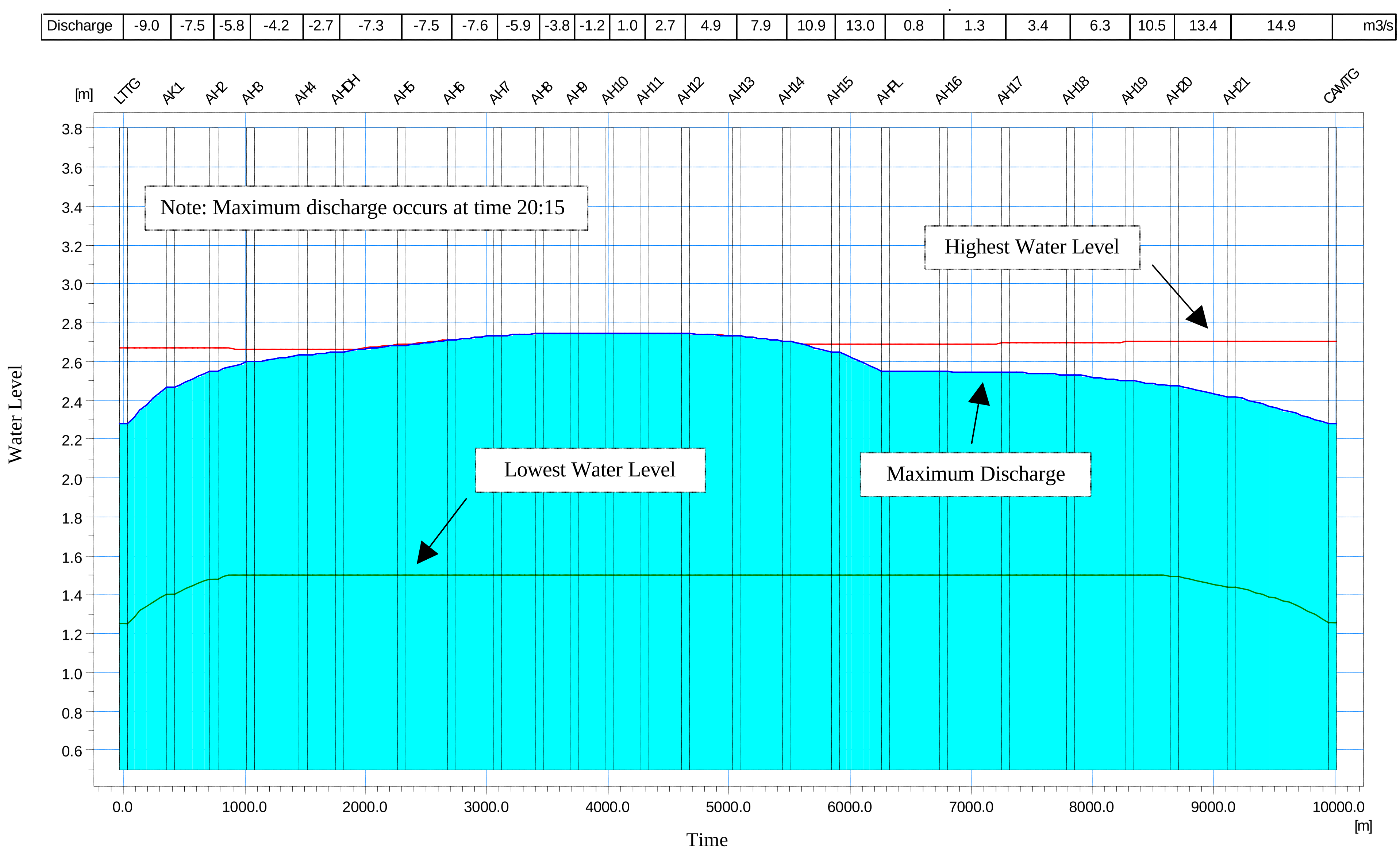
Rubble Masonry Revetment

Side-Slope = 1:1.25

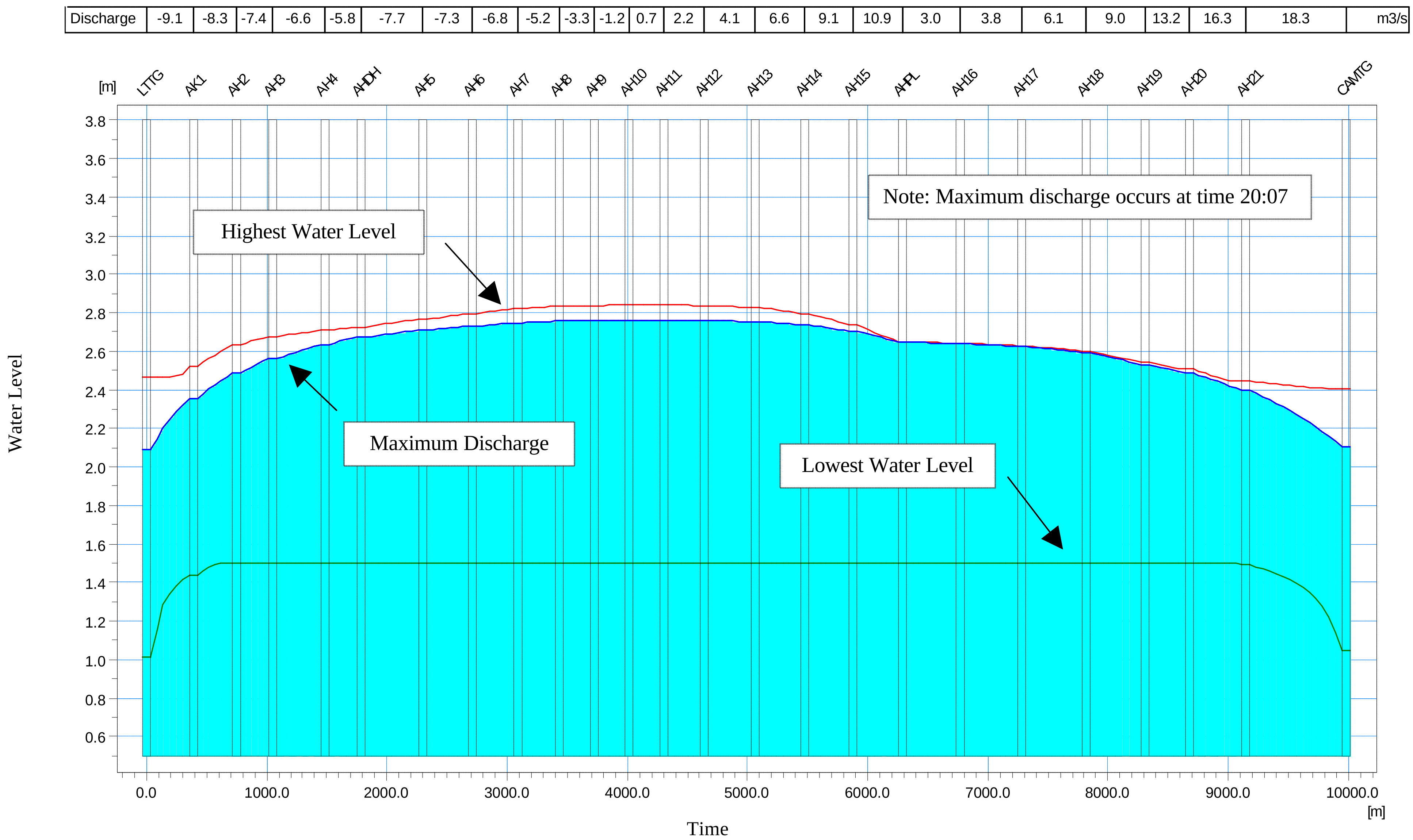
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.3.2 Alternative Channel Cross-Section Benchmark Designs
Japan International Cooperation Agency	



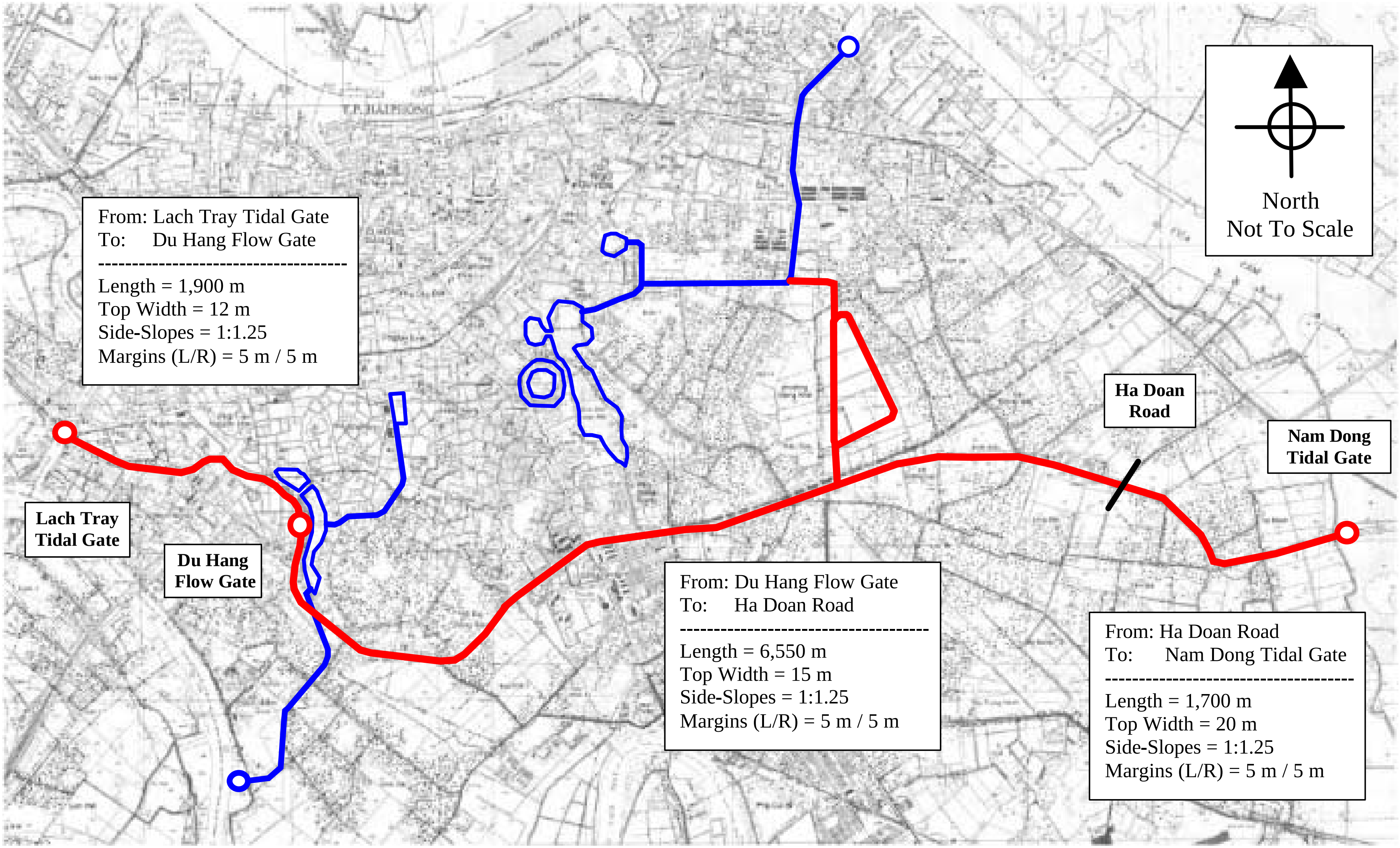
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.3.3 Simulated Water Levels in An Kim Hai Channel: 5 Year ARI Storm, High Tide
Japan International Cooperation Agency	



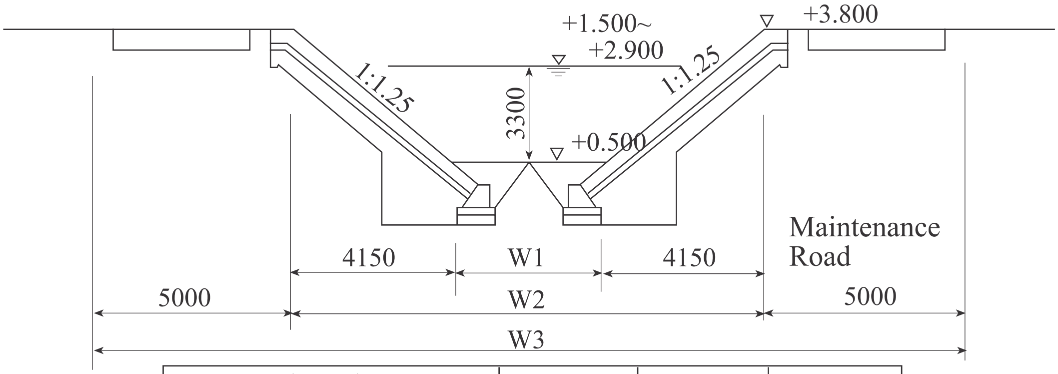
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.3.4 Simulated Water Levels in An Kim Hai Channel: 10 Year ARI Storm, Rising Tide
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.3.5 Simulated Water Levels in An Kim Hai Channel: 10 Year ARI Storm, Falling Tide
Japan International Cooperation Agency	

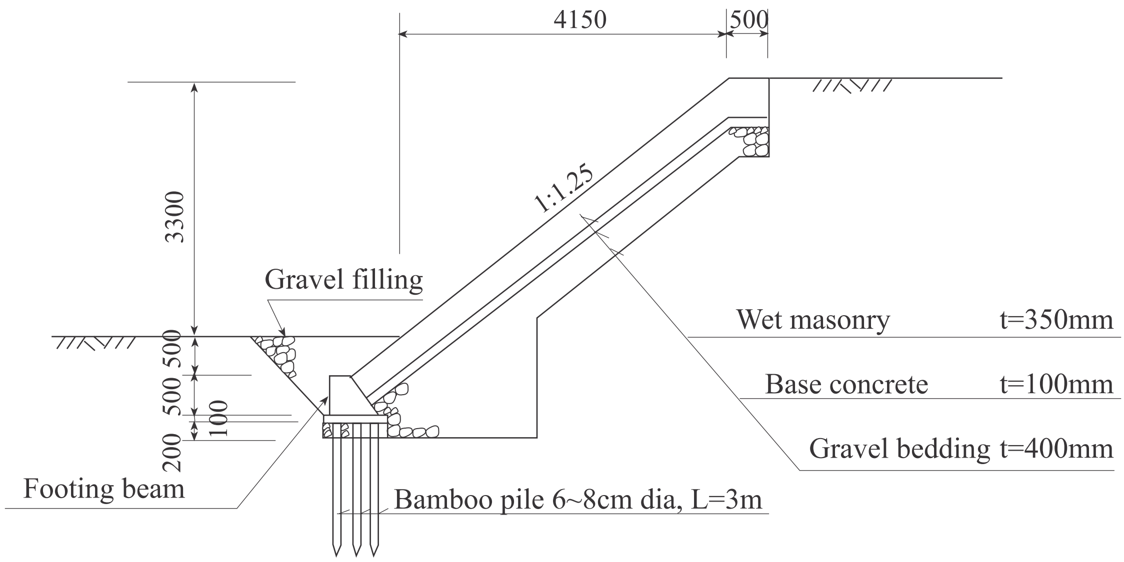


The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.3.6 Outline of Selected Design Layout For Rehabilitation Design of An Kim Hai Channel
Japan International Cooperation Agency	

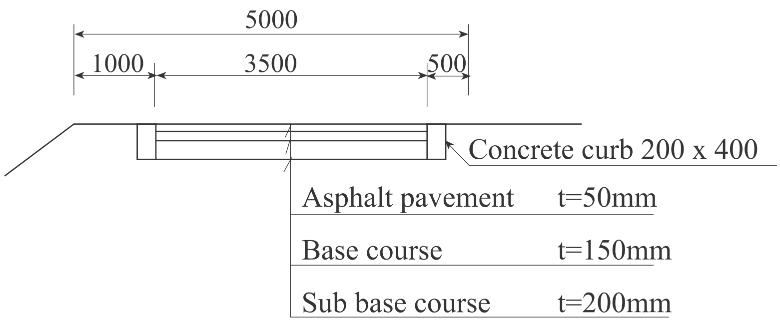


Channel	W1	W2	W3
From: Lachtray Tidal Gate To: Du Hang Flow Gate	3700	12000	22000
From: Du Hang Flow Gate To: Ha Doan Road	6700	15000	25000
From: Ha Doan Road To: Nam Dong Tidal Gate	11700	20000	30000

An Kim Hai Channel Section S=1:200

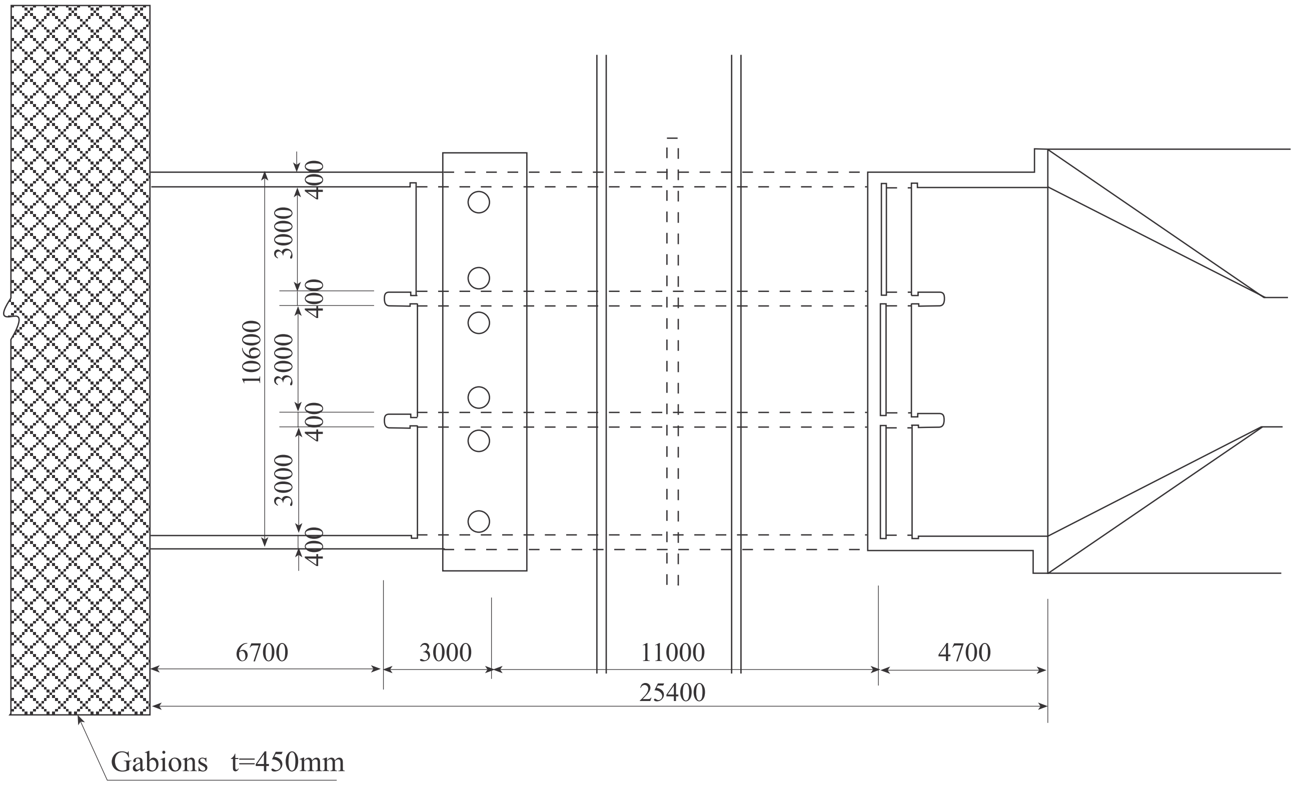


Wet Masonry Revetment Section S=1:100

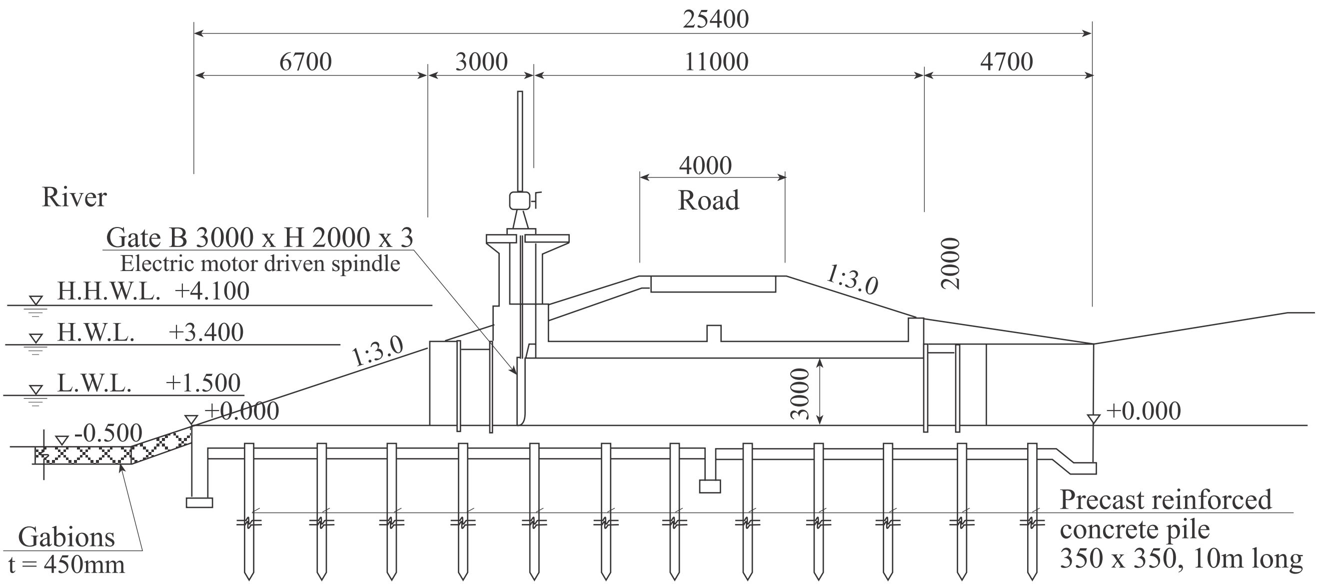


Maintenance Road Section S=1:100

The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	**Figure 2.3.7** **An Kim Hai Channel Section**
Japan International Cooperation Agency	

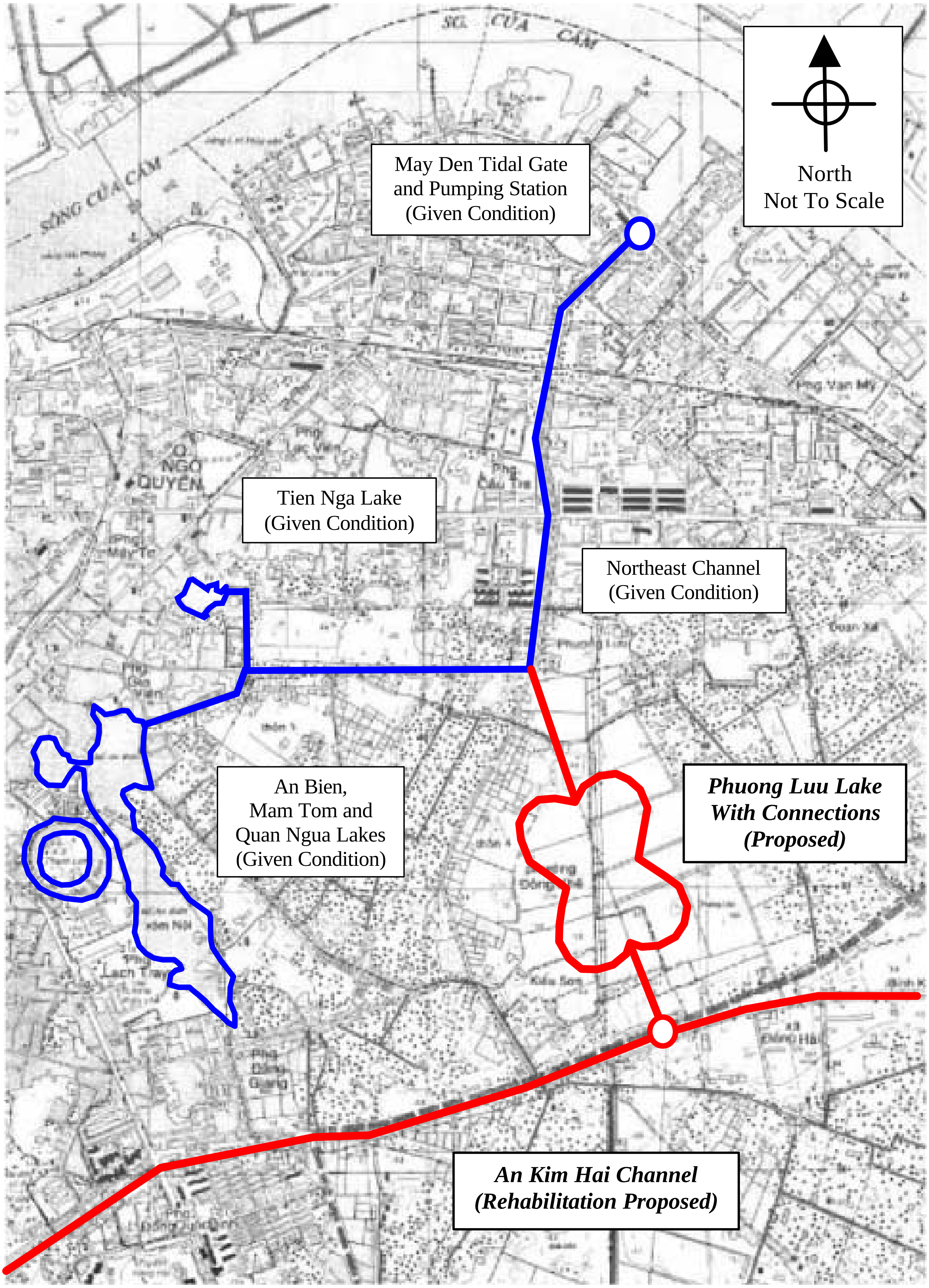


Plan

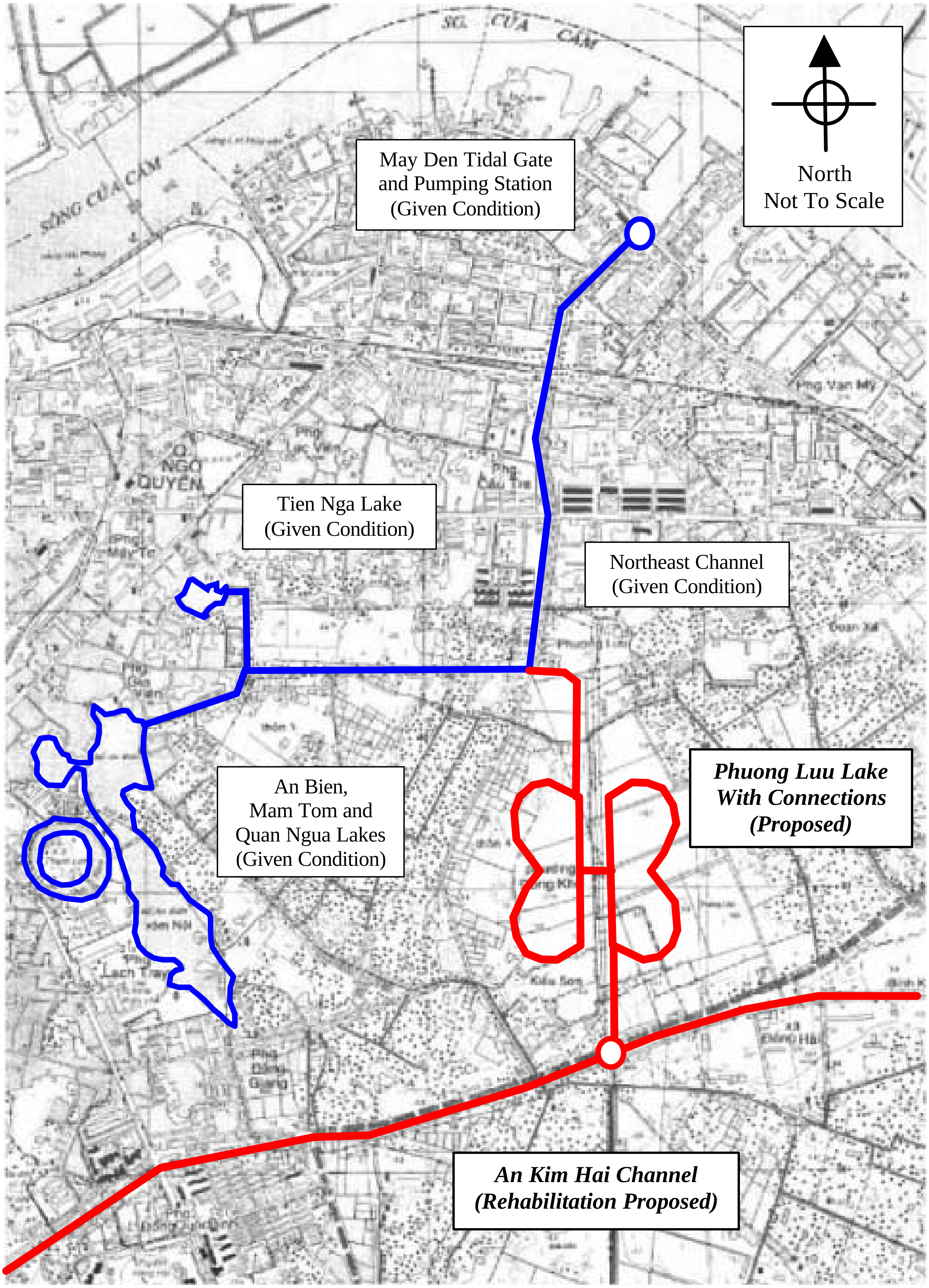


Section

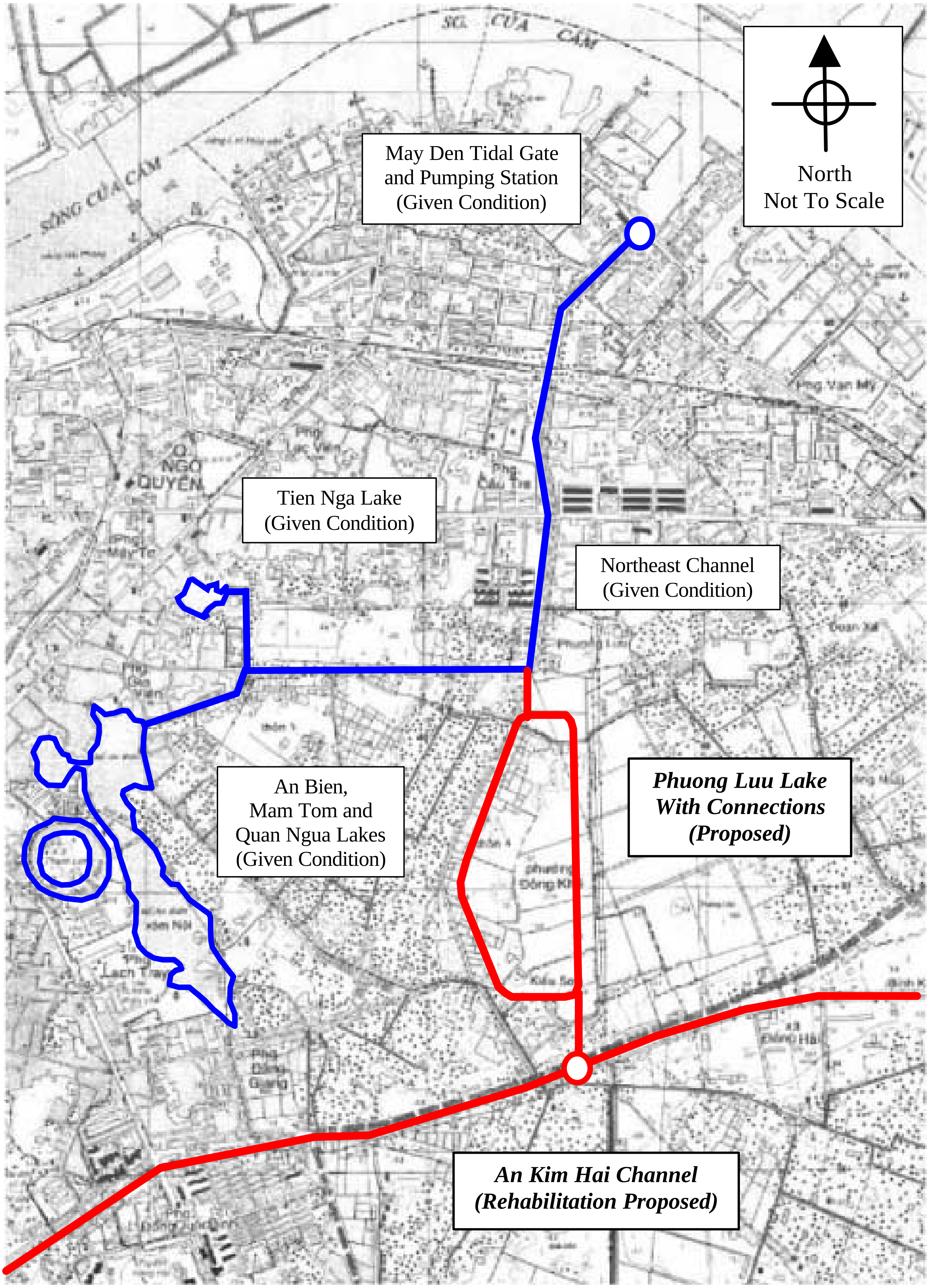
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.3.8 Tidal Gate Plan andSection
Japan International Cooperation Agency	



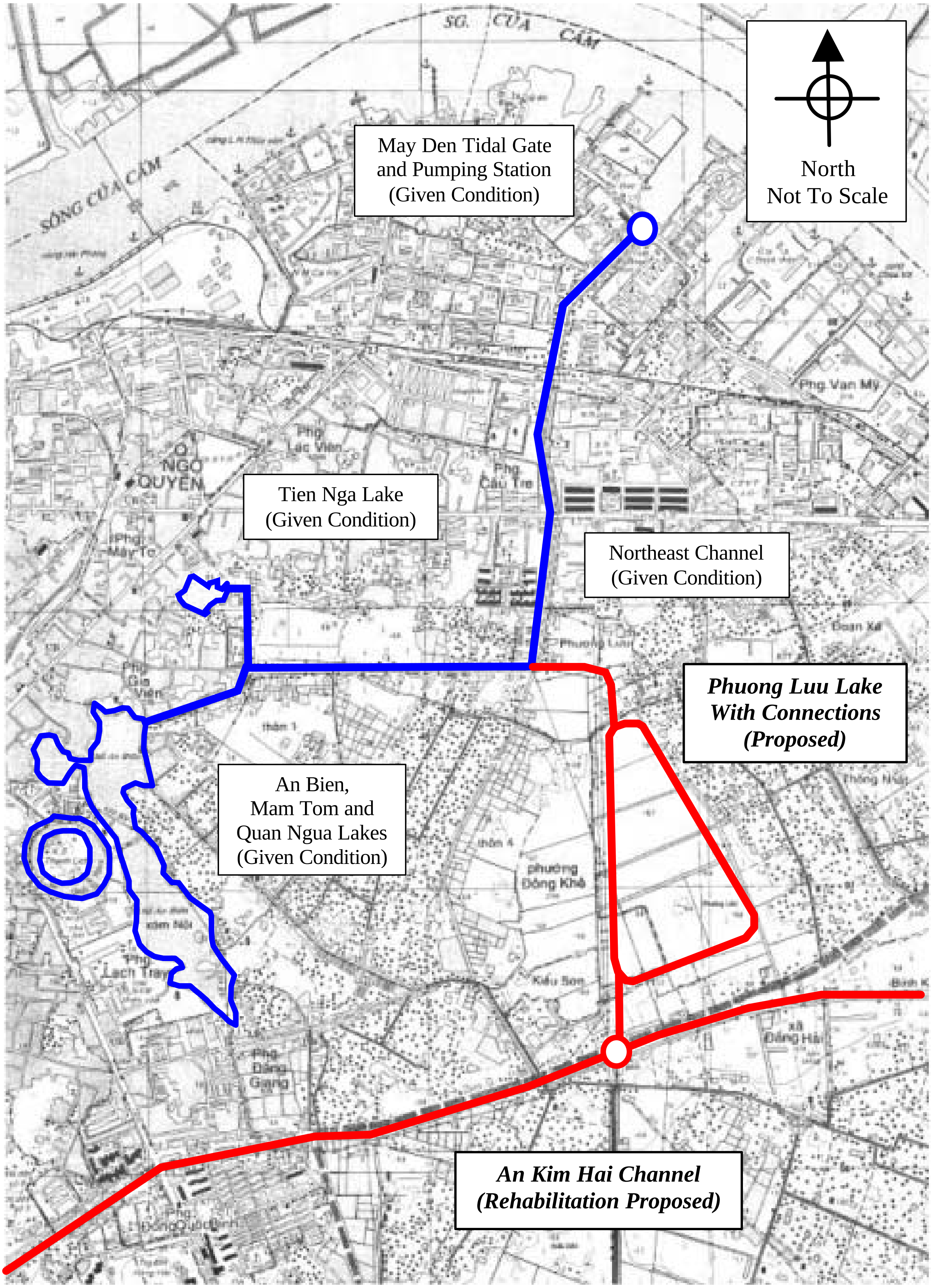
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.1 Phuong Luu Lake Layout Alternative PL-1
Japan International Cooperation Agency	



