SOCIALIST REPUBLIC OF VIETNAM
MINISTRY OF CONSTRUCTION

LOCAL WATER SUPPLY AND WASTEWATER SECTOR SURVEY

TECHNICAL REPORT ON HA LONG CITY WATER ENVIRONMENT IMPROVEMENT PROJECT

FINAL REPORT

January 2015

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIPPON KOEI CO. LTD.
SEWERAGE BUSINESS MANAGEMENT CENTRE
DOGAN, INC.
WATER AGENCY INC.
NIHON SUIDO CONSULTANTS CO., LTD.

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EXCHANGE RATE (Fact Finding Mission for FY 2014 Japanese ODA Loan Projects)

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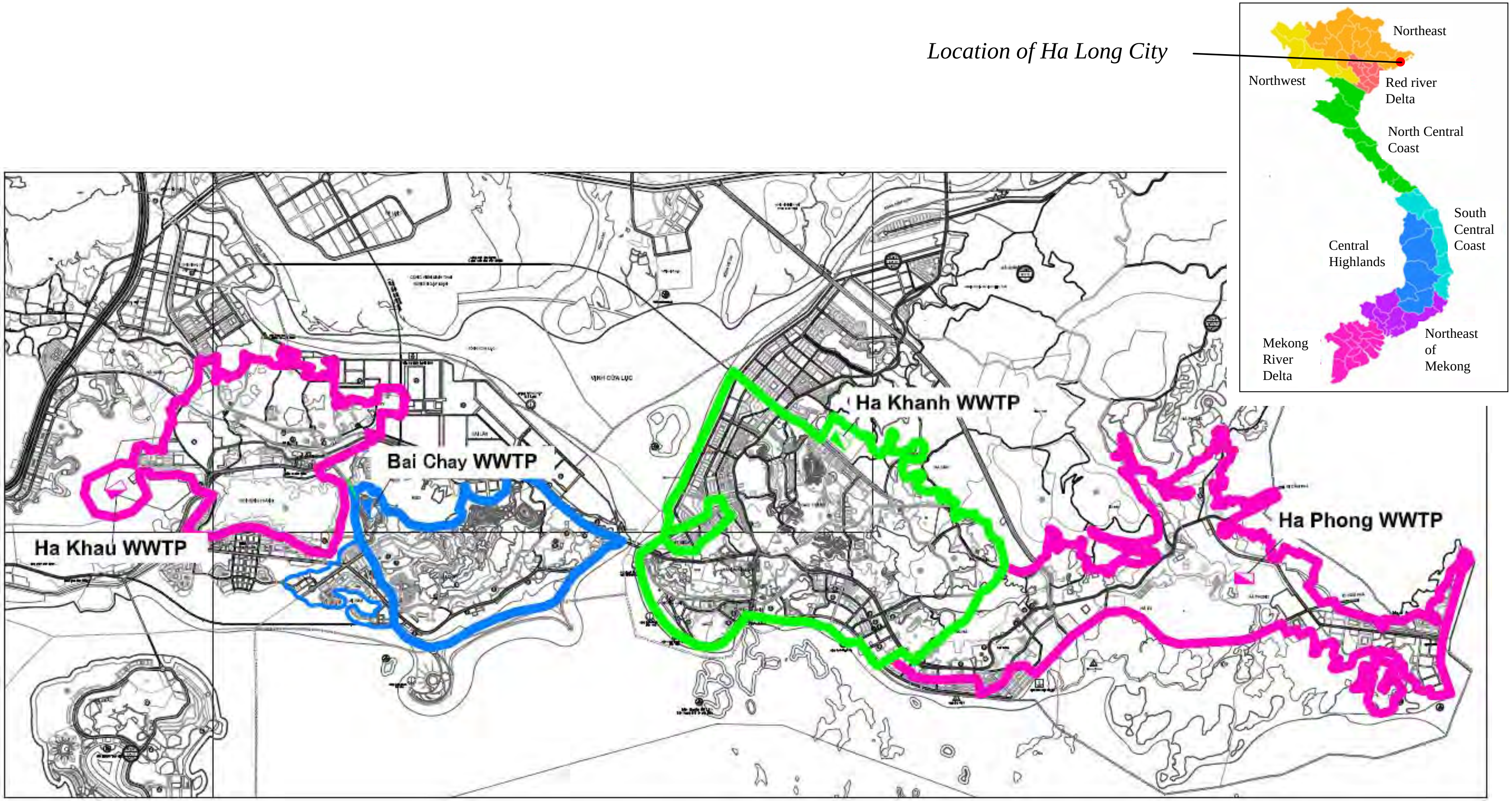

Location Map of the Study Area

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HA LONG CITY WATER ENVIRONMENT IMPROVEMENT PROJECT
TECHNICAL REPORT/ FINAL REPORT

TABLE OF CONTENTS

Chapter I Introduction 1
1.1 Objectives of the Study 1
1.2 Contents of the Study 1
1.2.1 Investigation of Current Situation in the Sewered Area 1
1.2.2 Pre-feasibility Study for Sewerage Development in Ha Long City 1
1.2.3 Proposal for the Engineering Services 2
1.3 Schedule of the Study 2

Chapter II Present Condition of Sewerage Project in Ha Long City 3
2.1 Natural Conditions of the Study Area 3
2.1.1 Geographical Conditions 3
2.1.2 Meteorological Conditions 3
2.1.3 Water Quality of Rivers and Ha Long Bay 3
2.2 Economic and Financial Conditions 4
2.2.1 Administrative Area 4
2.2.2 Demography and Tourism 4
2.2.3 Industrial Development 5
2.3 Existing Water Supply System 6
2.3.1 Current Condition of Water Supply System 6
2.3.2 Water Consumption 8
2.3.3 Water Tariff 8
2.4 Existing Sewerage System 8
2.4.1 Existing Service Area and Facilities 8
2.4.2 Organizations Related to Sewerage Development and Operation and Maintenance 10
2.4.3 Septic Tank and Septage Collection 10
2.4.4 Environmental Protection Fee and Operation Cost of Public Sewerage 11
2.4.5 Current Situation of Sewerage System 13
2.5 Existing Drainage System and Facilities 16
2.5.1 Current Status of Drainage System in Eastern Ha Long 16
2.5.2 Current Status of Drainage System in the Western Side of Ha Long 17
2.5.3 Current Inundation Conditions 17

Chapter III Existing and Ongoing Plans and Projects 18
3.1 Environmental Master Plan 18
3.2 City Development Master Plan 20
3.3 Sewerage and Drainage Master Plan 23
3.4 Original Feasibility Study for Sewerage Project in Ha Long City 23

Chapter IV Preliminary Review 24
4.1 Necessity of the Revision of Proposed Sewerage Plan 24
4.2 Set-up Planning and Design Conditions 25
4.2.1 Target Year of the Project 25
4.2.2 Service Area for the Proposed Sewerage System 25
4.2.3 Population Projection 25
4.2.4 Projection of Wastewater Volume 28
4.3 Preliminary Plan of Sewerage System and Facilities 29
4.3.1 Wastewater Treatment Plant 29
4.3.2 Collection System 41
4.3.3 Drainage System 41

4.4 Quantities of Construction Work ... 42
4.5 Preliminary Project Cost Estimates ... 42
4.5.1 Review of Construction Cost Estimates in Original Feasibility Study ... 42
4.5.2 Preliminary Construction Cost Estimated in this Study ... 43
4.6 Preliminary Implementation Plan ... 43
4.7 Operation and Management of WWTPs ... 44
4.8 Capacity Development ... 44

Appendix: Revised Sewerage Development Plan ... 46
1. Background of the Revision ... 46
2. Current Issues in the Existing Sewered Area ... 46
2.1 Low Coverage in Hon Gai Area (Eastern Area) ... 46
2.2 Insufficient Capacity of Bai Chay WWTP ... 48
2.3 Insufficient Condition of Tidal Gates ... 49
3. Proposed Sewerage Plan ... 50
3.1 Basic Strategy ... 50
3.2 Target Year ... 50
3.3 Area ... 51
3.4 Type of Collection System ... 51
3.5 Required Capacity of WWTPs ... 51
3.6 Incremental Capacity in the Project ... 53
3.7 Layout Plan of WWTPs ... 54
3.7.1 Ha Khanh WWTP ... 54
3.7.2 Ha Khau WWTP ... 55
3.7.3 Ha Phong WWTP ... 55
3.8 Improvement of Collection Network ... 56
3.8.1 Hon Gai Centre Ward in the Eastern Area ... 56
3.8.2 Other Wards in the Eastern Area ... 58
3.8.3 Western Area ... 58
3.9 Quantities of the Construction Works ... 58
3.10 Preliminary Cost Estimates ... 59

LIST OF TABLES

Table 1.2.2 Contents of Preliminary Review ... 1
Table 1.3.1 Schedule of the Study ... 2
Table 2.1.1 Seawater Quality Data in 2013 ... 3
Table 2.2.1 Population in Each Ward in 2013 ... 5
Table 2.2.2 Number of Tourists in 2011-2013 ... 5
Table 2.2.3 Industrial Zone in Ha Long City ... 6
Table 2.3.1 Capacity of Water Treatment Plant in 2012 ... 6
Table 2.3.2 Water Production and Consumption ... 8
Table 2.3.3 Water Tariff as of 2014 ... 8
Table 2.4.1 Summary of Public Sewerage System ... 9
Table 2.4.2 Summary of Private Sewerage System ... 10
Table 2.4.3 Annual Cost and Income for O&M of Sewerage System in Ha Long City ... 10
Table 2.4.4 Environmental Protection Fee (Category I) as of 2014 ... 11
Table 2.4.5 Environmental Protection Fee (Category II) as of 2014 ... 11
Table 2.4.6 Environmental Protection Fee (Category III) as of 2014 ... 12
Table 2.4.7 Unit Price for the O&M of Sewerage System ... 12
Table 2.4.8 Current O&M Situation of WWTPs ... 13
Table 2.5.1 Drainage and Collection Facilities in the Eastern Ha Long Area ... 16
Table 2.5.2 Drainage and Collection Facilities in the Western Ha Long Area ... 17
Table 3.1.1 Effluent Standards for Household Wastewater ... 18
Table 3.1.2 Effluent Standards for Industrial Wastewater ... 18
Table 3.1.3 Strategies for the Sewerage Development ... 20
Table 3.4.1 Outline of Sewerage Project under Japanese ODA Loan ... 23
Table 4.2.1 Population in Ha Long City from 2009 to 2013 ... 26
Table 4.2.2 Population Projection in Ha Long City from2014 to 2030 ... 27
Table 4.2.3 Target Population in the Original F/S and Preliminary Review ... 27
Table 4.2.4 Unit Wastewater Volume ... 28
Table 4.2.5 Capacity of WWTPs Required in 2025 ... 28
Table 4.3.1 Incremental Capacity ... 30
Table 4.3.2 Pollution Load per Capita ... 31
Table 4.3.3 Inflow and Effluent Quality Applied in the Project (Tentative) ... 32
Table 4.3.4 Comparison of Wastewater Treatment Process ... 33
Table 4.3.5 Comparison of Disinfection Processes ... 35
Table 4.3.6 Comparison of Alternatives of Sludge Treatment Process ... 36
Table 4.3.7 Comparison of Deodorization Process ... 39
Table 4.3.8 National Technical Regulation on Domestic Wastewater ... 40
Table 4.3.9 General Information of Ha Phong WWTP ... 41
Table 4.4.1 Quantities of Construction Work ... 42
Table 4.5.1 Project Cost Proposed in Local F/S (Estimated in 2008) ... 42
Table 4.5.2 Project Cost (Revised in 2014) ... 43
Table 4.6.1 Implementation Schedule of the First Phase Project ... 44
Table 4.7.1 Classification of WWTPs ... 44