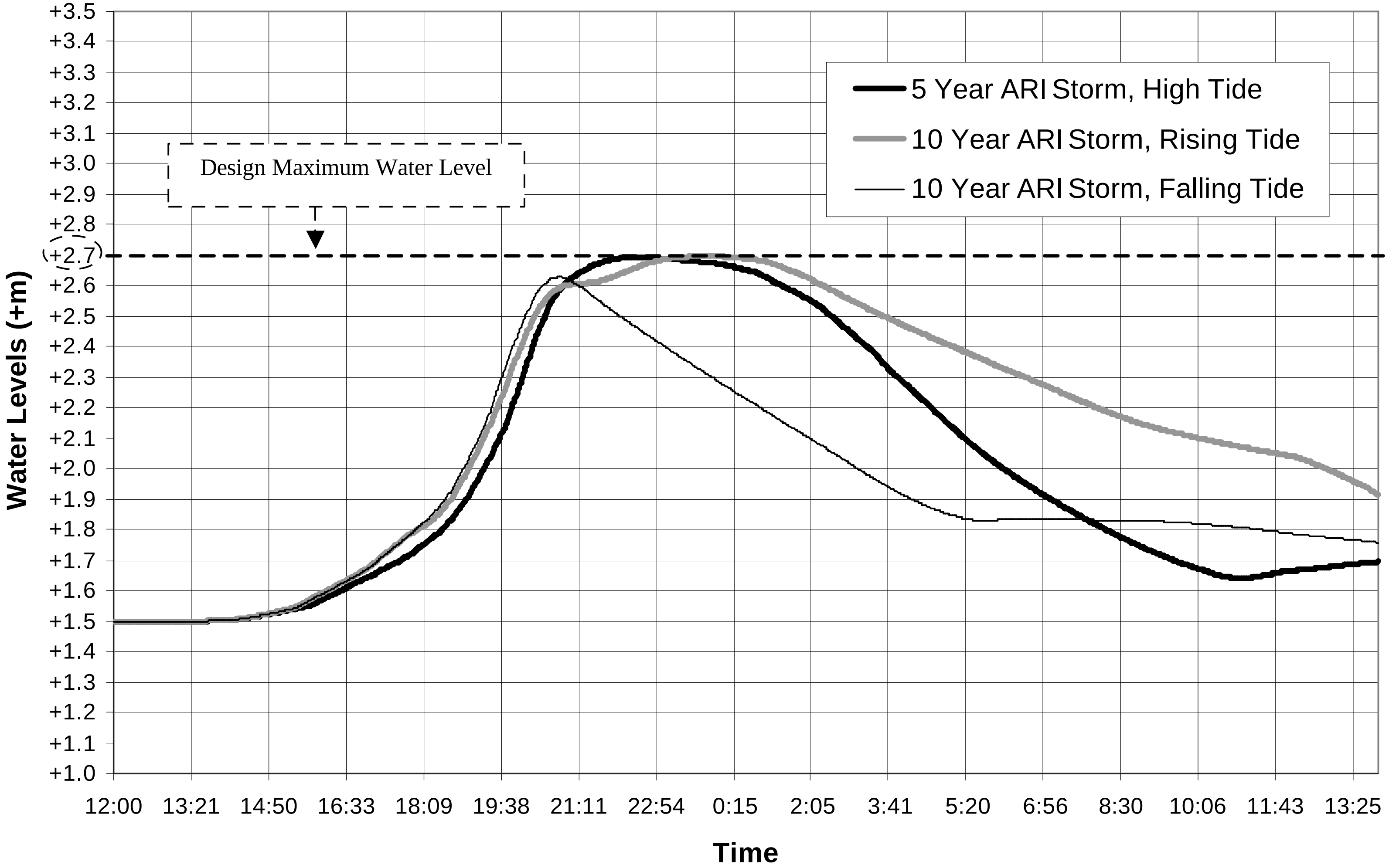
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.2 Phuong Luu Lake Layout Alternative PL-2
Japan International Cooperation Agency	



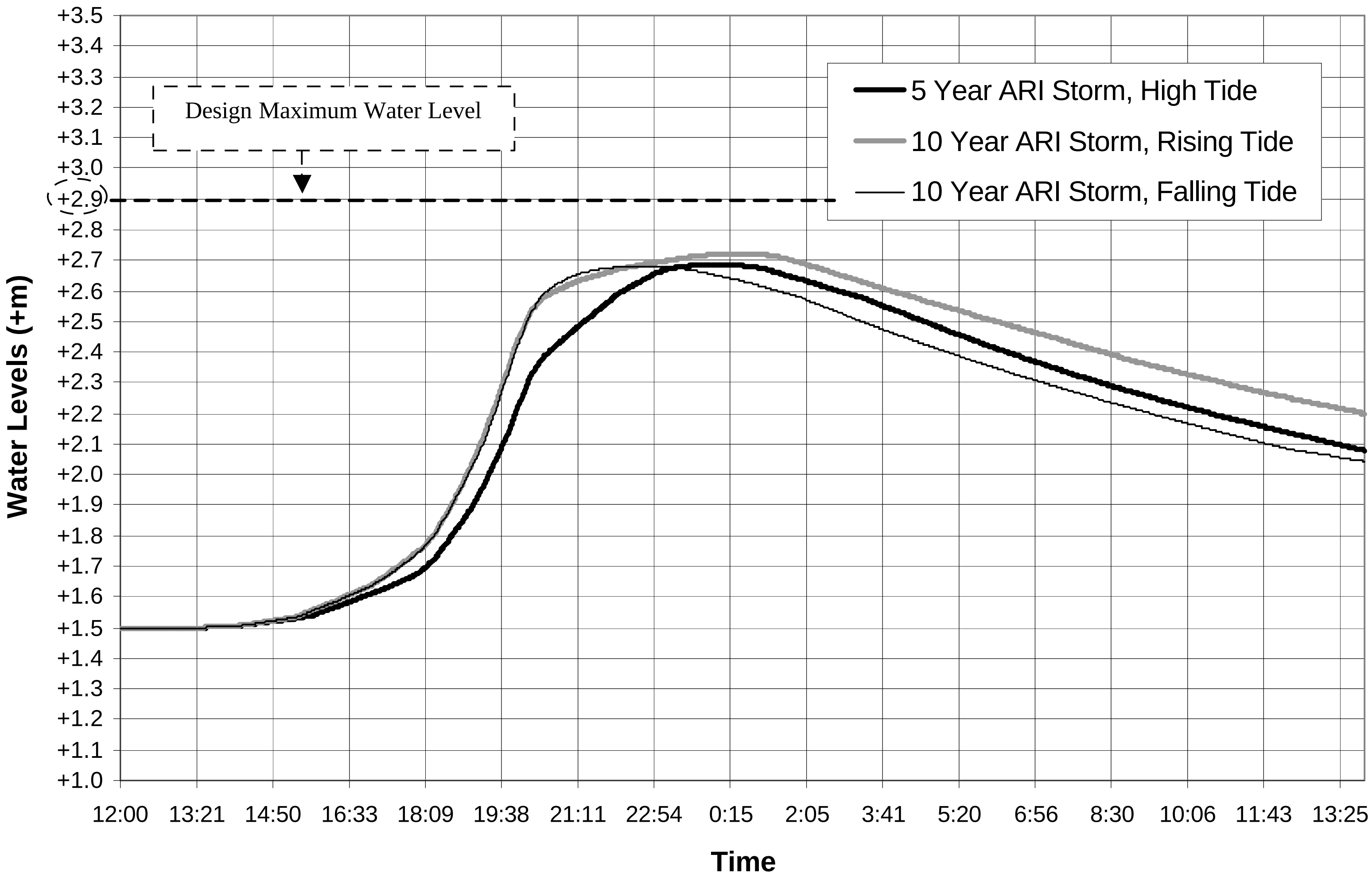
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.3 Phuong Luu Lake Layout Alternative PL-3
Japan International Cooperation Agency	



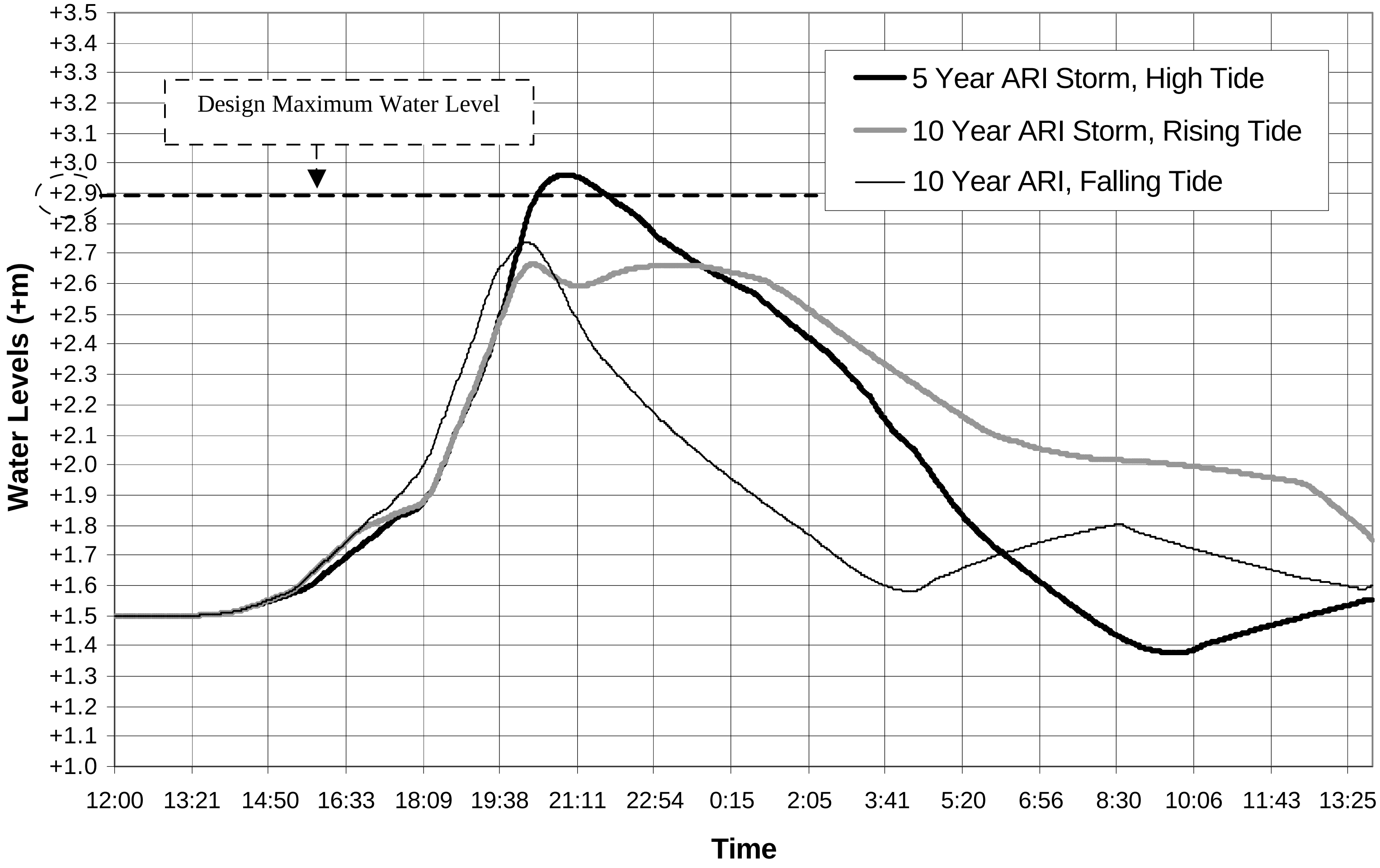
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.4 Phuong Luu Lake Layout Alternative PL-4
Japan International Cooperation Agency	



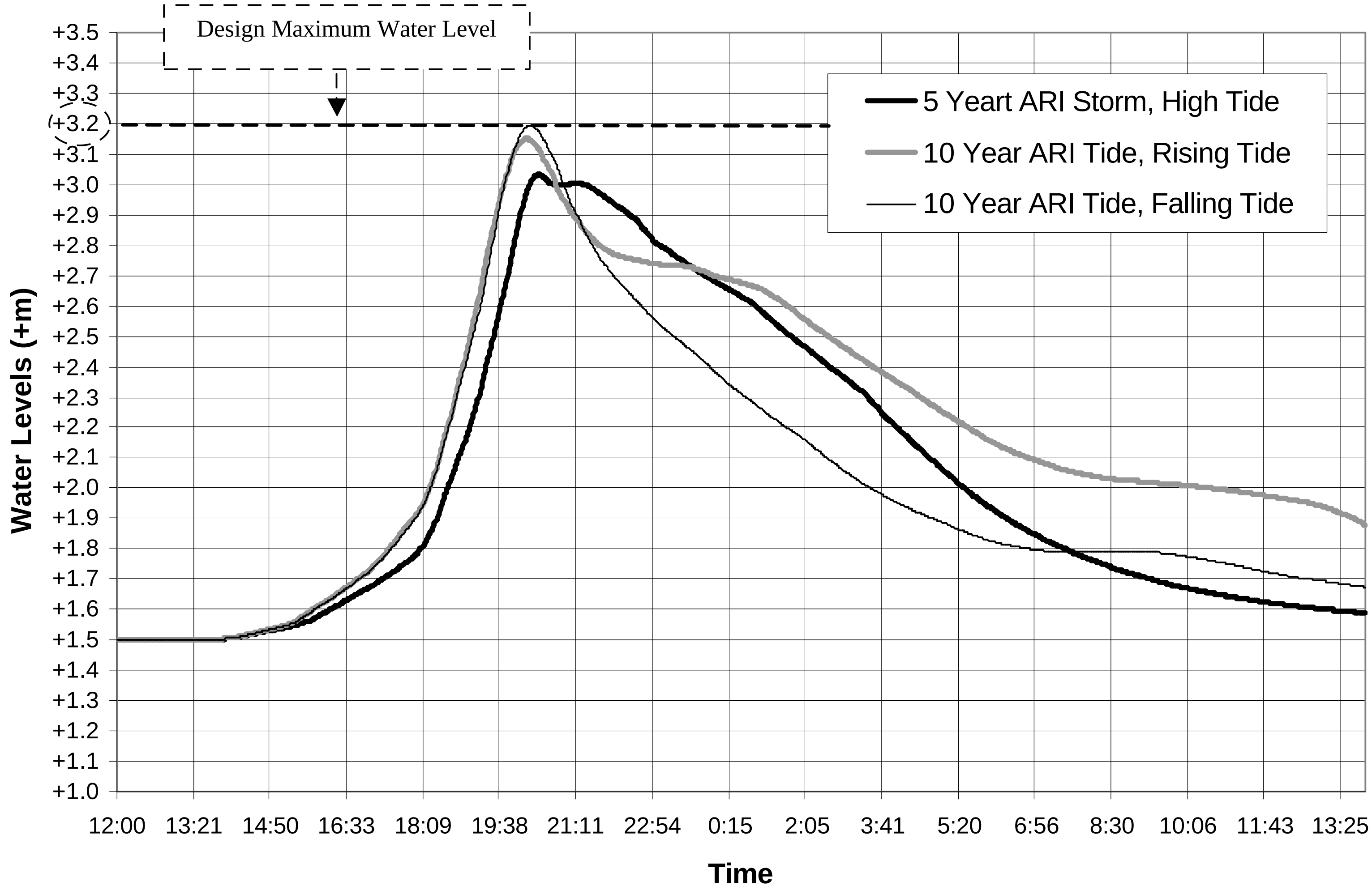
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.5 Results From Computer Simulations: Water Levels in Phuong Luu Lake
Japan International Cooperation Agency	



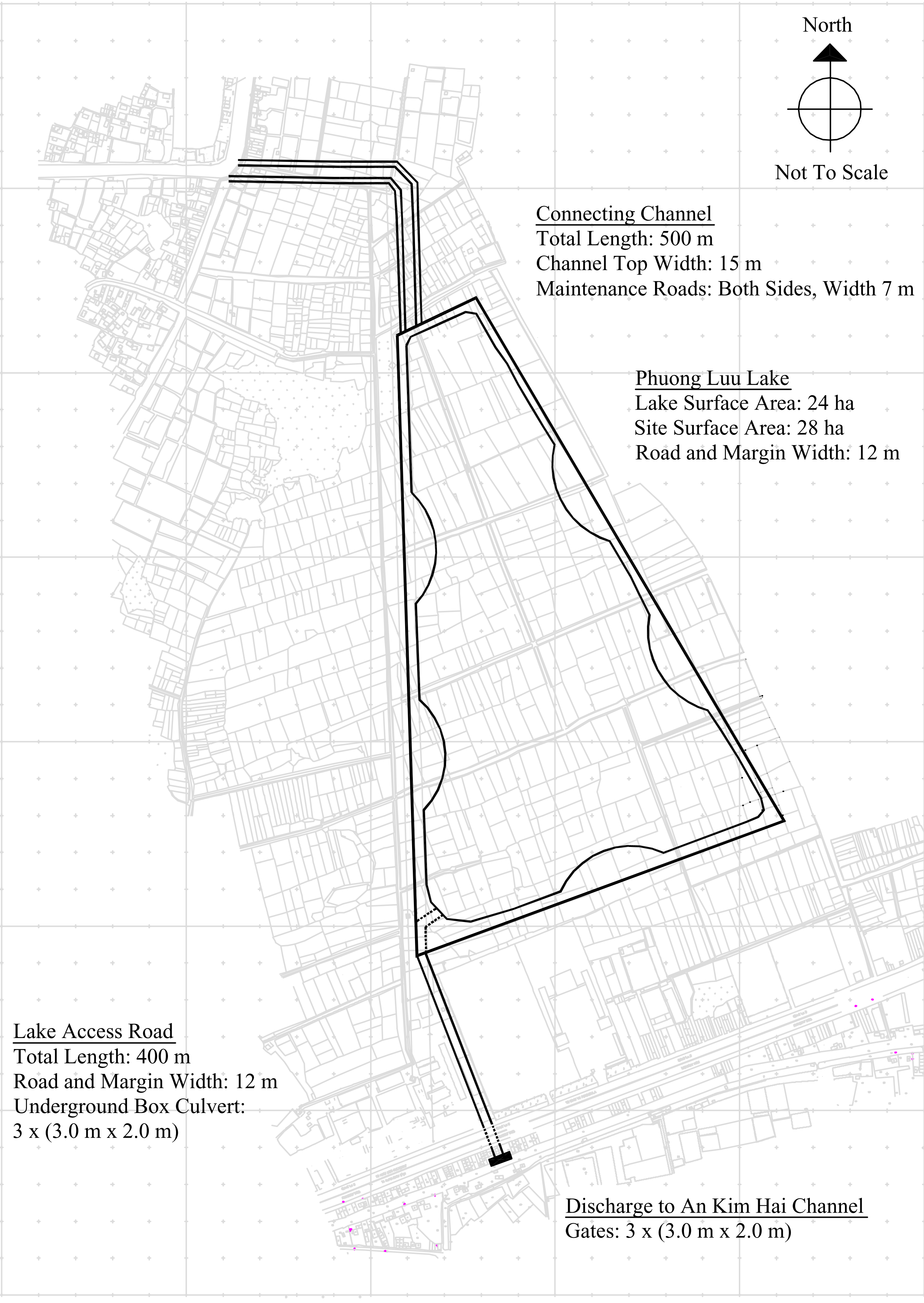
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.6 Results from Computer Simulations: Water Levels in An Bien Lake
Japan International Cooperation Agency	



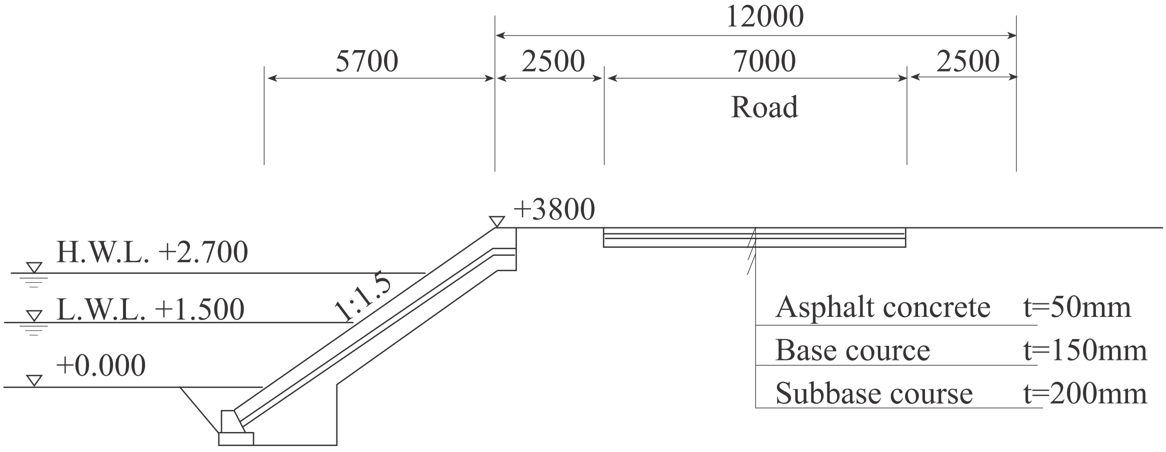
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.7 Results from Computer Simulations: Water Levels in Du Hang Lake
Japan International Cooperation Agency	



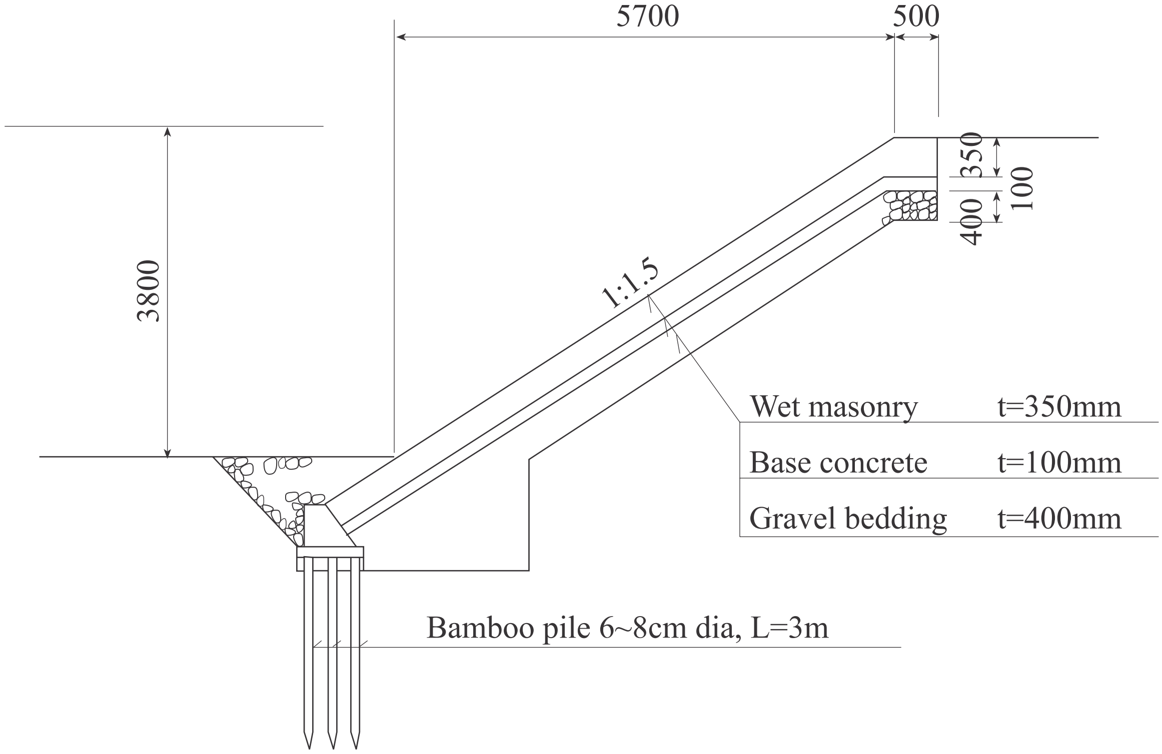
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.8 Results from Computer Simulations: Water Levels in Sen Lake
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.4.9 Preliminary Layout Design of Phuong Luu Lake and Connections
Japan International Cooperation Agency	

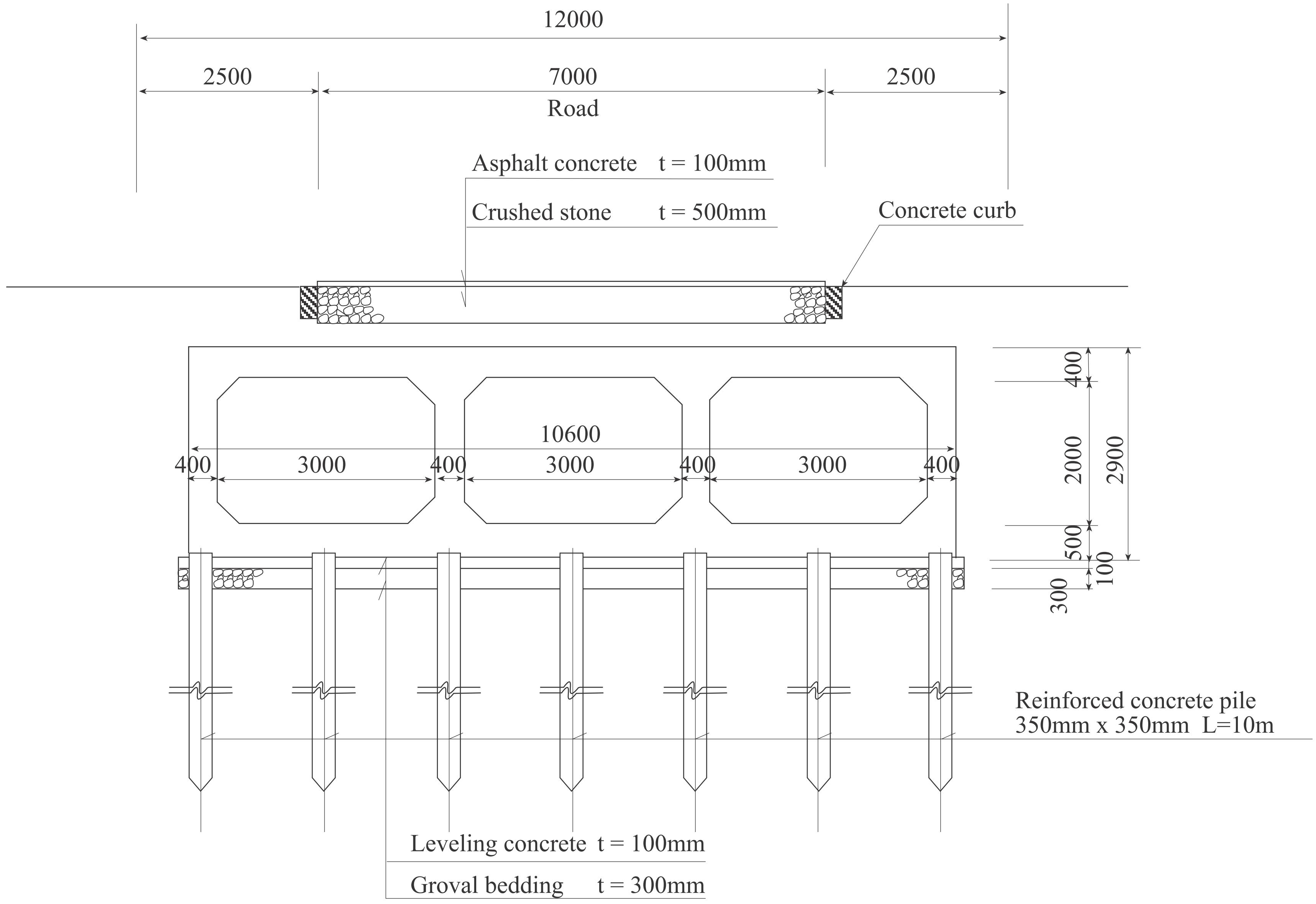


Lake Bank Protection and Road Section S=1:200



Wet Masonry Revetment Section S=1:100

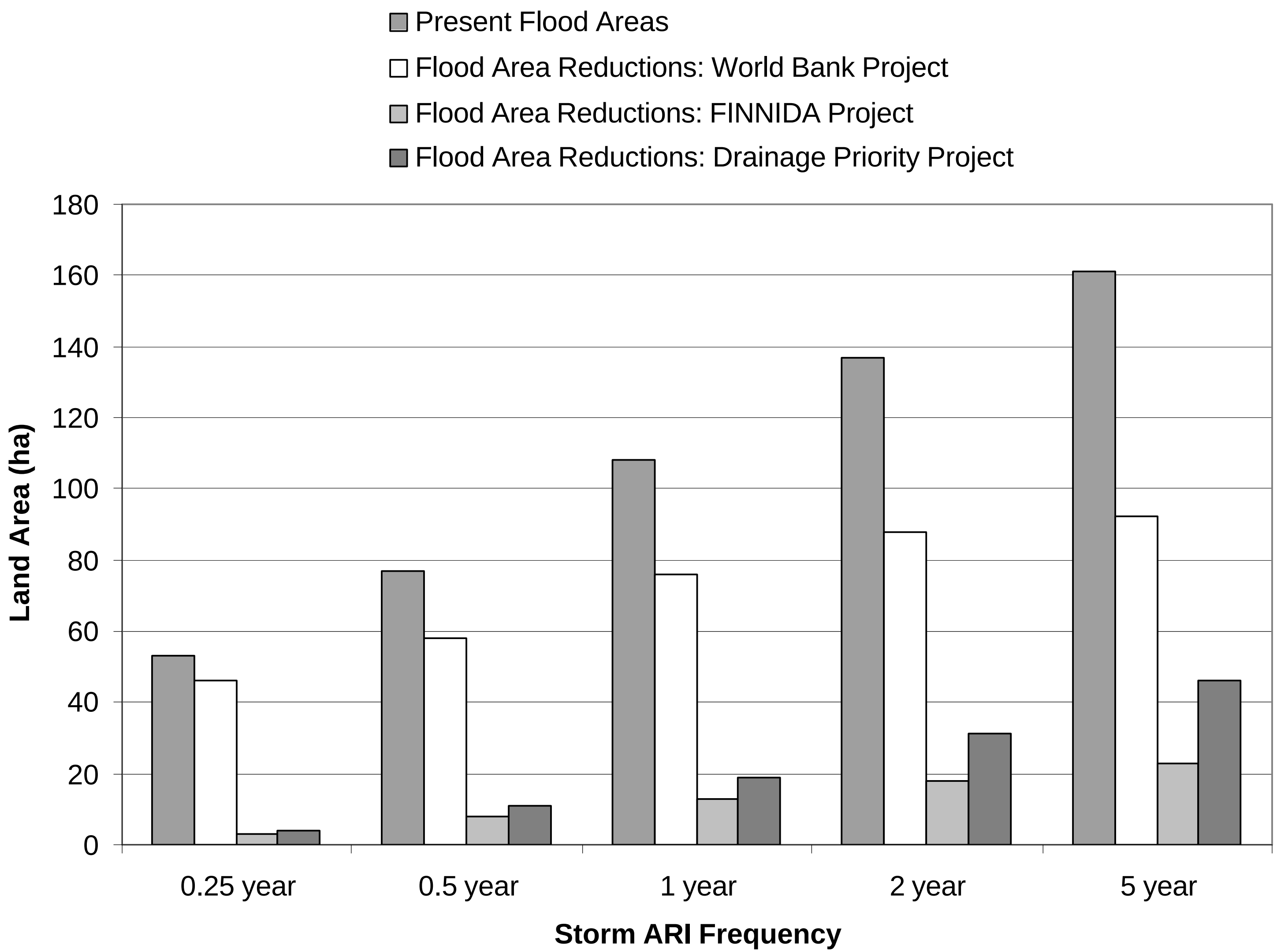
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	**Figure 2.4.10 Lake Bank Protection and Road Plan and Section**
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

Japan International Cooperation Agency

Figure 2.4.11
Box Culvert
(B 3.0m x H 2.0m x 3) Section



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.8.1 Incremental Flood Reductions in Central Area After Implementation of Phase I Projects
Japan International Cooperation Agency	

PART 3 FEASIBILITY STUDY OF SEWERAGE PRIORITY PROJECT

CHAPTER 1 BACKGROUND

1.1 Sewerage Improvement Master Plan

(1) Background

Sewerage system development was identified in the Master Plan for the target year 2020. The Study Area consists of the following sub-areas.

- Class A area

  Class A area comprises existing urbanized areas in the Haiphong City area with high population densities. Class A Areas include Old City Center (OCC) within Hong Bang District, Le Chan District, south of Le Chan District (2 communes), Ngo Quyen District, and west of Ngo Quyen District (4 communes).
- Class B area

  Class B area comprise urbanizing areas outside the Haiphong City Area with middle population densities and tourist areas. This includes Kien An District, Do Son Town, and Quan Toan Area.
- Class C area

  Class C area comprise rural or undeveloped areas outside the Haiphong City area with low population density where agricultural land use dominates. This includes Minh Duc, New Development Area, and Dinh Vu.

(2) Present Condition of the Study Area

<u>Class A area</u>: Sewage disposal in Class A area is based on septic tanks followed by wastewater discharge into combined sewer network. Wastewater from the combined sewer network is then discharged into the local receiving waters, including the local rivers, lakes and channels.

For Class A area the main problems with sewage management are as follows:

- Lakes and channels are extremely polluted because of very poor sanitation conditions
- Septic tanks are used, but degree of treatment is not effective
- The combined sewer system is characterized by tidal water ingress into the network

<u>Class B area</u>: For Class B area the main problems with sewage management are as follows:

- Septic tanks are used, but degree of treatment is not effective

- There are some existing combined sewer networks. However, functional and operational problems of the combined sewer network occur because of poor septic tank management
- Pollution of surface water bodies is mainly localized and is not considered to be a problem

Class C area: For Class C area the main problems with sewage management are as follows:

- Septic tanks exist in some houses, but degree of treatment is not effective
- Wastewater disposal is based mainly on direct discharge to nearby ditches, channels, and rivers
- In Dinh Vu the sewerage system is the responsibility of the Economic Zone. However, public authority should monitor the effluent quality discharged from the industrial zone

(3) Planning Objectives

Planning objectives for sewage management are as follows:

- To provide sewerage system in areas with high population densities
- To reduce wastewater discharges to surface water bodies
- To provide a solution that is sustainable and compatible with local standards and practices

This will lead to:

- Healthy living environment
- Favorable urban development

(4) Planning Strategy

Population density is the key parameter in determining appropriate level of sewage disposal system for a given area. The following population density-based selection criterion was adopted to select appropriate sewage disposal system in the Study Area.

Population density	Range	Target
High	more than 40 person/ha	Sewer System
Medium	11-39 person/ha	Septic Tank Based System
Low	less than 10 person/ha	Improved Latrine (Twin Pit Latrine, VIP Latrine, Compost Latrine etc.)

Besides population density criteria, following aspects are also considered:

- Current and expected situation of water supply in the area
- Current and expected septic tank development

- Situation of the receiving water quality for treated or raw sewage, that is, seriousness for preserving the quality of the receiving water bodies
- Areas with special interest like ports, tourist spots, industrial areas, etc.

Based on the population density, the appropriate target sewerage systems in 2020 are selected as follows:

Area	Population Density (2020) Persons/hector	Target Sewerage System
3 Urban Districts	73	Sewer
Kien An Dist.	40	Sewer
Do Son Town	11	Septic
Quan Toan	14	Septic
Minh Duc	22	Septic
Dinh Vu	--	No action
New Development Area	13	Septic

Urban Area (3 central urban districts) and Kien An District are to be served with a sewer system, while other areas in the Study Area are to be served by Septic Tank Based System. No action is proposed in Dinh Vu as wastewater treatment is the responsibility of the Economic Zone Authority. However, proper monitoring is required for the effluent discharged by the Economic Zone to the public water bodies. Since Do Son is a tourism area, a simplified septic tank based sewer system is proposed for the city center and tourism area.

(5) Planning Methodology

A comprehensive sewerage system development master plan for the target year 2020 was prepared. However, the level of particularization differs in each areas. For Class A area, holistic planning was carried out along with an alternative study. Detailed planning was performed for Class B area while outline planning was done for Class C area.

(6) Sewerage Improvement Master Plan for Class A Area

The salient features of the master plan for Class A area is given below.

Catchment	Area (Ha)	Beneficiary (2020)	Proposed Sewer System	Implementation Target Year
Central Area	1103	239,938	Combined Sewer	2010
Old City Center (OCC)	856	121,452	Combined Sewer	2020
New Urban Area (NUA)	3282	193,939	Separate Sewer	2020
Total	5241	555,329	--	--

In the M/P, two wastewater treatment plants (WWTP) are proposed and accordingly the whole area is divided into two segments, namely, West WWTP command area and East WWTP command area. The coverage and beneficiary of these command areas are given below.

Area, population and sewage generation by treatment plant command area

			Catchment	Population (2020)	Area (ha)
West Wastewater Treatment Area				**439,079**	**2,654**
	Phase I	Combined sewer system	Central Area	239,938 (2010)	1,103
	Phase II	Combined sewer system	Old City Center	121,452	856
		Combine sewer extension	Central Area	259,286	1,103
		Separate sewer system	Part of NUA	58,341	695
		sub-total(Phase II)		439,079	1,551
East Wastewater Treatment Area				**135,598**	**2,587**
	Phase II	Separate sewer system	Part of NUA	135,598	2,587
Grand Total				**574,677**	**5,241**

Sewage generation was estimated based on water consumption. Total water consumption includes domestic, industrial and institutional water consumption. Sewage generation is calculated considering sewage generation ratio, sewerage service ratio and groundwater infiltration. Estimated sewage generation in 2020 is 87,485 m^3/day.

The planned wastewater quality for 2020 is proposed as follows:

- Domestic wastewater: 50 g/c/d of BOD
- Commercial wastewater: 350 mg/l of BOD
- Industrial wastewater: 400 mg/l of BOD

Considering the unit water consumption of 130 l/c/d (based on water supply sector of the master plan), the pollution load for domestic wastewater is 380 mg/l before considering groundwater infiltration. With 10 % groundwater infiltration, the load is 350 mg/l.

Treated wastewater quality was decided in conformity to the effluent standards in Vietnam. Considering the rivers surrounding Haiphong, the effluent quality should meet Class B river requirements, which is 50 mg/l of BOD.

Based on the design principle explained before, required sewerage facilities are estimated and given in Table 3.1.1 and shown in Figure 3.1.1. Based on the proposed facilities and unit costs, costs estimates of the Project are worked out. The total cost is estimated at US$152 million as direct construction cost. Phase I direct construction cost is US$50 million. The total compensation is US$3.2 million, out of which Phase I requirement is US$2.2 million.

For the east treatment plant, a stabilization pond is most recommended because land is likely to be available for this relatively small-scale treatment plant, though actual land acquisition is yet to be carried out.

For the west WWTP, five treatment options are closely examined. These are Wastewater Stabilization Pond (WSP), Modified Wastewater Stabilization Pond (MWSP), Aerated lagoon (AL), Oxidation Ditch (OD) and Conventional Activated Sludge Process (CAS). A summary of salient features for the five options is given in Table 3.1.2. It can be found from the table that the effluent BOD load is less than Vietnam standard of 50 mg/l of BOD for all cases except MWSP, in which case it is around 100 mg/l. The required land area is lowest for CAS at 12 ha while it is highest for WSP at 130 ha. The construction cost is lowest for MWSP at US$25 million. The O&M cost is also lowest for MWSP at US$0.6 million/year.