Table A3.1 Population Projection for the Target Year 2025 ... 52
Table A3.2 Capacity of WWTPs in 2025 ... 53
Table A3.3 Incremental Capacity of WWTPs ... 53
Table A3.4 Required Capacity of Maturation Pond ... 54
Table A3.5 Quantities of the Construction Works ... 59
Table A3.6 Project Cost (Revised in 2014) ... 59

LIST OF FIGURES

Figure 2.1.1 Monitoring Point of Water Quality 4
Figure 2.2.1 Administrative Area of Ha Long City 4
Figure 2.3.1 Water Supply Network in Western Ha Long City 7
Figure 2.3.2 Water Supply Network in Eastern Ha Long City 7
Figure 2.4.1 Sewerage System in Ha Long City (as of 2014) 9
Figure 3.1.1 Proposed Sewerage Project in Western Ha Long City 19
Figure 3.1.2 Proposed Sewerage Project in Eastern Ha Long City 20
Figure 3.1.3 Land Use Plan in Western Ha Long City 21
Figure 3.1.4 Land Use Plan in Eastern Ha Long City 22
Figure 3.4.1 Target Area of the Sewerage Project under Japanese ODA Loan 23
Figure 4.2.1 Revised Target Area 25
Figure 4.3.1 Location of WWTP 29
Figure 4.3.2 Layout Plan of Ha Phong WWTP 40

Figure A2.1 Actual Sewered Area in the World Bank Project 47
Figure A2.2 Expected Wastewater Volume to Bai Chay WWTP 49
Figure A3.1 Treatment Area in Each WWTP in Ha Long City 51
Figure A3.2 Layout Plan of New Treatment Facilities in Ha Khanh WWTP 54
Figure A3.3 Layout Plan of Ha Khau WWTP 55
Figure A3.4 Layout Plan of Ha Phong WWTP 56

LIST OF PICTURES

Picture 2.4.1 Current Situation of PS and Tidal Gates 14
Picture 4.3.1 Proposed Site in the Western Area 29
Picture 4.3.2 Proposed Site in the Eastern Area 30

Picture A2.1 Uncollected Wastewater in the Target Area of Ha Khanh WWTP 48
Picture A2.2 Current Situation of Tidal Gates 50

ABBREVIATIONS

BOD	Biochemical Oxygen Demand
CAS	Conventional Activated Sludge
CSO	Combined Sewer Overflow
D/D	Detailed Design
DO	Dissolved Oxygen
DONRE	Department of Natural Resources and Environment
EIA	Environmental Impact Assessment
E/S	Engineering Service
EU	European Union
FS	Feasibility Study
FF	Fact Finding
HRT	Hydraulic Retention Time
JICA	Japan International Cooperation Agency
L/A	Loan Agreement
MLSS	Mixed Liquor Suspended Solids
O&M	Operation and Maintenance
OD	Oxidation Ditch
ODA	Official Development Assistance
PS	Pumping Station
RAP	Resettlement Action Plan
QNPPC	Quang Ninh Province People’s Committee
SBR	Sequencing Batch Reactor
SS	Suspended Solid
T-N	Total Nitrogen
T-P	Total Phosphorus
TSS	Total Suspended Solid
URENCO	Ha Long City Urban Environment Company
UV	Ultra Violet
VAT	Value Added Tax
WB	World Bank
WDPMU	Wastewater and Drainage Project Management Unit
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Chapter I Introduction

1.1 Objectives of the Study

Quang Ninh Province and Ha Long City have been requested to improve the water environment in Ha Long Bay. To tackle with this issue, the feasibility study (F/S) for the expansion of sewerage system in Ha Long City was carried out by local consultant in 2008. The proposed project was shortlisted for the Japan's ODA loan and International Cooperation Agency (JICA) carried out this study to review the proposed project since the local F/S was carried out a long time ago. The objectives of this study are as follows:

- Correct the related information such as population, water quality, and geotechnical information;
- Review the project plan feasibility study (F/S);
- Identify current issues in the sewered area;
- Verify and update the planned conditions such as population and target area;
- Verify the adequacy of existing plan and necessity to be updated; and
- Propose the contents of engineering service (E/S) and implementation plan.

1.2 Contents of the Study

1.2.1 Investigation of Current Situation in the Sewered Area

The following are investigated to understand the current situation and issues of the sewerage project in Ha Long City.

- Volume and quality of inflow/effluent of existing wastewater treatment plants (WWTPs) ,
- Operation of WWTPs when it is raining,
- Current issues of existing WWTPs,
- Situation of existing septic tank usage for a large number of users such as hotels, and
- Tariff structure for water and wastewater users.

1.2.2 Pre-feasibility Study for Sewerage Development in Ha Long City

The following are investigated in the study to establish the project scheme of the sewerage project in Ha Long City.

Table 1.2.2 Contents of Preliminary Review

Item	Contents
1) Target year	Set the target year for the sewerage plan in the entire Ha Long City including existing and planned sewerage systems considering the related plan and project schedule.
2) Target area	Set the target area for the planned sewerage project.
3) Type of collection system	Set the type of collection system (combined or separated).
4) Planned population	Revision of the planned population proposed in local F/S according to the latest population projection which is based on the census conducted in 2009.
5) Wastewater volume	• Set planning conditions such as unit water consumption,

	wastewater volume (daily average/daily maximum), and inflow/infiltration ratio. • Estimation of the planned wastewater volume based on the above planning conditions and setting the capacity of WWTP.
6) Study for WWTPs	• Location of WWTPs. • Setting the influent/effluent quality. • Treatment process of WWTPs. • Process calculation for the selected treatment process. • Draft layout plan and hydraulic profile for planned WWTP. • Confirmation of resettlement and land acquisition requirements for the location of WWTPs.
7) Route of main sewer (interceptor)	• Verification of proposed sewer plan in the F/S. • Selection of pipeline construction method. • General comparison study between microtunneling (pipe jacking) method and open cut method with multiple pump station will be carried out. • Proposal of sewer plan.
8) Preliminary cost estimation	Preliminary cost estimation by utilizing the unit cost of existing study.
9) Operation and maintenance plan	Operation and maintenance planning considering the evaluation of existing organization and issues.
10) Implementation schedule	Set the implementation schedule for the project. This project will be carried out as a yen loan project which will be provided in two stages: i.e., E/S loan and project loan.

Source: JICA Study Team

1.2.3 Proposal for the Engineering Services

The required information of the engineering services including the revision of local F/S and detailed design of the project will be investigated in this study. The following will be proposed for the E/S loan:

- Scope of the engineering service (e.g., revision of basic design, detailed design and environmental impact assessment (EIA) assistance) and relevant survey (e.g., topographic and geotechnical survey);
- Staffing and their requirements; and
- Schedule and project cost.

1.3 Schedule of the Study

The schedule of the study is shown in Table 1.3.1.

Table 1.3.1 Schedule of the Study

	July	August	September	October
First Site Study	▬▬▬▬			
JICA FF Mission		▬		
Second Site Study			▬▬▬▬	
JICA Appraisal Mission				▬▬

Source: JICA Study Team

Chapter II Present Condition of Sewerage Project in Ha Long City

2.1 Natural Conditions of the Study Area

2.1.1 Geographical Conditions

Ha Long City, located in the coastal strip corridor of the Gulf of Tonkin, is part of the extremely important growth triangle of Hanoi-Hai Phong-Quang Ninh, with the advantage of a deep water port development, tourism, economic marine minerals, and a convenient transportation system. The urban development in Ha Long City has been progressing rapidly and some coastal areas have been reclaimed and huge amount of public and private development are being carried out.

Total area of Ha Long City is 22,249.8 ha composed mainly of mountainous area. The natural terrain is characterized by a curved coastline embracing the Gulf of Tonkin. The terrain of Ha Long City is complex and divided by springs and rivers like the Troi, Man, Yen Lap, Thanh, and Bang rivers and rivulets.

2.1.2 Meteorological Conditions

Ha Long City has a coastal climate with two distinct seasons: winter from November to April of next year and summer from May to October.

The annual average temperature is 23.7 °C, with no large fluctuations, from 16.7 ^oC to 28.0 ^oC. In summer, the average high temperature is 34.9 ^oC, the hottest being 38.0 ^oC. In winter, average low temperature is 13.7 °C, the coldest being 5.0 ^oC.

Average annual rainfall is 1,832 mm, unevenly distributed among the two seasons. In summer, it is raining from May to October, accounting for 80-85% of the total annual rainfall. The highest rainfall is in July and August, at about 350 mm. Winter is the dry season, with little rain from November to April of the following year, accounting for only about 15-20% of the total annual rainfall. Rainfall is least in December and January, at only about 4-40 mm.

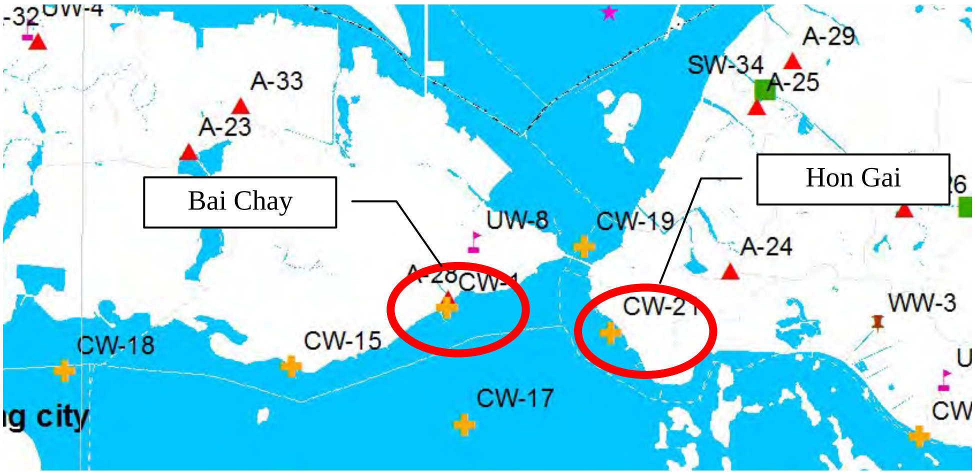
2.1.3 Water Quality of Rivers and Ha Long Bay

Water environment in Ha Long Bay has deteriorated because of the lack of appropriate wastewater treatment for residential, commercial, and industrial areas. According to the water quality survey carried out by the Department of Natural Resources and Environment (DONRE) in Quang Ninh Provincial Party's Committee (QNPPC), the seawater quality in Bai Chay and Hon Gai areas are summarized in Table 2.1.1 and the locations of sampling are indicated in Figure 2.1.1.