For in-depth understanding and comparison of cost, all direst and O&M costs are converted into net present value. Two discount rates are used, namely 5 % and 8 %. Summary is given below.

Process	Net Present Value	Unit: US$1,000
	Discount Rate	
	5%	8%
WSP	30,102	22,015
MWSP	24,064	17,254
AL	32,965	21,820
OD	43,784	28,638
CAS	55,645	36,023

At 8 % discount rate, MWSP is the cheapest and AL is the second cheapest.

In the draft Master Plan, two possible alternative scenarios are proposed. In one option, Modified Wastewater Stabilization Pond (MWSP) will be implemented in Phase 1, which will be upgraded into Aerated lagoon (AL) in Phase II. In other option, AL will be implemented in Phase 1, which will be continued in Phase II.

However, it is to be noted that the effluent quality of MWSP cannot meet Vietnam effluent standard. Thus, the most recommended option is AL.

(7) Sewerage Improvement Master Plan for Class B and C Areas

Similar methodology was used for Class B area as that used for Class A. Since septic tank based system is sufficient for Quan Toan, facilities planning and cost estimates were carried out for Kien An and Do Son. As no central sewer system is required for Class C, improved latrine and hygienic sanitation is proposed for that area.

(8) Total Cost and Implementation

The total cost for sewerage development for the entire Study Area is US$207 million. Phase I cost is US$69 million.

Construction of the sewerage project is expected to start from 2004. However, pre-construction activities should start from 2001 in order to facilitate smooth implementation of the Project.

(9) Nightsoil and Septage Management

Since the construction of WWTP for the Phase I of the Class A area is expected to be completed by 2006, strategies for nightsoil and septage management were drawn as an interim measure. Total cost for this component is US$15 million.

1.2 Selection of Sewerage Priority Project

Based on the selection criteria explained in previous chapter, Phase I for the Class A area is selected for the priority project.

The salient features of the sewerage priority project is as follows:

- Location — Central area of Class A area
- Area — 1103 ha
- Population — 240,000 (in 2010)
- Collection System — Combined Sewer System
- Estimated Sewage — 36,000 m^3/day (in 2010)
- Treatment Plant — Near Vinh Niem Tidal Gate
- Construction Cost — US$50 million
- Land acquisition — US$2.2 million
- Total Direct Cost — US$52.2 million
- Implementation Period — 2004 to 2010

CHAPTER 2 SEWERAGE PRIORITY PROJECT

2.1 System Concept of Priority Project

In the project area, at present most of the households have septic tanks. The effluent of the septic tanks enters into the combined sewer where it gets mixed with gray water and during rainy time, with storm water. Main sewers collect combined flow from branch and tertiary sewers and discharge into lake, channel and rivers.

The sewerage priority project proposes to intercept the combined flow before it enters into the surface water bodies and separate sewage from storm water by the means of Combined Sewer Overflows (CSO). Collected sewage is to be collected by sewer pipelines to the wastewater treatment plant (WWTP). The system concept is shown in Figure 3.2.1.

The principal advantage of this system is that all existing combined sewer pipes can be utilized. This will reduce to investment cost and implementation time.

2.2 Compatibility with Other Projects

(1) Related On-going Projects for Sewerage

The proposed World Bank Sanitation Project consists of the following system and facility measures for sewerage improvements:

- Construction of interceptor sewers for 2 lakes in Class A area: Le Chan District (Sen Lake) and Ngo Quyen District (Tien Nga Lake)
- Construction of septage treatment facilities at Trang Cat Landfill
- Procurement of sewer cleaning and septage collection vehicles and vacuum trucks
- Revolving fund for households to purchase and install septic tanks

The project is divided into various components. Tender for vehicle procurement component was completed while other components are yet to start. All components are supposed to be completed by 2005.

Proposed FINNIDA projects consist of the following system and facility measures for sewerage improvements:

- Rehabilitation and construction of pilot scale wastewater collection and treatment system in Dong Quoc Bin area in Ngo Quyen District

This is not included in the on-going phase. There is no fixed timetable for the implementation.

(2) Relation between Priority Project and Other On-going Projects

Interceptor Sewer (1B): Details are not finalized yet. If these interceptors completely cover the perimeter of two lakes (Sen and Tien Nga), few CSOs can safely be eliminated from the SPP.

Septage Management (1B): Even after the implementation of the SPP, these facilities can serve Old City Center and New Development Area until the implementation of Phase II. Also SADCO is planning to have a business enterprise for septage management, which can use these facilities to serve areas outside the urban districts, namely Kien An or Do Son. In other ways, the septage treatment plant can be used as sludge treatment plant for the sludge coming out from the proposed Wastewater Treatment Plant. The vehicles can be used as sewer and manhole cleaning vehicles.

Pilot Treatment Plant (FINNIDA): This plant is very small and pilot scale in nature. This will have no impact on the SPP.

2.3 Project Components

The facilities for sewerage priority project consist of five components, namely combined sewer overflows (CSOs), sewer pipelines, pumping stations, wastewater treatment plant and supplementary component. CSOs will be placed at the outlet of combined sewer pipes discharging into surface water bodies. CSOs will separate wastewater from storm water. Pipes will be constructed to collect wastewater separated by CSOs. These will deliver wastewater into main collector pipe. Main collector pipe is proposed to be placed along the National Road No. 5. This will collect wastewater from sewer pipes and transport the wastewater to the WWTP near the Vinh Niem Tidal Gate. Sewage lift pump is to be placed in case gravity flow becomes difficult. Sewage is to be treated in WWTP satisfying VN standard before discharging into river. Storm water separated in CSOs is to be allowed to bypass into surface water bodies.

2.4 Planning and Design Methodology

(1) Collection Principle

The existing combined sewer pipes are collecting most of the sewage at present except from the houses located near the water bodies, which directly discharge their wastewater into the water bodies. Based on the relative elevation of the land and sewer pipe, catchment of the each outlet is identified. The amount of discharge at each outlet is calculated based on water consumption. At the outlet, CSOs are placed to intercept and separate the sewage. Storm water is allowed to bypass into the surface water bodies while sewage is collected through new sewage pipes.

In the Study, three types of sewage pipelines are proposed, namely, conveyance, trunk and lateral. Wastewater is collected from lateral to trunk and from trunk to conveyance. The major sewage pipeline, which delivers all collected wastewater to the treatment plant, is called conveyance. Typically it will have a bigger diameter and will be placed rather deep in the ground. All pipelines delivering wastewater to conveyance is named as trunk. Pipelines delivering wastewater to trunk is named as lateral.

The capacity of the sewer pipelines are to be designed to collect the volume equal to 3 times the Average Dry Weather Flow (ADWF) for the year 2020. ADWF is the flow that occurs in the sewer system when there is no rainfall, essentially this means the sewerage only. Also, sewage collection for Phase II area is considered during the pipe dimensioning. Lift pumping stations are required when sewer elevation becomes too deep. Conveyance pipe delivers the sewage to the WWTP, where 1 x ADWF is treated before discharge into river. This amount is equal to the total sewerage generated. During storm, 3x ADWF amount of flow will enter the treatment plant. At that time, full treatment will be provided to 1 x ADWF. Only preliminary treatment is carried out for the remaining 2 x ADWF flow, but this will occur only during the rainfall. The system mechanism is shown in Fig. 3.2.2.

For areas where combined sewer pipes do not exist, new combined sewer pipes are proposed under ‘Drainage Priority Project’. For areas where existing combined sewer pipes are not functioning properly and will not be rehabilitated under any on-going and planned project, rehabilitation measures are also proposed under ‘Drainage Priority Project’.

For the houses now directly discharging their sewage into the surface water bodies due to lack of nearby sewer pipes, interceptor pipes are proposed under ‘Sewerage Priority Project’ as supplementary components, which is explained in Chapter 7 of Part 3.

Laterals and trucks are designed in a way so that minimum numbers of trunks and minimum numbers of pumping stations are required to reduce the cost and implementation time. Also, due consideration is given to the fact that these pipelines will be used to carry wastewater from the Phase II area in future.

(2) Collection Coverage Area

The coverage area for the priority project is examined critically from hydrological, hydraulic, hydrogeological, and topographic points. Also, existing, on-going and planned facilities related with drainage, sewerage and other relevant sectors are also duly considered.

The boundaries of the coverage area are marked by rivers and channels, railroad and National road No.5. On the northern side the boundary is the railroad and Da

Nang Street, on the east it is the proposed Phoung Luu Lake and Northeast channel, on the south it is the National Road No. 5, and on the west it is the Lach Tray River. The modified area is shown in Figure 3.2.3.

(3) Collection Sub-catchments

From the topographic, hydraulic and location viewpoints, it is proposed to locate one major conveyance pipe along the road no. 5. The whole cover area is proposed to be divided into three sub-catchments oriented in the north south direction. These are west, central and east sub-catchments lying between the railroad and road no.5. The west sub-catchment is the area west of Du Hang Lake, while the east sub-catchment is the area east of An Bien Lake. The area between these two is the central sub-catchment.

(4) Organization of the Report

In the subsequent sections, project components are illustrated. These include Combined Sewer Overflows, sewer pipelines, pumping stations, and treatment plant. In each component, planning issues and design criteria are explained first, followed by alternative study and selection of the most recommended alternative. Finally detail technical design is presented. Supplementary components of the project are explained after that. This is followed by implementation schedule and cost estimates. Finally, issues like institutional and organizational development, EIA and project evaluation are presented.

CHAPTER 3 COMBINED SEWER OVERFLOWS (CSO)

3.1 Planning Issues and Design Criteria

(1) Identification of Command Area of Outlet

Based on the information of existing and planned combined sewer pipes in the Sewerage Priority Project (SPP) area, every outlet of the combined sewer into the surface water bodies is identified. Sewer line survey conducted under the Study provided the information of the existing pipelines while SADCO provided information of the planned pipelines under 1B project. The command areas of sewage collected into each outlet are also identified based on ground elevation, flow direction inside the sewer and other related information. Based on water consumption, amount of sewage expected in each outlet in 2020 is calculated. There are 65 such CSO command areas are identified and shown in Fig. 3.3.1.

(2) CSO Location

CSOs can be placed at each existing outlet or these can be placed after combining a number of outlets. In the first case, though number of CSOs will be higher, operation and maintenance will be simple since the size of the CSOs will be rather small. In the second option, new combined sewer pipes have to be constructed to combine a number of outlets. These pipes will have bigger diameter since these are combined sewer. Also the depth will be higher since these will be placed after the existing outlet. In many cases small pumps will be required. The size of the CSOs will be bigger and will require constant monitoring and skilled maintenance. Manual control will be difficult, and will require expensive mechanical instruments. In this option, number of CSOs will be fewer but it would require skilled maintenance and expensive installation.

Considering the investment cost and importance of proper maintenance required to ensure the smooth functioning of the whole system, CSO control structure is placed at each existing outlet. However, in this case, more manpower is required to maintain the system.

3.2 Alternative Study

(1) Types of CSOs Control Structure

CSOs are well known and widely practiced method used to separate sewage from the combined sewer flow. In USA, over 45 % of the communities with population over 100,000 have some kind of CSO control structure. There are various types of CSOs in practice. Briefs of some of these are given as follows.

Side Weir Type: Typically consists of a weir parallel to the wastewater flow located in the side of the sewer pipe. The weir should be high enough to prevent any discharge of dry-weather flows, but low and long enough to discharge the required excess flow during the wet weather.

Transverse Weir: A weir or small dam placed directly across the sewer, perpendicular to the line of flow, is used to direct ADWF to the interceptor sewer (Fig. 3.3.2). Increase of flow during wet weather results in flow overtopping the weir and discharging to the overflow outlet.

Orifice: These diversion structures allow flow from combined sewer to pass through a circular or rectangular office and enter the interceptor. The orifice is sized to allow the ADWF, and possibly some of the wet weather flow, to pass. The orifices can be oriented in a variety of ways, including horizontally at the invert of the sewer known as ‘drop inlet’, and vertically on the side of the weir (Fig. 3.3.3). Often these types of CSOs are used in conjunction with a transverse weir.

Leaping Weir: A leaping weir is formed by an opening in the invert of a sewer of such dimensions as to permit ADWF to fall through the opening and pass to the interceptor. During storms, the increased velocity and depth of flow cause most of the flow to leap the opening and enter the overflow outlet. The steel weir plate is normally designed so that it can be adjusted for various flow conditions.

High Outlet Regulator: A variation of orifice type CSO in which the invert of the overflow pipe is typically above the crown of the combined sewer.

Relief Siphon: This is a means of regulating the maximum water surface elevation in a sewer with smaller variations in high water level than can be obtained with other devices. A siphon works automatically and does not require any auxiliary mechanisms. The siphon inlet is typically set as far below the top water level as possible to minimize the carryover of floating scum and debris to the overflow outlet.

Mechanical Regulator: This is also known as automatic regulator or reverse taintor gate regulator. This responds to the water level in the combined sewer or interceptor sewer. In either case, the float travel and the corresponding gate travel may be adjusted to regulate closely the flow to the interceptor.

Gate Regulator: The principal is same as mechanical regulator except the gates are controlled manually (Fig. 3.3.4).

Tipping Plate Regulator: In these devices, the plate or gate is pivoted off-center, and its motion is controlled by the difference of water levels above and below the gate. Multiple gates can be used to increase the capacity of an installation.

Hydro Brake Regulator: The configuration imparts a more-or-less centrifugal motion to the entering fluid. This action, which commences when a predetermined liquid head has been reached, effectively reduces the rate of discharge. This device has been used extensively on combined sewers to limit the flow to the interceptor, thus maximizing storage in the combined sewer.

Vortex CSO: This is a new type of weir, which uses the helical vortex motion created by special internal shape. There are no moving or mechanical parts, thus it is easy to operate and maintain. This not only limits the excess flow into the interceptor sewer during wet weather, but also due to centrifugal force generated inside, it can separate suspended solids.

(2) Selection of CSOs Control Structure

The following factors are carefully considered during the selection process of CSO control structure for the Study:

- Construction cost
- Size
- Ease of construction
- Required maintenance
- Design simplicity

Three types of CSO control structures are considered as suitable for Haiphong. Orifice type CSO is selected to be placed when the command area is less than 10 ha. For command areas more than 10 ha, either gate type or weir type CSO is selected. In case the risk of tidal ingress is low, weir type CSO is to be placed. On the other hand, gate type is suitable to prevent outlet water back-flow. A brief description is given below.

Type	Command Area	Merits and demerits
Weir	More than 10ha	It is maintenance free, but it is difficult to control the quantity of overflow. When outfall water level rises, water may flow backward.
Gate	More than 10ha	The volume of intercepted wastewater is controlled by the gate. It requires manual control.
Orifice	Less than 10ha	In case of small area, orifice type can be adopted to reduce maintenance. However, a functional decline due to a blockage is expected.

Type of each CSO is determined based on the criteria explained before. As most of the large outlets have the tidal influence, gate type CSOs are proposed for large outlets. This will require manual control of the gate in case of heavy rainfall. Since the gates are small in nature, one staff can operate around 10 gates. Location of CSOs are shown in Fig. 3.3.1.

It can be mentioned here that because of the selection of gate type CSO for the inlet with tidal influence, SPP becomes fairly independent from the drainage priority project. A good share of benefits from the SPP can be obtained even it is implemented without the drainage priority project.

In developed nations, various levels of treatment process are employed for the by passed storm water coming out of the CSO. Considering cost involvement and degree of expected pollution, no such treatment is proposed in the Study.

3.3 Technical Design

(1) Methodology for Sewage Generation Estimation

In the Master Plan Study, sewage generation estimation for the SPP area was provided in Table 4.3.6 (of Volume 1, Main Report). This generation includes ward or phoung wise domestic, commercial, institutional and industrial sewage generation. The calculation considered sewage coverage area ratio, and sewerage service ratio. However, the CSO command area is different from the phoung boundary. As a result an indirect approach is used to calculate the sewage generation for each CSO command area.

Area for each CSO command area is measured from the topographic maps. Each command area includes more than one phoungs. Considering the area of various phoungs included in each command area, a weighted population density is adopted for each phoungs from the population density estimated in the Master Plan Study for each phoungs. Population of each phoung is thus calculated by multiplying the area and weighted population density. However, the total population calculated in this way is slightly different (2 %) from the phoung wise total population. This difference is again adjusted based on the area of each command area. The entire calculations are shown in Table 3.3.1.

Population of each command area is used to estimate domestic sewage generation. However, district level data is used to estimate commercial, institutional and industrial sewage generation. The total sewage generation for these categories is estimated by multiplying the area of each command area with the unit sewage generation for respective districts. To make this estimation more representative, water bodies are excluded from the area calculation.

Table 3.3.2 shows the area of lake in the West Treatment Area. Table 3.3.3 shows the district wise land area excluding water bodies. Unit sewage generation for each district and for each category is calculated based on the land area excluding water bodies. A summary of this calculation is given in Table 3.3.4.

Domestic sewage generation for each command area based on command area population is calculated later in conjunction with the trunk and lateral layout.

(2) CSO Control Structures

As explained above, Orifice type CSO is proposed for smaller outlets having a command area of less than 9 ha. Gate type orifice is proposed for the large outlets having a command area more than 10 ha. Five different sizes of the gate type CSO are considered based on the command area. Design parameters like unit flow, average flow and pipe size for both storm water and wastewater are given in Table 3.3.5.

Though total number of CSO command area is 65, total number of CSO structures is 61, out of which 41 are gate type and 20 are orifice type. There are 4 command areas where it is not possible to place CSO easily. As a result, manhole pumps (small capacity sewage lift pumps placed inside of a manhole) are placed in each of such 4 areas to transfer the sewage to adjoining command area. The breakdown for each sub-catchment and CSO types is shown in Table 3.3.6.

(3) Bill of Quantities for CSO Control Structures

Bill of quantities for gate type and orifice type CSO control structures are given in Table 3.3.7 and 3.3.8, respectively. These include all materials items like pipes, screen and manhole cover, and all work items like excavation, formwork and de-watering.

CHAPTER 4 SEWER PIPELINES

4.1 Planning Issues and Design Criteria

(1) Basic Criteria

Trunk layout is to be planned in a way so that the number of required trunks and laterals is minimized. This will lead to low investment cost, faster implementation, and less maintenance. Also Phase II implementation was fully taken into consideration, as some of these trunks will carry additional sewage after the completion of Phase II. Diameter, depth and gradient are to be selected considering both Phase I and Phase II. Due consideration is given to the trunk layout so that a minimum number of pumping stations is required. Selection of trunk route based on CSO command area is shown in Fig. 3.4.1.

(2) Flow Consideration

For the design of the pipelines, the following flow is considered:

- Hourly Average Dry Weather Flow (ADWF) 1.5 ADWF
- Wet Weather Flow 3 ADWF

(3) Earth Covering and Construction Method

The minimum earth covering is determined at 1.0 m to prevent any collapse of the pipes. The maximum depth of earth covering is determined to be 7.0 m in order to minimize construction cost.

However, the earth covering will increase gradually to satisfy the required gradient. It is conventional that sewage flows in the pipeline by gravity. As the SPP area has relatively flat topography, it is expected that the pipelines will become deep rapidly. When depth is more than 7 meters, earth covering is too big. At that stage, a sewage lift pumping station is required, so that pipes can be placed at shallow depths.

There are various methods of pipeline construction. It is conventional and economic to adopt an open cut method in the case of the depth is in between 1.0 and 4.0 m. However, it is possible to use an open cut method even at the depth of 5.0 m when there are few adverse influences of the construction. For example, open cut method is available even at the depth of 5.0 m in case there are few houses in the vicinity and there is enough room spatially, or when construction is carried out beneath a newly planned road and where there is no inhabitant nearby.

When the earth covering is in between 4 and 7 meters, the pipe-jacking method is adopted. From the restriction of the pipe jacking method, the pipe diameter should be at least 800 mm. When the sewer pipe diameter is under 800 mm decided from the hydraulic condition, a pipe diameter of 800 mm is adopted due to the restriction of the safety of the pipe jacking method.

(4) Conveyance

From the topographic, hydraulic and location viewpoints, it is proposed to place one major conveyance along the Road No. 5. With this location, it will be easy to collect all the wastewater from the trunks and to transfer that to the WWTP.

4.2 Alternative Study

(1) West Sub-catchment

For the west sub-catchment, five alternative trunk routes are considered. These are shown in Fig. 3.4.2. These are as follows:

- W1 Along the river
- W2 Along existing road
- W3 Along Southwest channel
- W4 Along existing road and Road no.5
- W5 Along planned road

Considering the ease of connection with the combined sewer outlets, W1 is the most recommended option. With this option, only one trunk is required for the whole sub-catchment. However, two laterals are required for the complete collection. Layout is shown in Fig. 3.4.3.

(2) Central Sub-catchment

This is the biggest sub-catchment among the three and the population density is also the highest. For the central sub-catchment, five alternative trunk routes are considered. These are shown in Fig. 3.4.2. These are as follows:

- C1 Along the Du Hang lake
- C2 Along existing road
- C3 Along planned road
- C4 Along existing road
- C5 Along the An Bien lake

It is rather difficult to have only one trunk for the central sub-catchment. Considering the ease of connection with the combined sewer outlets, C1, C3 and C5 are the most recommended options. With this option, though three trunks are required for the sub-catchment, it will eliminate the need for a pumping station and laterals. Layout is shown in Fig. 3.4.3.

(3) East Sub-catchment

For the east sub-catchment, four alternative trunk routes are considered. This is shown in Fig. 3.4.2. These are as follows:

- W1 Along the planned road in the western side
- W2 Along existing road
- W3 Along Northeast channel
- W4 Along the planned road in the eastern side

Apparently it is difficult to have only one trunk for the eastern sub-catchment. There can be two choices. First, to have multiple trunks and second, to have fewer trunks with meandering and long layout. Considering the implementation time and connection for the Phase II, it is proposed to have fewer trunks. With this option, two trunks are required for the whole sub-catchment. However, two laterals are required for the complete collection. Layout is shown in Fig. 3.4.3.

(4) Conveyance

Proposed conveyance is divided into three sections. the first section is from the pumping station to the road no. 5. The second section is along the road no. 5. The third section is defined as the section between road no. 5 and the WWTP.

For the first section, that is the portion of conveyance between the pumping station and the Road no. 5, the most optimum location is to place that along the planned Vat Cao extention road.

For the second section, that is the portion of conveyance along the Road no. 5, the most optimum location is to place that along the proposed maintenance road along the An Kim Hai Channel.

For the third section, that is the portion between the WWTP and the Road no.5, a number of options are considered. This is shown in Fig. 3.4.2. These are:

- C-1 along existing road
- C-2 along Southeast channel
- C-3 along the planned road
- C-4 through the industrial area road

C-1 option has a number of limitations due to the narrow width of the road. This will lead to construction difficulty and can not serve as an access road to the WWTP. Under 1B project, a 6 m wide maintenance road will be constructed along the Southeast channel. It will be easy to place conveyance under that road and this can be used as a dedicated access road since the road will be under SADCO control. C-3 option is also feasible, however, the actual implementation is not definite and the road can not be used as a dedicated road. Option C-4 will interfere with the activity of the industrial zone. Thus option C-2 is selected as the route for the third section of the conveyance.

The layout of conveyance is shown in Fig. 3.4.4.

4.3 Technical Design

(1) Gradient and Velocity

The minimum velocity of the wastewater inside the combined sewer pipe is adopted as 1 m/s. This will ensure the self cleaning velocity to prevent deposition inside the pipe. Various hydraulic parameters like slope, hydraulic radius and flow for different pipe diameter are given in Table 3.4.1. All commercially available pipe diameters are covered in the table from diameter of 300 mm to 2000 mm. Gradient is calculated based on required velocity. However, in case the required gradient becomes less than 0.08 %, it is proposed to increase the gradient to 0.08 % to ensure smooth flow. This is the case for the pipe with diameter of more than 1350 mm. Therefore, all pipes with a diameter 1350 mm or more should have a slope of 0.0008. According to the Japanese Sewerage Standard, pipe flow calculated based on minimum velocity and gradient is the full capacity and a safety allowance is required to get the allowable flow. According to that standard, the allowance is 100 % for smaller pipe diameters (from 300 mm to 600 mm), 50 % for the medium diameter pipes (from 700 mm to 1500 mm), and 25 % for the larger diameter pipes (from 1650 mm to 2000 mm).

All the calculations mentioned above are repeated again for the combined sewer pipe. In this case, the minimum velocity is adopted as 0.8 m/s. This calculation is required for dimension pipelines for phase II separate system, which have a direct impact on Phase I pipe dimension.

(2) Design Approach

Each trunk and lateral is divided into segments with nodal value. A schematic layout is shown in Figure 3.4.5. Length, flow, slope, velocity and diameter are calculated for each segment. Invert elevation, and earth covering at each nodal point is also calculated. The whole design calculation is iterative in nature. Only final results are explained here.

Preliminary calculation shows that the east trunk is the governing pipe for the determination of conveyance depth. It is found out that the required depth at the entrance of the treatment plant is around 8m. To reduce the cost and difficulty of construction, operation and maintenance, a sewage lift pumping station is required in the eastern sub-catchment.

Selection of pumping station is also directly related with pipe design parameters like depth and gradient. Location of the pumping station and the pipe design is also an iterative process. Result in one set of calculation is to be fed into the second set and the expected modification is fed into the first set. Pipe design is only explained here based on selected location for the pumping station. Issues related with pumping station selection are given in the following section.

(3) Calculation for Pipe Diameter and Flow

Detail calculation for pipe diameter and flow is given in Table 3.4.2.

Each pipe is divided into various suitable segments. Each segment in turn receives sewage from a number of command areas, and sometimes from Phase II area. Domestic flow is calculated based on population for each command area. A 10 % infiltration flow is added with the combined domestic, institutional, commercial and industrial sewage generation. A peak factor of 3 is used to accommodate the 3 times ADWF. This flow is then compared with Table 3.4.1 to find the proper pipe diameter and slope. Also the full capacity and allowable capacity are given in the table.

(4) Calculation for Longitudinal Section

Detail calculation for longitudinal section is given in Table 3.4.3.

Length of each pipe segment is measured from the topographic maps. Ground elevation of each nodal point is also taken from the topographic maps. The upstream and downstream invert elevation of each pipe segment is calculated from the length and slope. Subsequently, earth covering at each nodal point is calculated. From the iterative calculation, it was found that the governing invert elevation for conveyance come from East Lateral 2 (ET2). This elevation is used for selecting lift head for the pumping station, which is around 3.5m.

Flow from one segment of East Lateral is not possible to collect since the diameter of that segment is very small, resulting in a higher slope. One manhole pump is placed at that location.

Table 3.4.3 also gives the pipe dimension for the connection pipe lines required after the four manhole pumps required due to special location of command area, which was mentioned before.

(5) Manholes

Manhole interval is set depending on the pipe diameter. It is 50 m for 300 mm dia pipe, 75 m for pipe dia from 400 to 600 mm, 100m for pipe dia from 700 to 1000 mm, 150 m for pipe dia from 1100 to 1500mm, and 200m for pipe dia from 1650 to 1800 mm. The total number of manholes is 190, details of which are given in Table 3.4.4.

Plan and sections of different types of manholes are given in Figure 3.4.6.

(6) Geotechnical Recommendation

The geotechnical conditions of the sites have not been investigated within the Study. The conclusions and recommendations are only based on the earlier soil investigations carried out with borings, with standard penetration tests (SPT), auger drillings and sampling, in October - November 1998 in IB Project. Detail results can be found in the Supporting Report.

Concrete, steel or plastic pipes of diameter < 800 mm may be founded on ≥ 150 mm thick compacted sand or gravel layer, when pipes are placed on soft to firm silty sand or silty clay layer (N > 2).

When pipes with diameter < 800 mm are on very soft soil (N < 2), pipes are recommended to be founded on 200mm sand bed rounded with geotextile (filter fabric) and surface of sand bed leveled with 100mm sand layer.

Concrete pipes with a diameter of more than diameter 800 mm should be founded either on concrete slab (d = 100mm) or on timber bed. The need of pile foundation shall be checked during detailed design.

The trenches may be, in general, excavated with nearly vertical sides without supporting up to the depth of 1.3 m. If the backfill is thicker than 2.0m, depth may be 1.8 m. The deeper trenches may be excavated with sloping sides with gradient 2 (vertical) to 1 (horizontal) without support provided that, the bottom of the trench is above ground water level, and the depth of the trench is less than 2.0m.

All trenches that reach below groundwater level shall be supported with watertight sheeting. In addition, it is recommendable to construct vertical supported sides in every case when the depth of the trench is more than 2.5m.

The slopes may be supported either with timber poling boards or with steel sheet piles. The maximum depth of timber poling board is 3.0m. Movable shoring devices may be used when depth is less than 2 m.

(7) Bill of Quantities for Sewer Pipes

All pipes are made of reinforced concrete except the pressure pipes after manhole pumps, which are made of steel. Different types of concrete beddings are required depending on the pipe diameter and depth. Four types of bedding are shown in Figure 3.4.7. For the socket type connections, a rubber ring should be placed inside the joint. This is also given in Figure 3.4.7.

The bill of quantity for the sewer pipe length is shown in Table 3.4.4. This specifies each pipe segment by its construction method, diameter, length and earth covering. The total pipe line length is 19.92 km, out of which 11.77 km is open cut, 7.66 km is jacking and 0.49 km is pressure. A summary is given as follows.

Sewer Pipe Length

Unit: meter

Pipe Diameter (mm)	Open Cut	Pipe Jacking	Pressure Pipe
100	0	0	230
125	0	0	260
300	920	760	0
400	1,600	0	0
500	1,780	0	0
600	380	580	0
700	940	0	0
800	550	0	0
900	1,520	440	0
1000	1,700	1,240	0
1100	1,500	330	0
1200	880	2,720	0
1350	0	0	0
1500	0	0	0
1650	0	640	0
1800	0	950	0
Total	**11,770**	**7,660**	**490**

The bill of quantity for the sewer construction is given in Table 3.4.5. It includes all the items required for the construction such as excavation, backfilling, pavement, concrete, formwork, reinforcement bar, de-watering, etc.

The bill of quantity for the manhole is given in Table 3.4.6. Types of manholes are selected based on Japanese Sewerage Standard. There are 5 types of manholes based on base diameter. However, there are different types for the base diameter of 1.5 meter (Type 3 and 3A). The bill of quantity includes all work items required for the construction.

CHAPTER 5 PUMPING STATION

5.1 Planning Issues and Design Criteria

(1) Manhole Pumps

As explained in previous sections, small pumps are required where flow is difficult to ensure. These pumps are placed inside the manhole so it is called a manhole pump. In total five manhole pumps are considered in this Study. Four manhole pumps are required to transfer sewage from certain CSO command area to nearby command area due to difficulty in placing sewer pipelines. One manhole pump is required in East Lateral to ensure allowable depth of the downstream pipelines.

(2) Sewage Lift Pump

From the calculation of trunk layout, a sewage lift pumping station is required in the eastern side. Design is to be done in a way that investment and operation and maintenance (O&M) costs are minimum.

According to the Vietnamese regulation, required buffer zones for a sewage pumping station are 25 m from residential area and 4 m from road.

Though provision for standby pumps is made, no option for generator is considered. The capacities of the sewer pipes are for 3 ADWF. So a power failure during dry weather will not cause serious problem. Power failure during wet weather will cause problems. To solve this problems, a number of ways can be considered. In one option, extra water is allowed to enter into a bypass manhole in the pumping station. This in turn can be delivered into the conveyance by gravity. This may cause inundation of low lands in the vicinity. In the second option, local inundation can be avoided by controlling CSO gates to prevent storm water coming into the pumping station. In this case, total combined flow is discharged into the water bodies. Expecting power failure is for short term during a storm period, this will have minimum impact on surface water quality.

5.2 Alternative Study

(1) Manhole Pumps

A manhole pump is only suitable when the 3 ADWF is less than 0.1 m^3/sec. Four different types of manhole pumps are proposed based on flow rate. This is shown in the next table.

Types of Manhole-type relay pumping station

Type	Catchment area	Wastewater	°	Pump dia	Pump no.	D (well dia)	d (effective depth)
	ha	m^3/s	m^3/min	mm		m	m
MP1	10	0.01	0.6	80	2	1.5	0.8
MP2	15	0.015	0.9	100	2	1.5	1.2
MP3	25	0.025	1.5	125	2	1.8	0.6
MP4	50	0.05	3	150	2	1.8	1.2

All of these types will have the following same criteria:

- Pit type Wet pit
- Pump type Vertical detachable submersible pump
- Screen type Manual bar screen
- Grit chamber Sand trap

(2) Sewage Lift Pump

Three locations are selected for the pumping station site. These are Van Cao, Kieu Son and An Da. Detailed investigation for these sites including topographic survey, geo-technical investigation and environmental impact assessment were carried out. Van Cao is located along the National Road No. 5. A number of ponds and few houses are located in this site. Kieu Son site is also along the National Road No. 5. Though there is a big pond, there are some houses in the site. This site is surrounded by many households. An Da site is far from the National Road No. 5, and along the proposed Van Cao Extenion road. The site is swampy agricultural land with no houses nor structures. There are also very few houses in the vicinity.

An Da site is selected considering:

- No resettlement is required
- Cost-effective from technical aspect
- Far from National Road no. 5
- Ease of construction as located by the side of planned road
- Less earth filling compared to other two sites.
- Low expected social and environmental impacts

Site layout for the An Da Pumping Station is shown in Figure 3.5.1, which incorporates the buffer zone.

5.3 Technical Design

(1) Manhole Pumps

Based on the area covered and the flow condition, manhole pump type MP1 is selected for command area W6 and W7, type MP2 is selected for command area W14, type MP3 is selected for command area W15, and type MP4 is selected for the sewer pipe segment ET2-1. Details of pressure pump, pump head and manhole depth is given in Table 3.5.1.

Plan and section of manhole pump is shown in Figure 3.5.2.

(2) Bill of Quantity for Manhole Pumps

The bill of quantity for the manhole pump is given in Table 3.5.2. It includes all materials and work items required for the construction.

(3) Sewage Lift Pumping Station

Design of the An Da pumping station is given in Table 3.5.3.

The necessary number of pumps is recommended based on Japanese standard, which means capacity of each pump is one-third of the total requirement. There will be 3 pumps and one standby. In the pumping station, there are additional facilities required. These include screenings, grit chamber, scum removal facility, and sludge handling facility. The pit will be of dry type.

The required capacity of the pumping station is 0.535 m^3/sec. The required capacity of each pump is 0.178 m^3/sec. Diameter of the suction pipe is 300 mm. Actual head is 3.5 m. Including the head loss around pump and force main, required head is 5.5 m. Considering pump efficiency and transmission efficiency, the motor rating is 18.5 kW.

Two screens will be placed before the pump while two grit chambers will be placed after the pump. Screen opening size is between 15 and 25 mm. Grit chamber will be placed on the ground and with retention time of 30 sec. Depth of the sand pit is 30 cm considering a surface loading of 3,600 $m^3/m^2/d$ for combined sewage. Dimension of the grit chamber is 9 m × 1.8 m × 0.5 m, where 0.5 m is the depth of the chamber.

Plan and section of the pumping station is given in Figure 3.5.3 and Figure 3.5.4, respectively.

(4) Geotechnical Recommendation

The geotechnical conditions of the site have been investigated with rotary drilling and standard penetration tests (SPT) in November – December, 2000. Detail results can be found in the Supporting Report.

The soil stratum has very low bearing capacity (< 40 kPa) and it is compressible. The settlements due to 20 kPa additional load will be about 150 - 200 mm. The recommended foundation method for the pumping station is pile foundation. Piles should reach to stiff low plastic clay (layer 5). The estimated bearing capacity of

25 m long cohesion/friction concrete pile (300 mm × 300 mm) is only about 150 kN.

(5) Bill of Quantity for Sewage Lift Pumping Station

The bill of quantity for the pumping station is given in Table 3.5.4. It includes both civil works component and electrical/mechanical components.

CHAPTER 6 WASTEWATER TREATMENT PLANT (WWTP)

6.1 Planning Issues and Design Criteria

(1) Location

The proposed location for the WWTP in the Master Plan of the Study was identical to that proposed by Haiphong Sanitation master plan. Land available at that area is about 10ha. This restriction compels to select Activated Sludge Process only. In the M/P of the Study, Aerated Lagoon (AL) was the most recommended option followed by Modified Stabilization Pond (MSP). Both require more land than 10 ha available at the site. Moreover, a new industrial zone is proposed to be established at that site.

The Study thus proposed to shift the location of the WWTP to further south near the Lac Tray River. The present land use is principally agricultural in nature. Land availability is enough to accommodate the WWTP. Though land acquisition for Phase I is sufficient during the Phase I implementation, steps should be taken to prohibit other uses for the Phase II area. This is very important to ensure smooth operation of the treatment plant, either MSP or AL.

(2) Buffer Zone

According to VN regulation, a buffer zone is required around the WWTP, the values depending on the plant size. For the present case, it is 25 m from dike, 10 m from provincial road and 5 m from waterways.

6.2 Alternative Study

(1) Location

For the AL as treatment process minimum land requirement is around 27 ha total in Phase I and Phase II without required buffer zone. Including the buffer zone (which is a requirement of Vietnamese Regulation) and operational buildings, land requirement is 38 ha.

Because of the land availability, the Study proposed to shift the location of the WWTP as proposed in the draft master plan to further south near the Lac Tray River. The present land use is principally agricultural in nature. In the vicinity of the proposed WWTP, there is an existing dike. A number of roads are planned to be constructed in that area. In this location, area available is around 31 ha. Thus, available land even in this newly proposed area is not enough to accommodate the WWTP.

Considering all alternatives, the Study proposes to relocate the dike and shift one road slightly. The present dike is far from the river edge and vast area is not utilized for any purpose. By relocating the dike, this unutilized land can be effectively used for the WWTP. Shifting of the dike would be between 50 and 100 m. The Study also proposes to shift the north-south oriented road for about 60 m towards west to make it possible to construct the WWTP. Area available after relocating the dike and road is around 38 ha, which is sufficient to construct the treatment plant. The proposed site details are shown in Fig. 3.6.1.

These proposed relocation would cause little adverse impact. Shifting of dike will not cause any performance decrease for the flood control purpose. Shifting of road also has no negative impact on transportation or urban planning.

The total sewerage priority project is shown in Fig. 3.6.2.

(2) Treatment Process

In the draft Master Plan, MSP and AL were proposed. Though MSP is the less expensive method, it requires larger land and its effluent quality cannot satisfy VN standard. After detail discussion with PMU, TUPWS, SADCO and UPI, it was decided to adopt AL as the treatment process. This will require a land of around 38 ha total in Phase I and Phase II.