Table 2.1.1 Seawater Quality Data in 2013

	TSS (mg/l)	BOD (mg/l)	Coliform (MPN/100ml)	Oil (mg/L)	Conductance (mS/cm)
Bai Chay	16-20	1.6-4.03	3-40	0.031-0.247	44.56-44.82
Hon Gai	21-31	3.1-7.4	1-1100	0.121-0.403	40.03-41.37
Coastal water QCVN 10, 2008/BTNMT	50	- (COD:4)	1000	0.1	-

Source: DONRE



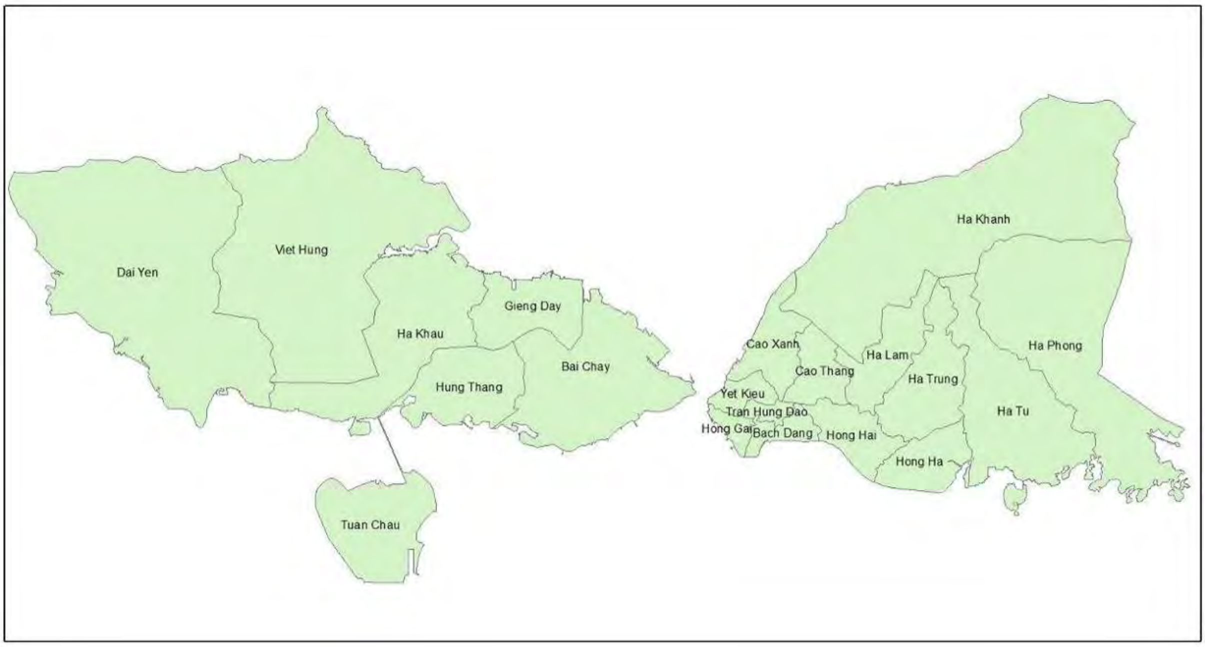
Source: DONRE

Figure 2.1.1 Monitoring Point of Water Quality

2.2 Economic and Financial Conditions

2.2.1 Administrative Area

Ha Long City is divided by the Cua Luc Bay into the western and eastern areas. Ha Long City consists of 20 wards, seven wards in the western area and 13 wards in the eastern area as shown in Figure 2.2.1.



Source: JICA Study Team

Figure 2.2.1 Administrative Area of Ha Long City

2.2.2 Demography and Tourism

(1) Demography

The population of Ha Long City in 2012 was 367,220 (permanent residents were 227,874 persons, temporary residents such as trouristwere 139,364); urbanization rate was 100%, according to the city development master plan.

The population in each ward in 2013 obtained from the sub-department of statistics office of Ha Long City is shown in Table 2.2.1.

Table 2.2.1 Population in Each Ward in 2013

Eastern Ha Long	Hà Khánh	Hà Phong	Cao Xanh	Hà Tu	Hà Trung	Hà Lầm	Cao Thắng	158,945	235,007
	7,048	9,952	16,538	13,438	8,101	10,788	17,811		
	Yết Kiêu	Trần Hưng Đạo	Hồng Hải	Hồng Gai	Bạch Đằng	Hồng Hà	-		
	10,571	9,944	19,717	8,452	9,888	16,697	-		
Western Ha Long	Hà Khẩu	Giếng Đáy	Bãi Cháy	Hùng Thắng	Tuần Châu	Việt Hưng	Đại yên	76,062	
	13,567	13,815	22,180	6,327	2,097	9,408	8,668		

Source: Sub-department of Statistics Office of Ha Long City

In the city development master plan, future population is forecasted as follows:

- Population in 2020: 442,400 (permanent residents are 270,000 persons, temporary residents are 172,400 persons)
- Population in 2030: 573,000 (permanent residents are 350,000 persons, temporary residents are 223,000 persons)

(2) Tourism

Since Ha Long City is located in Ha Long Bay which is registered as a World Natural Heritage, Ha Long City has an advantageous position in the development of tourism industry as well as good conditions to attract domestic and international tourists. In the economic development strategy of Ha Long City, tourism has been identified as a key economic sector, motivating the development of other economic sectors.

The total number of tourists visiting Quang Ninh Province is increasing but the number of tourists that visited Ha Long Bay slightly decreased in the last three years as shown in Table 2.2.2.

Table 2.2.2 Number of Tourists in 2011-2013

	2011	2012	2013
Total number of visits of tourists	**6,200,000**	**7,005,000**	**7,518,000**
Stay tourist	2,500,000	3,176,000	3,608,000
Day tourist	3,700,000	3,829,000	3,910,000
Tourists visiting Ha Long Bay	2,900,000	2,574,000	2,545,000
Tourists visiting historical and culture relics	2,200,000	2,580,000	3,247,000
Total revenue (VND in billions)	3.400	4.347	5.042

Source: Department of Culture, Sport and Tourism of Quang Ninh Province

2.2.3 Industrial Development

In Ha Long City, the main industries in addition to tourism are the mining and processing industries with total employees of 38,900 in 2009.

The whole city has about 1,346 industrial companies, seven of which have foreign investment as their economic base. The number of companies producing industrial processing accounts for 82.47%, which is largely made up of food-processing plants, then garment production equipment and fabricated metal production, wood products, forest products, and printing produce other types with a low proportion.

Currently, Ha Long City has two industrial zones which have investments for infrastructure construction that can accommodate secondary investors such as Cai Lan Industrial Zone and Viet Hung Industrial zone (Ha Long) as shown in Table 2.2.3.

Table 2.2.3 Industrial Zone in Ha Long City

No.	Industrial Zone	Address	Area (ha)	
			Phase I	Total
1	Cai Lan IZ	Bai Chay Ward, Halong City	78	250
2	Viet Hung IZ	Viet Hung Ward, Halong City	179.8	300.9

Source: Development Planning of Industry – Handicraft of Halong City, 2006-2015, Vision to 2020

2.3 Existing Water Supply System

2.3.1 Current Condition of Water Supply System

The water supply system was established separately in the western and eastern areas and covers the main residential area in Ha Long City. The water sources of the water treatment plant (WTP) are surface water (dam water and river water) and groundwater. The capacities of WTPs are summarized in Table 2.3.1.

Table 2.3.1 Capacity of Water Treatment Plant in 2012

No.	Water Treatment Plant (WTP)	Water Supply for Ha Long City in 2012 (m^3/day)	
		Western Area	Eastern Area
1	WTP	22,000	25,000
2	Well	400	5,400
3	Industrial WTP	20,000	-

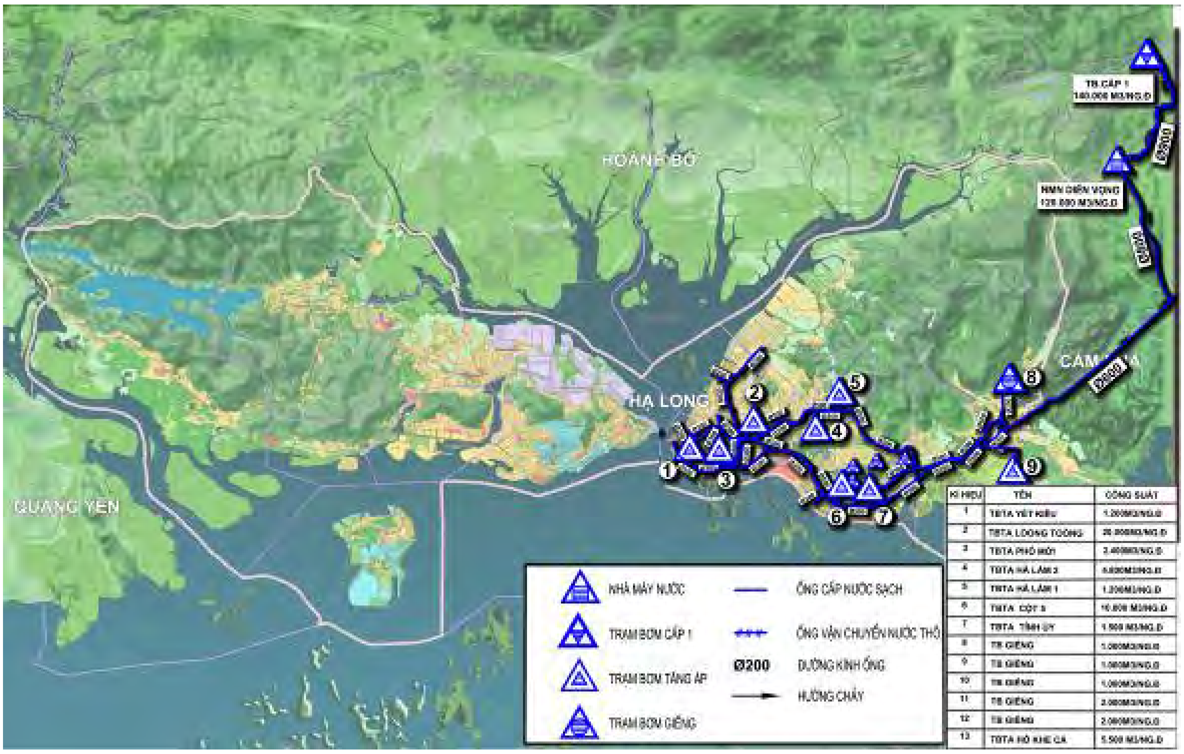
Source: City Development Master Plan

In the western area, WTP with a capacity of 20,000 m^3/day, which was built in the 1970s, supplies treated water for all the western Ha Long City. The water resource of the WTP is surface water (dam) which is about 700 m away from the WTP. The water supply system in western Ha Long City is shown in Figure 2.3.1.

Source: City Development Master Plan

Figure 2.3.1 Water Supply Network in Western Ha Long City

In the eastern area, WTP with a capacity of 25,000 m^3/day supplies treated water for all the eastern Ha Long City. The water resource of the WTP is surface water (river). The water supply system in eastern Ha Long City is shown in Figure 2.3.2.



Source: City Development Master Plan

Figure 2.3.2 Water Supply Network in Eastern Ha Long City

2.3.2 Water Consumption

The water consumption and production record is shown in Table 2.3.2. The estimated water consumption per connection in each category are about 0.6 m^3/day for residents and 2.8 m^3/day for hotels, respectively.

Table 2.3.2 Water Production and Consumption

Chỉ tiêu (Item)	Năm (Year)			
	2010 (m^3)	2011 (m^3)	2012 (m^3)	2013 (m^3)
1. Water supply for residents per day	36,282	37,928	40,728	41,540
Hồng Gai (Hon Gai)	*23,199*	*23,989*	*25,693*	*26,349*
Bãi Cháy (Bai Chay)	*13,083*	*13,939*	*15,035*	*15,191*
2. Water supply for hotels per day	649	800	971	1,064
Hồng Gai (Hon Gai)	*178*	*183*	*188*	*193*
Bãi Cháy (Bai Chay)	*471*	*617*	*783*	*871*
3. Water production volume per day	50,980	54,740	57,523	57,984
Hồng Gai (Hon Gai)	*29,161*	*31,059*	*32,812*	*33,713*
Bãi Cháy (Bai Chay)	*21,819*	*23,681*	*24,711*	*24,270*

Source: Water supply company

2.3.3 Water Tariff

The water tariff as of 2014 is shown in Table 2.3.3.