6.3 Technical Design

(1) Basic Principle

The WWTP will be designed giving full consideration about the Phase II. As a result, a number of facilities will be designed with capacity including Phase II. For all other facilities also, provision will be kept for the extension in the Phase II.

At the entrance of the WWTP, a lift pumping station is required. The capacity of the pumping station will be 3 ADWF. After that preliminary treatment facility will be placed for the 2 ADWF flow. Preliminary treatment facilities will consist of a settling pond of 3 hour retention time and a chlorination tank for disinfection. This will be used in the wet weather to provide certain treatment. The settling pond will store water for the first 3 hours and stored water will be returned to the secondary treatment line after the rain stops. This will ensure proper treatment for the first flash for a 3 hour period. Any flow occurring after first 3 hours will pass through chlorination tank for disinfection before bypassing into the river. The secondary treatment will consist of a series of aerated lagoon for the capacity of 1 ADWF. Settling tanks will be placed after that to separate sludge. Before discharging, the flow will pass through a chlorination tank for disinfection.

The treated wastewater will be discharged into the Lac Tray River. There is no water intake down stream of the treatment plant, thus it is a Class B river according to the Vietnamese standard. This requires that the discharge BOD should be less than 50 mg/l. Also, there is no fishing village or other important place near the treatment plant. Thus, discharge into the river satisfies environmental requirements.

Sludge will be treated in sludge drying bed. Water from the bed will be re-circulated for treatment. Dried sludge will be disposed to landfill site or reused or treated at the proposed septage treatment facility.

The treatment flow diagram is given in Figure 3.6.3.

The sewage generation estimated in the master plan study for Phase I area was 40,000 m^3/day in 2010. Due to modification of the cover area for Phase I, the sewage generation is recalculated as 36,000 m^3/day in 2010. The estimation details are given in Table 3.6.1. Other vital information for the treatment plant is given in the following.

Estimated Generation of Sewage m^3/day

Year	Combined			Separate	Total
	Phase I	Phase II	Sub-total	Phase II	
2010	36,000	0	36,000	0	36,000
2020	40,074	20,462	60,536	11,464	72,000

Average Dry Weather Flow (ADWF) m^3/s

Year	Combined			Separate	Total
	Phase I	Phase II	Sub-total	Phase II	
2010	0.417	0.000	0.417	0.000	0.417
2020	0.464	0.237	0.701	0.133	0.833

Hourly maximum flow (1.5ADWF) m^3/s

Year	Combined			Separate	Total
	Phase I	Phase II	Sub-total	Phase II	
2010	0.625	0.000	0.625	0.000	0.625
2020	0.696	0.355	1.051	0.199	1.250

Wet Weather Flow m^3/s

Year	Combined			Separate	Total
	Phase I	Phase II	Sub-total	Phase II	
2010	1.250	0.000	1.250	0.000	1.250
2020	1.391	0.710	2.102	0.199	2.301

3 ADWF in case of combined sewer
1.5 ADWF in case of separate sewer

Design flow

Pumping station	Peak Wet Weather Flow = 3 ADWF
	Hourly Maximum Flow = 1.5ADWF
Primary Treatment	Wet Weather Flow = 2ADWF
Secondary Treatment	Average Dry Weather Flow = 1 ADWF
Chlorination Tank	Average Dry Weather Flow = 1 ADWF
In-plant pipe	Hourly Maximum Flow = 1.5ADWF

Treatment Flow

Inflow →P/S→Aerated Lagoon →Settling Pond →Chlorination tank →public water body

Sludge in Settling Pond→Sludge drying bed

Excess wet weather flow→Primary treatment→public water bodies

(2) Inlet Pumping Station

The same methodology is used for this pumping station as that adopted for the An Da pumping station. After implementation of Phase II, both combined and separate wastewater will enter in this plant. Two different pumping stations are proposed for the combined flow and separate flow because of the composition difference. Provision is kept for the flow of Phase II area for the combined flow also. All civil works will be made for Phase II demand. However, pumps and motors will be placed for Phase I only. For this purpose, preliminary design for Phase II separate sewerage area is also performed.

Wet weather sewage flow calculated from the sewer pipe design (2.253 m^3/sec) is slightly different from that calculated from the capacity of treatment plant (2.102 m^3/sec). Design of pumping station is carried out using the higher value.

To save energy cost and construction cost, provision is kept for smaller capacity pump. If the Phase I combined flow is 3Q', three pumps are proposed with the capacities of 1Q', 1Q' and 2Q'. During dry weather pump with the capacity of 1Q' will operate, while during wet weather one 1Q' pump and the 2Q' pump will operate. This will ensure a standby capacity of 1Q'. Phase II combined flow is approximately double. In that stage two pumps with 2Q' capacity will be installed. At that stage, one 2Q' pump will operate in dry weather and three 2Q' pumps will operate in wet weather. Two pumps with capacity Q' (total 2Q') will remain as standby.

The detail design of the pumping station for combined flow is given in Table 3.6.2.

The required capacity of the pumping station is 2.253 m^3/sec. The required capacities of pumps are 0.751 m^3/sec for three pumps and 0.376 m^3/sec for two pumps. Diameter of the suction pipe is 600 mm and 400 mm, respectively. Actual heads are 7.3 m for both types of pumps. Including the head loss around pump and force main, required head is 9.3 m. Considering pump efficiency and transmission efficiency, the motor ratings are 110 kW for bigger pumps and 55 kW for smaller pumps.

Six screens will be placed before the pump while six grit chambers will be placed after the pump. Screen opening size is between 15 and 25 mm. Grit chamber will be placed on the ground and with retention time of 30 sec. Depth of the sand pit is 30 cm considering a surface loading of 3,600 m^3/m^2/d for combined sewage. Dimension of the grit chamber is 9 m $\times$ 1.6 m $\times$ 0.8 m, where 0.8 m is the depth of the chamber.

The pumping station will receive separate sewage in Phase II. A tentative design for Phase II separate sewage pumping station is given in Table 3.6.3.

The required capacity of the pumping station is 0.199 m^3/sec. There will be three pumps and one standby pump. The required capacity of pump is 0.066 m^3/sec each.

Diameter of the suction pipe is 300 mm. Actual heads are 7.3 m. Including the head loss around pump and force main, required head is 9.3 m. Considering pump efficiency and transmission efficiency, the motor ratings are 15 kW.

The plan and section of the pumping station is shown in Figure 3.6.4.

(3) Preliminary Treatment for Bypass Flow

During the wet weather, the treatment plant will receive 3 ADWF while the treatment capacity is 1 ADWF. The remaining 2 ADWF will enter into storm water sedimentation pond.

Preliminary treatment facilities will consist of a settling pond of 3 hour retention time and a chlorination tank for disinfection. This will be used in the wet weather to provide certain treatment. The settling pond will store water for the first 3 hours and stored water will be returned to the secondary treatment line after the rain stops. This will ensure proper treatment for the first flash for a 3 hour period. Any flow occurring after first 3 hours will pass through chlorination tank for disinfection before bypassing into the river.

Two ponds are considered for such preliminary treatment. One pond will be constructed in each phase. With a depth of 1.5 m, the required surface area of each pond is 1 ha. Side slope of the bank is 1:2. A free board of 0.5 m is provided. The retention time is 3 hours, which will lead to one-third BOD reduction. The details calculation are given in Table 3.6.4. The plan and section is shown in Figure 3.6.5.

(4) Aerated Lagoons

The flow will be distributed in a number of lagoons by splitter chamber. The plan and section of the splitter chamber is shown in Figure 3.6.6. There will be 4 lagoons for Phase I and 4 lagoons for Phase II. Out of 4 lagoons in Phase II, 2 will receive flow from combined sewer system while the rest 2 will receive flow from separate sewer system. The retention time is set in a way that is sufficient to reduce more than 85 % of BOD load and 80 % of SS load. This effluent from the lagoon will comply with the VN standards, which is 50 mg/l of BOD for discharging into a Class B river like Lac Tray.

Since the process is semi-natural, efficiency depends on the ambient temperature. For the winter season, design air temperature is set at 14ºC while the design air temperature for summer months is 28ºC. Design calculation is done separately for winter and summer. Thus the retention time will be 3 days in winter and 1.9 days in summer. This means that during the summer months, full time aerator operation will not be required.

With a depth of 3 m, area of each lagoon is 9,000 m^2. The side slope of the bank is set at 1:2. A free board of 0.5 m is also provided.

Oxygen will be supplied by fixed type surface aerator. Though moving type is more efficient, it requires skilled operation. It is proposed to set eight aerators in each lagoon. Total number of aerators is 64, eight in each lagoon. Aerator power is 55 kW.

The detail calculation is given in Table 3.6.5. The Plan and section is shown in Figure 3.6.7.

(5) Settling Ponds

Settling ponds will be designed for 1 ADWF. There will be 8 ponds corresponding to aerated lagoons. One day retention is sufficient for the acceptable settlement. Cleaning interval is 6 months. With a depth of 1.5 m, area of each pond is 6,000 m^2. The side slope is set at 1:2. A free board of 0.5 m is provided. The detail calculation is given in Table 3.6.6. The plan and section is shown in Figure 3.6.8.

(6) Chlorination Tank

There will be two types of chlorination tank, one for the flow coming out from secondary treatment train with 1 ADWF capacity and another for the bypass water coming out from the storm water settling pond with 2 ADWF capacity. Two tanks are proposed for each type, one for each Phase.

Chlorination will be carried out by liquid chlorine to reduce the risk. A contact time of 15 min is selected. The treated wastewater chlorination tank is designed with a depth of 1.5 m, and required surface area is 500 m^2. The detail calculation is given in Table 3.6.7.

For the storm water chlorination tank, using the same contact time and same depth as above, the required surface area is 840 m^2. The detail calculation is given in Table 3.6.7.

(7) Sludge Treatment

Sludge treatment is proposed through sludge drying bed. There will be 8 bed series corresponding to lagoon number. In each series, there will be 2 beds. Target water content in the dried sludge is 60 %. Drying duration is fixed on the basis of gravity settling, wind, evaporation, temperature, relative humidity and probability of rainfall during drying. Drying duration is found as 23 days. Area required for each bed is 703 m^2. Dried sludge volume is 40 m^3/day. The detail calculation is given in Table 3.6.8. The plan and section is shown in Figure 3.6.9.

There are a number of options for the disposal of the dried sludge:

- Use as soil improvement material.
- Use as cover soil of the landfill site.
- Dispose to the landfill site.

- Further treatment at the proposed septage treatment facility.

(8) Internal Pipelines

All the internal pipelines are calculated based on peak flow of 1.5 ADWF. Detail calculation is given in Table 3.6.9.

Since the outfall river is a tidal river, discharge is not possible continuously. Considering that it is possible to discharge into the river for half of the time, the pipelines can still handle the discharge. All pipelines are designed for 1.5 ADWF and there is a 100 % allowance for small diameter pipes.

(9) Required Building Space

A number of control and administrative offices are required for the effective operation of the plant. These are control building, pump station, machine house, electric panel house, sludge pump house, chlorination house and watchman space. The number of buildings, and their space (both total and Phase I) are given in Table 3.6.10. A more detail breakdown for the control building is given in Table 3.6.11. The plan and section of the control building is shown in Figure 3.6.10. The plan and section of the O&M machine building is shown in Figure 3.6.11.

(10) Layouts

Treatment plant layout is given in Figure 3.6.12. A more detail layout is given in Figure 3.6.13. Hydraulic profile for the plant is given in Figure 3.6.14. It may be mentioned here that during the period when the water level of the outside river is higher than the top elevation of chlorination tank, discharge is not possible. During that time, water will be stored within various ponds by closing the outlet. Pipe capacity is sufficient to discharge the stored water during the low tide. Pipeline plan layout inside the plant is shown in Figure 3.6.15.

(11) Geotechnical Recommendations

The geotechnical conditions of the site have been investigated with rotary drilling and standard penetration tests (SPT) in November – December, 2000. Detail results can be found in the Supporting Report.

The site of the Wastewater Treatment Plant is situated at the end of South- West Channel along Lach Tray River in the South-West part of the project area. The area is mainly rice field and some irrigation channels cross the area. Ground surface is in general on level +2.5 to +3.0 m (the north Vietnam Datum). The site borders Lach Tray River and a dyke in the South and the South -West Channel in the West.

The soil conditions are poor at the site and soil stratum has low shearing strength. The prevailing clayey soils are compressible. The calculated geotechnical bearing capacity of upper soil stratum (layer 2) is only qa = 40 kPa for square pad footing. At least 500 mm compacted sand pad should be spread under the footings. Geotextile (filter fabric) is recommended between fill material and natural soil.

The floors of light buildings can be constructed by slab-on–grade and 200 mm compacted sand or gravel layer should be spread under the floor.

The total settlement of the footings with 200 kN vertical load is about 60 - 70 mm. Differential settlements may in that case be about 15 to 25 mm. If there are buildings with high column loads (> 200 kN) or / and the settlements of the structures are critical, pile foundation should be used. Piles should penetrate at least to stiff low plastic clay (layer 5). The estimated bearing capacity of 25 m long cohesion/friction concrete pile (300 mm $\times$ 300 mm) is only about 165 kN.

(12) Bill of Quantity

Detail civil bill of quantity for the treatment plant is given in Table 3.6.12. A facility list for electro-mechanical portion is given in Table 3.6.13.

CHAPTER 7 SUPPLEMENTARY COMPONENT

7.1 Manhole Pump

In the detailed design stage, flow in each pipeline should be checked. Careful consideration is made to ensure uninterrupted flow in all pipelines in the Study. In case it is found that flow is not possible in certain time, manhole pumps should be used. Four types of manhole relay pumping stations are proposed in the previous sections. Costs for five additional manhole pumps are included in the Study.

7.2 Interceptor Pipe

In the SPP area, not all households are connected with the existing sewer pipes. New combined sewer and rehabilitation of existing pipes are included in the drainage priority project. In addition, there are a number of households now discharging their wastewater directly to surface water bodies. To collect such wastewater, new interceptor pipes are considered to be constructed. Exact location and layout should be fixed during the detail design stage. Cost for a total 20 km of such pipe is included in the Study. This includes 10 km of 300 mm dia pipe, 5 km of 400 mm dia pipe, 3 km of 500 mm pipe and 2 km of 700 dia pipe. Total number of manholes is estimated as 270 with 900 mm diameter.

CHAPTER 8 COST ESTIMATES

8.1 Investment Cost

Investment cost includes direct construction cost and compensation cost.

Direct construction cost is estimated based on bill of quantities given in this chapter and unit price presented in Chapter 3, Part 1 of volume 2. Details cost estimation can be found in the Supporting Report. A summary is given below.

Item	Cost (US$1000)
1. Trunk Sewer, Open Excavation	6,791
2. Trunk Sewer, Pipe jacking Method	17,575
3. CSO	2,266
4. Manhole	354
5. Manhole Pump	419
6. An Da Pumping Station	926
7. Treatment Plant	12,975
Total	41,306

The cost of supplementary component is estimated roughly. Total cost is US$4.4 million (of which, costs for pipe is US$3.8 million, for manhole is US$0.4 million and for manhole pump is US$0.2 million).

Considering 10 % preparatory and mobilization cost, direct construction cost for the main component is US$50.36 million.

Cost of land acquisition and compensation is estimated based on actual field condition and details is given in Supporting Report. Total cost is US$2.2 million. A summary is given below.

Item	Cost (US$1000)
1. Treatment Plant (23 household and 38 ha)	1,568
2. Pumping station (3,800 m^2)	11
3. Dike Relocation	586
Total	2,165

The total investment cost for the sewerage priority project is US$52.56 million.

8.2 O&M Cost

To operate the new facilities proposed in the Priority Project, new staffs are required. A detail estimation of the incremental staff is given in Table 3.8.1. The estimation is based on the work performance of the existing staff, expected work load, available working hour, available equipment and other factors. Total number of new staff is 51.

Unit cost for various levels of labor is given in Chapter 3 of Part 1, Volume 2. The unit cost for the staff is assumed based on that information. Estimated incremental staff cost for Sewerage PP is given in Table 3.8.2. Yearly cost for Phase I is US$0.1 million. Office accessory cost is assumed as 20 % of the staff cost.

Electric power is require to operate 10 manhole pumps, An Da pumping station, treatment plant inlet pumping station, grit collector, aerator, various pumps and lighting. Based on the unit cost of VND846/kWh, the total yearly cost is US$0.14 million. Details are given in Table 3.8.3. For repair and minor maintenance, an additional 20 % cost is estimated.

Hypo Chlorite will be required for the disinfection process. The yearly cost is US$49,000. Detail calculation is shown in Table 3.8.4.

The sludge generated after the sludge drying bed has to be disposed to the disposal site. The cost includes loading, hauling, and transporting. The annual cost is estimated as US$82,000. Detail calculation is shown in Table 3.8.5.

To operate any treatment plant, regular water quality monitoring is a must. There are some tests that should be carried out at least 2 times per month, while other tests should be done at least 2 times per year. Detail calculation is shown in Table 3.8.6. Annual cost US$2,600.

Total O&M cost is summarized below. The total cost is US$0.5 million/year.

O&M cost Unit: US$1,000/Year

Item	Phase I
Staff cost	104
Office accessory	21
Electricity charges	140
Maintenance & repairs	28
Chemicals and cleaning materials	49
Sludge transportation and disposal	82
Wastewater examination	3
Total	426

CHAPTER 9 PROJECT IMPLEMENTATION PLAN

9.1 Implementation Schedule

The implementation of the sewerage priority project is proposed to start from mid 2004 (beginning with pre-construction work) and to be completed by mid 2010. Loan arrangement is to be completed by mid 2003. Detail design and pre-construction will take about one year to complete. Treatment plant will be constructed over 3 years and is to be completed by 2007. Pumping station will be constructed over 2 years and is to be completed by 2009. CSOs, pipelines and supplementary components will be constructed gradually over the entire six year implementation period.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Feasibility Study										
Loan Arrangement										
Detailed Design										
Pre-Construction Work										
CSO										
Pipelines										
Pumping Station										
Treatment Plant										
Supplementary Components										

9.2 Operational and Organization Plan

(1) Operational Plan

The Project includes CSOs, sewer pipes, pumping stations, and wastewater treatment plant. Proper operations of these facilities are important to tap optimum service from these facilities.

There are two types of CSOs proposed in the Project, namely gate type and orifice type. Both types of CSOs need periodic maintenance. Screens are placed in all CSOs. Workers should periodically clean those screens. However, gate type CSOs also need gate operation. When rainfall intensity and duration are high, gates should be closed manually. These gates are simple to operate and SADCO staffs can operate these gates based on a operation manual. One staff can operate a number of CSOs depending on the location. There is no need to keep dedicated staff for such gate operation since need for such operation occurs only limited times in a year. SADCO's district level regular staff can handle this situation in addition to their regular duties.

Sewer pipes and manholes need periodic cleaning. Smaller diameter pipes can be cleaned manually while suction pumps should be used for larger diameter pipes. SADCO already has these types of equipment and there is a provision of additional equipment under 1B project.

Pumping stations need periodic cleaning and also periodic instrument inspection. Repair should be done based on the operational manual if required. Repair cost is included in the O&M cost.

Routine water quality test is important for the smooth operation of wastewater treatment plant. Parameters and frequency of such tests are proposed in the Study. The plant also needs periodic cleaning. Since discharge is not continuous, regular gate control is required.

(2) Project Management in SADCO

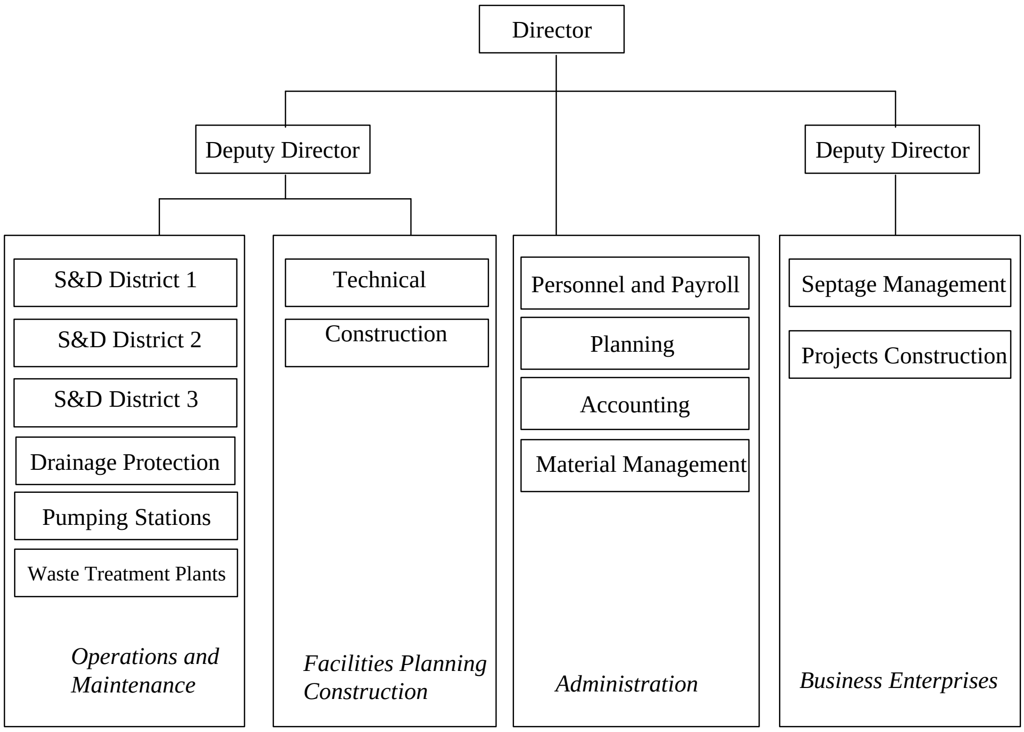
Prior to the implementation of the proposed project implementation, the existing PMU in SADCO will have the experience with the World Bank 1B project. The PMU is being strengthened along with the overall capacity building efforts of the Finnida funded Water Supply, Drainage, Sewerage, and Sanitation Management Program, 2001-2004 (WSDSSMP). To date progress in developing the staff in SADCO has been slow. However by the time the priority project for sewerage is ready for implementation, it is expected that the capability of the PMU to effectively execute and manage the priority projects will be improved.

However, for planning purposes, it should be assumed that:

- The PMU unit will require further technical assistance to facilitate their participation in the implementation of the priority project
- International advisors will need to participate directly in the bidding, procurement and construction supervision

(3) Prior Reorganization of SADCO

SADCO will need to be reorganized to successfully implement the priority project. The overall organizational structure will be as in the following figure.



Organizational Structure of SADCO prior to implementation of the priority projects.

(4) Institutional Changes

The priority project on sewerage will build the wastewater treatment plants. This will require creation of Wastewater Treatment Plant unit. The main institutional consequences of the priority project on sewerage are summarized in following table.

Main Institutional Consequences of Priorities Project on Sewerage

Priority Project Element	Institutional Consequences
Phase 1 (2000-2010) Sewerage • West WWTP (Q=36,000 m^3/day) • Relay P/S (Q=0.5m^3/sec) • CSO Control Structure (61), Manhole Pump (10) • Sewer Pipelines (20 km)	• Creation of technical unit in SADCO for WWTP with trained S&D engineers • Increased O&M

(5) Manpower Estimates

The following table provides an estimate of the incremental staffing needs for sewerage priority project. This is based on present staff, their efficiency, incremental work load, available facilities and work approach. This also includes staff required for regular monitoring of water quality in the treatment plants.

Incremental Staffing Needs for the Sewerage Priority Project

	Incremental Staff (Number)				
	Engineer/ University	Technical/ School	Total O&M	Admin.	Total
Phase I (begin 2006)					
West WWTP	2	18	20	10	30
Relay P/S	0	4	4	2	6
CSO control structure, Manhole pump	0	6	6	3	9
Sewer pipe	0	4	4	2	6
Total	2	32	34	17	51
Phase II (begin 2013, incremental to Phase I)					
West WWTP	2	18	20	10	30
East WWTP	2	12	14	7	21
Relay P/S	0	12	12	6	18
CSO control structure, Manhole pump	0	6	6	3	9
Sewer pipe	0	12	12	6	18
Total	4	60	64	32	96

(6) Manpower Training

Training and technical assistance will be undertaken to:

- Strengthen the capacity of the project management unit (PMU) to ensure that it can effectively implement the sewerage project
- Increase the technical competence of sewerage teams, wastewater treatment plant operators, and pumping station operators to ensure sustainability of new system improvements

The following set of specific courses must be developed and delivered:

Unit	Specific Courses
Project Management	• Project management system • Financial management skills (planning and budgeting • Bidding and Contract Management • Engineering skills • Foreign Languages
Sewerage	• Sewer Cleaning, Rehabilitation and Maintenance • Engineering and Maintenance of Sewerage Systems
Technical Department	• O&M of Wastewater Treatment Plants • O&M of Sewerage Pumping Stations

During the commissioning phase for wastewater treatment plant and pumping stations, it will be essential to have technical experts to ensure that the plants and stations are operating efficiently. Operating procedures and manuals must be developed to provide technical guidance for SADCO staff.

Specific measures for manpower training are proposed as follows.

1) To receive technical assistance from WSC

WSC has relatively long history in Haiphong in the fields of sanitation improvement and management. Their technical skills as well as financial and administrative skills are considered most developed among the sanitation-related companies in Haiphong. Water treatment skills and pipe maintenance skills may be applicable for sewerage management including sewage treatment and pipe maintenance. Through the collection of sewage charge which is currently done by WSC on behalf of SADCO as surcharge on water charge, the 2 companies are already in cooperation. It may be advisable therefore that training opportunity is given by WSC to SADCO through receiving SADCO staff in WSC for training for certain period. Alternatively WSC may give training by dispatching their staff as trainee to SADCO. Since WSC has implemented water supply projects to date, their project management experience and knowledge can also be learnt and transferred to SADCO.

2) To learn from the preceding projects and experience in the cities in Vietnam

In Vietnam, sewerage projects will be implemented in the near future the cities of Hanoi and Ho Chi Minh. Their experience and knowledge can be learnt and transferred to SADCO in various manner in the similar manner as mentioned above for the cooperation between WSC and SADCO.

3) To study in appropriate academic organizations

In Haiphong, the Haiphong Private university has an Environment Faculty and can offer the educational opportunities for sanitation and environmental subjects. Marine university can also offer opportunities for related subjects. In Hanoi located only 2 hours distance from Haiphong, several universities are established which can offer courses related to sanitation management including the followings:

- Hanoi University of Civil Engineering (Center for Environmental Engineering for Towns and Industrial Area)
- Hanoi University of Technology (Center for Environmental Science and Technology)
- Hanoi National University
- Hanoi Architecture University
- Hanoi Politechnique University
- Dong Do Private University
- Asian Institute of Technology, Hanoi Branch

The offered courses by Hanoi University of Technology, which is closely related sanitation management, for example, include Environmental Chemistry, Environmental Pollution Control, Water Pollution and Treatment Technologies, Design and Management of Wastewater Treatment Plant, Collection and Treatment of Solid Waste and Sewerage Network for Urban Areas.

These courses would provide good training opportunities.

4) Training by means of the technical assistance by overseas public sector organizations

Ministries and municipal governments of the advanced countries have long experience in the drainage management and their cooperation should be sought.

(7) Cost Estimate for Training and Technical Assistance

The estimate total cost for training is US$36,000 and for technical assistance for a sewerage advisor to project management unit, wastewater treatment plant advisor, and pumping station advisor is US$450,000. The details are given in the following table. Training and technical assistance will be provided over a two- year period from 2006 to 2007. It may be mentioned here that cost for training and technical assistance is not included in the Priority Project cost estimates.

Estimated Cost for Training and Technical Assistance

I. Training	1	2	3	4	5	6
	Trainee	Course Units	Days/ Unit	Trainer Days	Cost/ Day	Total Cost
1. Sewerage and Drainage Units						
Cleaning, Rehabilitation, and Maintenance	70	7	5	35	100	$ 3,500
Engineering and Maintenance	10	2	5	10	100	$ 1,000
CSO O&M	6	2	5	10	100	$ 1,000
Equipment Operation and Maintenance	70	7	20	140	100	$ 14,000
2. Project Management Unit						
Project Management Systems	10	1	5	5	100	$ 500
Financial Management	5	2	5	10	100	$ 1,000
Bidding and Contract Management	5	1	10	10	100	$ 1,000
3. Drainage Protection Unit						
Point Source Sampling	15	2	10	20	100	$ 2,000
Environmental Monitoring	15	2	10	20	100	$ 2,000
New Regulation and Inspection Procedures	15	1	10	10	100	$ 1,000
4. Pumping Stations						
O&M of Pumping Stations	4	3	20	60	100	$ 6,000
5. Wastewater Treatment Plants						
O&M of Waste Treatment Plants	12	6	5	30	100	$ 3,000
TOTAL COSTS TRAINING						$ 36,000

II. Technical Assistance - Priority Projects	Person Months	Cost/ Month	Total Cost
1. Sewerage and Drainage Advisor - Project Management	12	25000	$ 300,000
2. Wastewater Treatment Plant Advisor	3	25000	$ 75,000
3. Pumping Stations Advisor	3	25000	$ 75,000
TOTAL COST TECHNICAL ASSISTANCE			$ 450,000

CHAPTER 10 PROJECT EVALUATION

10.1 Objective Achievement

(1) Project Objectives

The Implementation of the Sewerage Priority Project has 3 major objectives as follows:

- Improvement of public health
- Improvement of the quality of ambient water bodies
- Reinforcement of the economic activities and upgrade the environment for future economic growth

Public health improvement objective will be achieved by allowing the connected households and buildings to discharge both black and grey waters into the system and thereby providing a sanitary environment.

Sewage discharged into the water bodies without treatment, will be collected and treated in the waste water treatment plant. Pollution loads flowing into the water bodies will be much reduced and the quality of ambient water bodies will be much improved.

With the upgraded sanitary condition, land value of the project area will be enhanced and economic growth will be stimulated. These economic benefit will be discussed in the following section of this chapter.

(2) Objective Achievement Evaluation

1) Evaluation by Means of Impact Indicators

(a) Public Health Iimprovement

The overall public health condition will be improved which will have beneficial impacts on the whole city population which will be 1.909 million in the year 2010 and 2.121 million in the year 2020.

2) Evaluation by Means of Development Indicators

Sewerage Priority Project will provide the central sewerage system for about 11km^2 where 240 thousand residents will be living in the year 2010 and 286 thousand in the year 2020. Living environment will be upgraded in this directly affected area. Economic potential of this area will also be enlarged.

In the year 2010, BOD load to be discharged into the water bodies will be reduced by 9,673 kg per day. Namely, about 72 % of the BOD load will be removed, which would be discharged if Sewerage Priority Project is not implemented.

3) Evaluation by Means of Operation Indicators

Through the implementation of the Sewerage Priority Project, about 36,000 m^3 of sewage in 2010 will be treated at the waste water treatment plant. The discharge water quality after treatment will be around 50 mg/l which satisfies the Vietnamese standard.

10.2 Economic Evaluation

10.2.1 General Principles

The general principles regarding economic evaluation background and methodology for the sewerage priority project are similar to those set out above for the drainage project in Part 2, 8.2. As in the case of drainage, economic benefits are difficult to quantify.

For example, while the sewerage project will undoubtedly bring about significant improvements in public health, there are not adequate epidemiological data to assess the extent to which this is so. It is not possible to disentangle the contribution that improved drainage makes in the reduction of waterborne disease, when so many other factors are likely to have an effect. In particular, the relatively small number of households who have access to potable water supply via house connections, remains a major potential source of waterborne disease.

The sewerage project also does not immediately create a direct benefit for individual households in a way in which their willingness to pay for this service can be demonstrated. The project will not immediately lead to an increase in the number of properties connected to public sewers; however, this may be expected to occur in the longer term.

As with the drainage project, it is judged that if adequate data were available, the economic justification of the project would be revealed by an increase in property values in the affected area, or by an increase in the economic productivity of the affected area, but data are not available to predict precisely what these impacts would be.

The same approach, using “switching values”, which estimate the increases in property values or land productivity required to demonstrate project justification, is used, and a judgment then made as to whether such increases can reasonably be expected.

Similar assumptions are made as for the evaluation of the drainage project, i.e. (a) that there is no economic growth in the Study Area after year 2001, and (b) that economic growth will correspond to the Average Scenario referred to in the Sanitation Master Plan Report. Results of the analysis are as follows.

10.2.2 Least-Cost Solution

For the preparation of the long-term plan for sewerage improvement as an integral part of SMP, 4 alternatives are formulated; S1, S2, S3 and S4. These alternatives are compared from various aspects including the scope of beneficial impact, technical feasibility and cost-effectiveness. Consequently, S3 has been selected. The proposed Sewerage Priority Project is the phase 1 or the first phase of the proposed S3 alternative.

Among the 4 alternatives, target area of S1 is smaller, not covering the old city center while the other 3 have the same target area. While S2 is the most cost-effective, the small-bore technology adopted for S2 is not yet fully proven, requiring small pilot-scale project to be implemented before full-scale project is realized. Of the 2 remaining alternatives of S3 and S4, S3 requires the smaller investment cost per beneficiary or about 85 % of S4, the second least-costly. Conclusion will not be affected when comparison is made in terms of the overall cost including O&M cost because O&M cost is small compared with the investment cost and its ratio to the investment cost is about the same for the all alternatives.

10.2.3 Economic Feasibility

The approach used for sewerage is similar to that described above for drainage. Details of the calculations are contained in Tables 3.10.1 and 3.10.2.

(1) Base Case Property Values and Urban Productivity

The priority sewerage project provides direct benefits for properties located in the same as the priority drainage project, although the number of people obtaining service is slightly less, i.e. about 90 %. Otherwise, the following calculations assume the same general parameters about incomes, property values, and productivity as detailed in Part 2, 9.2.3 above.

The current value of properties in the project area, assumed to be the same in the 2003 base year for the “No Growth” case, is therefore US$795.7 million. For the “Average growth” scenario it is US$1,678 million.

A similar factor is applied to the productivity data, the present worth of value added in the area being estimated at US$1,211 million under the “No Growth” scenario and US$2,820 million under the “Average Growth” scenario.

(2) Economic Feasibility of the Priority Sewerage Project: Impact on Property Values and Productivity

The costs of the sewerage project as shown above are now compared with the two selected indicators to test if the impact required to demonstrate economic justification is in fact likely to be met. The table below shows the costs of the project in relation to the two indicators, i.e. property values and productivity. In each case, present values at a 10 % discount rate, a 20-year time horizon, and a 2003 base year are used.

Cost of Sewerage Project as Percentage of Property Values and Productivity in the Project Area

	Present Value of the Property or GRP as of 2023 with 2003 as the Base Year (US$ million)	Present Worth of Project Cost (US$45.51 million) as % of Values in Column (b)
(a)	(b)	(c)
Property value – under No Growth case	796	5.7%
Property value - Average Growth case	1,678	2.7%
Project Area GRP value – under No Growth case	1,211	3.8%
Project Area GRP value – under Average Growth case	2,820	1.6%

It is the judgment of the Study Team that these data provide a reasonable economic justification in cost-benefit terms for the sewerage project, taken in isolation, as long as the “Average Growth” scenario is realized. Under the “No Growth” scenario, which is rather unrealistic, the data do not convincingly demonstrate that the sewerage project would be economically justified.

The various assumptions and estimates used to address project impacts are adequate as sensitivity tests on the benefit side. Sensitivity of the results to variations in cost estimates is also tested. The following table shows the percentage increases required to demonstrate project justification under three assumptions, namely the base case (as in the preceding table) and where project costs are increased by 10 % and 20 % respectively.

Cost of Sewerage Project as Percentage of Property Values and Productivity in the Project Area: Sensitivity to Cost Estimates

	Base Case	Costs + 10%	Costs + 20%
Property value – under No Growth case	5.7%	6.3%	6.8%
Property value - under Average Growth case	2.7%	3.0%	3.2%
Project Area GRP value – under No Growth case	3.8%	4.2%	4.6%
Project Area GRP value – under Average Growth case	1.6%	1.8%	1.9%

These results suggest that the sewerage project would probably satisfy economic justification criteria even with an increase in project costs of 20 %

10.3 Financial Evaluation and Affordability

10.3.1 Affordability of Sewerage Program

Affordability of the sewerage program as a whole, not just the priority project, is assessed for the reasons described earlier for drainage, using per capita GRP in direct beneficiary areas; per capita income of direct beneficiaries, and total HPPC expenditures as the key indicators. Results are summarized in the following two tables.

In column (2) of these tables, investment costs are amortized, thereby showing how much it will cost, year by year, to repay loans required to finance the program. It is assumed here that funds will be borrowed on terms that correspond on average to a 25-year loan at a 5 % interest rate. Note that even if funds are provided in grant form, or on a more favorable basis than the above, they may still represent financial opportunities foregone, and will thus typically involve real economic costs to the recipient.