Table 2.3.3 Water Tariff as of 2014

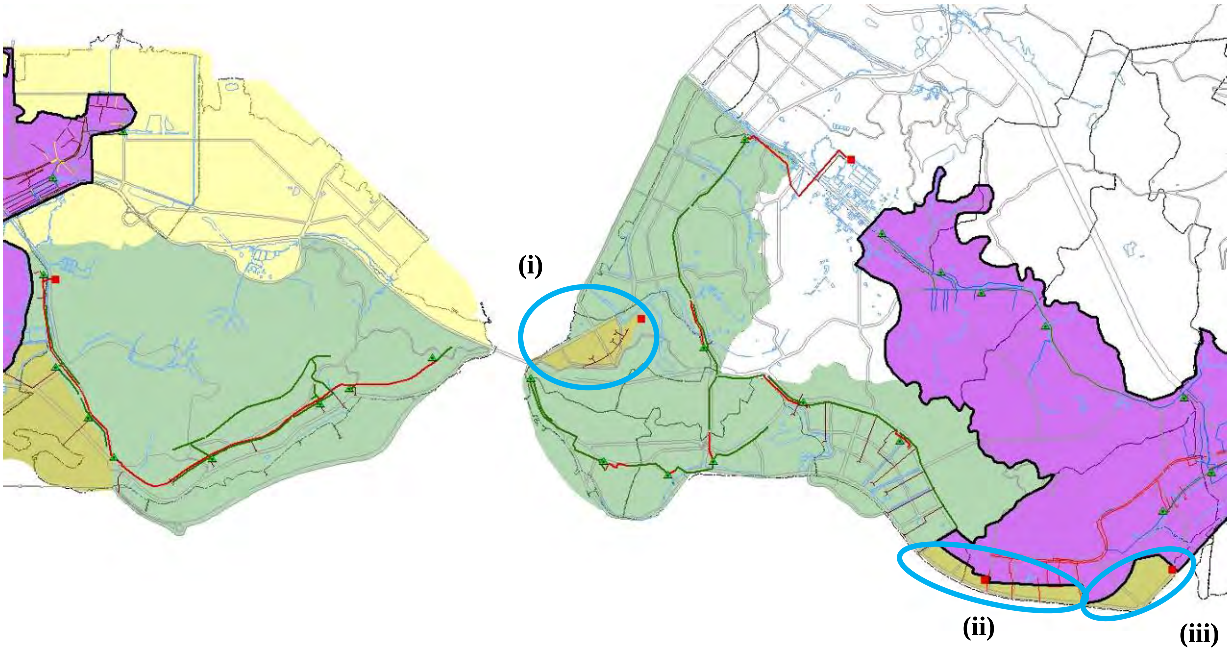
Water Consumption Purposes	Sale Price without VAT (VND/m^3)	Remarks
1. Domestic use by households (household/month)		
- Up to 10 m^3	6,200	
- 10 m^3-20 m^3	7,800	
- 20 m^3-30 m^3	8,500	
- More than 30 m^3	9,300	
2. Administrative agencies	7,800	
3. Serving public purposes	7,800	
4. Professional units	9,300	
5. Production facilities	10,100	
6. Business, services, tourism, construction		
- Water supply to ships	19,000	
- Water supply to business, services, construction	14,000	

Source: Decision No. 1528/QD-UBND, dated June 27, 2012 of the Quang Ninh PPC

2.4 Existing Sewerage System

2.4.1 Existing Service Area and Facilities

There are two public and three private WWTPs in Ha Long City as shown in Figure 2.4.1. The public sewerage system was developed in Bai Chay (western Ha Long City) and Hong Gai (eastern Ha Long City) under the World Bank-financed project. The private sewerage systems were developed in the urban development areas in Hon Gai. One WWTP developed by a private company is currently undergoing commissioning procedure as of July 2014. The summary of public sewerage system is shown in Table 2.4.1 and that of private sewerage system is shown in Table 2.4.2, respectively.



Source: JICA Study Team

Figure 2.4.1 Sewerage System in Ha Long City (as of 2014)

Table 2.4.1 Summary of Public Sewerage System

Area	Western Area (Bai Chay)		Eastern Area (Hong Gai)	
Planned population				
Resident	25,700		108,485	
	Bai Chay	25,700	Ha Long	12,836
			Yet Kieu	10,516
			Tran Hung Dao	12,710
			Bach Dang	16,931
			Cao Xanh	32,255
			Hong Hai	23,237
Tourist	6,000		-	
Total	31,700		108,485	
Area of WWTP	2.5 ha		4.4 ha	
Type of collection	Interceptor		Interceptor	
WWTP	Bai Chay WWTP		Ha Khanh WWTP	
Capacity (daily average basis)	3,500 m^3/day		7,200 m^3/day	
Treatment process	Sequencing Batch Reactor (SBR) + Maturation pond (disinfection)		SBR+ Maturation pond (disinfection)	
Start Operation	2006		2010	
Pumping Station	7		7	

Source: JICA Study Team

Table 2.4.2 Summary of Private Sewerage System

Area	(i)	(ii)	(iii)
Company	CIENCO5	LICOGI	LICOGI
Service area	27.75 ha	33.51 ha	- ha
Planned population	5,690	7,500	3,800
Type of collection	Separate sewer	Separate sewer	Separate sewer
WWTP	CIENCO5	LICOGI-1	LICOGI-2
Capacity (daily average basis)	2,000 m^3/day	1,200 m^3/day	1,200 m^3/day
Treatment process	CAS	CAS	CAS
Start Operation	March, 2011	March, 2011	2014 (Not Yet Operated)

Source: JICA Study Team

2.4.2 Organizations Related to Sewerage Development and Operation and Maintenance

Public and private WWTPs in Ha Long City are operated by a public corporation, namely Ha Long City Urban Environment Company (hereinafter called "URENCO"). URENCO is in charge of O&M of sewerage system, solid waste disposal, and cemetery management in Ha Long City.

The annual cost and income of URENCO for O&M of sewerage system are shown in Table 2.4.3.

Table 2.4.3 Annual Cost and Income for O&M of Sewerage System in Ha Long City

(Unit: VND)

	Description	2011	2012	2013	Notes
I	**Costs: Operation & Maintenance**				
1	Bai Chay WWTP	2,989,623,000	3,871,939,000	3,766,402,000	Figures are provided by Ha Long Urban Environment Joint tock Company
2	Ha Khanh WWTP	3,664,598,000	3,961,831,120	4,117,711,765	
3	Vung Dang Waste Water Treatment Station	-	835,400,287	548,518,778	
4	LICOGI Waste Water Treatment Station	-	-	669,644,940	
	Anual Dredging Cost	16,900,000,000	10,120,000,000	4,440,000,000	
	Total:	**23,554,221,000**	**18,789,170,407**	**13,542,277,483**	
II	**Waste water tariff in Ha Long City's area**				
1	Environmental Protection Tariff of waste water	9,938,641,739	12,741,045,940	14,974,193,840	The tariff is included Receipt of fresh water provided by Quang Ninh Water Supply JS Compnay

Source: Wastewater and Drainage Project Management Unit (WDPMU)

2.4.3 Septic Tank and Septage Collection

According to regulations in Vietnam, all households and hotels should have septic tanks for the treatment of human waste. It was informed by the Wastewater and Drainage Project Management Unit (WDPMU) that all effluent from hotels' septic tank have been collected by existing sewer line (interceptors) constructed through a World Bank (WB) loan project and the capacity of existing WWTP is already full and excess wastewater is discharged to the sea without appropriate treatment.

Regarding septage management, septage collection is the responsibility of the private companies. The activities are being carried out only when the owner of a septic tank requests to collect the septage, which means that septage management is insufficient in Ha Long City. Septage collection from the residents is difficult due to the structural issue of septic tanks. A certain part of existing septic tanks are installed under the houses without an outlet for the extraction of septage and it is difficult to collect the septage from the ordinary households.

2.4.4 Environmental Protection Fee and Operation Cost of Public Sewerage

(1) Environmental Protection Fee

The environmental protection fee is shown below.

Category-I: For the Users of Public Water Supply System

Table 2.4.4 Environmental Protection Fee (Category I) as of 2014

No.	Subjects	Fee Rate	
		Ha Long City Cam Pha City	Remaining districts, towns, and cities
1	For residential households	10% of water tariff	7%
2	For administrative and professional offices; social - economic organizations; schools; hospitals; production facilities; basic construction works and other materials productions subjects; restaurants, hotels, motels and tourist resorts, tourist boats	20% of water tariff	10%

Note: VAT is not included in the above table.
Source: Decision on Approval of Environmental Fee Collection for Domestic Wastewater in Quang Ninh Province (Decision No. 1470/2014/QD-UBND)

Category-II: Environmental protection fee for domestic wastewater discharged from individuals, households using water extracted by themselves in areas where domestic clean water supply system is already available

Table 2.4.5 Environmental Protection Fee (Category II) as of 2014

No.	Locality	Unit	Fee level
1	Ha Long City	Dong/people/year	25,000
2	Cam Pha City	Dong/people/year	23,000
3	Mong Cai City	Dong/people/year	14,000
4	Uong Bi City	Dong/people/year	12,000
5	Van Don District	Dong/people/year	14,000
6	Hoanh Bo District	Dong/people/year	13,000
7	Quang Yen Town, Hai Ha District, Tien Yen District, Dam Ha District	Dong/people/year	11,000
8	Ba Che District, Dong Trieu District, Binh Lieu District, Co To District	Dong/people/year	10,000

Note: VAT is not included in the above table.
Source: Decision on Approval of Environmental Fee Collection for Domestic Wastewater in Quang Ninh Province (Decision No. 1470/2014/QD-UBND)

<u>Category-III: Environmental protection fee for domestic wastewater discharged from organizations, individuals using water extracted by themselves</u>

Table 2.4.6 Environmental Protection Fee (Category III) as of 2014

No.	Locality	Unit	Ha Long City Cam Pha City	Remaining districts, towns, and cities
1	State agencies	Dong/utility/month	65,000	30,000
2	People armed units (excluding production facilities, processing facilities belonging to armed forces units)	Dong/utility/month	270,000	120,000
3	Managing headquarters, branch offices, offices of organizations and individuals not associated with production and processing sites.	Dong/utility/month	220,000	100,000
4	Facilities: car washing, motorcycle washing, vehicle repair, motorcycle repair	Dong/utility/month	130,000	60,000
5	Hospitals, clinics, restaurants, hotels, training facilities, research facilities, business and other services facilities			
5.1	Business, hotels, rest-houses, motels			
-	Up to 10 bedrooms	Dong/utility/month	60,000	25,000
-	From 10 – 20 bedrooms	Dong/utility/month	100,000	45,000
-	From 20 – 30 bedrooms	Dong/utility/month	210,000	95,000
-	From 30 – 40 bedrooms	Dong/utility/month	310,000	140,000
-	From 40 – 50 bedrooms	Dong/utility/month	520,000	240,000
-	More than 50 bedrooms	Dong/utility/month	840,000	385,000
5.2	Restaurants, shops, bars belonging to restaurant business			
	Business with up to 5 dining tables (6 people per table)	Dong/utility/month	20,000	9,000
	Business with from 5 to 10 dining tables	Dong/utility/month	60,000	25,000
	Business with more than 10 dining tables	Dong/utility/month	100,000	45,000
5.3	Hospitals, clinics, training facilities, research facilities			
	Hospitals, health facilities			
+	Up to 100 patient beds	Dong/utility/month	600,000	25,000
+	From 100 to 250 patient beds	Dong/utility/month	1,000,000	45,000
+	From 250 up to 700 patient beds	Dong/utility/month	2,800,000	120,000
+	More than 700 patient beds	Dong/utility/month	4,180,000	180,000
-	Training facilities, research facilities	Dong/utility/month	70,000	30,000
-	Clinics	Dong/utility/month	25,000	10,000
5.4	Other business, services facilities	Dong/utility/month	40,000	15,000
6	Other organizations, individuals	Dong/utility/month	40,000	15,000

Note: VAT is not included in the above table.
Source: Decision on Approval of Environmental Fee Collection for Domestic Wastewater in Quang Ninh Province (Decision No. 1470/2014/QD-UBND)

(2) Operation Cost of Public Sewerage

Operation cost of sewerage system which is paid by Ha Long City to URENCO is stipulated in the decision of Quang Ninh PPC as follows: The operation cost shown in Table 2.4.7 includes O&M of WWTPs, pumping stations (PSs), and pipelines.