Sewerage program costs, number of direct beneficiaries in the Study Area and Haiphong, and costs per capita are shown in the following:

Sewerage Program Costs, Study Area and Haiphong, 2001-2020

Costs in 2000 prices

Year	Capital Costs (US$'000)	Amort. Val of (1) (US$'000)	Cumulative Val of (2) (US$'000)	Recurrent Costs (US$'000)	Total Costs (US$'000)	Study Area Population	Cost Per Capita Study Area (US$)	Cost Per Capita Haiphong (US$)
2001	0	0	0	0	0	567,387	0.00	0.00
2002	0	0	0	0	0	573,785	0.00	0.00
2003	1,970	140	140	0	140	580,183	0.24	0.08
2004	8,032	570	710	0	710	586,581	1.21	0.40
2005	17,859	1,267	1,977	0	1,977	592,579	3.34	1.10
2006	19,475	1,382	3,359	0	3,359	599,245	5.61	1.85
2007	16,710	1,186	4,544	309	4,853	605,911	8.01	2.63
2008	10,712	760	5,304	430	5,734	612,576	9.36	3.08
2009	10,712	760	6,065	559	6,624	619,242	10.70	3.51
2010	8,789	624	6,688	573	7,261	625,908	11.60	3.80
2011	22,861	1,622	8,310	585	8,895	632,517	14.06	4.61
2012	31,389	2,227	10,537	646	11,183	639,126	17.50	5.73
2013	31,389	2,227	12,764	897	13,661	645,735	21.16	6.92
2014	14,333	1,017	13,781	1,147	14,928	652,344	22.88	7.49
2015	14,333	1,017	14,798	1,189	15,987	658,953	24.26	7.93
2016	14,333	1,017	15,815	1,233	17,048	665,556	25.61	8.37
2017	14,333	1,017	16,832	1,276	18,108	672,160	26.94	8.80
2018	14,333	1,017	17,849	1,318	19,167	678,763	28.24	9.22
2019	14,333	1,017	18,866	1,361	20,227	685,367	29.51	9.63
2020	14,333	1,017	19,883	1,403	21,286	691,970	30.76	10.04

Affordability of the proposed program can be assessed in light of the information provided in the following table:

Affordability of the Sewerage Program, 2001-20:
Costs as Percentage of Key Indicators

Costs in 2000 prices

Year	Total Cost (US$'000)	Total Cost as % of Study Area GRP (%)	Total Cost as % of Haiphong GRP (%)	Total Cost As % of HPPC Exp. (%)	Total Cost as % of Study Area Disp. Inc. (%)	Annual Per Cap. Cost in Study Area (US$)
2001	0	0.00	0.00	0.00	0.00	0.00
2002	0	0.00	0.00	0.00	0.00	0.00
2003	140	0.03	0.02	0.19	0.06	0.24
2004	710	0.13	0.08	0.92	0.26	1.21
2005	1,977	0.34	0.22	2.42	0.69	3.34
2006	3,359	0.52	0.33	3.69	1.03	5.61
2007	4,853	0.66	0.44	4.85	1.33	8.01
2008	5,734	0.71	0.47	5.24	1.42	9.36
2009	6,624	0.75	0.50	5.59	1.50	10.70
2010	7,261	0.75	0.51	5.68	1.51	11.60
2011	8,895	0.87	0.59	6.55	1.74	14.06
2012	11,183	1.03	0.70	7.77	2.06	17.50
2013	13,661	1.19	0.81	8.99	2.39	21.16
2014	14,928	1.24	0.84	9.33	2.48	22.88
2015	15,987	1.26	0.86	9.51	2.53	24.26
2016	17,048	1.29	0.87	9.68	2.57	25.61
2017	18,108	1.31	0.89	9.83	2.61	26.94
2018	19,167	1.32	0.90	9.97	2.65	28.24
2019	20,227	1.34	0.91	10.10	2.68	29.51
2020	21,286	1.36	0.92	10.22	2.72	30.76

Note: Investment costs on amortized basis

This table indicates that the sewerage program, in isolation, satisfies affordability criteria. In 2010 it will account for only 0.75 % of Study Area GRP, and less than 6 % of HPPC expenditure . As proposed in Vol 1., Ch. 7.4, the target for full recovery of O and M costs in the form of user charges should be the year 2010. Achievement of this target would only require 0.12 % of beneficiaries' disposable incomes that year.

The results are however sensitive to the assumptions made about economic growth, and therefore of disposable incomes and HPPC expenditures. Table 3.10.3 shows how the preceding results would change if economic growth is half of that estimated above, and costs increase by 10 % and 20 %. Overall affordability in terms of GRP would still be satisfactory, but the impact on the HPPC budget would be specially significant, and in 2010 the sewerage program would account for 9 % of HPPC expenditure.

10.3.2 Funding Requirements and Financing Plan

As in the case of drainage, it is proposed that external assistance should be obtained for the priority project. It is assumed that funding will be available on the following terms:

- Interest rate for construction and procurement 1.3 %, and for engineering 0.75 %
- Funding available for 85 % of project costs, repayable over 30 years after a 10-year grace period, during which time interest only is paid

Table 3.10.4 shows the repayment schedule and total financial burden under these conditions. The Average Growth Scenario and base case project costs (in current prices) are assumed.

It is also assumed that the responsibility for repayment of loans for the selected priority projects ultimately rests with HPPC. Table 3.10.4 shows the percentage of HPPC expenditure that would be required to repay the loan, plus the associated recurrent costs of the projects. In addition, HPPC would have to fund the 15 % of project costs not financed by the external lender.

The table shows that during the project construction period, when 15 % of project costs must be found in cash terms, the financial burden for HPPC is relatively high, rising to about 2.5 % of predicted HPPC expenditure in 2004. When actual loan repayment begins, i.e. in 2013, the financial burden peaks again, rising to 2 % at its maximum.

10.4 Technical Evaluation

Sewerage Priority Project comprises the combined sewers, CSOs (combined sewer overflow), sewers (lateral, trunk and conveyance sewers), pumps and waste water treatment plant. For the selection of the most appropriate system for sewerage development, various alternatives were considered and compared.

From the technical feasibility aspect, the alternatives were examined whether they are based on proven technology with adequate number of projects already implemented in the world, in particular in Asia, technology level of which are comparable with Vietnam. Required skill level for the O&M of the sewerage system for the alternatives were examined in the light of the current level in Vietnam as well as the expected level in the future after improvement. In this context, among the conceived alternatives, small-bore with simplified treatment plant alternative was dropped considering that it is yet not proven-technology with very limited number of examples which are implemented outside of Asia. As a waste water treatment plant, the aerated lagoon type was selected with various reasons. One of the major reasons is that the plant can be operated and maintained by SADCO personnel after certain manpower training.

The selected sewerage system is based on the combined sewer system which is a system based on sure and proven technology that are in operation in many countries including Asia. Construction of the system will not require any special and advanced technology. Required facility and equipment are not peculiar to this priority project and can either be manufactured in Vietnam or can be imported from overseas.

CSO is a rather new facility introduced in Vietnam. However, the operation, i.e., gate operation, will be properly done with appropriate instruction based on operation manual. For orifice type CSO, no manual operation is required while ordinary maintenance work is needed. Required skill level for the aerated lagoon is medium among the studied options and within the reach of Vietnamese engineers and technical staff with some training.

In order to ensure successful operation of the system, it is recommended that external technical assistance for acquiring the operation technology by ODA (Official Development Aid) and guidance by the manufacturers of the facility/equipment at the initial stage of the operation be obtained. Similar projects in other cities in Vietnam to precede this project should be studied and experience and knowledge should be transferred to the personnel to be engaged in this project.

Together with these efforts, the Sewerage Priority Project is considered to be technically feasible.

10.5 Environmental Impact Assessment

10.5.1 Environmental Impacts of Sewerage Project

The main impacts of the proposed project are described for design phase, construction phase and operation phase. Alternative without the project implementation has also been described. Details of the EIA and mitigating measures are described in the Supporting Report, Part C.

The proposed sewerage project is expected to bring the following positive impacts: (i) improvement of sanitation and public health condition, and (ii) up to 80 to 100 % reduction of pollution loads to lakes and channels in the project area.

The biggest adverse impacts during the project implementation are: (i) land acquisition and resettlement of about 23 households and relocation of dike, (ii) release of effluent from WWTP to Lach Tray River, (iii) disposal of treatment sludge, and (iv) offensive odor from the WWTP.

Assessment Advantages and Disadvantages of the Project to Living Environment in City Center

Causes	Impacts		Time scale	Need for mitigation
	Positive	Negative		
Dust from construction, traffic		- -	Temporary	Yes
Noise during construction.		- -	Temporary	Yes
Traffic jam during construction, transportation		- -	Temporary	Yes
Risk of soil and ground water contamination		-	Long-term	Yes
Soil erosion following the felling of trees, etc., as a result of facility construction and consequent deterioration of water quality		-	Temporary	Yes
Effect on existing infrastructure		-	Temporary	Yes
Health risk for worker		-	Temporary	Yes
Impact on cultural, historical aspect	+	-	Temporary	No
Employment creation	+		Temporary	No
Usage of sludge as fertilizer	+		Long-term	Yes
Recycle of sludge for landscaping	+		Long-term	No
Reduction of health risks due to improvement of sewerage system	+ + +		Long-term	No
Reduction of wastewater related diseases	+ + +		Long-term	No
Improvement of health of city community	+ + +		Long-term	No
Improvement of city's aesthetics	+ + +		Long-term	No

Legend:
- - - Very negative   - - Negative   - Less negative
+ Less positive   + + Positive   + + + Very Positive

Assessment of Advantages and Disadvantages of the Project to Vinh Niem Commune

Cause	Impact		Time scale	Need for mitigation
	Positive	Negative		
Acquisition of 38 ha of land and relocation of 23 households		- - -	Long-term	Yes
Odor nuisance from WWTP		- - -	Long-term	Yes
Discharge of treated wastewater to Lach Tray River affecting water quality, and downstream water use		- - -	Long-term	Yes
Generation of wastewater related diseases		- -	Long-term	Yes
Disposal of solid waste and sludge collected from WWTP		- -	Long-term	Yes
Dust from transportation, construction		- -	Temporary	Yes
Safety for workers		-	Temporary	Yes
Traffic jam during construction, transportation		-	Temporary	Yes
Exhausted gases generated from construction		-	Temporary	No
Noise from WWTP and pumping station		-	Long-term	No
Social order and security		-	Temporary	Yes
Influences on aesthetics and ecology		-	Long-term	No
Influences on cultural, historical aspect	+	-	Temporary	Yes
Creation of employment	+		Temporary	No
Environmental awareness for community	+ +		Long-term	No

Legend:
- - - Very negative   - - Negative   - Less negative
+ Less positive   + + Positive   + + + Very Positive

The above tables show that the positive aspects of the project exceed the negative ones. Although there are long-term negative impacts, those can be minimized with mitigation measures and good management of operation and maintenance of the WWTP.

The major environmental impacts of the proposed projects are presented in more detail in Table 3.10.5.

If the project is not implemented, the current status of pollution in lakes and channels will get worse due to ever increasing wastewater volume and pollution load. Lakes and channels are already seriously polluted, and the situation will become more critical without the proposed sewerage.

10.5.2 Mitigation Measures for Sewerage Project

(1) General Instructions

Environmental matters have to be integrated in all the design work and planning of the project. The designing has to be done by minimizing the adverse impacts on environment; use of existing facilities and siting of new facilities at environmentally less sensitive areas are good examples of approaches to minimize environmental impact. Where possible, existing rights-of-way has to be used rather than create new ones.

Mitigation measures are given separately for the design phase, the construction phase and the operation phase. The most important activity is to arrange land acquisition, resettlement, site-clearance and relocation of dike during design and pre-construction phase. During the operation phase, special attention should be paid to minimize the adverse impacts from the operation of the WWTP. The most critical impacts will be the offensive odor from the WWTP and discharge of effluent to the Lach Tray River. More detailed information is presented in Tables 3.10.5.

(2) Mitigation Measures during Design Phase

Detailed measurement survey has to be conducted, and the exact number and type of houses and infrastructure to be relocated have to be identified. Land acquisition and resettlement has to be done according to the approved resettlement procedures described in Resettlement Action Plan (RAP) to be prepared during the detailed design phase of the project. The RAP should include a detailed public relation program, and the .affected residents should be informed about the potential impact of the project in the earliest possible stage of the project.

Location and size of resettlement areas has to be decided during the detailed design phase, and the necessary infrastructure and other structures should be designed. It is recommended that resettlement of project affected people should be arranged to the nearest possible vicinity of their existing houses in the same villages.

(3) Mitigation Measures during Construction Phase

1) General Instructions

The general instructions concerning working conditions, prevention of noise, odor, litter and dust during works, protection of water and sediment, health and safety, and public relations mentioned in the project documents have to be followed.

2) Construction of WWTP and Sewers

During construction, excavation and leveling, there is a risk of infiltration of surface water and wastewater into groundwater lading to local contamination of groundwater. This is a risk especially during excavation of deep trenches for different kind of sewers. According to the geotechnical surveys the upper aquifer will not be disturbed in the construction site of wastewater treatment plant.

3) Mitigation Measures during Operation Phase

Long-term mitigation measures will be needed during the operation phase to minimize the adverse impacts from WWTP. Buffer zone with trees should be established around the area to prevent dispersion of offensive odor and gases. Treatment process should be controlled frequently to guarantee the quality of effluent to be discharged to the Lach Tray River. Leachate from sludge drying beds has to be circulated back to the treatment process.

4) Summary of Mitigation Measures for Sewerage Project

Phase	Main mitigation measures	Responsible organization
Design	International and Vietnamese design criteria and standards to be used Underground structures have to be identified before construction of conveyances and other sewers Relocation of the dyke in Vinh Niem has to be designed Works designed to by implemented during dry season	Design Consultant
Construction	Minimize dust, odor, litter, noise and traffic emissions by good operation management and site supervision Appropriate working methods have to be followed Groundwater contamination and infiltration to trenches has to prevented during construction of conveyances Sites have to be kept clean and safe during and after the work Safety and health regulations has to be strictly followed Protective clothing and operational training for workers is essential Transportation has to be minimized and routes selected to avoid public nuisance Transportation during rush hours and night has to be avoided Construction sites and time has to be informed to the local people in advance	Contractor
O&M	Minimize odor, litter and noise emissions by good operation management and site supervision Appropriate working methods have to be followed Sites have to be kept clean and safe during and after the work Safety and health regulations have to be strictly followed Protective clothing and operational training for workers are essential Regular environmental monitoring program should be implemented	PIO

10.5.3 Evaluation of the Impacts with the Counter-Measures

Impacts of the project will be monitored in every phase of the project according to the monitoring program (see Supporting Report). The monitoring program is concentrating especially on the operation phase.

Implementation of smooth land acquisition and resettlement will need good co-operation between local authorities and project affected people. The Vietnamese resettlement procedures give good basis to minimize the problems.

Environmental impacts caused by operation of WWTP can be minimized with good plant management and using proper working methods.

10.6 Organizational Setup and Capability of the Implementing and Managing Bodies

10.6.1 Recommended Organizational Setup

In the Study, the following implementation setup is recommended for the efficient implementation of the Sewerage Priority Project.

(a) One Project Management Unit (PMU) should be set up which will be responsible for the 2 priority projects of Sewerage Priority Project and Drainage Priority Project, considering:

- Same regulatory and supervising body, i.e., TUPWS and same managing and O&M body is responsible for both priority projects
- Facility and function of both are closely related and dependant each other
- Timing of the implementation is expected to be about the same

The PMU will assume the prime responsibility of the project implementation including tendering, construction supervision and other related works. TUPWS will be responsible for giving necessary instruction to PMU for smooth implementation when deemed necessary. SADCO will extend assistance for daily works of PMU when deemed necessary.

According to the preliminary estimation, the resettlement for the Sewerage Priority Project will be limited to about 23 households as the WWTP site was carefully selected in the Feasibility Study. Nevertheless, acquisition of sizable agricultural area in Vinh Niem area is inevitable. Project Implementing Organization (PIO) should prepare a detailed Resettlement (and Compensation) Action Plan (RAP) in the early stage of the Detailed Design, and carry out the plan under the guidance of Haiphong PC in accordance with the Decree No.22/1998/ND-CP (1998) and other relevant regulations. Public consultation and close coordination with local PC (especially commune-level) are essential.

After entering the O&M stage, SADCO will manage the project including all the O&M works.

10.6.2 Capability of the Implementing Body

Sizable scale projects has been implemented in the recent years in the field of sanitation improvement, i.e., water supply (1A) and drainage (1B). In the latter case, the same implementation setup was adopted, i.e., PMU, TUPWS and SADCO and the project is successfully being implemented. Before the start of the Priority Projects, a few more projects are expected to be implemented in the same manner. Capability for resettlement project component of HPPC is expected to be strengthened as explained for Drainage Priority Project.

Considering the above, it is considered that the Sewerage Priority Project can successfully be implemented by the recommended implementation setup.

10.6.3 Capability of the Managing Body

To date, SADCO has experience in managing the drainage system of combined sewers but it has no experience in full-scale central sewerage system. It is recommended in the Study that new sections should be created within SADCO for O&M of the sewerage facility and overall control of the system together with the increase of staffs. Before the implementation of Drainage Priority Project, small-scale sewage plant is scheduled to be implemented in 1B project and some experience is expected to be obtained.

If all the recommended organizational reinforcement as well as staff augmentation and their training should be realized together with other efforts to strengthen their capability, SADCO is considered to be capable of managing the Sewerage Priority Project.

10.7 Overall Project Evaluation

The Sewerage Priority Project will meet the primary objective of the sanitation and environment improvement for the project area as well as for the city by providing a central sewerage system. Public health will be enhanced through the reduction of the water-borne diseases. Pollution load inflow into the water bodies will be decreased, resulting in the water quality improvement of the ambient waters.

From an economic point of view, the expected contribution of Sewerage Priority Project to the economic growth in the future in terms of GRP growth and property value increase can justify the investment cost incurred to implement the project. The project cost is considered within the affordable range of the HPPC/Government in terms of the annual equivalent cost of the project assuming sinking fund with the condition of 5 % annual interest rate and 25 repayment period. From financial viewpoint, the assumed concessionary loan is considered repayable by HPPC/Government.

From technical feasibility viewpoint, no difficulty is expected for construction and manufacturing of the project facility. Assuming the recommended organizational strengthening including the setting up of new sections for sewerage control including that for waste water treatment plant as well as adequate training of the staff, operation and maintenance can effectively be carried out by SADCO.

Though no significant social impact is expected, Resettlement Action Program should be formulated to alleviate the negative impact including resettlement and secure the cooperation of the project affected people. Alleviation measures also should be taken to minimize the negative environmental impact, including the provision of buffer zone around the waste water treatment plant site. Assuming these efforts, Sewerage Priority Project is considered as socially acceptable.

In conclusion, Sewerage Priority Project is evaluated to be feasible for implementation.

Table 3.1.1 Class A Area Sewerage Facilities List

West Wastewater Treatment Area						
	Phase I	Combined sewer system	CSO	nos.	60	
			sewer	m	20,000	
			sewer trunk and conveyance	m	20,000	actual sewer length, including open cut, jacking method
			sub pumping station	nos.	10	
			main pumping station	nos.	1	
			West WWTP	nos.	0.50	36,000m3/day(planning capacity 72,000m3/day)
	Phase II	Combined sewer system	CSO	nos.	60	
			sewer(average dia 500mm)	m	42,800	50 m/ha
			Conveyance (average dia 1000mm)	m	20,000	actual sewer length, including open cut, jacking method
			sub pumping station	nos.	4	4 nos/1000ha, about 3m3/min
			main pumping station	nos.	1	1 nos/1000ha, about 10m3/min
			West WWTP	nos.	0.25	20,462m3/day(planning capacity 72,000m3/day)
		Separate sewer system	sewer(average dia 500mm)	m	69,500	100 m/ha
			Conveyance (average dia 1000mm)	m	6,950	10% of total sewer length, including open cut, jacking method
			sub pumping station	nos.	3	4 nos/1000ha, about 3m3/min
			main pumping station	nos.	1	1 nos/1000ha, about 10m3/min
			West WWTP	nos.	0.25	11,464m3/day(planning capacity 72,000m3/day)
		sub-total(Phase II)	CSO	nos.	60	
			sewer(average dia 500mm)	m	112,300	
			Conveyance (average dia 1000mm)	m	26,950	
			sub pumping station	nos.	7	about 3m3/min
			main pumping station	nos.	2	about 10m3/min
			West WWTP	nos.	0.50	31,926m3/day(planning capacity 76,874m3/day)
	Total		CSO	nos.	120	
			sewer	m	132,300	
			conveyance	m	46,950	including Interceptor
			sub pumping station	nos.	17	about 3m3/min
			main pumping station	nos.	3	about 10m3/min
			West WWTP	nos.	1.00	planning capacity 72,000m3/day
East Wastewater Treatment Area						
	Phase II	Separate sewer system	sewer(average dia 500mm)	m	258,700	100 m/ha
			conveyance(average dia 1000mm)	m	7,761	3% of total sewer length, including open cut, jacking method
			sub pumping station	nos.	11	4 nos/1000ha, about 3m3/min
			main pumping station	nos.	3	1 nos/1000ha, about 10m3/min
			East WWTP	nos.	1.00	planning capacity 15,712m3/day

Table 3.1.2 Comparison of Treatment Process

Design flow	72,000	m3/day
Land compensation cost	3	US$/m2 for agricultural land
House compensation cost	5,000	US$/house

		Main facilities	Required area	Required land	House loss	Cost			
						Construction	Compensation	sub-total	O & M
			ha	ha	nos.	million US$	million US$	million US$	million US$/year
Stabilization Pond	**WSP**	Anaerobic Pond, Facultative Pond, Maturation Pond, Average depth=1.5m	108	130	260	26.85	5.20	32.05	0.62
Modified Stabilization Pond	**MSP**	First Pond, Second Pond, Average depth=3.0m	36	44	88	24.16	1.76	25.92	0.59
Aerated Lagoon	**AL**	Aerated Lagoon, Settling Pond, average depth=3.0m	23	27	54	25.83	1.08	26.91	1.36
Oxidation Pond	**OD**	Oxidation Ditch, Settling Tank, Sludge Thickening Tank, Sludge Drying Bed, Average depth=3.0m	12	17	34	34.45	0.68	35.13	1.80
Activated Sludge Process	**ASP**	Pretreatment Facilities, Primary Sedimentation Tank, Aeration Tank, Secondary Sedimentation Tank, Sludge Thickening Tank, Sludge Drying Bed, Average depth=4.0m	8	12	24	43.07	0.48	43.55	2.23

Table 3.3.1 Population Estimation for CSO Command Area

			Population Density					Population (after 1st Trail)					Adjusted Population				
sub_dist	ZONE_NAM	AREA (ha)	D1999	D2005	D2010	D2015	D2020	P1999	P2005	P2010	P2015	P2020	P1999	P2005	P2010	P2015	P2020
210	C01	21.82	150.81	159.87	161.86	163.86	165.86	3291	3488	3532	3575	3619	3414	3594	3629	3663	3698
210	C02	11.89	150.81	159.87	161.86	163.86	165.86	1793	1900	1924	1948	1971	1860	1958	1977	1995	2014
210	C03	3.35	150.81	159.87	161.86	163.86	165.86	505	536	543	549	556	525	552	557	563	568
210	C04	2.68	150.81	159.87	161.86	163.86	165.86	404	428	434	439	444	419	441	445	450	454
210	C05	6.69	150.81	159.87	161.86	163.86	165.86	1009	1069	1083	1096	1110	1047	1102	1113	1123	1134
311	C06	9.93	299.86	338.24	366.51	394.64	422.64	2977	3358	3638	3917	4195	3089	3459	3738	4013	4287
717	C07	22.83	82.58	104.09	123.31	140.44	157.45	1885	2376	2815	3206	3594	1956	2448	2892	3284	3673
308	C08	15.68	375.96	356.70	353.70	351.00	348.55	5894	5592	5545	5503	5464	6116	5762	5698	5638	5583
308	C09	16.16	375.96	356.70	353.70	351.00	348.55	6074	5763	5715	5671	5632	6303	5938	5872	5810	5754
309	C10	19.13	423.30	444.16	465.07	486.01	506.98	8096	8495	8895	9296	9697	8401	8753	9140	9524	9908
310	C11	25.63	415.58	451.66	481.09	510.43	539.71	10650	11575	12329	13081	13832	11051	11926	12668	13402	14133
311	C12	55.13	299.86	338.24	366.51	394.64	422.64	16530	18646	20204	21755	23299	17153	19211	20760	22288	23806
717	C13	25.09	82.58	104.09	123.31	140.44	157.45	2072	2612	3094	3524	3951	2150	2691	3179	3610	4037
717	C14	17.41	82.58	104.09	123.31	140.44	157.45	1438	1812	2147	2445	2741	1492	1867	2206	2505	2801
307	C15	23.31	468.06	456.36	444.66	432.95	421.25	10908	10636	10363	10090	9818	11319	10958	10648	10338	10031
307	C16	14.38	468.06	456.36	444.66	432.95	421.25	6730	6562	6394	6225	6057	6984	6761	6569	6378	6189
717	C17	18.68	82.58	104.09	123.31	140.44	157.45	1543	1944	2303	2623	2941	1601	2003	2367	2688	3005
717	C18	13.80	82.58	104.09	123.31	140.44	157.45	1139	1436	1701	1938	2172	1182	1480	1748	1985	2220
717	C19	11.86	82.58	104.09	123.31	140.44	157.45	979	1234	1462	1665	1867	1016	1272	1502	1706	1908
717	C20	4.41	82.58	104.09	123.31	140.44	157.45	365	460	544	620	695	378	473	559	635	710
202	E01	40.10	90.96	102.71	111.21	119.64	128.02	3648	4119	4460	4798	5134	3785	4244	4582	4916	5246
205	E02	10.79	340.30	331.80	323.29	314.78	306.27	3673	3581	3490	3398	3306	3811	3690	3585	3481	3378
204	E03	22.10	330.26	322.00	313.74	305.49	297.23	7297	7115	6932	6750	6567	7572	7331	7123	6915	6710
205	E04"	18.76	340.30	331.80	323.29	314.78	306.27	6383	6224	6064	5905	5745	6624	6413	6231	6049	5870
201	E04'	17.98	115.89	110.30	109.45	108.70	108.03	2083	1983	1968	1954	1942	2162	2043	2022	2002	1984
205	E05	8.40	340.30	331.80	323.29	314.78	306.27	2859	2787	2716	2644	2573	2966	2872	2790	2709	2629
205	E06	10.71	340.30	331.80	323.29	314.78	306.27	3644	3553	3462	3371	3280	3781	3661	3557	3454	3351
212	E07	22.30	59.75	72.64	81.16	89.59	97.94	1333	1620	1810	1998	2184	1383	1669	1860	2047	2232
212	E08	13.75	59.75	72.64	81.16	89.59	97.94	821	998	1116	1231	1346	852	1029	1146	1262	1376
212	E09	38.78	59.75	72.64	81.16	89.59	97.94	2317	2817	3148	3474	3798	2405	2903	3234	3560	3881
201	E10	17.02	115.89	110.30	109.45	108.70	108.03	1973	1877	1863	1850	1839	2047	1934	1914	1895	1879
201	E11	13.27	115.89	110.30	109.45	108.70	108.03	1537	1463	1452	1442	1433	1595	1508	1492	1477	1464
212	E12	8.54	59.75	72.64	81.16	89.59	97.94	510	620	693	765	836	529	639	712	784	854
207	E13	7.93	422.40	411.84	401.28	390.72	380.16	3348	3265	3181	3097	3014	3474	3364	3268	3173	3079
212	E14	4.58	59.75	72.64	81.16	89.59	97.94	274	333	372	410	448	284	343	382	420	458
209	E15"	4.30	429.97	379.62	359.63	340.28	321.48	1850	1633	1547	1464	1383	1920	1683	1590	1500	1413
210	E15'	2.77	150.81	159.87	161.86	163.86	165.86	418	443	449	454	460	434	457	461	466	470
210	E16	34.46	150.81	159.87	161.86	163.86	165.86	5197	5509	5578	5647	5716	5393	5676	5731	5785	5840
209	E17	11.88	429.97	379.62	359.63	340.28	321.48	5108	4510	4272	4042	3819	5300	4647	4390	4141	3902
207	E18	3.38	422.40	411.84	401.28	390.72	380.16	1426	1390	1354	1319	1283	1479	1432	1392	1351	1311
207	E19	5.55	422.40	411.84	401.28	390.72	380.16	2344	2286	2227	2168	2110	2432	2355	2288	2222	2156
212	E20	3.81	59.75	72.64	81.16	89.59	97.94	228	277	309	342	373	236	285	318	350	382
212	E21	21.19	59.75	72.64	81.16	89.59	97.94	1266	1540	1720	1899	2076	1314	1586	1767	1945	2121
211	E22	5.17	81.27	93.09	101.44	109.71	117.92	420	481	525	567	610	436	496	539	581	623
211	E23	7.02	81.27	93.09	101.44	109.71	117.92	571	654	712	770	828	592	673	732	789	846
212	E24	69.15	59.75	72.64	81.16	89.59	97.94	4132	5023	5612	6195	6773	4288	5176	5767	6347	6920
720	E25	8.59	19.89	25.85	31.82	37.79	45.74	171	222	273	324	393	177	229	281	332	401
211	E26	15.61	81.27	93.09	101.44	109.71	117.92	1268	1453	1583	1712	1840	1316	1497	1627	1754	1881
211	E27	15.03	81.27	93.09	101.44	109.71	117.92	1221	1399	1524	1648	1772	1267	1441	1566	1689	1810
211	E28	7.67	81.27	93.09	101.44	109.71	117.92	623	714	778	841	904	647	736	799	862	924
305	W01	10.40	480.67	468.65	456.64	444.62	432.60	4998	4873	4748	4623	4498	5186	5020	4878	4736	4596
304	W02	12.86	282.35	275.29	268.23	261.17	254.11	3631	3540	3449	3359	3268	3768	3648	3544	3441	3339
304	W03	3.81	282.35	275.29	268.23	261.17	254.11	1076	1049	1022	995	968	1117	1081	1050	1020	989
304	W04	4.10	282.35	275.29	268.23	261.17	254.11	1159	1130	1101	1072	1043	1202	1164	1131	1098	1066
304	W05	36.64	282.35	275.29	268.23	261.17	254.11	10346	10087	9829	9570	9311	10735	10393	10099	9804	9514
312	W06	5.23	213.52	271.44	309.04	346.32	383.32	1118	1421	1618	1813	2007	1160	1464	1662	1857	2050
304	W07	1.29	282.35	275.29	268.23	261.17	254.11	364	355	345	336	327	377	365	355	345	334
312	W08	12.33	213.52	271.44	309.04	346.32	383.32	2632	3346	3809	4268	4724	2731	3447	3914	4373	4827
312	W09	8.02	213.52	271.44	309.04	346.32	383.32	1711	2176	2477	2776	3072	1776	2242	2545	2844	3139
312	W10	11.19	213.52	271.44	309.04	346.32	383.32	2388	3036	3457	3874	4288	2478	3129	3552	3969	4381
312	W11	10.15	213.52	271.44	309.04	346.32	383.32	2167	2755	3137	3515	3891	2249	2839	3223	3601	3975
312	W12	33.25	213.52	271.44	309.04	346.32	383.32	7099	9025	10275	11514	12744	7366	9299	10557	11796	13022
718	W13	20.91	28.99	40.59	52.19	63.79	75.39	606	849	1091	1334	1577	629	875	1121	1367	1611
305	W14	6.24	480.67	468.65	456.64	444.62	432.60	2997	2922	2847	2772	2697	3110	3011	2926	2840	2756
306	W15	9.33	418.47	408.01	397.55	387.09	376.62	3906	3808	3710	3613	3515	4053	3924	3812	3701	3592
312	W16	44.56	213.52	271.44	309.04	346.32	383.32	9514	12095	13770	15431	17080	9872	12462	14149	15809	17452
718	W17	20.01	28.99	40.59	52.19	63.79	75.39	580	812	1044	1276	1508	602	837	1073	1307	1541
		1060.72	14266.02	14899.12	15349.51	15783.74	16217.85	208518.85	223090.83	233584.21	243790.79	253960.02	216370	229860	240006	249765	259487
								236446	251771	263361	274540	285663					
							EX	20206	22080	23628	25096	26557					
							IN	130	169	274	321	381					
								216370	229860	240006	249765	259487					
0	EII	106.04											12982	14660	15873	17077	18273
0	CII	248.50											67036	59124	54849	50306	45513
0	WII1	36.94											13011	12453	12411	12379	12355
0	WII2	79.95											12935	12612	12288	11965	11642
0	WII3	157.09											27376	29099	30599	32124	33670
		628.52											133340	127948	126021	123850	121452

Table 3.3.2 Area of Lake in the West Treatment Area

Name	measured area ha	District	Drainage System	Use	Remarks
Thien Nga	1.4	Ngo Quen	North-east system	Regulating Lake	Phase I Combined
Mam Tom	1.8	Ngo Quen	North-east system	Regulating Lake	Phase I Combined
Quan Ngua	2.8	Ngo Quen	North-east system	Regulating Lake	Phase I Combined
An Bien	19.2	Ngo Quen	North-east system	Regulating Lake	Phase I Combined
Sen	1.7	Le Chan	South-west system	Regulating Lake	Phase I Combined
Du Hang/Lam Tuong	6.1	Le(2.207),Du(3.899)	South-west system	Regulating Lake	Phase I Combined
Phuong Luu	-	Dong Hai, Dang Lam Com	-	Regulating Lake	Phase II Separate
Don Nghia	47.7	Vinh Niem Com.	-	Regulating Lake	Phase II Separate
Tan Bac	4.6	Hong Ban(2.3), Le(2.3)	-	Regulating Lake	Phase II Combined
Total	85.3				

Table 3.3.3 Land, Lake and River Area by District

Unit: ha

District	District Area	Treatment Area	Land	Lake	River
Hong Bang Dist.	1,520	426	356	2	68
Ngo Quyen Dist.	1,095	954	837	25	92
Le ChanDist.	442	447	427	6	15
Du Hang Kenh Com.	269	280	276	4	0
Vinh Niem Com.	563	473	335	48	90
(add-E24)Dong Hai	-	2	2	0	0
(add-E25)Dang Lam	-	7	7	0	0
Total	3,889	2,589	2,230	85	265
West TA Phase I Combined area		1,112			
West TA Phase II Combined area		789			
West TA Phase II Separate area		687			
total		1,477			

Table 3.3.4 Unit Sewage by Phase and District

	Area (ha)				Flow (m3/day)			Unit Flow (m3/day/ha)		
	Land Area	Phase I	Phase II		Phase I	Phase II		Phase I	Phase II	
		Combined	Combined	Separate	Combined	Combined	Separate	Combined	Combined	Separate
District	ha	2020	2020	2020	2020	2020	2020	2020	2020	2020
Commercial										
Hong Bang Dist.	354		354			548			1.550	
Ngo Quyen Dist.	990	664	211	116	1,172	511	203	1.766	2.426	0.205
Le ChanDist.	427	367	60		729	123		1.985	2.057	
Du Hang Kenh Com.	276	136		140	95		54	0.701		0.194
Vinh Niem Com.	335	48		287	44		268	0.909		0.800
sub-total	2,383	1,215	624	543	2,040	1,183	525	0.856	0.496	0.220
Institutional										
Hong Bang Dist.	354		354			857			2.424	
Ngo Quyen Dist.	990	664	211	116	1,302	778	226	1.962	3.692	0.228
Le ChanDist.	427	367	60		1,367	231		3.723	3.857	
Du Hang Kenh Com.	276	136		140	95		54	0.701		0.194
Vinh Niem Com.	335	48		287	44		268	0.909		0.800
sub-total	2,383	1,215	624	543	2,808	1,867	548	1.178	0.783	0.230
Industrial										
Hong Bang Dist.	354		354			1,752			4.953	
Ngo Quyen Dist.	990	664	211	116	1,183	1,530	205	1.782	7.262	0.207
Le ChanDist.	427	367	60		616	104		1.677	1.738	
Du Hang Kenh Com.	276	136		140	132		74	0.973		0.270
Vinh Niem Com.	335	48		287	61		372	1.263		1.111
sub-total	2,383	1,215	624	543	1,991	3,386	652	0.836	1.421	0.274
Total										
Hong Bang Dist.	354		354			3,158			8.928	
Ngo Quyen Dist.	990	664	211	116	3,656	2,819	635	**5.509**	13.379	5.472
Le ChanDist.	427	367	60		2,711	459		**7.385**	7.651	
Du Hang Kenh Com.	276	136		140	323		182	**2.374**		1.298
Vinh Niem Com.	335	48		287	148		909	**3.082**		3.163
total	2,383	1,215	624	543	6,839	6,436	1,725	5.629	**10.307**	**3.175**

Treatment Area (not including Lake)

		Land		
	Land Area	Phase I	Phase II	
		Combined	Combined	Separate
District	ha	2020	2020	2020
Hong Bang Dist.	354		354	
Ngo Quyen Dist.	990	664	211	116
Le ChanDist.	427	367	60	
Du Hang Kenh Com.	276	136		140
Vinh Niem Com.	335	48		287
total	2,383	1,215	624	543

Table 3.3.5 Type of the CSO Control Structure

Type		Area	Sewage(3Q)		Sewer
			Unit Q	Qave	Pipe dia.
		ha	m3/s/ha	m3/s	mm
Orifice		0-9	0.0012	0.006	100
Gate	I	10-19		0.018	150
	II	20-29		0.030	200
	III	30-39		0.042	250
	IV	40-49		0.054	300
	V	50-		0.066	350

Table 3.3.6 CSO Control Structure List

Unit : nos.

Type		Area	Sub-Catchment Area			Total
		ha	WEST	CENTER	EAST	
Orifice		0-9	3	5	12	20
Gate	I	10-19	5	9	8	22
	II	20-29	2	4	4	10
	III	30-39	2	0	3	5
	IV	40-49	1	0	1	2
	V	50-	0	1	1	2
Weir		10-19	0	0	0	0
		20-29	0	0	0	0
		30-39	0	0	0	0
		40-49	0	0	0	0
		50-	0	0	0	0
Total			13	19	29	61
Orifice		sub-total	3	5	12	20
Gate		sub-total	10	14	17	41
Weir		sub-total	0	0	0	0

Table 3.3.7 Bill of Quantity of Gate Type

		Unit	Gate Type				
			I	II	III	IV	V
pipe for sewage	D1	mm	150	200	250	300	350
pipe for stormwater	D2	mm	1200	1500	1650	1800	2000
length	l1	mm	900	900	1200	1200	1200
	l2	mm	300	300	300	300	300
	l3	mm	100	100	150	150	150
	l4	mm	600	600	600	600	600
	l5	mm	150	150	200	200	200
width	w1	mm	900	900	1200	1200	1200
	w2	mm	150	150	200	200	200
depth	d1	mm	2200	2500	2650	2800	3000
	d2	mm	200	200	250	250	250
	d3	mm	150	150	200	200	200

	L	m	2.2	2.2	2.65	2.65	2.65
	L'	m	1.9	1.9	2.25	2.25	2.25
	W	m	1.2	1.2	1.6	1.6	1.6
	W'	m	0.9	0.9	1.2	1.2	1.2
	D	m	2.35	2.65	2.85	3	3.2
	D'	m	2.2	2.5	2.65	2.8	3
	V	m3	6.20	7.00	12.08	12.72	13.57
	V'	m3	3.76	4.28	7.16	7.56	8.10
	A1	m2	=L*D 5.17	5.83	7.5525	7.95	8.48
	A1'	m2	=L'*D' 4.18	4.75	5.9625	6.3	6.75
	A2	m2	=W*D 2.82	3.18	4.56	4.8	5.12
	A2'	m2	=W'*D' 1.98	2.25	3.18	3.36	3.6
excavation		m3	20.4	22.8	32.9	34.5	36.7
backfilling		m3	13.8	15.5	19.9	20.9	22.2
surplus soil disposal		m3	6.6	7.4	12.9	13.6	14.4
pavement		m2	8.2	8.2	10.8	10.8	10.8
crusher-run stone		m3	0.40	0.40	0.85	0.85	0.85
reinforced concrete		m3	2.44	2.72	4.93	5.16	5.47
formwork		m2	28.3	32.0	42.5	44.8	47.9
reinforcing bar		kg	147	163	296	310	328
screen		nos.	W900xH600 1	W900xH600 1	W1200xH900 1	W1200xH900 1	W1200xH900 1
gate		nos.	dia150 1	dia200 1	dia250 1	dia300 1	dia350 1
reinforced concrete pipe		m	dia150 5	dia200 5	dia250 5	dia300 5	dia350 5
grating cover		nos.	900x1200 1	900x1200 1	1200x150(1	1200x150(1	1200x150(1
step		nos.	W=300 6	W=300 7	W=300 8	W=300 8	W=300 9
manhole cover		nos.	dia600 1	dia600 1	dia600 1	dia600 1	dia600 1
stop log		nos.	W900xH600 1	W900xH600 1	W1200xH900 1	W1200xH900 1	W1200xH900 1
de-watering		LS	1	1	1	1	1
retaining wall		LS	1	1	1	1	1
flap gate		nos.	dia 1200 1	dia 1500 1	dia 1650 1	dia 1800 1	dia 2000 1

LS=lump sum

Table 3.3.8 Bill of Quantity of Orifice Type

		Unit	OrificeType	
			I	
pipe for sewage	D1	mm		100
pipe for stormwater	D2	mm		700
length	l1	mm		600
	l2	mm		300
	l3	mm		100
	l4	mm		600
	l5	mm		150
width	w1	mm		600
	w2	mm		150
depth	d1	mm		1800
	d2	mm		150
	d3	mm		150
	L	m		1.9
	L'	m		1.6
	W	m		0.9
	W'	m		0.6
	D	m		1.95
	D'	m		1.8
	V	m3		3.33
	V'	m3		1.73
	A1	m2	=L*D	3.705
	A1'	m2	=L'*D'	2.88
	A2	m2	=W*D	1.755
	A2'	m2	=W'*D'	1.08
excavation		m3		13.671
backfilling		m3		10.08
surplus soil disposal		m3		3.591
pavement		m2		6.5
crusher-run stone		m3		0.26
reinforced concrete		m3		1.61
formwork		m2		18.84
reinforcing bar		kg		96
screen		nos.	W600xH600	1
orifice		nos.	dia100	1
reinforced concrete pipe		m	dia100	5
grating cover		nos.	600x900	1
step		nos.	W=300	5
manhole cover		nos.	dia600	1
stop log		nos.	W600xH300	1
de-watering		LS		1
retaining wall		LS		1
flap gate		nos.	dia 700	1

Table 3.4.1 Minimum slopes for gravity-flow combined sewer

Based on Manning's equation with a minimum velocity of 1.0 m/s. n=0.013
Steeper slopes should be used for diameter greater than 1350 mm.

Diameter	Area	Perimeter	Hydraulic radius	Velocity	Slope	Flow	Allowanc	Adjusted Flow
D	A	p	R	V	I	Q		Q
mm	m2	m	m	m/s	%o	m3/s	%	m3/s
300	0.07069	0.94248	0.075	1.0	0.0053	0.071	100	0.035
400	0.12566	1.25664	0.100	1.0	0.0036	0.126	100	0.063
500	0.19635	1.57080	0.125	1.0	0.0027	0.196	100	0.098
600	0.28274	1.88496	0.150	1.0	0.0021	0.283	100	0.141
700	0.38485	2.19911	0.175	1.0	0.0017	0.385	50	0.257
800	0.50265	2.51327	0.200	1.0	0.0014	0.503	50	0.335
900	0.63617	2.82743	0.225	1.0	0.0012	0.636	50	0.424
1000	0.78540	3.14159	0.250	1.0	0.0011	0.785	50	0.524
1100	0.95033	3.45575	0.275	1.0	0.0009	0.950	50	0.634
1200	1.13097	3.76991	0.300	1.0	0.0008	1.131	50	0.754
1350	1.43139	4.24115	0.338	1.0	0.0007	1.431	50	0.954
1500	1.76715	4.71239	0.375	1.0	0.0006	1.767	50	1.178
1650	2.13825	5.18363	0.413	1.0	0.0006	2.138	25	1.711
1800	2.54469	5.65487	0.450	1.0	0.0005	2.545	25	2.036
2000	3.14159	6.28319	0.500	1.0	0.0004	3.142	25	2.513
The minimum practical slope for construction is about 0.0008 m/m								
1350	1.43139	4.24115	0.338	1.055	0.0008	1.510	50	1.006
1500	1.76715	4.71239	0.375	1.131	0.0008	1.999	50	1.333
1650	2.13825	5.18363	0.413	1.206	0.0008	2.578	25	2.062
1800	2.54469	5.65487	0.450	1.278	0.0008	3.251	25	2.601
2000	3.14159	6.28319	0.500	1.371	0.0008	4.306	25	3.445

Table 3.4.2 Computation table for design of the trunck sewer (1/4) (East Sub-Treatment Area)

Line	Location					Residential flow				Commercial/Institutional/Industrial flow																					Infiltration		Total design flow				Sewer design				
										Hong Bang District				Ngo Quyen District				Le Chan District				Du Hang Keng Com.				Vinh Niem Com.															
	Fro m	To	Subare a	Area	Cum. Total	Pop.	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum . Tota	Avg. unit flow	Cum . Avg.	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Cum. Avg. flow	Infiltrati on rate	Infiltrati on flow	Cum. Avg. flow	Peak factor	Cum. Peak flow	Cum. Peak flow	Sewer diamete r	Slope	Capacit y full	Allowa ble Capacit	Velocit y full
				ha	ha	person	person	L/capita?d	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	m3/d	%	m3/d	m3/d		m3/d	m3/s	mm	m/m	m3/s	m3/s	m/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
									(8x9/1000)				(12x13)				(16x17)				(20x21)				(24x25)				(28x29)	(10+14+18+22+26+30)		(31x32/100)	(31+33)		(34x35)	(36/86400)					
ET1-1	0	2	EII	106.0		18,273																								1,093											
			E1	40.1		5,246								40.1																											
			E2	10.8	156.9	3,378	26,896	130	3,496					10.8	50.9	5.509	280													4,870	10	487	5,357	3.0	16,071	0.186	700	0.0017	0.385	0.257	1.0
ET1-2	2	3	E3	22.1		6,710								22.1																											
			E4'	18.0		1,984								18.0																											
			E4"	18.8		5,870								18.8																											
			E5	8.4	224.2	2,629	44,090	130	5,732					8.4	118.1	5.509	651													7,475	10	748	8,223	3.0	24,669	0.286	800	0.0014	0.503	0.335	1.0
ET1-3	3	6	E6	10.7		3,351								10.7																											
			E7	22.3		2,232								22.3																											
			E8	13.7		1,376								13.7																											
			E9	38.8	309.7	3,881	54,929	130	7,141					38.8	203.7	5.509	1,122													9,356	10	936	10,291	3.0	30,874	0.357	900	0.0012	0.636	0.424	1.0
	to ET1-4																																								
ELT1-1	4	5	E10	17.0	17.0	1,879	1,879	130	244					17.0	17.0	5.509	94													338	10	34	372	3.0	1,115	0.013	300	0.0053	0.071	0.035	1.0
ELT1-2	5	6	E11	13.3		1,464								13.3																											
			E12	8.5		854								8.5																											
			E13	7.9	46.8	3,079	7,276	130	946					7.9	46.8	5.509	258													1,203	10	120	1,324	3.0	3,972	0.046	400	0.0036	0.126	0.063	1.0
	to ET1-4																																								
ET1-4	6	11	E14	4.6	361.0	458	62,664	130	8,146					4.6	255.0	5.509	1,405													10,644	10	1,064	11,708	3.0	35,125	0.407	900	0.0012	0.636	0.424	1.0
	to ET1-5																																								
ELT2-1	7	8	E15'	2.8		470								2.8																											
			E15"	4.3	7.1	1,413	1,883	130	245					4.3	7.1	5.509	39													284	10	28	312	3.0	937	0.011	300	0.0053	0.071	0.035	1.0
ELT2-2	8	9	E16	34.5	41.5	5,840	7,723	130	1,004					34.5	41.5	5.509	229													1,233	10	123	1,356	3.0	4,068	0.047	400	0.0036	0.126	0.063	1.0
ELT2-3	9	10	E17	11.9	53.4	3,902	11,625	130	1,511					11.9	53.4	5.509	294													1,806	10	181	1,986	3.0	5,958	0.069	500	0.0027	0.196	0.098	1.0
ELT2-4	10	11	E18	3.4		1,311								3.4																											
			E19	5.5	62.3	2,156	15,092	130	1,962					5.5	62.3	5.509	343													2,305	10	231	2,536	3.0	7,608	0.088	500	0.0027	0.196	0.098	1.0
	to ET1-5																																								
ET1-5	11	12	E20	3.8		382								3.8																											
			E21	21.2	448.4	2,121	80,258	130	10,434					21.2	342.3	5.509	1,886													13,413	10	1,341	14,754	3.0	44,261	0.512	1,000	0.0011	0.785	0.524	1.0
	to ET1-6																																								
ELT3-1	16	17	C1	21.8		3,698								21.8																											
	17	12	-	0.0	21.8		3,698	130	481						21.8	5.509	120													601	10	60	661	3.0	1,983	0.023	300	0.0053	0.071	0.035	1.0
	to ET1-6																																								
ET1-6	12	12'	-		470.2		83,956	130	10,914						364.2	5.509	2,006													14,013	10	1,401	15,415	3.0	46,244	0.535	1,100	0.0009	0.95	0.634	1.0
	to P/S																																								
ET2-1	13	14	E24	69.2		6,920								69.2																											
			E25	8.6	77.7	401	7,322	130	952					8.6	77.7	5.509	428													1,380	10	138	1,518	3.0	4,554	0.053	400	0.0036	0.126	0.063	1.0
ET2-2	14	15	E26	15.6		1,881								15.6																											
			E27	15.0	108.4	1,810	11,013	130	1,432					15.0	108.4	5.509	597													2,029	10	203	2,232	3.0	6,695	0.077	500	0.0027	0.196	0.098	1.0
	to C-2																																								
C-1	9	12	E22	5.2		623								5.2																											
			E23	7.0		846								7.0																											
			E28	7.7	490.1	924	86,349	130	11,225					7.7	384.0	5.5089	2,116													14,434	10	1,443	15,877	3.0	47,632	0.551	1,100	0.0009	0.95	0.634	1.0
C-2	12	18	-		598.4		97,361	130	12,657						492.4	5.5089	2,713													16,463	10	1,646	18,109	3.0	54,327	0.629	1,100	0.0009	0.95	0.634	1.0
	to C-3																																								
					CSO control structure																										additional wastewater from Phase II Area										

Table 3.4.2 Computation table for design of the trunck sewer (2/4) (Center Sub-Treatment Area)

Line	Location					Residential flow				Commercial/Institutional/Industrial flow																					Infiltration		Total design flow					Sewer design				
										Hong Bang District				Ngo Quyen District				Le Chan District				Du Hang Keng Com.				Vinh Niem Com.															
	From	To	Subarea	Area	Cum. Total	Pop.	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg.	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg.	Cum. Avg. flow	Infiltration rate	Infiltration flow	Cum. Avg. flow	Peak factor	Cum. Peak flow	Cum. Peak flow	Sewer diameter	Slope	Capacity full	Allowable Capacity	Velocity full
				ha	ha	person	person	L/capita?d	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	m3/d	%	m3/d	m3/d		m3/d	m3/s	mm	m/m	m3/s	m3/s	m/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
									(8x9/1000)				(12x13)				(16x17)				(20x21)				(24x25)				(28x2	(10+14+18+22+26+30)		(31x32/100)	(31+33)		(34x35)	(36/86400)					
CT1-1	17	18	C2	11.9		2,014								11.9																											
			C3	3.4	15.2	568	2,582	130	336					3.4	15.2	5.509	84													420	10	42	462	3.0	1,385	0.016	300	0.0053	0.071	0.035	1.0
C-3	18	19	C4	2.7	616.4	454	100,398	130	13,052					2.7	510.3	5.509	2,811													16,956	10	1,696	18,652	3.0	55,955	0.648	1200	0.0008	1.131	0.754	1.0
C-4	19	26	C5	6.7		1,134								6.7																											
			C6	9.9		4,287												9.9																							
			C7	22.8	655.8	3,673	109,491	130	14,234						517.0	5.509	2,848		9.9	7.385	73	22.8	22.8	2.3742	54.2					18,302	10	1,830	20,133	3.0	60,398	0.699	1200	0.0008	1.131	0.754	1.0
	to C-5																																								
CLT1-1	20	21	C9	16.2	16.2	5,754	5,754	130	748									16.2	16.2	7.385	119									867	10	87	954	3.0	2,862	0.033	300	0.0053	0.071	0.035	1.0
	to CT2-1																																								
CT2-1	21	22	CII	248.5		45,513																								2,561											
			C8	15.7	280.3	5,583	56,851	130	7,391									15.7	31.8	7.385	235									10,187	10	1,019	11,206	3.0	33,617	0.389	900	0.0012	0.636	0.424	1.0
CT2-2	22	23	C10	19.1	299.5	9,908	66,758	130	8,679									19.1	51.0	7.385	376									11,616	10	1,162	12,778	3.0	38,334	0.444	1,000	0.0011	0.785	0.524	1.0
CT2-3	23	24	C11	25.6	325.1	14,133	80,891	130	10,516									25.6	76.6	7.385	566									13,643	10	1,364	15,007	3.0	45,021	0.521	1,000	0.0011	0.785	0.524	1.0
CT2-4	24	25	C12	55.1		23,806												55.1																							
			C13	25.1	405.3	4,037	108,734	130	14,135										131.7	7.385	973	25.1	25.1	2.374	60					17,729	10	1,773	19,502	3.0	58,506	0.677	1200	0.0008	1.131	0.754	1.0
CT2-5	25	26	C14	17.4	422.7	2,801	111,535	130	14,500										131.7	7.385	973	17.4	42.5	2.374	101					18,134	10	1,813	19,948	3.0	59,844	0.693	1200	0.0008	1.131	0.754	1.0
C-5	26	34	-		1078.5		221,025	130	28,733						517.0	5.509	2,848		141.6	7.385	1,046		65.3	2.374	155					36,437	10	3,644	40,081	3.0	120,242	1.392	1650	0.0008	2.578	2.062	1.206
	to C-6																																								
CT3-1	27	28	C15	23.3	23.3	10,031	10,031	130	1,304									23.3	23.3	7.385	172									1,476	10	148	1,624	3.0	4,871	0.056	400	0.0036	0.126	0.063	1.0
CT3-2	28	29	C16	14.4	37.7	6,189	16,220	130	2,109									14.4	37.7	7.385	278									2,387	10	239	2,626	3.0	7,877	0.091	500	0.0027	0.196	0.098	1.0
CT3-3	29	30	C17	18.7	56.4	3,005	19,225	130	2,499										37.7	7.385	278	18.7	18.7	2.374	44					2,822	10	282	3,104	3.0	9,312	0.108	600	0.0021	0.283	0.141	1.0
CT3-4	30	31	C18	13.8	70.2	2,220	21,445	130	2,788										37.7	7.385	278	13.8	32.5	2.374	77					3,143	10	314	3,458	3.0	10,373	0.120	600	0.0021	0.283	0.141	1.0
CT3-5	31	32	C19	11.9	82.0	1,908	23,353	130	3,036										37.7	7.385	278	11.9	44.3	2.374	105					3,419	10	342	3,761	3.0	11,284	0.131	600	0.0021	0.283	0.141	1.0
C-6	32	48	C20	4.4	1165.0	710	245,088	130	31,862						517.0	5.509	2,848		179.3	7.385	1,324	4.4	114.1	2.374	271					39,959	10	3,996	43,955	3.0	131,865	1.526	1650	0.0008	2.578	2.062	1.206
	to C-7																																								

CSO control structure

additional wastewater from Phase II Area

Table 3.4.2 Computation table for design of the trunck sewer (3/4) (West Sub-Treatment Area)

Line	Location					Residential flow				Commercial/Institutional/Industrial flow																					Infiltration		Total design flow				Sewer design				
										Hong Bang District				Ngo Quyen District				Le Chan District				Du Hang Keng Com.				Vinh Niem Com.															
	From	To	Subarea	Area	Cum. Total	Pop.	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Cum. Avg. flow	Infiltration rate	Infiltration flow	Cum. Avg. flow	Peak factor	Cum. Peak flow	Cum. Peak flow	Sewer diameter	Slope	Capacity full	Allowable Capacity	Velocity full
				ha	ha	person	person	L/capita?d	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	m3/d	%	m3/d	m3/d		m3/d	m3/s	mm	m/m	m3/s	m3/s	m/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
									(8x9)				(12x13)				(16x17)				(20x21)				(24x25)				(28x29)	(10+14+18+22+26+30)		(31x32/100)	(31+33)		(34x35)	(36/86400)					
WT1-1	33	34	WII1	36.9		12,355																								381											
			WII2	80.0		11,642																								824											
			WII3	157.1		33,670																								1,619											
			W1	10.4	284.4	4,596	62,262	130	8,094									10.4	10.4	7.385	77									10,995	10	1,099	12,094	3.0	36,283	0.420	900	0.0012	0.636	0.424	1.0
WT1-2	34	35	W2	12.9	297.2	3,339	65,601	130	8,528									12.9	23.3	7.385	172									11,524	10	1,152	12,676	3.0	38,029	0.440	1,000	0.0011	0.785	0.524	1.0
WT1-3	35	36	W3	3.8	301.1	989	66,590	130	8,657									3.8	27.1	7.385	200									11,681	10	1,168	12,849	3.0	38,546	0.446	1,000	0.0011	0.785	0.524	1.0
WT1-4	36	37	W4	4.1	305.2	1,066	67,656	130	8,795									4.1	31.2	7.385	230									11,849	10	1,185	13,034	3.0	39,103	0.453	1,000	0.0011	0.785	0.524	1.0
WT1-5	37	38	W5	36.6	341.8	9,514	77,170	130	10,032									36.6	67.8	7.385	501									13,357	10	1,336	14,693	3.0	44,078	0.510	1,000	0.0011	0.785	0.524	1.0
	to WT1-6																																								
WLT1	39	40	W6	5.2		2,050												5.2																							
			W7	1.3		334												1.3																							
			W8	12.3		4,827												12.3																							
			W9	8.0	26.9	3,139	10,351	130	1,346									8.0	26.9	7.385	198									1,544	10	154	1,698	3.0	5,095	0.059	400	0.0036	0.126	0.063	1.0
	to WT1-6																																								
WT1-6	40	41	-		368.7		87,521	130	11,378										94.7	7.385	699									14,901	10	1,490	16,391	3.0	49,173	0.569	1,100	0.0009	0.95	0.634	1.0
WT1-7	41	42	W10	11.2	379.8	4,381	91,902	130	11,947									11.2	105.9	7.385	782									15,553	10	1,555	17,108	3.0	51,325	0.594	1,100	0.0009	0.95	0.634	1.0
WT1-8	42	43	W11	10.1	390.0	3,975	95,877	130	12,464									10.1	116.0	7.385	857									16,145	10	1,614	17,759	3.0	53,278	0.617	1,100	0.0009	0.95	0.634	1.0
WT1-9	43	44	W12	33.2	423.2	13,022	108,899	130	14,157									33.2	149.3	7.385	1,102									18,083	10	1,808	19,892	3.0	59,675	0.691	1200	0.0008	1.131	0.754	1.0
WT1-10	44	48	W13	20.9	444.2	1,611	110,510	130	14,366										149.3	7.385	1,102					20.9	20.9	3.082	64	18,357	10	1,836	20,193	3.0	60,578	0.701	1200	0.0008	1.131	0.754	1.0
	to C-7																																								
WLT2-1	47	48	W14	6.2		2,756												6.2																							
			W15	9.3		3,592												9.3																							
			W16	44.6		17,452												44.6																							
			W17	20.0	80.1	1,541	25,341	130	3,294										60.1	7.385	444					20.0	20.0	3.082	62	3,800	10	380	4,180	3.0	12,540	0.145	700	0.0017	0.385	0.257	1.0
	to C-7																																								
C-7	48	49	-		1,689		380,939	130	49,522										388.7	7.385	2,871						40.9	3.082	126	58,997	10	5,900	64,897	3.0	194,691	2.253	1800	0.0008	3.251	2.601	1.278
					629	Phase II combined area																																			
					1,061	Phase I combined area																																			
					CSO control structure																										additional wastewater from Phase II Area										

Table 3.4.2 Computation table for design of the trunck sewer (4/4) (South Sub-Treatment Area)

Line	Location					Residential flow				Commercial/Institutional/Industrial flow																					Infiltration		Total design flow				Sewer design				
										Hong Bang District				Ngo Quyen District				Le Chan District				Du Hang Keng Com.				Vinh Niem Com.															
	From	To	Subarea	Area	Cum. Total	Pop.	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Area	Cum. Total	Avg. unit flow	Cum. Avg. flow	Cum. Avg. flow	Infiltration rate	Infiltration flow	Cum. Avg. flow	Peak factor	Cum. Peak flow	Cum. Peak flow	Sewer diameter	Slope	Capacity full	Allowable Capacity	Velocity full
				ha	ha	person	person	L/capita?d	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	ha	ha	m3/d/ha	m3/d	m3/d	%	m3/d	m3/d		m3/d	m3/s	mm	m/m	m3/s	m3/s	m/s
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
									(8x9)				(12x13)				(16x17)				(20x21)				(24x25)				(28x29)	(10+14+18+22+26+30)		(31x32/100)	(31+33)		(34x35)	(36/86400)					
ST1			S1	545	545	58,341	58,341	130	7,584																					7,584											
																									Commercial/Institutional/Industrial					1,729											
																									total					9,314	10	931	10,245	1.5	15,368	0.178	700	0.0011	0.308	0.205	0.8

Table 3.4.3 Longitudinal Section of Trunk Sewer

East Trunk Sewer 1 (ET1)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering		
						U/S	D/S	U/S	D/S	U/S	D/S	
ET1-1	0	2	520	700	0.0017	0.830	-0.054	3.03	3.79	1.50	3.14	
ET1-2	2	3	550	800	0.0014	-0.054	-0.824	3.79	2.79	3.04	2.81	
ET1-3	3	6	1,000	900	0.0012	-0.824	-2.024	2.79	3.48	2.71	4.60	
ET1-4	6	11	440	900	0.0012	-2.024	-2.552	3.48	3.48	4.60	5.13	
ET1-5	11	12	1,240	1,000	0.0011	-2.552	-3.916	3.48	3.80	5.03	6.72	
ET1-6	12	12'	10	1,100	0.0009	-3.916	-3.925	3.80	3.80	6.62	6.63	to An Da Relay Pumping Station
C-1	12'	15	380	1,100	0.0009	-0.418	-0.760	3.80	3.40	3.12	3.06	
C-2	15	18	220	1,100	0.0009	-0.760	-0.958	3.40	3.84	3.06	3.70	
C-3	18	19	350	1,200	0.0008	-1.058	-1.338	3.84	3.84	3.70	3.98	
C-4	19	26	1,300	1,200	0.0008	-1.338	-2.378	3.84	3.10	3.98	4.28	
C-5	26	32	580	1,650	0.0008	-2.378	-2.842	3.10	3.80	3.83	4.99	
C-6	32	48	60	1,650	0.0008	-2.842	-2.890	3.80	3.80	4.99	5.04	
C-7	48	49	950	1,800	0.0008	-3.040	-3.800	3.80	3.60	5.04	5.60	to West WWTP
			7,600									

basically pipe bottom connection
but, bending points of (C-2 to C-3, and C-6 to C-7) is pipe top connection

East Trunk Sewer 2 (ET2)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
ET2-1	13	14	440	400	0.0036	1.200	-0.384	3.20	3.20	1.60	3.18	**Manhole Pump 1**			drop
ET2-2	14	15	800	500	0.0027	1.700	-0.460	3.20	3.40	1.00	3.36	to C-2	Invert elevation=	-0.760	**0.300**
			1,240												

East Lateral Trunk Sewer 1 (ELT1)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
ELT1-1	4	5	180	300	0.0053	1.400	0.446	3.15	4.03	1.45	3.28				drop
ELT1-2	5	6	420	400	0.0036	0.446	-1.066	4.03	3.48	3.18	4.15	to ET1-4	Invert elevation=	-2.024	0.958
			600												

East Lateral Trunk Sewer 2 (ELT2)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
ELT2-1	7	8	300	300	0.0053	2.350	0.760	3.65	3.65	1.00	2.59				
ELT2-2	8	9	120	400	0.0036	0.760	0.328	3.65	3.67	2.49	2.94				
ELT2-3	9	10	400	500	0.0027	0.328	-0.752	3.67	3.20	2.84	3.45				drop
ELT2-4	10	11	200	500	0.0027	-0.752	-1.292	3.20	3.48	3.45	4.27	to ET1-5	Invert elevation=	-2.552	1.260
			720												

East Lateral Trunk Sewer 3 (ELT3)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
ELT3-1	16	17	500	300	0.0053	0.740	-1.910	3.74	3.99	2.70	5.60				drop
ELT3-2	17	12	260	300	0.0053	-1.910	-3.288	3.99	3.80	5.60	6.79	to C-3	Invert elevation=	-3.916	0.628
			760												

Central Trank Sewer 1 (CT1)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				drop
CT1-1	17	18	360	300	0.0053	2.150	0.242	3.99	3.84	1.54	3.30	to C-3	Invert elevation=	-1.058	1.300
			360												

Central Trank Sewer 2 (CT2)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
	101	102	540	700	0.0017	2.000	1.082	4.00	4.20	1.30	2.42				
	102	103	220	800	0.0014	1.082	0.774	4.20	4.30	2.32	2.73				
	103	104	80	800	0.0014	0.774	0.662	4.30	4.30	2.73	2.84				
	104	21	760	800	0.0014	0.662	-0.402	4.30	3.73	2.84	3.33				
CT2-1	21	22	320	900	0.0012	-0.402	-0.786	3.73	3.87	3.23	3.76				
CT2-2	22	23	100	1000	0.0011	-0.786	-0.896	3.87	3.99	3.66	3.89				
CT2-3	23	24	720	1000	0.0011	-0.896	-1.688	3.99	3.10	3.89	3.79				
CT2-4	24	25	380	1200	0.0008	-1.688	-1.992	3.10	3.10	3.59	3.89				drop
CT2-5	25	26	150	1200	0.0008	-1.992	-2.112	3.10	3.10	3.89	4.01	to C-5	Invert elevation=	-2.378	0.266
			1,670												

3,270 including phase II pipeline

Table 3.4.3 Longitudinal Section of Trunk Sewer (2/2)

Central Lateral Trunk Sewer 1 (CLT1)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				drop
CLT1-1	20	21	80	300	0.0053	1.680	1.256	4.11	3.73	2.13	2.17	to CT2-1	Invert elevation=	-0.402	1.658
			80												

Central Trunk Sewer 3 (CT3)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						Upper	Lower	Upper	Lower	Upper	Lower				
CT3-1	27	28	120	400	0.0036	1.410	0.978	3.41	3.40	1.60	2.02				
CT3-2	28	29	380	500	0.0027	0.978	-0.048	3.40	3.90	1.92	3.45				
CT3-3	29	30	380	600	0.0021	-0.048	-0.846	3.90	3.40	3.35	3.65				
CT3-4	30	31	380	600	0.0021	-0.846	-1.644	3.40	3.80	3.65	4.84				drop
CT3-5	31	32	200	600	0.0021	-1.644	-2.064	3.80	3.80	4.84	5.26	to C-6	Invert elevation=	-2.842	0.778
			1,460												

West Trunk Sewer 1(WT1)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
	201	202	260	400	0.0036	2.500	1.564	4.50	4.50	1.60	2.54				
	202	33	100	400	0.0036	1.564	1.204	4.50	4.36	2.54	2.76				
WT1-1	33	34	200	900	0.0012	1.204	0.964	4.36	4.36	2.26	2.50				
WT1-2	34	35	400	1,000	0.0011	0.964	0.524	4.36	4.35	2.40	2.83				
WT1-3	35	36	180	1,000	0.0011	0.524	0.326	4.35	4.35	2.83	3.02				
WT1-4	36	37	180	1,000	0.0011	0.326	0.128	4.35	4.33	3.02	3.20				
WT1-5	37	40	120	1,000	0.0011	0.128	-0.004	4.33	3.40	3.20	2.40				
WT1-6	40	41	600	1,100	0.0009	-0.004	-0.544	3.40	4.10	2.30	3.54				
WT1-7	41	42	300	1,100	0.0009	-0.544	-0.814	4.10	4.70	3.54	4.41				
WT1-8	42	43	320	1,100	0.0009	-0.814	-1.102	4.70	4.70	4.41	4.70				
WT1-9	43	44	1060	1,200	0.0008	-1.102	-1.950	4.70	4.10	4.60	4.85				drop
WT1-10	44	48	360	1,200	0.0008	-1.950	-2.238	4.10	3.80	4.85	4.84	to C-7	Invert elevation=	-3.040	0.802
total			3,360												

3,720 including phase II pipeline

West Lateral Trunk Sewer 1 (WLT1)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
	38	39	250	125	pressure			3.50	3.50	1.00	1.00	**Manhole Pump 2**			
	39		10	100	pressure			3.50		1.00	1.00	**Manhole Pump 3**			drop
WLT1-	39	40	500	400	0.0036	2.200	0.400	3.50	3.40	0.90	2.6	to WT1-6	Invert elevation=	-0.004	0.404
			500												

West Lateral Trunk Sewer 2 (WLT2)

Line	From	To	Distance	Pipe dia.	Slope	Invert elevation		Ground Elevatio		Earth Covering					
						U/S	D/S	U/S	D/S	U/S	D/S				
	45	46	220	100	pressure			3.48	3.50	1.00	1.00	**Manhole Pump 4**			
	46		10	125	pressure			3.50		1.00	1.00	**Manhole Pump 5**			drop
WLT2-	47	48	420	700	0.0017	0.800	0.086	3.00	3.80	1.50	3.01	to C-7	Invert elevation=	-2.238	2.324
			420												

U/S = Up Stream End, D/S = Down Stream End

Table 3.4.4 The Bill of Quantity of Trunk Sewer (by earth covering)

Line	From	Distance	Pipe dia	Earth Covering Upper	Earth Covering Lower	Earth Covering Average	Construction Method	Open dia (mm)	Jacking dia (mm)	Pressure 100 d=1.0	Pressure 125 d=1.0	Jacking 300 >=4	Open 300 >=3	Open 300 >=2	Open 300 >=1	Jacking 400 >=4	Open 400 >=3	Open 400 >=2	Open 400 >=1	Jacking 500 >=4	Open 500 >=3	Open 500 >=2	Open 500 >=1	Jacking 600 >=4	Open 600 >=3	Open 600 >=2	Open 600 >=1
East Trunk Sewer 1 (ET1)																											
	ET1-1	520	700	1.50	3.14	2.32	Open	700																			
	ET1-2	550	800	3.04	2.81	2.93	Open	800																			
	ET1-3	1,000	900	2.71	4.60	3.66	Open	900																			
	ET1-4	440	900	4.60	5.13	4.87	Jacking		900																		
	ET1-5	1,240	1,000	5.03	6.72	5.87	Jacking		1000																		
	ET1-6	10	1,100	6.62	6.63	6.62	Jacking		1100																		
	C-1	380	1,100	3.12	3.06	3.09	Open	1100																			
	C-2	220	1,100	3.06	3.70	3.38	Open	1100																			
	C-3	350	1,200	3.70	3.98	3.84	Open	1200																			
	C-4	1,300	1,200	3.98	4.28	4.13	Jacking		1200																		
	C-5	580	1,650	3.83	4.99	4.41	Jacking		1650																		
	C-6	60	1,650	4.99	5.04	5.02	Jacking		1650																		
	C-7	950	1,800	5.04	5.60	5.32	Jacking		1800																		
East Trunk Sewer 2 (ET2)																											
	ET2-1	440	400	1.60	3.18	2.39	Open	400										440									
	ET2-2	800	500	1.00	3.36	2.18	Open	500														800					
East Lateral Trunk Sewer 1 (ELT1)																											
	ELT1-1	180	300	1.45	3.28	2.37	Open	300						180													
	ELT1-2	420	400	3.18	4.15	3.67	Open	400									420										
East Lateral Trunk Sewer 2 (ELT2)																											
	ELT2-1	300	300	1	2.59	1.80	Open	300							300												
	ELT2-2	120	400	2.49	2.942	2.72	Open	400										120									
	ELT2-3	400	500	2.842	3.452	3.15	Open	500													400						
	ELT2-4	200	500	3.452	4.272	3.86	Open	500													200						
East Lateral Trunk Sewer 3 (ELT3)																											
	ELT3-1	500	300	2.70	5.60	4.15	Jacking		300			500															
	ELT3-2	260	300	5.60	6.79	6.19	Jacking		300			260															
Central Trank Sewer 1 (CT1)																											
	CT1-1	360	300	1.54	3.30	2.42	Open	300						360													
Central Trank Sewer 2 (CT2)																											
	CT2-1	320	900	3.23	3.76	3.49	Open	900																			
	CT2-2	100	1000	3.66	3.89	3.77	Open	1000																			
	CT2-3	720	1000	3.89	3.79	3.84	Open	1000																			
	CT2-4	380	1200	3.59	3.89	3.74	Open	1200																			
	CT2-5	150	1200	3.89	4.01	3.95	Open	1200																			
Central Lateral Trunk Sewer 1 (CLT1)																											
	CLT1-1	80	300	2.13	2.17	2.15	Open	300						80													
Central Trunk Sewer 3 (CT3)																											
	CLT3-1	120	400	1.60	2.02	1.81	Open	400											120								
	CLT3-2	380	500	1.92	3.45	2.69	Open	500														380					
	CLT3-3	380	600	3.35	3.65	3.50	Open	600																	380		
	CLT3-4	380	600	3.65	4.84	4.25	Jacking		600															380			
	CLT3-5	200	600	4.84	5.26	5.05	Jacking		600															200			
West Trunk Sewer 1(WT1)																											
	WT1-1	200	900	2.26	2.50	2.38	Open	900																			
	WT1-2	400	1,000	2.40	2.83	2.61	Open	1000																			
	WT1-3	180	1,000	2.83	3.02	2.93	Open	1000																			
	WT1-4	180	1,000	3.02	3.20	3.11	Open	1000																			
	WT1-5	120	1,000	3.20	2.40	2.80	Open	1000																			
	WT1-6	600	1,100	2.30	3.54	2.92	Open	1100																			
	WT1-7	300	1,100	3.54	4.41	3.98	Open	1100																			
	WT1-8	320	1,100	4.41	4.70	4.56	Jacking		1100																		
	WT1-9	1060	1,200	4.60	4.85	4.73	Jacking		1200																		
	WT1-10	360	1,200	4.85	4.84	4.84	Jacking		1200																		
West Lateral Trunk Sewer 1 (WLT1)																											
	WLT1-1	250	125	1.00	1.00	1.00	Open	125			250																
	WLT1-1	10	100	1.00	1.00	1.00	Open	100		10																	
	WLT1-1	500	400	0.90	2.60	1.75	Open	400											500								
West Lateral Trunk Sewer 2 (WLT2)																											
	WLT2-1	220	100	1.00	1.00	1.00	Open	100		220																	
	WLT2-1	10	125	1.00	1.00	1.00	Open	125			10																
	WLT2-1	420	700	1.50	3.01	2.26	Open	700																			
total							19,920			230	260	760	0	620	300	0	420	560	620	0	600	1180	0	580	380	0	0
total (Open)							11,770								920				1600				1780				380
total (Jacking)							7,660					760				0				0				580			
total (pressure)							490			230	260																
												>=4	>=3	>=2	>=1												
												7660	5500	5350	920												
Manhole																											
	(Open)	Manhole Interval				m									50				75				75				75
		Manhole Number				nos.	132								18				21				24				5
	(Jacking)	Manhole Interval				m						100				100				100				100			
		Manhole Number				nos.	58					8				0				0				6			

Line	From	Jacking 700 >=4	Open 700 >=3	Open 700 >=2	Open 700 >=1	Jacking 800 >=4	Open 800 >=3	Open 800 >=2	Open 800 >=1	Jacking 900 >=4	Open 900 >=3	Open 900 >=2	Open 900 >=1	Jacking 1000 >=4	Open 1000 >=3	Open 1000 >=2	Open 1000 >=1	Jacking 1100 >=4	Open 1100 >=3	Open 1100 >=2	Open 1100 >=1	Jacking 1200 >=4	Open 1200 >=3	Open 1200 >=2	Open 1200 >=1	Jacking 1350 >=4	Jacking 1500 >=4	Jacking 1650 >=4	Jacking 1800 >=4
East Trunk Sewer 1 (ET1)																													
	ET1-1			520																									
	ET1-2							550																					
	ET1-3										1000																		
	ET1-4									440																			
	ET1-5													1240															
	ET1-6																	10											
	C-1																		380										
	C-2																		220										
	C-3																						350						
	C-4																					1300							
	C-5																											580	
	C-6																											60	
	C-7																												950
East Trunk Sewer 2 (ET2)																													
	ET2-1																												
	ET2-2																												
East Lateral Trunk Sewer 1 (ELT1)																													
	ELT1-1																												
	ELT1-2																												
East Lateral Trunk Sewer 2 (ELT2)																													
	ELT2-1																												
	ELT2-2																												
	ELT2-3																												
	ELT2-4																												
East Lateral Trunk Sewer 3 (ELT3)																													
	ELT3-1																												
	ELT3-2																												
Central Trank Sewer 1 (CT1)																													
	CT1-1																												
Central Trank Sewer 2 (CT2)																													
	CT2-1										320																		
	CT2-2														100														
	CT2-3														720														
	CT2-4																						380						
	CT2-5																						150						
Central Lateral Trunk Sewer 1 (CLT1)																													
	CLT1-1																												
Central Trunk Sewer 3 (CT3)																													
	CLT3-1																												
	CLT3-2																												
	CLT3-3																												
	CLT3-4																												
	CLT3-5																												
West Trunk Sewer 1(WT1)																													
	WT1-1											200																	
	WT1-2															400													
	WT1-3															180													
	WT1-4														180														
	WT1-5															120													
	WT1-6																			600									
	WT1-7																		300										
	WT1-8																	320											
	WT1-9																					1060							
	WT1-10																					360							
West Lateral Trunk Sewer 1 (WLT1)																													
	WLT1-1																												
	WLT1-1																												
	WLT1-1																												
West Lateral Trunk Sewer 2 (WLT2)																													
	WLT2-1																												
	WLT2-1																												
	WLT2-1			420																									
total		0	0	940	0	0	0	550	0	440	1320	200	0	1240	1000	700	0	330	900	600	0	2720	880	0	0	0	0	640	950
total (Open)					940				550				1520				1700				1500				880				
total (Jacking)		0				0				440				1240				330				2720				0	0	640	950
total (pressure)																													
Manhole																													
	(Open) Manhole Interval (m)				100				100				100				100				150				150				
	Manhole Number (nos.)				9				6				15				17				10				6				
	(Jacking) Manhole Interval (m)	100				100				100				100				150				150				150	150	200	200
	Manhole Number (nos.)	0				0				4				12				2				18				0	0	3	5