Table 2.4.7 Unit Price for the O&M of Sewerage System

Bai Chay WWTP	Ha Khanh WWTP
VND 2,987/m^3	VND 2,682/m^3

Note: The above unit cost is calculated based on 100% operational capacity of the WWTP and PS, inclusive of all costs necessary to complete a unit of work volume and normal profit.
Source: Quang Ninh PPC

2.4.5 Current Situation of Sewerage System

(1) Wastewater Treatment Plant

According to the site inspection and interview survey in this study, the current O&M situation of WWTPs is summarized as follows:

Table 2.4.8 Current O&M Situation of WWTPs

<table>
<tr><th></th><th>Bai Chay WWTP</th><th>Ha Khanh WWTP</th></tr>
<tr><td colspan="3">1. Basic Data</td></tr>
<tr><td>1) Capacity</td><td>Daily average : 3,500 m^3/d
Hourly max (dry) : 320 m^3/hour
Hourly max (storm water) : 450 m^3/hour</td><td>Daily average : 7,200 m^3/d
Hourly max (dry) : 600 m^3/hour
Hourly max (storm water) : 900 m^3/hour</td></tr>
<tr><td>2) Treatment process</td><td></td><td></td></tr>
<tr><td>Wastewater treatment</td><td>Sequencing Batch Reactor (SBR)</td><td>SBR</td></tr>
<tr><td>Disinfection</td><td>Maturation pond</td><td>Maturation pond</td></tr>
<tr><td>Sludge treatment</td><td>Thickening ➔Sludge drying bed
➔Landfill site</td><td>Thickening
➔Landfill site</td></tr>
<tr><td>3) Effluent discharge point</td><td>Bay near WWTP</td><td>River near WWTP</td></tr>
<tr><td colspan="3">2. Record of Wastewater</td></tr>
<tr><td>1) Inflow volume record as of 2014</td><td>3,500 m^3/day
(already exceeds the capacity)</td><td>3,000-5,300 m^3/day</td></tr>
<tr><td>2) Effluent quality</td><td>(Unit: mg/liter)
<table>
<tr><td></td><td colspan="2">Actual record</td></tr>
<tr><td></td><td>Inflow</td><td>Outflow</td></tr>
<tr><td>BOD</td><td>60-70</td><td>20-25</td></tr>
<tr><td>SS</td><td>90-95</td><td>21-22</td></tr>
<tr><td>T-N</td><td></td><td></td></tr>
<tr><td>NH_4^+</td><td>15-19</td><td>9-10</td></tr>
<tr><td>NO_3^-</td><td>0.2</td><td>0.1</td></tr>
<tr><td>T-P</td><td></td><td></td></tr>
<tr><td>PO_4^{3-}</td><td>1.0-1.2</td><td>0.2-0.3</td></tr>
<tr><td>Salinity (‰)</td><td>2.7-3.2</td><td>0.7-0.9</td></tr>
<tr><td>Coli (MPN)</td><td>480-580</td><td>70-100</td></tr>
</table>
*Source: Record in 2013</td><td>(Unit: mg/liter)
<table>
<tr><td></td><td colspan="2">Actual record</td></tr>
<tr><td></td><td>Inflow</td><td>Outflow</td></tr>
<tr><td>BOD</td><td>50-60</td><td>17-19</td></tr>
<tr><td>SS</td><td>90-100</td><td>13-19</td></tr>
<tr><td>T-N</td><td></td><td></td></tr>
<tr><td>NH_4^+</td><td>10-12</td><td>8-9.5</td></tr>
<tr><td>NO_3^-</td><td>0.3-0.4</td><td>0.2</td></tr>
<tr><td>T-P</td><td></td><td></td></tr>
<tr><td>PO_4^{3-}</td><td>1.0</td><td>0.7-0.9</td></tr>
<tr><td>Salinity (‰)</td><td>8-10</td><td>3.5-5</td></tr>
<tr><td>Coli (MPN)</td><td>300-400</td><td>100</td></tr>
</table>
*Source: Record in 2013</td></tr>
<tr><td colspan="3">3. Actual Operation</td></tr>
<tr><td>1) Operation of PS</td><td></td><td></td></tr>
<tr><td>High tide</td><td>Stop operation
(6-7 hours per 10 days)</td><td>Stop operation</td></tr>
<tr><td>Heavy rain</td><td>Stop operation
(it depends on the rain condition)</td><td>Operate as usual</td></tr>
<tr><td>2) Operation of WWTP</td><td></td><td></td></tr>
<tr><td>Operation during heavy rain</td><td>No inflow</td><td>Stored in regulation tank and full volume is treated in SBR tank.
The retention time in SBR tank is manually decreased during rainy days.</td></tr>
<tr><td>SBR cycle time</td><td>Fill : 20 min
React : 120 min
Settle : 70 min
Decant : 50 min (260 min)</td><td>Fill total
React : 120 min
Settle : 60 min
Decant : 60 min (240-260 min)</td></tr>
<tr><td>Maturation pond retention time</td><td>5 days</td><td>7days</td></tr>
<tr><td>Operation of SBR</td><td>- Time set or DO control
- Sludge withdrawal volume has not been defined.</td><td>- Manual operation (time-based)
- Sludge withdraw volume has not been defined.</td></tr>
</table>

Source: JICA Study Team

(2) PSs, Diversion, Tidal Gates, and Networks

The existing PSs are manhole-type (underground) pumping station and are operated automatically according to the water level of pump well. URENCO assigns the maintenance staffs of PSs and they periodically visit the PSs and remove the debris, rubbish, and scum from the screen so that the pumps are well operated. However, there are PSs which cannot be maintained because of the accumulated soil on the manhole cover as shown in Picture 2.4.1.

Regarding the maintenance of tidal gates, it was found to be insufficient according to the site inspection. Some tidal gates are completely broken due to the impact of wave, and there is huge amount of sand accumulated at the outlet of some tidal gates which prevent tidal gates from closing as shown in Picture 2.4.1. Due to these situations, seawater easily comes into the sewerage network during high tide and operation of PSs have to be stopped during high tide in Bai Chay.

In terms of maintenance of pipelines, drainage channels, roadside gutters, cleaning, and dredging have not been carried out sufficiently. Sand and debris are accumulated in the roadside ditches, which prevent wastewater and rainwater from flowing properly.

PS No.6 in Hong Gai Area

Roadside Gutter in Hung Thang Area

Tidal Gate in Bai Chay Area

Tidal Gate in Hong Gai Area

Source: JICA Study Team

Picture 2.4.1 Current Situation of PS and Tidal Gates

(3) Diagnosis of Current Situation

1) Wastewater Volume into WWTPs

The PSs are not operated during high tide in the treatment area of Bai Chay WWTP. The inflow volume is about 3,500 m^3/day, which is the same as the contract volume between Ha Long City and URENCO. The excess amount of wastewater is discharged to the sea from the outlet. Ha Long City recognizes that the capacity of Bai Chay WWTP is not enough and they are planning to investigate how to improve the current situation.

The inflow of Ha Khanh WWTP is from 3,000 to 5,300 m^3/day as of 2014 which is much less than its capacity because the existing interceptors does not cover the entire treatment area of Ha Khanh WWTP. The development of Ha Khanh WWTP and its interceptors were carried out as the second phase of the project using the surplus budget of the first phase of the project (Bai Chay) and the budget was not enough to cover the whole area. The interceptors and diversion chamber were constructed mainly to collect the wastewater from the coastal area; i.e. Hong Gai, Bach Dang, and Hong Hai Wards, and partially from the Tran Hung Dao Ward. Therefore, the wastewater from remaining area, i.e. Yet Kieu, Cao Xanh Wards and certain part of Tran Hung Dao Ward, are discharged without treatment. The population in actual covered area is about 43,000 (56% of target area) and in uncovered area is about 33,000 (44% of target area) as of 2013 respectively.

2) Wastewater Quality

The inflow quality including BOD, SS, T-N, T-P is low. Considering the salinity of seawater is about 3% in Bai Chay Region, 10-30% of seawater is assumed to be included in the inflow of Bai Chay WWTP.

3) Wastewater Treatment

Effluent quality of WWTPs satisfies the Vietnamese standard because the low quality of inflow does not require high treatment efficiency. According to the water quality data from URENCO, the inflow qualities of Bai Chay WWTP in June 2014 are 80 mg/liter of BOD and 90-100 mg/liter of SS and its effluent qualities in sunny days are 18-23 mg/liter of BOD and 18 mg/liter of SS, respectively.

The targets of the wastewater treatment at existing WWTPs are BOD and SS. The treatments of nitrate (N) and phosphate (P) are not carried out, hence, the quality of N and P of inflow and effluent is almost the same.

The regulation tank in Bai Chay WWTP is not operated sufficiently and the continuous inflow to the sequence batch reactor (SBR) tank, even during the aeration process, prevents it from operating in batch process. The capacity of regulation tank is 220m^3 which is correspond to about 1.5 hours of daily average flow. The peak inflow in wet weather is three times as much as that in dry weather, hence the regulation pond is insufficient in wet weather condition and the existing SBR system can be operated appropriately only in dry weather. However, the effluent quality can satisfies the Vietnamese regulation because the quality of inflow is not so serious .

In Bai Chay WWTP, the concentration of mixed liquor suspended solids (MLSS) in the SBR tank was roughly investigated by checking SV30. The SV30 on July 26, 2014 was less than 5% although it should be kept at 40-80% according to the operation manual prepared by WB. The operations staffs informed that the they check the sludge volume (SV60) every month and 30% of SV60 is considered to be acceptable. Considering the current situation, the checking of SV30 or SV60 should be carried out more frequently and they should modify the operation of SBR.

Regarding the maturation pond, it is used for disinfection and capture of leaked sludge from the SBR. Regarding the disinfection, it performs well during the sunny days but the efficiency decreases during cloudy and rainy days.

4) Sludge Treatment

The sludge volume is very limited and they will extract thickening sludge once every 1-2 months only. Thickening sludge is discharged to the sludge drying bed in Bai Chay WWTP. Collected septage used to be discharged to the sludge drying bed, but septage treatment is not being carried out now.

2.5 Existing Drainage System and Facilities

2.5.1 Current Status of Drainage System in Eastern Ha Long

Eastern Ha Long runs along the coast with a relatively large slope towards the sea, so has good drainage characteristics. The Three-city Sanitation Project of Vietnam – Quang Ninh Sub-project funded by WB, together with the Bai Chay Bridge Construction Project and new planned urban areas (coal storage area, Yet Kieu new urban area, Vung Dang new urban area, Cao Xanh–Ha Khanh new urban areas, reclamation areas) have had contributions to provide Hon Gai area with a relatively complete drainage system.

The sewer lines have features of being constructed asynchronously, belonging to many different projects, and therefore having many kinds of sewers and constructed of many different materials. In the eastern side of Ha Long, there are two drainage systems, i.e., combined system and completely separate system. There are many customer groups that discharge wastewater such as residential areas, services, public institutions, and production facilities, in which the residential areas use combined system and the new urban areas use separate system.

The WB project has invested in the relatively complete combined drainage system for the central wards: Hon Gai, Tran Hung Dao, Bach Dang, Hong Hai, parts of Yet Kieu, Cao Xanh. In the remaining areas, drainage system is the combined one, without much investment. The new urban areas such as Cao Xanh-Ha Khanh, will use separate sewer system in accordance with state regulations; storm water is discharged into the main channels to the sea; wastewater is collected and treated before being discharged into the centralized sewer system of the city.