Table 3.4.5 The Unit Bill of Quantity of Trunk Sewer

Unit : meter (for pipes)

		Excavation		Concrete Base		excavation	backfilling	surplus soi	pavement	crusher-rur	concrete	formwork	reinforcing bar	reinforced concrete pipe	timber	bamboo	levelling concrete(10cm)	soil improvement	de-watering	retaining wall
		width	depth	width	height															
		W	D	B	h															
		m	m	m	m	m3	m3	m3	m2	m3	m3	m2	kg	m	m3	m2	m2	m3	LS	m
Earth Covering = 1-2m																				
Sand	300	1.1	2.1	-	-	2.3	2.0	2.3	1.1	0.12	-	-	-	1.0	0.12	0.8	0.8	-	1.0	1.0
	400	1.2	2.2	-	-	2.6	2.1	2.6	1.2	0.14	-	-	-	1.0	0.14	0.9	0.9	-	1.0	1.0
	500	1.3	2.3	-	-	3.0	2.2	3.0	1.3	0.15	-	-	-	1.0	0.15	1.0	1.0	-	1.0	1.0
	600	1.4	2.4	-	-	3.4	2.2	3.4	1.4	0.17	-	-	-	1.0	0.17	1.1	1.1	-	1.0	1.0
	700	1.7	2.5	-	-	4.3	2.7	4.3	1.7	0.21	-	-	-	1.0	0.21	1.4	1.4	-	1.0	1.0
	800	1.8	2.6	-	-	4.7	2.7	4.7	1.8	0.23	-	-	-	1.0	0.23	1.5	1.5	-	1.0	1.0
	900	1.9	2.7	-	-	5.1	2.6	5.1	1.9	0.24	-	-	-	1.0	0.24	1.6	1.6	-	1.0	1.0
	1000	2.0	2.8	-	-	5.6	2.5	5.6	2.0	0.26	-	-	-	1.0	0.26	1.7	1.7	-	1.0	1.0
	1100	2.1	2.9	-	-	6.1	2.3	6.1	2.1	0.27	-	-	-	1.0	0.27	1.8	1.8	-	1.0	1.0
	1200	2.2	3.0	-	-	6.6	2.1	6.6	2.2	0.29	-	-	-	1.0	0.29	1.9	1.9	-	1.0	1.0
Earth Covering = 2-3m																				
Concrete 90 °	300	1.3	3.2	0.4	0.1	4.2	3.9	4.2	1.3	-	0.04	0.20	-	1.0	0.20	1.0	1.0	-	1.0	1.0
	400	1.4	3.3	0.5	0.1	4.6	4.1	4.6	1.4	-	0.05	0.20	-	1.0	0.21	1.1	1.1	-	1.0	1.0
	500	1.5	3.4	0.6	0.1	5.1	4.3	5.1	1.5	-	0.06	0.20	-	1.0	0.23	1.2	1.2	-	1.0	1.0
	600	1.6	3.5	0.7	0.1	5.6	4.5	5.6	1.6	-	0.07	0.20	-	1.0	0.24	1.3	1.3	-	1.0	1.0
Concrete 120 °	700	2.1	3.7	1.0	0.15	7.8	6.2	7.8	2.1	-	0.15	0.30	-	1.0	0.32	1.8	1.8	-	1.0	1.0
	800	2.2	3.8	1.1	0.15	8.4	6.4	8.4	2.2	-	0.17	0.30	-	1.0	0.33	1.9	1.9	-	1.0	1.0
	900	2.3	3.9	1.2	0.15	9.0	6.4	9.0	2.3	-	0.18	0.30	-	1.0	0.35	2.0	2.0	-	1.0	1.0
	1000	2.4	4.0	1.3	0.2	9.6	6.5	9.6	2.4	-	0.26	0.40	2.6	1.0	0.36	2.1	2.1	3.4	1.0	1.0
	1100	2.5	4.1	1.4	0.2	10.3	6.5	10.3	2.5	-	0.28	0.40	2.8	1.0	0.38	2.2	2.2	3.9	1.0	1.0
	1200	2.6	4.2	1.5	0.2	10.9	6.4	10.9	2.6	-	0.30	0.40	3.0	1.0	0.39	2.3	2.3	4.3	1.0	1.0
Earth Covering = 3-4m																				
Concrete 120 °	300	1.5	4.3	0.6	0.1	6.5	6.2	6.5	1.5	-	0.06	0.20	-	1.0	0.23	1.2	1.2	3.3	1.0	1.0
	400	1.6	4.4	0.7	0.1	7.0	6.5	7.0	1.6	-	0.07	0.20	-	1.0	0.24	1.3	1.3	3.6	1.0	1.0
	500	1.7	4.5	0.8	0.1	7.7	6.9	7.7	1.7	-	0.08	0.20	-	1.0	0.26	1.4	1.4	4.1	1.0	1.0
	600	1.8	4.6	0.9	0.1	8.3	7.1	8.3	1.8	-	0.09	0.20	-	1.0	0.27	1.5	1.5	4.5	1.0	1.0
Concrete 180 °	700	2.3	4.7	1.2	0.15	10.8	9.3	10.8	2.3	-	0.27	1.00	-	1.0	0.35	2.0	2.0	5.6	1.0	1.0
	800	2.4	4.8	1.3	0.15	11.5	9.5	11.5	2.4	-	0.29	1.10	-	1.0	0.36	2.1	2.1	6.1	1.0	1.0
	900	2.5	4.9	1.4	0.15	12.3	9.7	12.3	2.5	-	0.32	1.20	-	1.0	0.38	2.2	2.2	6.7	1.0	1.0
	1000	2.6	5.0	1.5	0.2	13.0	9.9	13.0	2.6	-	0.45	1.40	4.5	1.0	0.39	2.3	2.3	7.2	1.0	1.0
	1100	2.7	5.1	1.6	0.2	13.8	10.0	13.8	2.7	-	0.48	1.50	4.8	1.0	0.41	2.4	2.4	7.8	1.0	1.0
	1200	2.8	5.2	1.7	0.2	14.6	10.0	14.6	2.8	-	0.51	1.60	5.1	1.0	0.42	2.5	2.5	8.4	1.0	1.0

Table 3.4.6 The Unit Bill of Quantity of Manhole

Unit : manhole

Manhole Type			Type 1	Type 2	Type 3	Type 3 A for Jacking Method	Type 4 for Jacking Method	Type 5 for Jacking Method
pipe dia		mm	300-600	700-900	1000-1200	800-1200	1350-1500	1800
Base Dia		mm	900	1200	1500	1500	1800	1200 X 2100
depth (ave.)		m	2.5	3.0	3.5	5.0	5.0	5.0
Cover	cast-iron, dia600mm	nos.	1	1	1	1	1	1
PC block	600x900x H600	nos.	1	1	1	1	1	1
	900x H600	nos.	2	3	4	1	1	1
	900x H900	nos.				3	3	3
PC plate	dia1700mm x H150mm	nos.		1				
	dia2000mm x H150mm	nos.			1	1		
	dia2400mm x H200mm	nos.					1	
	1800mm x 2700mm x H200mm	nos.						1
concrete		m3	1.5	2.2	3.1	3.7	5.7	7.6
formwork		m2	8.6	12.5	17.3	21.7	28.9	40.9
excavation			at the bill of quantity of the pipe line					
backfilling			at the bill of quantity of the pipe line					
surplus soil disposal			at the bill of quantity of the pipe line					
pavement			at the bill of quantity of the pipe line					
crusher-run stone			at the bill of quantity of the pipe line					
bamboo			at the bill of quantity of the pipe line					
levelling concrete			at the bill of quantity of the pipe line					
soil improvement			at the bill of quantity of the pipe line					
de-watering			at the bill of quantity of the pipe line					
retaining wall			at the bill of quantity of the pipe line					

Table 3.5.1 Manhole Pump List

Manhole pump No.	Line	Subarea	Point	Peak flow m3/s	M/P type	Pressure pipe dia mm	Pressure pipe length m	Influent Pipe dia mm	Manhole depth m	Pump head m
Manhole Pump **1**	ET2-1		14	0.053	**MP4**	200	10	400	6.0	5.0
Manhole Pump **2**	WLT1-1	W6	38-39	0.010	**MP1**	125	250	300	3.0	5.0
Manhole Pump **3**	WLT1-1	W7	39	0.002	**MP1**	100	10	300	3.0	3.0
Manhole Pump **4**	WLT2-1	W14		0.014	**MP2**	100	220	300	3.5	5.5
Manhole Pump **5**	WLT2-1	W15		0.019	**MP3**	125	10	300	3.0	3.0

Table 3.5.2 The Bill of Quantity of Manhole Pump

Civil works

Items		Unit	Manhole Pump **1**	Manhole Pump **2**	Manhole Pump **3**	Manhole Pump **4**	Manhole Pump **5**
excavation		m3	150	50	50	55	60
backfilling		m3	80	25	25	28	30
surplus soil disposal		m3	150	50	50	55	60
bamboo foundation		m2	11	8	8	8	8
soil stabilization		m3	25	-	-	-	-
shoring	steel sheet pile type II 40cm x10m	m	16	-	-	-	-
supportings of shoring	H250	m	32	-	-	-	-
de-watering		LS	1	1	1	1	1
crusher-run stone		m3	2	2	2	2	2
levelling concrete		m3	1	1	1	1	1
reinforced concrete		m3	20	11	11	12	12
formwork		m2	150	78	78	86	86
reinforcing bar		kg	1,200	660	660	730	730
grating	1.2m x 0.6m	nos.	1	1	1	1	1
manhole cover	dia 600mm	nos.	3	3	3	3	3
stepladder	B=300mm	nos.	35	16	16	18	18
reinforced concrete pipe	dia 400mm	m	1	1	1	1	1
pavement		m2	50	40	40	40	40

Table 3.5.3 Design of An Da Pumping Station

Conditions					
Influent sewer					
Influent sewer diameter		m	1.10		
Ground level		m	3.800		
Invert level		m	-3.925		
Water depth		m	0.700		
Water level		m	-3.225		
Pump discharge					
Effluent sewer diameter		m	0.70		
Ground level		m	3.800		
Invert level		m	-0.418		
Water depth		m	0.700		
Water level		m	0.282		
Screen		before pump			
Grit chamber		after pump			
Capacity		m3/s	0.535		
Capacity calculation					
Screen					
type		fine screen 25mm		(15-25mm)	
number		screen	2		
Pump					
pump number		pumps	3		
standby number		pumps	1		
total number		pumps	4		
diameter of suction pump	d	mm	300	actual	296 mm
discharge capacity of pump	q	m3/s	0.178		
		m3/min	10.7		
flow velocity in suction pipe	v	m/s	2.6	actual	2.524 m/s 1.5-3.0m/s
actual head		m	3.5		
head loss around pump		m	1.5		
friction head loss of force main		m	0.5		
total head loss		m	5.5		
Power Input					
coefficient	k		0.163		
specific weight of liquid	γ		1.000		
pump efficiency	Ep	%	70		
capacity	Q	m3/min	10.7		
total head loss	H	m	5.5		
power Input	Pi	kW	13.7	Pi=k γ QH/Ep	
Prime Mover Output					
clearance	a		0.15		
transmission efficiency	Et		1.00		
prime mover output	Po	kW	15.8	Po=Pi(1+a)/Et	
motor		kW	18.5		
Grit chamber					
Influent		m3/s	0.535		
number of grit chamber		chamber	2		
mean velocity		m/s	0.3		
retention period		sec	30	30-60 sec	
depth of sand pit		cm	30		
surface loading		m3/m2/c	3,600	in case of combined sewer	
required area		m2	13		
chamber depth		m	0.5		
chamber width		m	1.8		
chamber length		m	9.0		

Table 3.5.4 The Bill of Quantity of An Da Pumping Station

Civil Works and Buildings

Item		Unit	BQ
excavation		m3	3,110
backfilling		m3	5,270
surplus soil disposal		m3	3,110
pile foundation work	PC pile dia 300 x 6m (long nose plier 6m)	nos.	40
	PC pile dia 300 x 6m	nos.	16
shoring	steel sheet pile type III 40cm x 10 m	m	49
supportings of shoring	H300x300x10x15, 94kg/m	ton	18.6
soil stabilization		m3	924
de-watering		LS	1
crusher-run stone		m3	55
levelling concrete		m3	19
reinforced concrete		m3	428
formwork		m2	1,680
reinforcing bar		kg	34,240
work platforms		m2	547
supportings		m3	265
control building		m2	42
reinforced concrete pipe	dia 1100mm	m	30
plant trees		m2	3,200
fence and gate		m	250
lighting		LS	1
water supply		LS	1
pavement		m2	210
drainage	side ditch B=300mm	m	140
house for guard		m2	30

Mechanical and Electrical Facilities

Item		Unit	nos.
Horizontal shaft sewage pump	300mmdia., 11m3/min, 5.5m, 18.5kW	pumps	4
Check valve	delivery, 300mmdia.	mm	4
Sluice valve	suction and delivery, 300mmdia.	set	8
Steel pipe	300mm-700mmdia	L.S	1
Gate	W800 x H800	set	1
Screen	fine screen, W800 x H800, 25mm	set	1
Chain block	1t, manual operation	set	1
Transformer	150 kVA	set	1
Incoming panel		set	1
Control panel		set	2
Local panel		set	4

Table 3.6.1 Estimated Generation of Sewage (West Treatment Area)

Area	Unit	Master Plan(including lake and river area)				Feasibility Study (including lake and river area)					
		Phase I	Phase II		Total	Phase I	Phase II		Total	Phase I	
		Combined	Combined	Separate		Combined	Combined	Separate		Combined	
		2,020	2020	2020	2020	2,020	2020	2020	2020	2010	2010
Hong Bang	m3/d		8,573		8,573		8,573		8,573		
Ngo Quyen	m3/d	18,345	7,990	3,185	29,520	13,489	7,990	3,185	24,664	16,497	12,130
Le Chan	m3/d	23,027	3,899		26,926	23,027	3,899		26,926	21,646	21,646
South of Le Chan	m3/d	3,576		8,279	11,856	3,576		8,279	11,856	1,781	1,781
Total	m3/d	44,948	20,462	11,464	76,874	40,092	20,462	11,464	72,018	39,924	35,557
									72,000		**36,000**
Hong Bang	ha		456		456		456		456		
Ngo Quyen	ha	646	337	112	1,095	475	337	112	924		
Le Chan	ha	378	64		442	378	64		442		
Du	ha	172		97	269	172		97	269		
Vinh	ha	79		484	563	79		484	563		
Total	ha	1,275	857	693	2,825	1,104	857	693	2,654		
	ha		2,132				1,961				

Note: Area excluded is included in East Treatment Area

Table 3.6.2 Design of Pumping Station (Combined sewer system)

Total (Phase I + Phase II)

Conditions									
Planned capactiy (3Q)		m3/s	2.253	from computation table					
Influent sewer									
Influent sewer diameter		m	1.80						
Ground level		m	3.600						
Invert level		m	-3.800						
Water depth		m	1.200						
Water level		m	-2.600						
Pump discharge									
Effluent sewer diameter		m	1.35						
Ground level		m	4.200						
Invert level		m	3.350						
Water depth		m	1.350						
Water level		m	4.700						
Screen		before pump							
Grit chamber		after pump							
Capacity calculation									
Screen									
type		fine screen 25mm		(15-25mm)					
number		screen	6						
Pump									
Pump number		pumps	3 →		**2**	**2**			
standby number		pumps	1 →		**1**				
total number		pumps	4			2			
Diameter of suction pump	d	mm	**600**	actual	596 mm	**400**	actual	400 mm	
Discharge capacity of pum	q	m3/s	0.751			0.376			
		m3/min	45.1			22.5			
Flow velocity in suction p	v	m/s	2.7	actual	2.657 m/s	3.0	actual	2.990 m/s	
Actual head		m	7.3			7.3			
Head loss around pump		m	1.5			1.5			
Friction head loss of force mai		m	0.5			0.5			
Total head loss		m	9.3			9.3			
Power Input									
Coefficient	k		0.163			0.163			
Specific weight of liquid	γ		1.000			1.000			
Pump efficiency	Ep	%	79			76			
Capacity	Q	m3/min	45.1			22.5			
Total head loss	H	m	9.3			9.3			
Power Input	Pi	kW	86.5	Pi=k γ QH/Ep		44.9	Pi=k γ QH/Ep		
Prime mover output									
Clearance	a		0.15			0.15			
Transmission efficiency	Et		1.00			1.00			
Prime mover output	Po	kW	99.4	Po=Pi(1+a)/Et		51.7	Po=Pi(1+a)/Et		
Motor		kW	110			55			
Grit chamber									
Influent		m3/s	2.253						
Number of grit chamber		chamber	6						
Mean velocity		m/s	0.3						
Retention period		sec	30	30-60 sec					
Depth of sand pit		cm	30						
Surface loading		m3/m2/d	3,600	in case of combined sewer					
Required area		m2	54.1						
chamber depth		m	0.8						
chamber width		m	1.6						
chamber length		m	9.0						

Table 3.6.3 Design of Pumping Station (Separate sewer system)

Total (Phase II)

Conditions

Planned capactiy		m3/s	0.199	
Influent sewer				
Influent sewer diameter		m	0.70	
ground level		m	3.600	
Invert level		m	-3.000	tentatively
water depth		m	0.420	
water level		m	-2.580	
Pump discharge				
Effluent sewer diameter		m	0.40	
ground level		m	4.200	
Invert level		m	4.300	
water depth		m	0.400	
water level		m	4.700	
Screen		before pump		
Grit chamber		after pump		

Capacity calculation

Screen				
type		fine screen 25mm		(15-25mm)
number		screen	2	
Pump				
Pump number		pumps	3	
standby number		pumps	1	
total number		pumps	4	
Diameter of suction pump	d	mm	200	actual 184 mm
Discharge capacity of pun	q	m3/s	0.066	
		m3/min	4.0	
Flow velocity in suction p	v	m/s	2.5	actual 2.113 m/s 1.5-3.0m/s
Actual head		m	7.3	
Head loss around pump		m	1.5	
Friction head loss of force mai		m	0.5	
Total head loss		m	9.3	
Power Input				
Coefficient	k		0.163	
Specific weight of liquid	γ		1.000	
Pump efficiency	Ep	%	60	
Capacity	Q	m3/min	4.0	
Total head loss	H	m	9.3	
Power Input	Pi	kW	10.0	Pi=k γ QH/Ep
Prime mover output				
Clearance	a		0.15	
Transmission efficiency	Et		1.00	
Prime mover output	Po	kW	11.5	Po=Pi(1+a)/Et
Motor		kW	15	
Grit chamber				
Influent		m3/s	0.199	
Number of grit chamber		chamber	2	
Mean velocity		m/s	0.3	
Retention period		sec	30	30-60 sec
Depth of sand pit		cm	30	
Surface loading		m3/m2/d	1,800	in case of combined sewer
Required area		m2	9.6	
chamber depth		m	0.6	
chamber width		m	0.6	
chamber length		m	9.0	

Table 3.6.4 Stormwater Sedimentation Pond

Total (Phase I + Phase II)

Conditions					
Wastewater Flow			121,072	m3/day	(2ADWF)
Influent BOD			120	mg/l	
Influent SS			200	mg/l	
Effluent BOD			80	mg/l	BOD removal ratio
Effluent SS			100	mg/l	SS removal ratio
rainfall duration			6	hours	
rainfall frequency			30	nos.	
Estimation					
Removal BOD load			36.3	ton/year	
Removal SS load			90.8	ton/year	
Design					
Settling Pond					
Detention time		t	3.0	hours	
Depth		d	1.5	m	
Required surface volume		V	15,134	m3	
Required surface area		A	1.0	ha	
Pond Configuration					
Number of Pond			2	nos.	
Area of pond			5,045	m2	
Width			60	m	
Length			84	m	84.07778
Slope	1.0	:	2.0		
Width of bottom			57	m	
Length of bottom			81	m	
Actual bottom area			4,617	m2	
Width of water surface			63	m	
Length of water surface			87	m	
Actual water surface			5,481	m2	
Freeboard			0.5	m	
Width of top			65	m	
Length of top			89	m	
Actual water surface			5,785	m2	
Actual detention time			3.0	hours	

Table 3.6.5 Aerated Lagoon Treatment Process (AL)

Total (Phase I + Phase II)									
Conditions									
Wastewater Flow			72,000	m3/day	(ADWF)				
Influent BOD			350	mg/l					
Influent SS			315	mg/l					
Effluent BOD			50	mg/l	BOD removal ra		86	%	
Effluent SS			60	mg/l	SS removal ratio		81	%	
Estimation									
BOD load	25.2 ton/day		9,198	ton/year					
SS load	22.7 ton/day		8,278	ton/year					
Removal BOD load	21,600 kg/day		7,884	ton/year					
Removal SS load	18,360 kg/day		6,701	ton/year					
Design									
Aerated Lagoon (AL)									
		Q	72,000	m3/d	→	0.000264	19.0	Mgal/d	
Influent waste temperature in winter		Ti	20	°C	→		68.0	?	
Influent waste temperature in summer		Tis	26	°C	→		78.8	?	
Ambient air temperature in winter		Ta	14	°C	→		57.2	?	
Ambient air temperature in summer		Tas	28	°C	→		82.4	?	
Proportionality constant		f	0.000012		→		0.000012		
Surface area		A	84,000	m2	x	10.7639	904,168	ft2	
Lagoon water temperature in winter		Tw	17.8	℃	←		64.1	?	Tw=(AfTa+QTi)/(Af+Q)
Lagoon water temperature in summer		Tws	26.7	℃	←		80.1	?	Tws=(AfTas+Qtis)/(Af+Q
BOD removal-rate constant in winter		k_T	2.20	d^{-1}	k_T=2.5(1.06)^(Tw-20)				
BOD removal-rate constant in summer		k_{Ts}	3.70	d^{-1}	k_T=2.5(1.06)^(Tws-20)				
Mean cell-residence time		θ c	3.0	days	***in winter***		1.9	days	***in summer***
AL depth		d	3.0	m			3.0	m	
Required surface area		A	7.2	ha			4.5	ha	
Effluent BOD		Le	46.0	mg/l	Le=Li/(1+k_T x θ c		44.1	mg/l	
BOD Removal			86.9	%			87.4	%	
Lagoon Configuration									
Number of AL			8	nos.					
Volume of lagoon			27,000	m3					
Area of lagoon			9,000	m2					
Width			64	m					
Length			140	m	141				
Slope	1.0	:	2.0						
Width of bottom			58	m					
Length of bottom			134	m					
Actual bottom area			7,772	m2					
Width of water surface			70	m					
Length of water surface			146	m					
Actual water surface			10,220	m2	x	8	81,760		
Freeboard			0.5	m					
Width of top			72	m					
Length of top			148	m					
Actual Top surface			10,656	m2					
The concentration of biological solids produced									
Influent BOD		So	350						
Effluent BOD		S	46.0						
cell yield coefficient		Y	0.65						
endogenous decay coefficient		kd	0.07						
mean cell-residence time		θ c	3.0						
biological solids produced		X	163	mg/L VSS	X=Y(So-S)/(1+kd? c)				
The suspended solids in the lagoon effluent before settling									
Influent SS		Li	315	mg/l					
SP influent SS		SS	519	mg/l	SS=Li+X/0.80				
The amount of biological solids wasted per day									
observed yield		Yobs	0.537		Yob=Y/(1+kd?c)				
net waste activated sludge produced each day		Px	11,757	kg/d	Px=YobsQ(So-S)/1000				
The oxygen requirement									
conversion factor for converting BOD5 to BODL		f	0.68						
oxygen requirement		Or	15,491	kgO2/d	=Q(So-S)/1000/f-1.42Px				
The ratio of oxygen required to BOD5 removed									
BOD5 removed			21,887	kg/d					
the ratio of oxygen required to BOD5 removed			0.71						
The correction factor									
transfer rate in water at 20C and zero dissolved oxygen		No	1.8	kgO2/kWh					
salinity-surface tension correction factor		β	1						
oxygen saturation concentration for tap water at given tempera		Cwalt	9.45	17.8	°C				
oxygen saturation concentration for tap water 20C		Cs20	9.08						
operating oxygen concentration		CL	1.5						
temperature		T	17.8						
oxygen-transfer correction factor for waste		α	0.82						
correction factor		N/No	1.23	N/No=((βCwalt-CL)/Cs20) (1.024^(T-20)) α					
field-transfer rate		N	2.21	kgO2/kWh					
The amount of O2 transferred per day unit		O	53.0	kgO2/kWd					
The total power required		Pr	292	kW	Pr=Or/O				
Check the energy requirements for mixing									
the power requirement			16	kW/1000m3					
Each Lagoon volume			27,000	m3/lagoon					
Each Lagoon Power required			432	kW/lagoon					
Aerators number per lagoon			8	aerators/lagoon					
Aerator power			54.0	kW/aerator					
Use			***Eight 55kW***		***surface aerators each lagoon***				
Total aerator number			64	aerators					

Table 3.6.6 Settling Pond

Total (Phase I + Phase II)

Conditions

Wastewater Flow		72,000	m3/day (ADWF)			
Influent BOD		350	mg/l			
Influent SS	SSi	315	mg/l			
Effluent BOD		50	mg/l	BOD removal ratio	86	%
Effluent SS	SSe	60	mg/l	SS removal ratio	81	%

Estimation

SS load		22,680	kg/day	8,278,200	kg/year	
Removal SS load	Mass	18,360	kg/day	6,701,400	kg/year	
VSS ratio				0.70	=VSS/SS	
Volatile solids	$(Mass)_{VSS}$			4,690,980	kg/year	=0.70Mass
Fixed solids	$(Mass)_{FS}$			2,010,420	kg/year	=0.30Mass
Volatile solids reduction rate (after one ye	Rv			0.75		
Volatile solids average reduction rate (afte	Rv'			0.19		=Rv*(tc/2)/12
Cleaning month interval of each pond	tc			6.0	month	
Volatile solids accumulation						
after tc months	VSStc			1,905,711	kg	$=(1-Rv')*(Mass)_{VSS}*(tc/12)$
after one year	VSSyear			3,811,421	kg/year	$=(1-Rv')*(Mass)_{VSS}$
Total mass of solids accumulated						
after tc months	SStc			2,910,921	kg	$=VSStc+(Mass)_{FS}*(tc/12)$
after one year	SSyear			5,821,841	kg/year	$=VSSyear+(Mass)_{FS}$

Design

Settling Pond

Detention time	t	1.0	days			
Depth	d	1.5	m			
Required surface area	A	4.8	ha			
Accumulated mass of sludge per unit area				60.64	kg/m2	

The required depth assuming that the deposited solids will compact to an average value of 15 percent and that the density of the accumulated solids is equal to 1.06

density of solids	Sd			1.06		
compaction rate	Cr			0.15		
The required depth	dr			0.38	m	=SStc/Sd/Cr

Pond Configuration

Number of Pond		8	nos.			
Area of pond		6,000	m2			
Width		67	m			
Length		90	m	89.5522388		
Slope	1.0 :	2.0				
Width of bottom		64	m			
Length of bottom		87	m			
Actual bottom area		5,568	m2			
Width of water surface		70	m			
Length of water surface		93	m			
Actual water surface		6,510	m2			
Freeboard		0.5	m			
Width of top		72	m			
Length of top		95	m			
Actual water surface		6,840	m2			
Actual detention time		1.0	days			

Table 3.6.7 Chlorination Tank

Total (Phase I + Phase II)

(Treated Wastewater)

Conditions

Wastewater Flow		72,000	m3/day	(ADWF)
Influent BOD		50	mg/L	
Effluent SS		60	mg/L	
Chlorination dosage		3	mg/L	

Design

Chlorination Tank

Design flow	Q	72,000	m3/day	(ADWF)
Detention time	t	15.0	min	
Tank Volume	V	750	m3	
Tank depth	d	1.5	m	
Required surface area	A	500	m2	

Tank Configuration

Number	2
Width	3
Length	83

(Stormwater)

Conditions

Wastewater Flow		121,100	m3/day	(2ADWF)
Chlorination dosage		10	mg/L	

Design

Chlorination Tank

Design flow	Q	121,100	m3/day	(2ADWF)
Detention time	t	15.0	min	
Tank Volume	V	1,261	m3	
Tank depth	d	1.5	m	
Required surface area	A	841	m2	

Tank Configuration

Number	2
Width	3
Length	140

Table 3.6.8 Sludge Drying Bed

Total (Phase I + Phase II)

Conditions					
Yearly solids produced	Sy	5,821,841	kg/year		
Design					
Sludge Drying Bed					
Daily solids produced	Sd	15,950	kg/day		
Sludge concentration		20,000	mg/l		
Sludge feeded	Qs	798	m3/day		
		291,092	m3/year		
Sludge feeded frequency		16	nos./year		
Sludge feeded per one time		18,193	m3/one time		
pump operating hours		80	hour		
Pump number		3	pumps		
Pump capacity		1.3	m3/min	0.021	m3/sec
Pump dia		125	mm		
Drying duration					
Drying duration by gravity	Nw	2	days		
Drying duration by evaporation					
wind speed	V	1.0	m/sec		
evaporation maximum	D	4.9	g/m3	=(0.0384x10^(0.0231(t+10)) -0.017)x(100-Hr)	
temperature	t	26	℃		
relative humidity	Hr	80	%		
drying duration by evaporation	Nd	19	days	=75/((0.40xV^(1/3)+0.42)xD)	
Probability of rainfall (more than 3mm/d	R	0.08			
Drying duration	N	23	days	=(Nw+Nd)/(1-R)	
Drying Bed Configulation					
Thickness of feeded sludge		20	cm		
Required surface area	A	9.0	ha		
series number		8	series	1.13	ha/series
beds number per series		16	beds	703	m2/bed
width	W			26.0	m
length	L			27.1	m
Sludge produced					
Dryed sludge water contents		60	%		
Dryed sludge volume	Vs	40	m3/day		
Check					
Sludge loading rate		65	kg/m2/yeai	=Sy/10000A	
			59-98kg/m2*year for primary and waste activated digested		
Dosage solids loading		4.0	kg/m2	=Sd x N/10000A	
			less than 3.0-4.0kg/m2		
		O.K.			

Table 3.6.9 Pipe line

Conditions

Combined sewer

Average Dry Weather Flow	Qad	60,536	m3/day (ADWF)
Hourly Dry Weather Flow	Qhd	90,804	m3/day (1.5ADWF)
Wet Weather Flow	Qw	181,608	m3/day (3ADWF)
to Stormwater Sedimentation	Q	121,072	m3/day (2ADWF)

Separate sewer

Average Dry Weather Flow	Qad	11,464	m3/day (ADWF)
Hourly Dry Weather Flow	Qhd	17,196	m3/day (1.5ADWF)

						pipeline	flow m3/sec	pipe dia mm
Sewage line								
Combined sewer								
Pumping station - Splitter chamber	Q	90,804	m3/day	1.051	m3/sec	1	1.051	1,000
Separate sewer								
Pumping station - Splitter chamber	Q	17,196	m3/day	0.199	m3/sec	1	0.199	400
Combined sewer + Separate sewer								
Splitter chamber - Aerated Lagoon	Q	108,000	m3/day	1.250	m3/sec	8	0.156	400
Aerated Lagoon - Settling Pond	Q	108,000	m3/day	1.250	m3/sec	8	0.156	400
Settling Pond - Chlorination Tank	Q	108,000	m3/day	1.250	m3/sec	8	0.156	400
						4	0.313	600
						2	0.625	800
Chlorination Tank - River	Q	108,000	m3/day	1.250	m3/sec	1	1.250	1,100
Stormwater line								
Pumping station - Stormwater sedimentation Pond								
	Q	121,072	m3/day	1.401	m3/sec	1	1.401	1,100
						2	0.701	800
Sludge line								
Settling Pond - Sludge Drying Bed	Q	18,193	m3/one time			3	0.021	150

Table 3.6.10 Building Space for O & M of WWTP

		Number		Space		
		Phase I+II	Phase I		Phase I+II	Phase I
		nos.	nos.	m2/Build.	m2	m2
1	Control building	1	1	640	640	640
2	Pump station building	1	1	160	160	60
3	O & M machine building	1	1	240	240	240
4	Electric panel house for AL	8	4	10	80	40
5	Sludge Pump Maintenace House	2	1	40	80	40
6	Building for chrolination	2	1	20	40	20
7	House for watchman	1	1	30	30	30
	Total	16	10		1,270	1,070

Table 3.6.11 Room Space of Control Building

No.	Item	m2
1	Operating panel room	120
2	Generator room	80
3	Laboratory	120
4	Balance room	40
5	Office	50
6	Meeting room	50
7	Rest room	10
8	Worker's room	20
9	Kitchen	5
10	Toilet	10
11	Shower	5
12	Warespace for documents	30
13	Warespace for materials	30
14	Entrance hole	20
15	Passage	50
	Total	640

Table 3.6.12 The Bill of Quantity of West Wastewater Treatment Plant (1/3)

Civil Works and Buildings

1 Pumping Station (Combined sewer system)

Item		Unit	BQ
excavation		m3	5,150
backfilling		m3	5,200
surplus soil disposal		m3	5,150
pile foundation work	PC pile dia 300 x 6m (follower 6m)	nos.	90
shoring	steel sheet pile type III 40cm x10m	m	83
supportings of shoring	H300x300x10x15, 94kg/m	ton	32.4
soil stabilization		m3	1,520
de-watering		LS	1
crusher-run stone		m3	70
levelling concrete		m3	24
reinforced concrete		m3	570
formwork		m2	2,100
reinforcing bar		kg	45,000
work platforms		m2	1,430
supportings		m3	380
control building		m2	54

2 Aerated Lagoon Treatment Process (AL)

	Item		Unit	BQ
1	excavation		m3	12,800
2	backfilling		m3	0
3	surplus soil disposal		m3	12,800
4	soil stabilization	lime soil stabilization, t=30cm	m3	12,800
5	preparation of pond bottom		m2	31,100
6	pretection of bottom	concrete t=10cm, crushed stone t=15cm	m2	10,400
7	trimming of slope		m2	12,800
8	riprap stone		m2	1,640
9	inlet works		nos.	8
10	outlet works	the same of inlet works	nos.	8
11	access slope	concrete t=20cm	m2	840
12	de-watering		LS	1

inlet works or outlet works			
	crusher-run stone	m3	1.2
	levelling concrete	m3	0.6
	reinforced concrete	m3	3.3
	formwork	m2	20
	reinforcing bar	kg	130
	stop log B400mm x H1000mm	nos.	1

Table 3.6.12 The Bill of Quantity of West Wastewater Treatment Plant (2/3)

3 Settling Pond

	Item		Unit	BQ
1	excavation		m3	49,000
2	backfilling		m3	0
3	surplus soil disposal		m3	49,000
4	soil stabilization	lime soil stabilization, t=30cm	m3	8,200
5	preparation of pond bottom		m2	22,000
6	trimming of slope		m2	5,800
7	riprap stone		m2	1,300
8	inlet works		nos.	8
9	outlet works	the same of inlet works	nos.	8
10	access slope	concrete t=20cm	m2	480
11	de-watering		LS	1

inlet works or outlet works			
	crusher-run stone	m3	1.2
	levelling concrete	m3	0.6
	reinforced concrete	m3	3.3
	formwork	m2	20
	reinforcing bar	kg	130
	stop log B400mm x H1000mm	nos.	1

4 Chlorination Tank

	Item		Unit	BQ
1	excavation		m3	250
2	backfilling		m3	100
3	surplus soil disposal		m3	250
4	bamboo foundation		m2	490
5	crusher-run stone		m3	100
6	levelling concrete		m3	50
7	reinforced concrete		m3	260
8	formwork		m2	980
9	reinforcing bar		kg	15600

5 Stormwater Sedimentation Pond

	Item		Unit	BQ
1	excavation		m3	4,700
2	backfilling		m3	0
3	surplus soil disposal		m3	4,700
4	soil stabilization	lime soil stabilization, t=30cm	m3	1,400
5	preparation of pond bottom		m2	4,700
6	trimming of slope		m2	1,300
7	riprap stone		m2	1,300
8	inlet works		nos.	1
9	outlet works	the same of inlet works	nos.	1
10	access slope	concrete t=20cm	m2	120
11	de-watering		LS	1

inlet works or outlet works			
	crusher-run stone	m3	1.7
	levelling concrete	m3	0.9
	reinforced concrete	m3	6.0
	formwork	m2	36
	reinforcing bar	kg	240

Table 3.6.12 The Bill of Quantity of West Wastewater Treatment Plant (3/3)

6 Sludge Drying Bed

	Item		Unit	BQ
1	excavation		m3	1,600
2	backfilling		m3	800
3	surplus soil disposal		m3	1,600
4	soil stabilization	lime soil stabilization, t=15cm	m3	6,800
5	preparation of bed		m2	45,000
6	crushed stone		m3	410
7	concrete		m3	1,530
8	formwork		m2	8,600
9	reinforcing bar		kg	61,200
10	coarse sand		m3	6,800
11	fine gravel		m3	9,000
12	coarse gravel		m3	320
13	perforated tile	dia150mm	m	3,500
14	concrete pipe	dia200mm	m	1,700

7 Control Building etc

as you will see from the enclosed paper

8 Other Works

Splitter chamber		chmbers	***1***
	excavation	m3	50
	backfilling	m3	10
	surplus soil disposal	m3	50
	bamboo foundation	m2	20
	crusher-run stone	m3	6
	levelling concrete	m3	2
	reinforced concrete	m3	16
	formwork	m2	110
	reinforcing bar	kg	640
gate of outfall	1500mmx1500mm	nos.	1
bank	banking	m3	15,600
	trimming of bank	m2	5,600
	bamboo foundation	m2	9,800
pavement		m2	3,400
banking		m2	17,000
drainage	dia 300mm	m	1,800
	U flume 300mm	m	1,800
landscape		m2	20,500
turfing		m2	10,400
de-watering		LS	1
Equipment	lawn tractor	tractor	1
	swamp bulldozer	bulldozer	1
	swamp shovel	shovel	1
	truck for sludge disposal, 10ton	truck	1
	wastewater examination equipment	LS	1
Fencing		m	1,720
Lighting		LS	1

Table3.6.13 The Bill of Quantity of West Wastewater Treatment Plant (E/M)