Table 2.5.1 Drainage and Collection Facilities in the Eastern Ha Long Area

No.	Type of Sewer	Size (mm)	Length (km) and No.
1	**Combined sewer**		
1.1	Open channel	B250 to 2000	3.65
1.2	Covered channel	B250 to 4000	54.70
1.3	Box-culvert	B500 to B3000	3.50
1.4	Round pipe	D300 to D1500	8.41
	Total of 1:		**70.27**
2	**Interceptor**		
2.1	Gravity pipe	D300 to D800	7.56
2.2	Pressure pipe	D150 to D400	4.70
3	**Pumping Station**	-	8

Source: Ha Long City Water Supply and Sanitation Project (World Bank)

2.5.2 Current Status of Drainage System in the Western Side of Ha Long

The western side of Ha Long has terrain with a large slope towards the sea. There are two main axes: old National Road 18A running along the shoreline and new National Road 18 running towards the west. Bai Chay is a tourism area, so it requires higher hygienic and sanitary conditions. The Drainage and Sanitation Project of Ha Long City undertook the construction of interceptor sewers to collect wastewater (D=300 mm of reinforced concrete), sewage pumping stations, pressure sewers for transferring waste water to the wastewater treatment plant located in Cai Dam, pressure pipes of DN=200 mm ± 500 mm, eight sewage pumping stations located along the old National Road 18A from the ferry station to the Ao Ca (fish pond) area.

In the western side of Ha Long, there are two drainage systems: combined system and completely separate system serving many different discharge sources (the existing residential areas, tourism areas in Bai Chay ward, production facilities and public institutions using the combined system, the new urban areas, new industrial parks, and tourism areas using the separate system). The central area has been invested in by the relatively completed combined drainage system in the WB project; the new urban areas of Hung Thang, Glaximco, Cai Lan and Viet Hung industrial parks have been invested in by the synchronous construction of separate sewer systems; the remaining areas, including of Gieng Day, Ha Khau, Dai Yen, and Viet Hung wards and the existing residential areas of Hung Thang ward, are using combined drainage systems.

Table 2.5.2 Drainage and Collection Facilities in the Western Ha Long Area

Stt	Type of Sewer	Size (mm)	Length (km) and No.
1	Combined sewer		
1.1	Open channel	B500 to 5500	2.12
1.2	Covered channel	B350 to 2000	13.36
1.3	Box-culvert	B500 to B5500	2.03
1.4	Round pipe	D300 to D1500	0.89
	Total of 1:		**18.40**
2	Interceptor		
2.1	Gravity pipe	D300	6.5
2.2	Pressure pipe	D200 to D500	6.24
3	Pumping Station	-	8

Source: Ha Long City Water Supply and Sanitation Project (World Bank)

2.5.3 Current Inundation Conditions

There are some flooding and inundation occurring in Ha Long City. The main reasons are as follows:

- Heavy rains along with high tide;
- Capacity of regulation ponds is insufficient because of urbanization (landfill) and lack of dredging; and
- Streams, drainage channels, and sewers are blocked due to solid waste, soil, rock, thereby reducing its section.

Currently in Ha Long City, some local inundation points are as follows:

1) Eastern side of Ha Long: Loong Toong road crossing, Km 5 road crossing, Cao Xanh road crossing, Kenh Liem area, Bai Muoi, Hong Ha, Ha Tu

Western side of Ha Long: areas of Dai Yen, Cai Dam, south of Ha Long Railway Station

Chapter III Existing and Ongoing Plans and Projects

3.1 Environmental Master Plan

The environmental master plan was approved in September 2014 by DONRE and Quang Ninh PPC with the QNPPC Decision No:1799/QD-UBND. The master plan is aiming to prepare an environmental planning of Quang Ninh Province by 2020, and a vision to 2030, in accordance with the master plan of socio-economic development of Quang Ninh Province and land use planning and sector planning objectives. This plan will prevent and mitigate the degradation of natural resources, environmental pollution, to gradually improve the environmental quality and efficiency of mining and rational use of natural resources as well as the environmental management capacity of the province.

Regarding the sewerage development in Ha Long City, the following shall be considered:

(1) Effluent standard

Quang Ninh Province will propose placing stricter effluent standards on the wastewater discharged into water bodies used for tourism or other critical uses like aquaculture, domestic water supply, and irrigation. The proposed effluent standards on wastewater discharge would be set in accordance with European Union (EU) standards in the main residential and commercial areas, as shown in Table 3.1.1 for household wastewater and Table 3.1.2 for industrial wastewater. For domestic wastewater, urban wastewater treatment systems are proposed to be developed, and for industrial wastewater, new regulations and guidelines to control industrial wastewater should be set with the enhancement of inspection and monitoring, and financial assistance program for enterprises as necessary.

Table 3.1.1 Effluent Standards for Household Wastewater

Parameter	For plants discharging in waters used for tourism and domestic purposes (based on EU standards)	For plants discharging in waters not used for tourism and domestic purposes (based on Vietnamese standards)
pH	6.5 – 9.5	5-9
BOD (mg/L)	25	30 – 50
TSS (mg/L)	35	50 – 100
NO_3 (mg/L)	10 – 15	30 – 50
Phosphorus (mg/L)	1 – 2	6 – 10

Source: SEDP

Table 3.1.2 Effluent Standards for Industrial Wastewater

Parameter	For plants discharging in waters used for tourism and domestic purposes (based on EU standards)	For plants discharging in waters not used for tourism and domestic purposes (based on Vietnamese standards)
pH	6.5 – 9.5	5-9
BOD (mg/L)	25	30 – 100
TSS (mg/L)	35	50 – 200
NO_3 (mg/L)	10 – 15	15 – 60
Phosphorus (mg/L)	1 – 2	4 – 8

Source: SEDP

It is required that advanced wastewater treatment technologies and high project cost should meet the proposed effluent standards. However, Ha Long Bay is a world heritage site and one of the most important resource for tourism, thus, it is appropriate for Vietnam and Quang Ninh Province to apply the stricter standard to preserve the water environment of Ha Long Bay and other coastal areas in Quang Ninh Province.

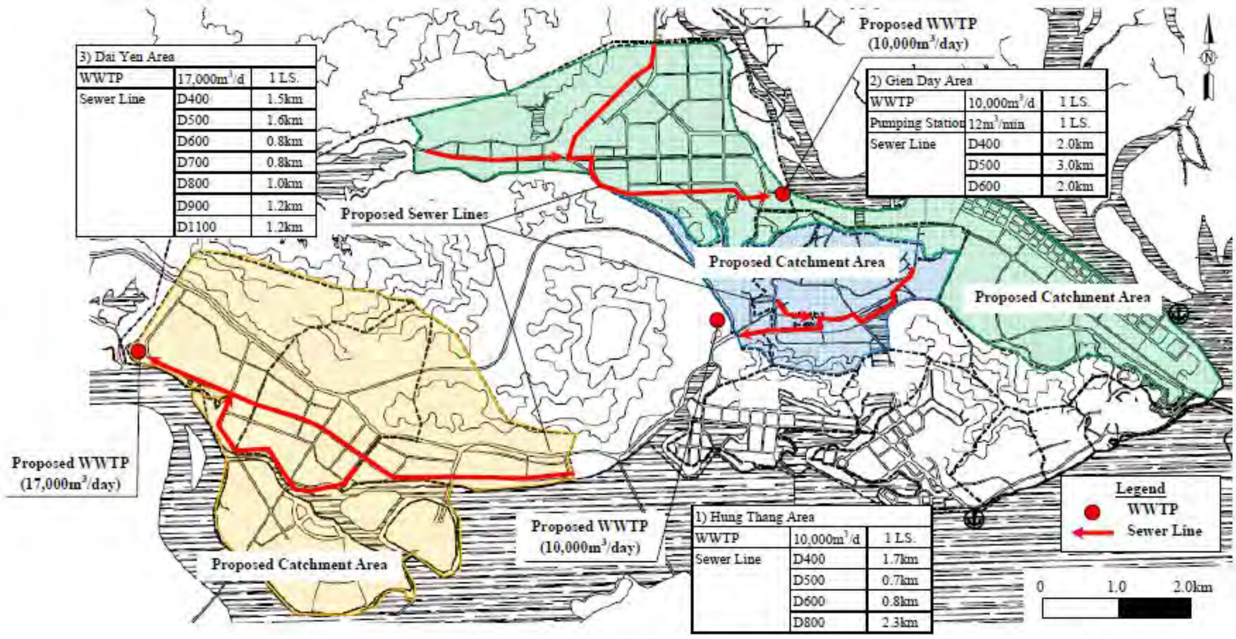
(2) Treatment Process

In order to meet the effluent standard and protect water environment in Quang Ninh Province, advanced wastewater treatment processes are required to be installed for every wastewater treatment plants in the urban areas. Before each project will commence, a feasibility study is required for every wastewater management system of each city, town and district. The wastewater treatment processes of each plant should be studied in detail and selected in the feasibility studies.

Regarding the effluent from hospitals, commercial buildings, and other facilities, pre-treatment before being discharged to public sewerage system is required to prevent the deterioration of sewer facilities and the inhibition of biological treatment process in WWTP. Quang Ninh Province shall set a regulation for the effluent from these facilities using other county's regulation as reference.

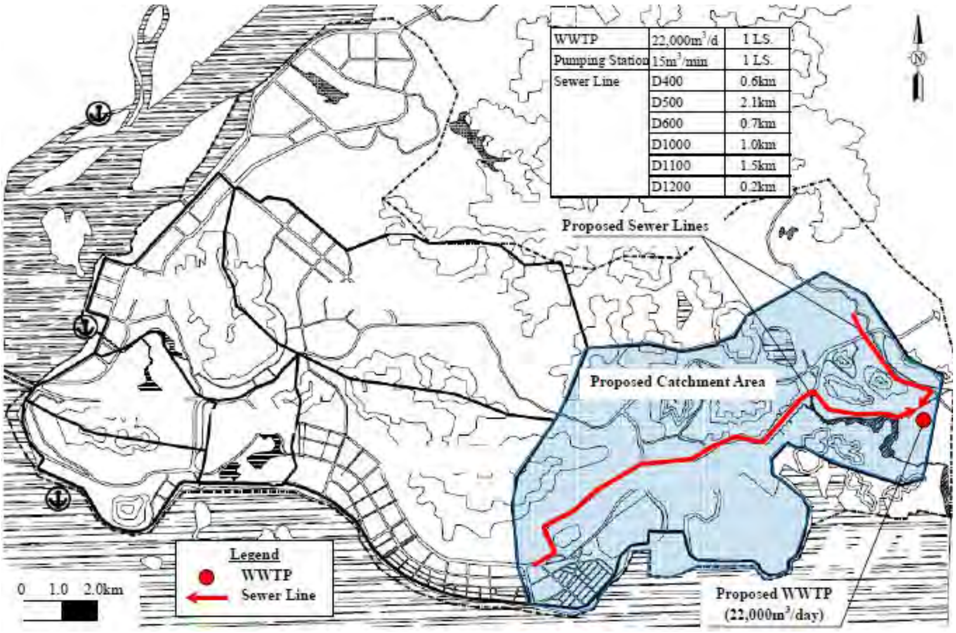
(3) Proposed Sewerage Project in Ha Long City

Four sewerage projects are proposed in Ha Long City. The outline of the project in the western and eastern Ha Long City is shown in Figure 3.1.1 and Figure 3.1.2, respectively.



Source: Environmental Master Plan

Figure 3.1.1 Proposed Sewerage Project in Western Ha Long City



Source: Environmental Master Plan

Figure 3.1.2 Proposed Sewerage Project in Eastern Ha Long City

3.2 City Development Master Plan

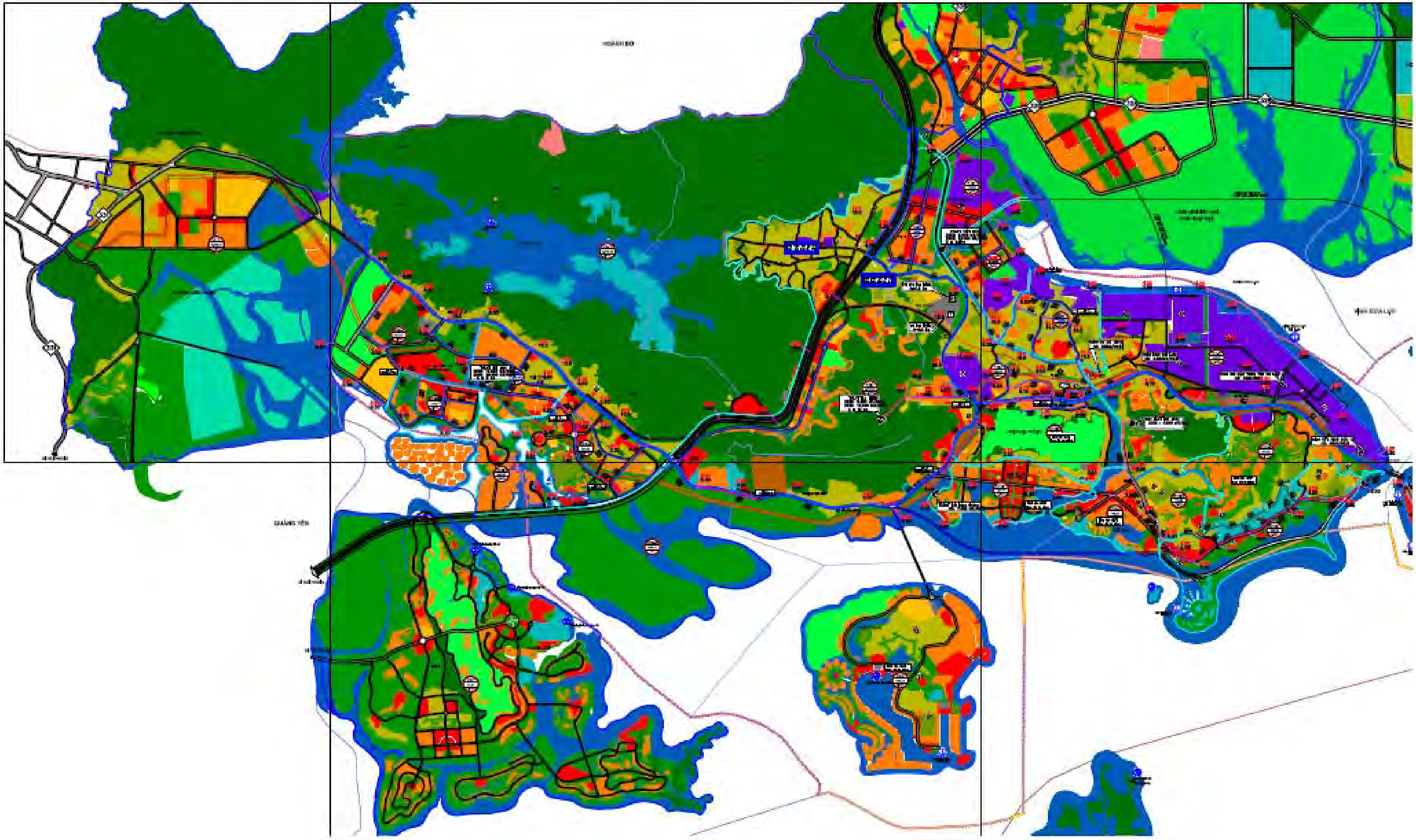
City development master plan was formulated to establish the construction master plan to 2030 and orientation to 2050 and it is under the appraisal phase as of September 2014. In the master plan, land use plan is proposed as shown in Figure 3.1.3 (western area) and Figure 3.1.4 (eastern area).

In terms of sewerage and drainage development, the combined sewer system and/or interceptor system is proposed in the existing residential areas and the separate wastewater system is proposed for the newly developed area. The strategy for the sewerage development in Ha Long City is proposed as shown in Table 3.1.3.

Table 3.1.3 Strategies for the Sewerage Development

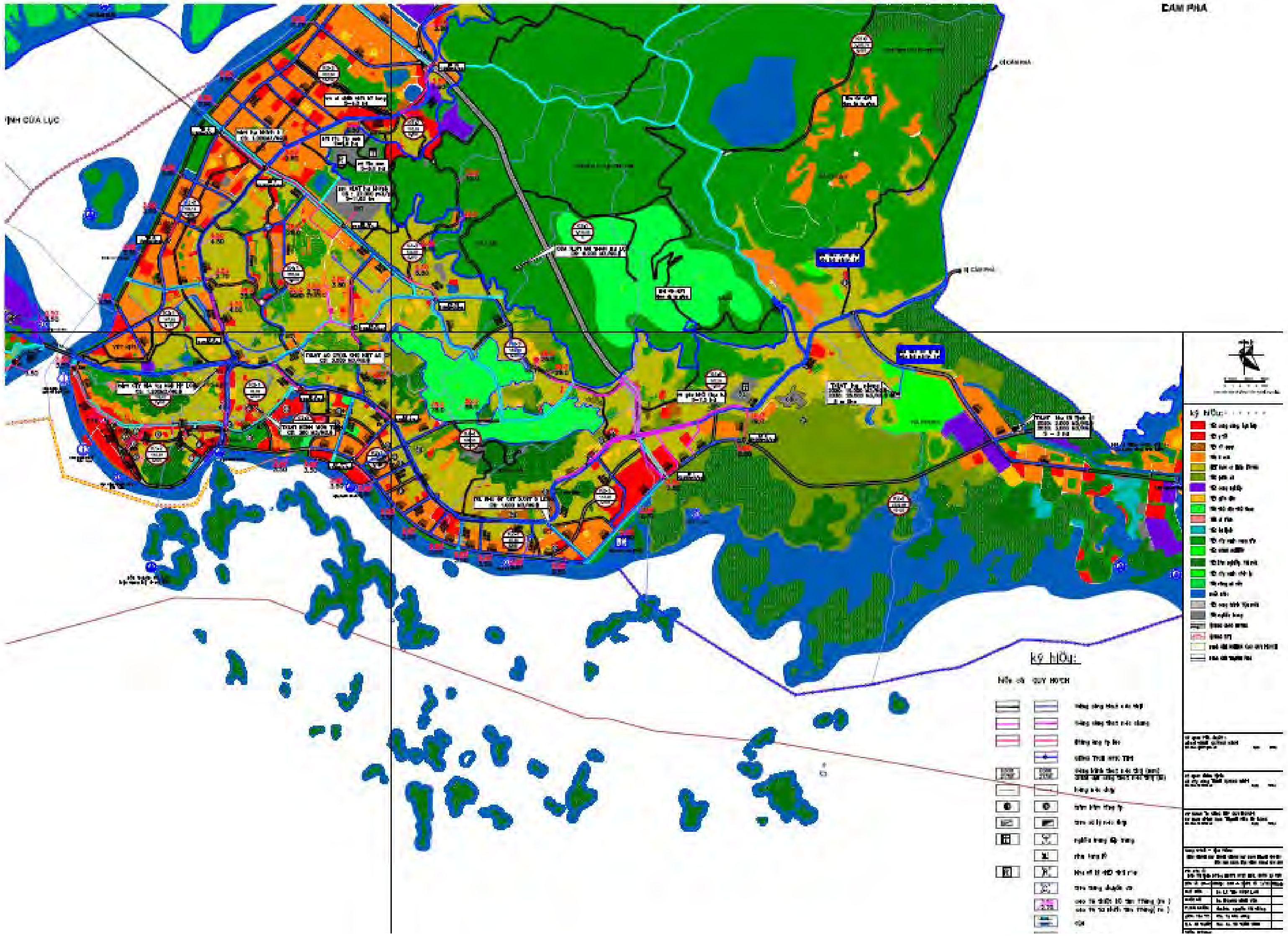
Catchment		Proposal
Eastern Area	1	Includes the Hon Gai central wards. Wastewater will be collected and transported by eight pumping stations to the WWTP in Ha Khanh. In this area, there is already an existing treatment plant with capacity of 7,000 m3/day that will be upgraded to 27,000 m3/day.
	2	The area east of Hon Gai. Wastewater will be collected and transported by ten pumping stations to the WWTP located in the farmland of Ha Phong Ward. Capacity of this WWTP is 19,000 m^3/day (by 2020) and 25,000 m^3/day (by 2030)
Western Area	3	Central areas of Bai Chay. Wastewater will be collected and transported by eight pumping stations to the WWTP in Cai Dam. The current capacity of the station is 3,500 m^3/day. It is expected that after 2025, the amount of wastewater here will be transferred to be treated in Ha Khau.
	4	Areas of Gieng Day- Ha Khau-Hung Thang. Wastewater will be collected and transported by eight pumping stations to the WWT station in Ha Khau. Capacity of this WWTP is 9,000 m^3/day (by 2020) and 18,000 m^3/day (by 2030)
	5	Areas of Viet Hung Commune. Wastewater will be collected and transported by one pumping station to the WWTP in the south of Viet Hung Commune. Capacity of this WWTP is 8,000 m^3/day (by 2020) and 13,000 m^3/day (by 2030)
	6	Areas of Dai Yen. Wastewater will be collected and transported by six pumping stations to the WWT station in the north of Dai Yen Commune. Capacity of this WWTP is 15,500 m^3/day (by 2020) and 20,000 m^3/day (by 2030)

Source: City Development Master Plan



Source: City Development Master Plan

Figure 3.1.3 Land Use Plan in Western Ha Long City



Source: City Development Master Plan

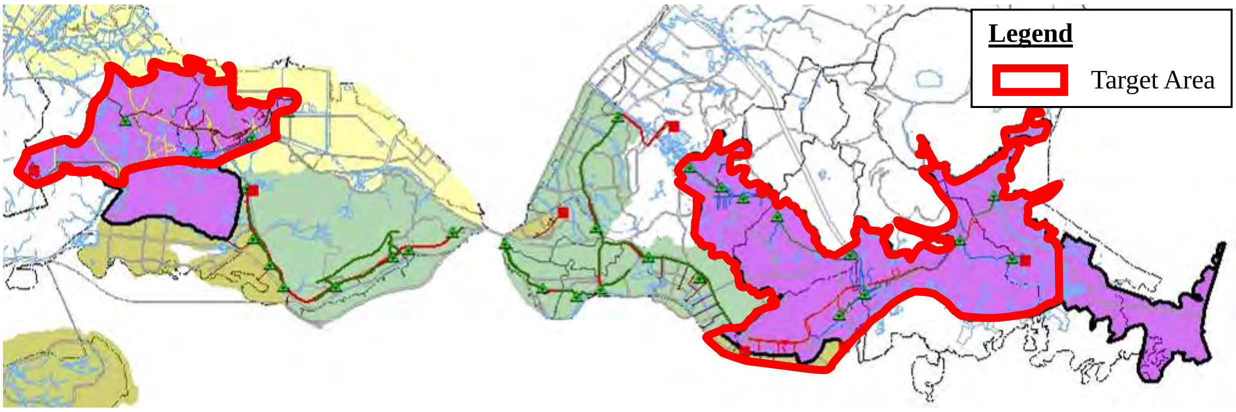
Figure 3.1.4 Land Use Plan in Eastern Ha Long City

3.3 Sewerage and Drainage Master Plan

The sewerage and drainage master plan to 2020 and orientation to 2030 for Quang Ninh Province was formulated in 2010 by QNPPC and approved by Decision No.22/QĐ-UBND. The proposal in the master plan was reflected in the environmental master plan.