Electrical and Mechnical Facilities

1 Pumping Station (Combined sewer system)

Item		Unit	BQ
Rack rake	automatic, W800mm x H2800mm	set	2
Belt conveyer	W600mm, L15m	set	1
Carrier	0.3m3	set	1
Hopper	6m3	set	1
Gate	W800mm x H800mm x L7600mm	set	6
Stoplog	W1500mm x H1500mm	set	6
Vertical shaft centrifugal pump	600mmdia., 45.1m3/min, 9.3m, 110kW	pumps	1
Vertical shaft centrifugal pump	400mmdia., 22.5m3/min, 9.3m, 55kW	pumps	2
Overhead crane		set	1
Grit collector		set	1
Belt conveyer	W600mm, L15m	set	1
Carrier	0.3m3	set	1
Hopper	6m3	set	1

2 Aerated Lagoon Treatment Process (AL)

Item		Unit	BQ
Aerator	55kW	set	32
Gate	W400mm x H400mm	set	8

3 Settling Pond

Item		Unit	BQ
Dredge pump	1.3m3/min, 20m, 7.5kW	set	3
Gate	W400mm x H400mm	set	8

4 Chlorination Tank

Item		Unit	BQ
Storage tank	5m3	set	2
Pump	32lit/h, 2kgf/cm2	set	4

5 Piping

Item		Unit	BQ
Ductile cast iron pipe	150mm-1000mm dia.	L..S	1
R.C. pipe	400mm-1100mm dia.	L..S	1

6 Electrical equipment

Item		Unit	BQ
Transformer	500kVA	set	1
Generator	500kVA	set	1
Incoming panel		set	1
Control panel		set	3
Local panel		set	35
Wiring and others		L.S	1

Table 3.8.1 Estimated incremental staff number for Drainage and Sewerage PP by Phase

Drainage

		Incremental Staff (Number)				
		O&M				
		Eng/Grad.	Tech/School	Total O&M	Indirect	Total
Phase I (in the year 2006)						
1Bproject etc.	2pumping station etc.	0	8	8	4	12
An Kim Hai Channel and Phong Luu Lake	10km, 24ha	0	4	4	2	6
Total		0	12	12	6	18
Phase II (in the year 2013, incremental to Phase I)						
Drainage P/S	2+8 pumping station etc.	0	20	20	10	30
Channel and lakes	5 km, 2 lakes	0	4	4	2	6
Drainage pipelines	10+62km	0	6	6	3	9
Total		0	30	30	15	45

Sewerage

		Incremental Staff (Number)				
		O&M				
		Eng/Grad.	Tech/School	Total O&M	Indirect	Total
Phase I (in the year 2006)						
West WWTP	Q=36,000m3/day	2	18	20	10	30
Relay P/S	Q=0.4m3/sec	0	4	4	2	6
CSO control structure, Manholepump	about 50 CSO control structures	0	6	6	3	9
Sewer pipe	84km	0	4	4	2	6
Total		2	32	34	17	51
Phase II (in the year 2013, incremental to Phase I)						
West WWTP	Q=72,000m3/day	2	18	20	10	30
East WWTP	Q=11,788m3/day	2	12	14	7	21
Relay P/S	1+4 nos.	0	12	12	6	18
CSO control structure, Manholepump	about 100 CSO control structures	0	6	6	3	9
Sewer pipe	84+471km	0	12	12	6	18
Total		4	60	64	32	96

Table 3.8.2 Estimated incremental Staff Cost for Sewerage PP by Phase

	Occupation title	Number of personnel	Unit Cost	Cost
		nos.	US$/person/year	US$/year
Phase I (in the year 2006)				
	Eng/Grad.	2	3,100	6,200
	Tech/School	32	2,000	64,000
	Indirect	17	2,000	34,000
	Total	51		104,200
Phase II (in the year 2013, incremental to Phase I)				
	Eng/Grad.	4	3,100	12,400
	Tech/School	60	2,000	120,000
	Indirect	32	2,000	64,000
	Total	96		196,400
Total (Phase I+II)				
	Eng/Grad.	6		18,600
	Tech/School	92		184,000
	Indirect	49		98,000
	Total	147		300,600

Table 3.8.3 Electricity Charges

Phase I

No	Facilities Name	Equipment Name	Motor Rating kW	Q'ty Duty	Q'ty Stn.By	Q'ty Total	Motor Load kW	Operating Hour hour/day	Load Factor hours	Power Consumption kWh/day
	Manhole Pump									
1	Manhole Pump No.1	Vertical Detachable Submersible Pump(150mm)	5.5	1	1	2	6	8	0.8	35
2	Manhole Pump No.2	Vertical Detachable Submersible Pump(80mm)	1.5	1	1	2	2	8	0.8	10
3	Manhole Pump No.3	Vertical Detachable Submersible Pump(80mm)	1.5	1	1	2	2	8	0.8	10
4	Manhole Pump No.4	Vertical Detachable Submersible Pump(100mm)	3.7	1	1	2	4	8	0.8	24
5	Manhole Pump No.5	Vertical Detachable Submersible Pump(125mm)	7.5	1	1	2	8	8	0.8	48
6	Others	Vertical Detachable Submersible Pump(80mm)	1.5	5	5	10	8	8	0.8	48
	An Da Lifting Pump Station									
7	Sewage Pump	Lifting Sewage Pump (300mm)	18.5	3	1	4	56	12	0.8	533
8	Lighting		1			0	1	12	0.8	10
	West Wastewater Treatment Plant									
9	Screen & Grit chamber	Grit Collector etc	15	1		1	15	8	0.8	96
10	Sewage Pump	Lifting Sewage Pump (600mm)	110	1	0	1	110	1	0.8	88
11	Sewage Pump	Lifting Sewage Pump (400mm)	55	1	1	2	55	24	0.8	1,056
14	Aerated Lagoon	Aerator	55	32	0	32	1,760	4.5	0.8	6,336
16	Settling Pond	Sludge pump	7.5	3	1	4	23	4	0.8	72
19	Others		10				10	8	0.8	64
20	Lighting		10				10	12	0.8	96
Total										8,524

Daily electricity consumption	kWh/day	8,524		
Yearly electricity consumption	kWh/year	3,111,435		
Unit cost	US$/kWh	0.06	VND/kWh	846
Daily electricity charges	US$/day	511		
Yearly electricity charges	US$/year	187,000		

Table 3.8.4 Calculation of Chemicals and Cleaning Materials Comsumption

Hypo Chlorite (NaOCL) for Disinfection

			Phase I	
(Treated Wastewater)				
Effective chlorine concentration	Cc	%	12	
Specific gravity	γ c		1.12	
Average dry weather flow	Q	m3/day	36,000	Phase I
NaOCL average dosing rate	Rd	mg/l	3	as 100% chlorine
Required capacity per day		kg/d	900	=Q*Rd/1000*100/Cc
		l/d	804	=Q*Rd/1000*100/Cc/?c
Monthly consumption		m3/month	24	
Yearly consumption		m3/year	289	
Unit cost of NaOCL		VND/kg	2,000	(12% Effective chlorine)
		US$/kg	0.15	
Daily cost		US$/day	135	
Yearly cost		US$/year	49,000	
(Stormwater)				
Effective chlorine concentration	Cc	%	12	
Specific gravity	γ c		1.12	
		m3/day	72,000	
		m3/hour	3,000	
		hours/year	275	
Average dry weather flow	Q	m3/year	825,000	Phase I
NaOCL average dosing rate	Rd	mg/l	10	as 100% chlorine
Required capacity per day		kg/year	68,750	=Q*Rd/1000*100/Cc
		l/year	61,384	=Q*Rd/1000*100/Cc/?c
Yearly consumption		m3/year	61	
Unit cost of NaOCL		VND/kg	2,000	(12% Effective chlorine)
		US$/kg	0.15	
Yearly cost		US$/year	10,313	
Total Yearly cost		US$/year	59,313	

Table 3.8.5 Sludge disposal cost

			Phase I	
Daily sludge volume(Sewage)	Vsd	m3/day	20	
Annual sludge volume(Sewage)	Vsa	m3/year	7,300	
Screenings and grit	Vsg	m3/year	2,190	
Stormwater pump capacity		m3/hour	3,000	2Q=2*36,000m3/day=3,000m3/hour
Average storm hours in year	has	hours	275	
Operating hours		hours	550	=has * 2
Expected average stormwater SS		mg/l	100	
Removal rate		%	50	
Removal sluge		ton	83	
Sludge water content		%	60	
Sludge weight		ton	138	
Sludge unit weight		ton/m3	1.1	
Annual sludge volume(Stormwate	Vst	m3	125	
Annual sludge volume	Vs	m3	9,615	=Vsa + Vsg + Vst
Sludge disposal unit cost		US$/m3	8.5	Including loading, hauling and spreading, haulage distance about
Annual sludge disposal cost		US$/year	81,728	

Table 3.8.6 Wastewater examination cost

Item	Sampling point	Number	Annual exa. number	Unit cost (US$)	Cost (US$/year)
Temperature	R, E	2	24	-	-
pH	R, E	2	24	-	-
BOD_5(20℃)	R, E	2	24	-	-
CODcr	R, E	2	24	-	-
Suspended Solid	R, E	2	24	-	-
DO	E	1	24	-	-
Kjeldahl Nitrogen	R	1	24	10	240
Ammonia Nitrogen	R, E	2	24	10	480
Nitrite (NO_2-N)	E	1	24	10	240
Nitrate (NO_3-N)	E	1	24	10	240
Total Phosphate	R, E	2	24	10	480
Coliform	E	1	2	20	40
Residual Chlorine	E	1	2	20	40
Mineral oil	E	1	2	20	40
Vegetable oil	E	1	2	20	40
Betra chlorethylen	E	1	2	20	40
Trichlore ethylen	E	1	2	20	40
Fluoride	E	1	2	20	40
Phenol	E	1	2	20	40
Sulfure	E	1	2	20	40
Cyanide	E	1	2	20	40
a radio-active activity total	E	1	2	20	40
ß radio-active activity total	E	1	2	20	40
Arsenic	E	1	2	20	40
Cadmium	E	1	2	20	40
Lead	E	1	2	15	30
Chrome(VI)	E	1	2	15	30
Chrome(III)	E	1	2	20	40
Copper	E	1	2	15	30
Zinc	E	1	2	15	30
Manganese	E	1	2	20	40
Nickel	E	1	2	20	40
Iron	E	1	2	15	30
Tin	E	1	2	20	40
Mercury	E	1	2	20	40
Total					2,590

Note: Sampling point raw; R Effluent; E

Table 3.10.1 Property Values: Sewerage Project

Year	Total Value (Land plus Bldgs, Property) ($mill) (1)	Annual equiv. of (1) (No Growth) ($mill) (2)	Annual Value (Avge. Growth)* ($mill) (3)	Present Value (PV) of (3) (2003 base Yr.) ($mill) (4)	Annual Project Costs ($mill) (7)	PV of Project Costs 2003 base Yr. ($mill) (8)	Cost as % of Property Value (No Growth) (7)	Cost as % of Property Value (Avge. Growth) (8)
2001	795.7	93	93					
2		93	101					
3		93	109	1,678	1.97	45.5	**5.7**	**2.7**
4		93	116		7.16			
5		93	124		13.20			
6		93	140		13.20			
7		93	157		10.74			
8		93	173		7.98			
9		93	190		8.09			
10		93	206		4.60			
11		93	219		0.43			
12		93	231		0.43			
13		93	243		0.43			
14		93	256		0.43			
15		93	268		0.43			
16		93	280		0.43			
17		93	292		0.43			
18		93	305		0.43			
19		93	317		0.43			
20		93	329		0.43			
21		93	329		0.43			
22		93	329		0.43			
23		93	329		0.43			

Table 3.10.2 Urban Productivity: Sewerage Project

Year	Value-Added (No Growth) ($mill) (1)	Present Value (PV) of (1) 2003 base yr* ($mill) (2)	Total Value-Added (Avge. Growth after 2001) ($mill) (3)	PV of (3) 2003 base yr ($mill) (4)	PV of Project Costs 2003 base yr ($mill) (5)	Proj. cost as % of Value Added (No Growth) (6)	Proj. cost as % of Value (Avge. Growth after 2001) (7)
2000							
2001	159		159				
2	159		172				
3	159	1,211	185	2,820	45.5	**3.76**	**1.61**
4	159		198				
5	159		211				
6	159		239				
7	159		267				
8	159		295				
9	159		323				
10	159		351				
11	159		372				
12	159		393				
13	159		414				
14	159		435				
15	159		456				
16	159		477				
17	159		498				
18	159		518				
19	159		539				
20	159		559				
21	159		587				
22	159		617				
23	159		648				

Table 3.10.3 Sewerage Program Costs in Relation to Key Indicators: Sensitivity to Key Assumptions

(20% increase in estimated costs, half the predicted economic growth rate)

values in 2000 prices

Year	Total Cost ($'000)	Cost as % of GRP in Study Area (%)	Cost as % of GRP in Haiphong (%)	Cost as % of HPPC Exp. (%)	Cost as % of Disp. Inc. Study Area (%)	Per Capita Cost in Study Area ($)
2001	0	0.00	0.00	0.00	0.00	0.00
2002	0	0.00	0.00	0.00	0.00	0.00
2003	168	0.04	0.02	0.24	0.07	0.29
2004	852	0.18	0.11	1.20	0.35	1.45
2005	2,372	0.48	0.29	3.23	0.95	4.00
2006	4,031	0.76	0.46	5.14	1.51	6.73
2007	5,824	1.03	0.63	7.01	2.06	9.61
2008	6,881	1.16	0.71	7.87	2.31	11.23
2009	7,949	1.27	0.78	8.67	2.55	12.84
2010	8,713	1.34	0.82	9.10	2.68	13.92
2011	10,674	1.59	0.97	10.81	3.18	16.88
2012	13,420	1.94	1.19	13.20	3.88	21.00
2013	16,393	2.31	1.41	15.69	4.61	25.39
2014	17,914	2.46	1.50	16.71	4.91	27.46
2015	19,184	2.57	1.57	17.45	5.13	29.11
2016	20,458	2.67	1.64	18.18	5.34	30.74
2017	21,730	2.77	1.70	18.88	5.55	32.33
2018	23,000	2.87	1.76	19.56	5.75	33.89
2019	24,272	2.97	1.82	20.22	5.94	35.42
2020	25,543	3.07	1.88	20.86	6.13	36.91

Table 3.10.4 Sewage Priority Project: Loan Repayment Schedule and Costs as Percentage of HPPC's Expenditure

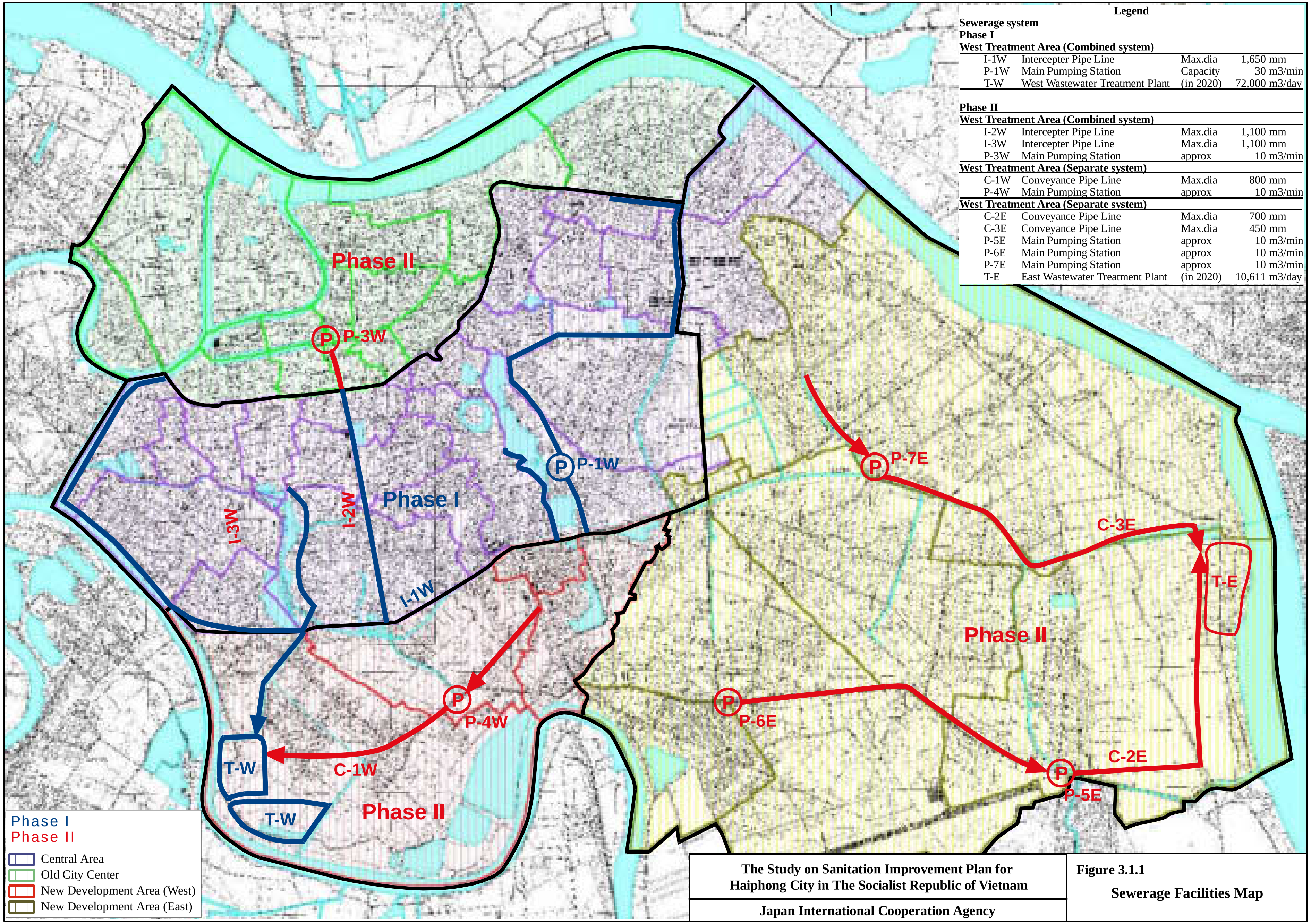
Unit: 1,000 dollar in current price

	Borrowing (85% of Total Investment)												
	Const-ruction & Procure-ment (1.3%/year)	Engi-neering (0.75%/year)	Total	Repay-ment of Principal	Payment of Interest	Total Repay-ment	15% of Total Invest-ment (Not Covered by Loan)	Recurring Cost	Total Project Cash Expendi-ture	HPPC's Expenditure	Raito of Re-payment to HPPC Exp.	Ratio of Sum of the 15% & Recurring Cost to HPPC Exp.	Ratio of Total Project Expenditure to HPPC Exp.
a	b	c	d = b+c	e	f	g = e+f	h	I	j = g+h+I	k	l =g/k	m = (h+I)/k	n = j/k
2003	0	766	766	0	0	0	1,325	0	1,325	77,066	0.0%	1.7%	1.7%
2004	4,894	782	5,676	0	6	6	2,071	0	2,077	83,548	0.0%	2.5%	2.5%
2005	11,986	797	12,783	0	75	75	1,787	0	1,862	90,259	0.1%	2.0%	2.1%
2006	12,226	813	13,039	0	237	237	1,823	0	2,060	102,432	0.2%	1.8%	2.0%
2007	9,702	830	10,531	0	402	402	1,452	355	2,209	115,057	0.3%	1.6%	1.9%
2008	7,070	846	7,916	0	534	534	1,065	362	1,962	128,146	0.4%	1.1%	1.5%
2009	7,212	863	8,075	0	633	633	1,087	509	2,229	141,712	0.4%	1.1%	1.6%
2010	3,640	880	4,520	0	733	733	562	519	1,814	155,770	0.5%	0.7%	1.2%
2011	0	0	0	0	733	733	0	530	1,263	168,894	0.4%	0.3%	0.7%
2012	0	0	0	0	733	733	0	540	1,273	182,482	0.4%	0.3%	0.7%
2013	0	0	0	3,056	787	3,843	0	551	4,394	196,545	2.0%	0.3%	2.2%
2014	0	0	0	3,056	748	3,804	0	562	4,366	211,098	1.8%	0.3%	2.1%
2015	0	0	0	3,056	710	3,766	0	573	4,339	226,154	1.7%	0.3%	1.9%
2016	0	0	0	3,056	671	3,727	0	585	4,312	241,728	1.5%	0.2%	1.8%
2017	0	0	0	3,056	633	3,688	0	597	4,285	257,834	1.4%	0.2%	1.7%
2018	0	0	0	3,056	594	3,650	0	608	4,258	274,488	1.3%	0.2%	1.6%
2019	0	0	0	3,056	556	3,611	0	621	4,232	291,705	1.2%	0.2%	1.5%
2020	0	0	0	3,056	517	3,573	0	633	4,206	309,501	1.2%	0.2%	1.4%
2021	0	0	0	3,056	479	3,534	0	646	4,180	328,319	1.1%	0.2%	1.3%
2022	0	0	0	3,056	440	3,496	0	659	4,154	348,281	1.0%	0.2%	1.2%
2023	0	0	0	3,056	402	3,457	0	672	4,129	369,456	0.9%	0.2%	1.1%
2024	0	0	0	3,056	363	3,419	0	685	4,104	391,919	0.9%	0.2%	1.0%
2025	0	0	0	3,056	325	3,380	0	699	4,079	415,748	0.8%	0.2%	1.0%
2026	0	0	0	3,056	286	3,342	0	713	4,055	441,025	0.8%	0.2%	0.9%
2027	0	0	0	3,056	248	3,303	0	727	4,030	467,840	0.7%	0.2%	0.9%
2028	0	0	0	3,056	209	3,265	0	742	4,006	496,284	0.7%	0.1%	0.8%
2029	0	0	0	3,056	171	3,226	0	757	3,983	526,458	0.6%	0.1%	0.8%
2030	0	0	0	3,056	132	3,188	0	772	3,959	558,467	0.6%	0.1%	0.7%
2031	0	0	0	3,056	93	3,149	0	787	3,936	592,422	0.5%	0.1%	0.7%
2032	0	0	0	3,056	55	3,111	0	803	3,914	628,441	0.5%	0.1%	0.6%
2033	0	0	0	219	16	236	0	819	1,055	666,650	0.0%	0.1%	0.2%
2034	0	0	0	219	15	234	0	835	1,069	707,183	0.0%	0.1%	0.2%
2035	0	0	0	219	13	232	0	852	1,084	750,179	0.0%	0.1%	0.1%
2036	0	0	0	219	12	231	0	869	1,100	795,790	0.0%	0.1%	0.1%
2037	0	0	0	219	10	229	0	886	1,115	844,174	0.0%	0.1%	0.1%
2038	0	0	0	219	8	227	0	904	1,132	895,500	0.0%	0.1%	0.1%
2039	0	0	0	219	7	226	0	922	1,148	949,947	0.0%	0.1%	0.1%
2040	0	0	0	219	5	224	0	941	1,165	1,007,703	0.0%	0.1%	0.1%
2041	0	0	0	219	3	223	0	959	1,182	1,068,972	0.0%	0.1%	0.1%
2042	0	0	0	219	2	221	0	979	1,200	1,133,965	0.0%	0.1%	0.1%
Total	56,730	6,577	63,307	63,307	12,594	75,901	11,172	25,171	112,244	9,917,709	0.8%	0.4%	1.1%

Note: A 2% annual inflation in terms of dollar is assumed.

Table 3.10.5 Summary of Major Impacts and Mitigation Measures for Sewerage Priority Project

Issue	Location	Major Impacts	Mitigation Measures	Net Effect	Monitoring
Pre-Construction					
Land Acquisition and Compensation	Agricultural area in Vinh Niem	Land acquisition of about 38 ha. About 23 households, 7 tombs, 5 small tidal gates and 25 power poles need to be removed. Relocation of dyke and road.	Resettlement Action Plan has to be done outlining principles and regulations for compensation and resettlement of project affected people. Resettlement is proposed to be done in Vinh Niem villages in the vicinity of construction site.	Long-term impacts on project affected people and landscape	Detailed measurement survey and information to residents.
Construction					
Construction of Sewer system and Pumping Station	Along main streets, proposed site for pumping statino (An Da)	No need for resettlement or permanent land acquisition. Possible contamination of upper aquifer during the construction of trunks.	Works should be designed and timed to minimize the impacts on traffic. Wastewater should be diverted to other sewer network during construction.Possible infiltration of groundwater to trench has to be prevented.	Major, but temporary impacts	Consultant has to supervise that agreed measures are implemented
Operation					
Operation of WWTP	Discharging of effluent (Lach Tray River)	Discharging of treated effluent will slightly increase the pollution load of BOD, nutrients and bacteria	Must meet the discharge standard. Discharging of effluent should be timed according to the tidal system.	Minor but permanent impacts	Monitoring of treatment process and effluent quality
	Groundwater	Pollution of groundwater by infiltrated wastewater from lagoon	Lagoons should be constructed without disturbing groundwater. Lining of lagoons has to be done tight to prevent infiltration of wastewater to soil and groundwater.	Minor but long-term impact	Monitoring of groundwater quality
	Air emissions and odor generated during wastewater treatment process	CH_4, H_2S, NH_3 and odor generated from treatment process will have local, long-term impacts in Vinh Niem area.	It is recommended to plant trees around the WWTP to minimize the impacts of odor and gases.	Minor but permanent impacts	Monitoring of air quality
	Sludge drying beds	Leachate from sludge beds	Leachate should be circulated to treatment process. Dried sludge can be used as fertilizer, if the concentrations of heavy metals are under acceptable limits or disposed to landfill.	Long-term impacts if no appropriate mitigation measures adopted.	Monitoring of sludge



Legend

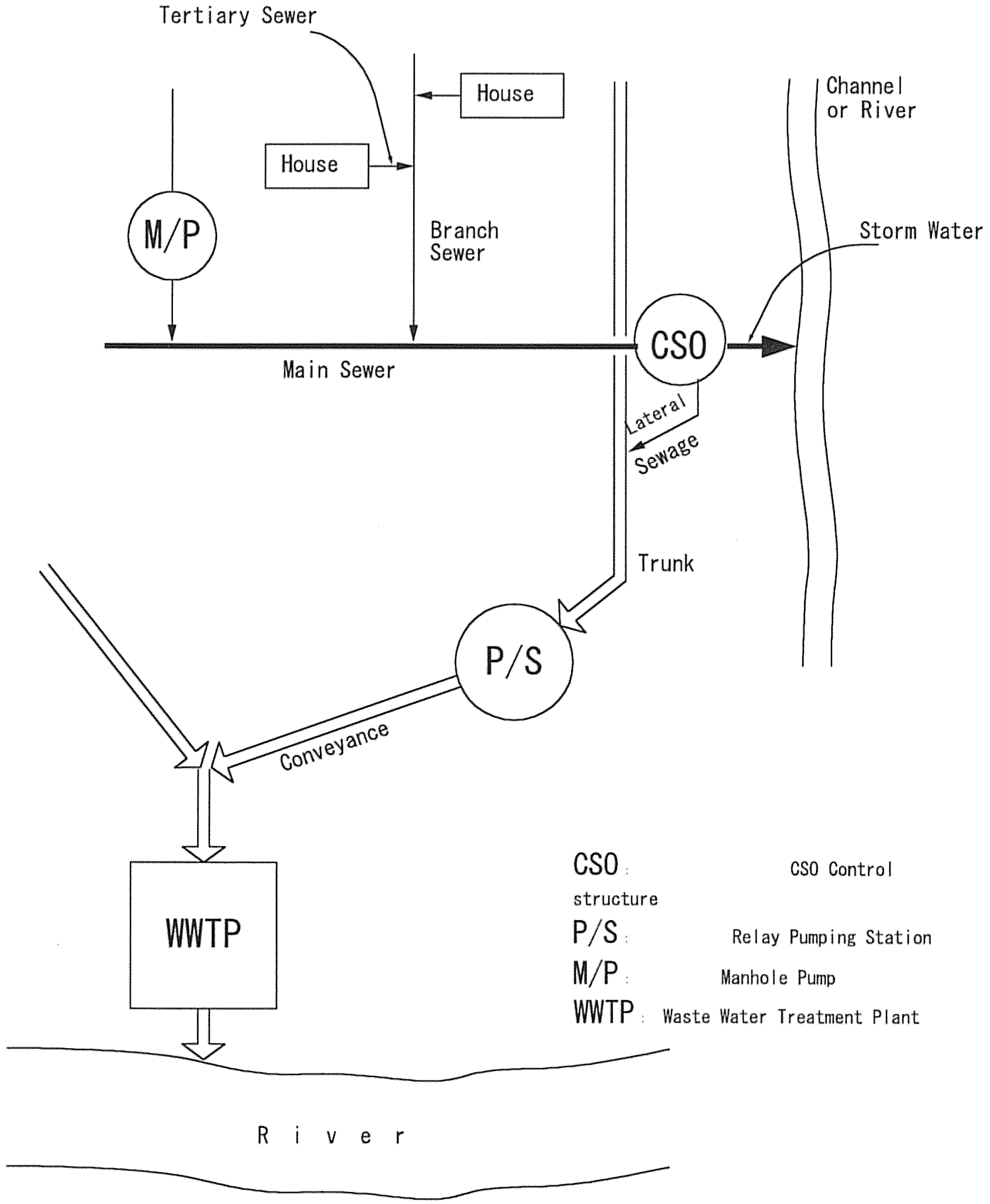
Sewerage system				
Phase I				
West Treatment Area (Combined system)				
I-1W	Intercepter Pipe Line	Max.dia	1,650 mm	
P-1W	Main Pumping Station	Capacity	30 m3/min	
T-W	West Wastewater Treatment Plant	(in 2020)	72,000 m3/day	
Phase II				
West Treatment Area (Combined system)				
I-2W	Intercepter Pipe Line	Max.dia	1,100 mm	
I-3W	Intercepter Pipe Line	Max.dia	1,100 mm	
P-3W	Main Pumping Station	approx	10 m3/min	
West Treatment Area (Separate system)				
C-1W	Conveyance Pipe Line	Max.dia	800 mm	
P-4W	Main Pumping Station	approx	10 m3/min	
West Treatment Area (Separate system)				
C-2E	Conveyance Pipe Line	Max.dia	700 mm	
C-3E	Conveyance Pipe Line	Max.dia	450 mm	
P-5E	Main Pumping Station	approx	10 m3/min	
P-6E	Main Pumping Station	approx	10 m3/min	
P-7E	Main Pumping Station	approx	10 m3/min	
T-E	East Wastewater Treatment Plant	(in 2020)	10,611 m3/day	

The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam

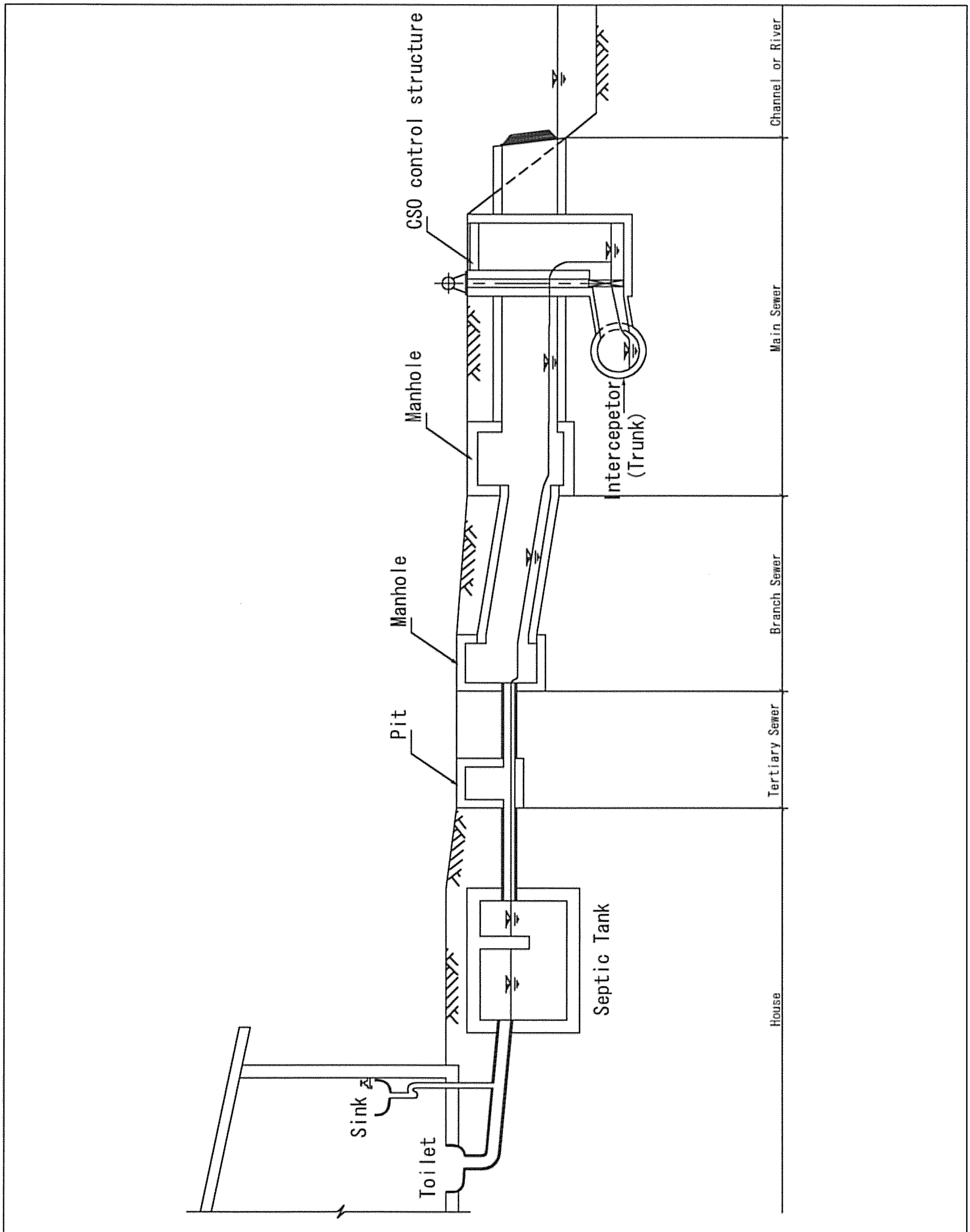
Japan International Cooperation Agency

Figure 3.1.1

Sewerage Facilities Map



The Study on Sanitation Improvement for Haiphong City in The Socialist Republic of Vietnam	Figure 3.2.1 Combined Sewer System Mechanism
Japan International Cooperation Agency	



The Study on Sanitation Improvement for Haiphong City in The Socialist Republic of Vietnam	Figure 3.2.2 Combined Sewer System Mechanism
Japan International Cooperation Agency	

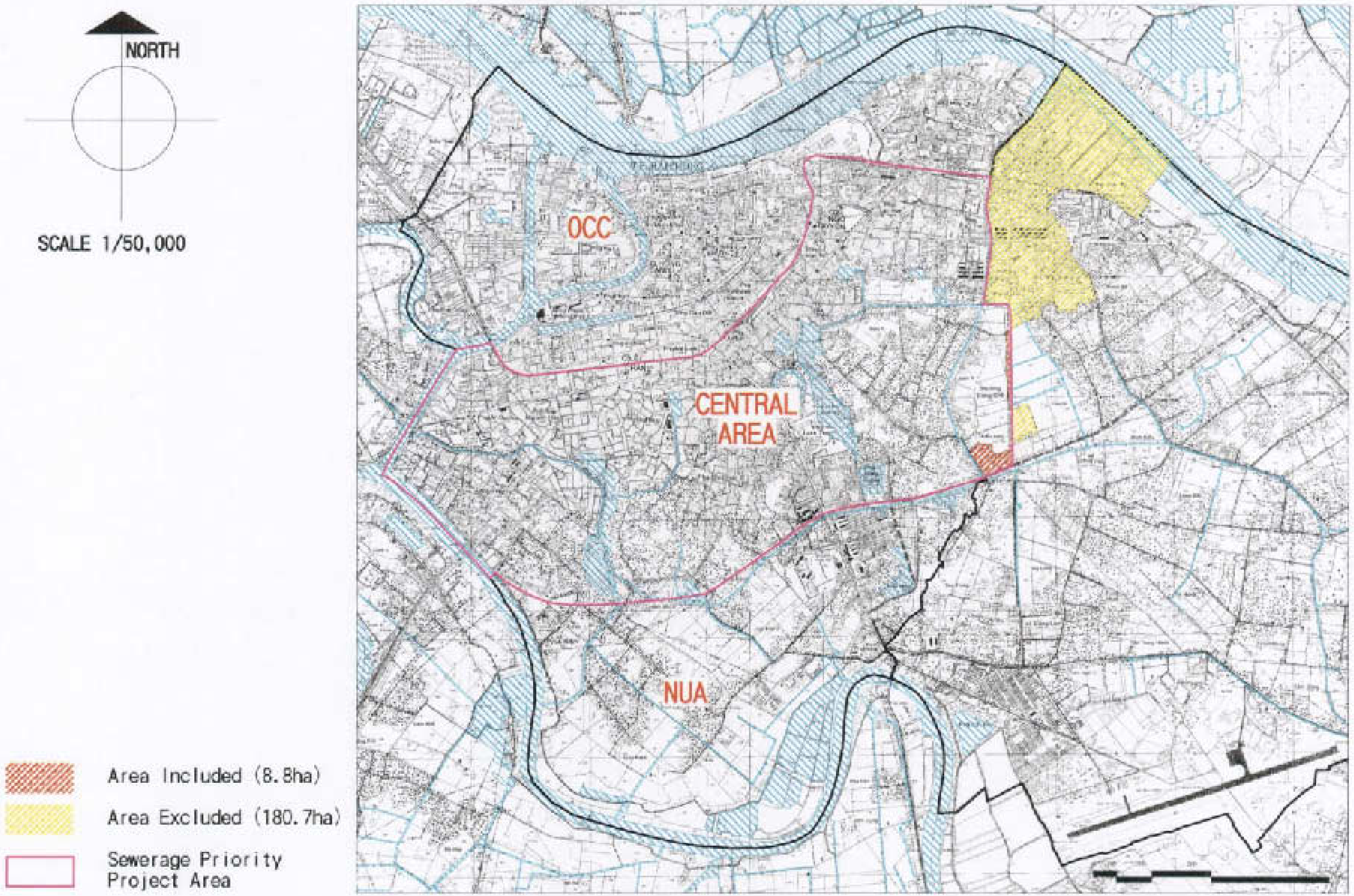


Figure 3.2.3 MODIFICATION OF THE COVERAGE AREA