3.4 Original Feasibility Study for Sewerage Project in Ha Long City

According to the results of the feasibility study carried out by a local consultant in 2008, Japanese official development assistance (ODA) loan was officially requested under the proposed project scheme. The project is approved by QNPPC by QNPPC Decision No. 1954/QD-UBND. The target area is shown in Figure 3.4.1 and the outline of the project is shown in Table 3.4.1, accordingly.



Source: Feasibility Study Report for Ha Long Environment Protection Project, Sub-project on Sewerage and Wastewater Treatment in Ha Long City

Figure 3.4.1 Target Area of the Sewerage Project under Japanese ODA Loan

Table 3.4.1 Outline of Sewerage Project under Japanese ODA Loan

Area	Western Area (Ha Khau)	Eastern Area (Ha Phong)
1) Service Area	283.14 ha	326.51 ha
2) Target Year	2015	2015
3) Planned Population		
Resident	45,332	61,083
Area of WWTP	3.5 ha	5.0 ha
4) Type of Collection	Interceptor	Interceptor
5) WWTP	Ha Khau WWTP	Ha Phong WWTP
Capacity (daily average basis)	5,000 m^3/day	6,500 m^3/day
Treatment process	CAS (Conventional Activated Sludge)	CAS (Conventional Activated Sludge)
Area	2.5 ha	4.4 ha
6) Quantity of Construction		
Sewer pipe		
Interceptor (D200-500)	25,806 m	
Pressure (D100-300)	10,405 m	
Manhole-type pumping station	4	10
Drainage pipe		
Pipe and culvert	4,484 m	
Concrete drain with cover	20,288 m	
Channel dredging	21,033 m^3	
Channel embankment	2,380 m	

Source: Feasibility Study Report for Ha Long Environment Protection Project, Sub-project on Sewerage and Wastewater Treatment in Ha Long City

Chapter IV Preliminary Review

4.1 Necessity of the Revision of Proposed Sewerage Plan

The project component for Japanese ODA loan was decided according to the local F/S carried out in 2008, and the subsequent environmental impact assessment (EIA) was approved by Quang Ninh Province. The F/S shall be revised due to the following reasons:

- The target year of the local F/S is 2015 and it shall be revised to a reasonable year.
- The population shall be revised according to the latest population projection because the population projection in the local F/S and the current population data are inconsistent.
- The classification of Ha Long City is Class I as of 2014, after it was upgraded in October 2013. Therefore, the preliminary review shall be carried out according to the design and planning criteria of Class I cities.
- Sewerage service has been provided by private companies, CIENCO5 and LICOGI, in a part of the target area and this area shall be excluded from the target area of the yen loan project.
- The urban development master plan in Ha Long City has been revised in July 2014. The sewerage plan shall be revised considering the revised master plan.
- DONRE established the new environmental master plan in 2014. The effluent quality, which is equivalent to the European standard, was proposed in the said master plan as shown in Table 3.1.1.
- The construction cost was estimated in 2008 and it shall be revised according to the current prices because six years have passed since the project cost was estimated.
- Combined sewer system is applied in the local F/S but some interceptors flow into the combined sewer and this type of collection system causes high wet weather effluent load. In order to decrease the combined sewer overflow (CSO), the sewer plan shall be revised.
- According to the revision of the wastewater volume due to the updating of the population projection and unit wastewater volume, the capacity of interceptors and PSs shall be revised.
- The proposed interceptors do not cover the whole target area and they shall be extended.
- The return period used in the runoff analysis for drainage planning in Class I cities shall be five years for trunk sewer and drainage channel and two years for branch sewer according to Vietnamese design criteria. The runoff calculation in the local F/S does not satisfy this condition and the parameters for drainage planning shall be examined carefully considering the situation of city development.
- The applied type of drainage facilities shall be examined carefully. The local F/S applied box culvert to the sloped road considering the sediments in the culvert and the ease of house connections; however, the circular pipe seems to be desirable in the said condition.

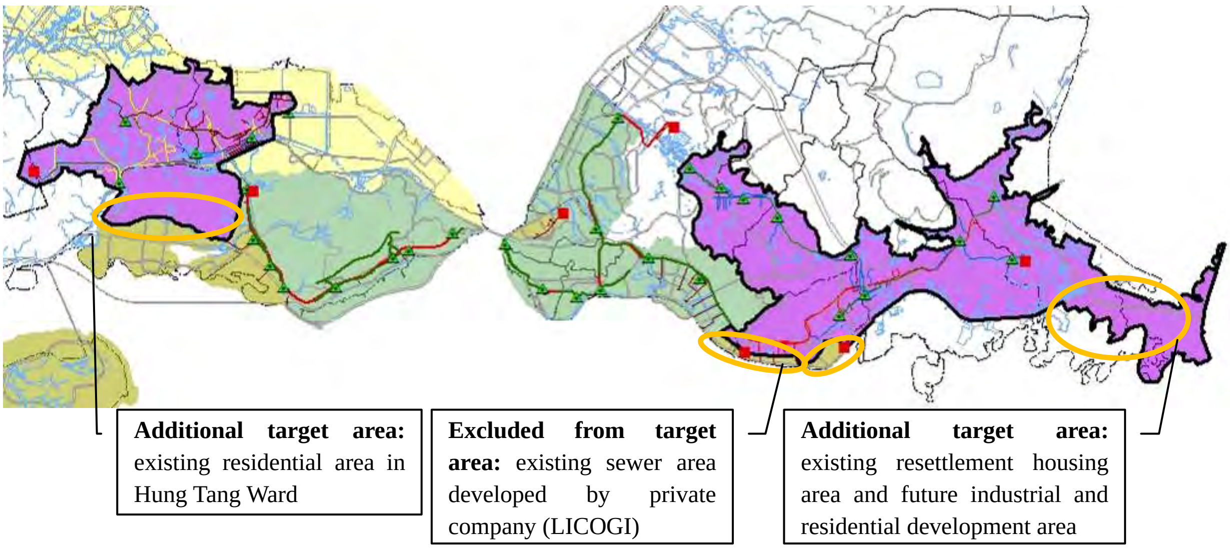
4.2 Set-up Planning and Design Conditions

4.2.1 Target Year of the Project

The target year for the proposed sewerage plan is set at 2025 which is about ten years after the commencement of the project (L/A). Considering the implementation schedule of this project, the sewerage system is expected to start operation around 2021 which is four years prior to the target year..

4.2.2 Service Area for the Proposed Sewerage System

The target area of the project was decided based on the local F/S. It was expanded to include the planned development area in the city development master plan and reduced to exclude the private development area where a private company (LICOGI) developed the WWTP through its own investment. The revised target area is shown in Figure 4.2.1.



Source: JICA Study Team

Figure 4.2.1 Revised Target Area

4.2.3 Population Projection

The population projection for this project was carried out by setting the growth ratio according to the population projection in the city development master plan. The population in Ha Long City is 235,007 in 2013 and it is projected to increase to 270,000 in 2020 and 350,000 in 2030. As a result of the said projection, the planned population is 39,300 in the western target area and 55,100 in the eastern target area. The population from 2009 to 2013 derived from statistical data in Ha Long City is shown in Table 4.2.1 and the projected population is shown in Table 4.2.2.

Table 4.2.1 Population in Ha Long City from 2009 to 2013

<table>
<tr><th rowspan="2">Administration Area of Wards
in Ha Long City</th><th colspan="6">Population</th></tr>
<tr><th></th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th></tr>
<tr><td rowspan="21">Western Ha Long


Eastern Ha Long

</td><td>Ha Long Total</td><td>218,830</td><td>226,239</td><td>229,497</td><td>231,913</td><td>235,007</td></tr>
<tr><td>Hà Khánh</td><td>6,394</td><td>6,638</td><td>6,763</td><td>6,875</td><td>7,048</td></tr>
<tr><td>Hà Phong</td><td>9,322</td><td>9,565</td><td>9,643</td><td>9,912</td><td>9,952</td></tr>
<tr><td>Hà Khẩu</td><td>11,768</td><td>12,414</td><td>12,841</td><td>13,186</td><td>13,567</td></tr>
<tr><td>Cao Xanh</td><td>15,878</td><td>16,298</td><td>16,505</td><td>16,562</td><td>16,538</td></tr>
<tr><td>Giếng Đáy</td><td>14,937</td><td>15,434</td><td>15,199</td><td>14,292</td><td>13,815</td></tr>
<tr><td>Hà Tu</td><td>12,604</td><td>12,941</td><td>13,147</td><td>13,334</td><td>13,438</td></tr>
<tr><td>Hà Trung</td><td>7,613</td><td>7,871</td><td>7,987</td><td>8,100</td><td>8,101</td></tr>
<tr><td>Hà Lầm</td><td>9,906</td><td>10,213</td><td>10,331</td><td>10,521</td><td>10,788</td></tr>
<tr><td>Bãi Cháy</td><td>20,235</td><td>21,121</td><td>21,472</td><td>21,681</td><td>22,180</td></tr>
<tr><td>Cao Thắng</td><td>16,323</td><td>17,069</td><td>17,308</td><td>17,582</td><td>17,811</td></tr>
<tr><td>Hùng Thắng</td><td>5,793</td><td>6,069</td><td>6,114</td><td>6,204</td><td>6,327</td></tr>
<tr><td>Yết Kiêu</td><td>9,529</td><td>10,091</td><td>10,291</td><td>10,472</td><td>10,571</td></tr>
<tr><td>Trần Hưng Đạo</td><td>9,687</td><td>9,554</td><td>9,608</td><td>9,821</td><td>9,944</td></tr>
<tr><td>Hồng Hải</td><td>18,066</td><td>18,610</td><td>18,861</td><td>19,184</td><td>19,717</td></tr>
<tr><td>Hồng Gai</td><td>7,283</td><td>7,904</td><td>8,293</td><td>8,410</td><td>8,452</td></tr>
<tr><td>Bạch Đằng</td><td>9,447</td><td>9,648</td><td>9,733</td><td>9,824</td><td>9,888</td></tr>
<tr><td>Hồng Hà</td><td>15,392</td><td>15,666</td><td>15,849</td><td>16,119</td><td>16,697</td></tr>
<tr><td>Tuần Châu</td><td>1,813</td><td>1,881</td><td>2,027</td><td>2,067</td><td>2,097</td></tr>
<tr><td>Việt Hưng</td><td>8,823</td><td>9,015</td><td>9,150</td><td>9,246</td><td>9,408</td></tr>
<tr><td>Đại yên</td><td>8,017</td><td>8,237</td><td>8,375</td><td>8,521</td><td>8,668</td></tr>
</table>

Source: Sub-department of Statistics Office of Ha Long City

Table 4.2.2 Population Projection in Ha Long City from2014 to 2030

		Statistic Data	→	Forecast→	→	→	Target Year		
				1.020	1.020	1.020	1.026	1.026	
		Ward	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**Target Population**
Western Ha Long									
Bai Chay WWTP	Existing	Bãi Cháy	**22,180**	**22,624**	**23,077**	**25,483**	**29,013**	**33,033**	**29,100**
Ha Khau WWTP (JICA)	Target	Giếng Đáy	13,815	14,092	14,374	15,872	18,071	20,575	
		Hà Khẩu	10,175	10,379	10,587	11,690	13,310	15,154	
		Hùng Thắng	6,011	6,131	6,254	6,906	7,862	8,952	
		total	**30,001**	**30,602**	**31,215**	**34,468**	**39,244**	**44,681**	**39,300**
Viet Hung WWTP	Future	Bãi Cháy	0	0	0	0	0	0	
		Giếng Đáy	0	0	0	0	0	0	
		Hà Khẩu	2,713	2,768	2,823	3,117	3,549	4,041	
		Việt Hưng	7,526	7,677	7,831	8,647	9,845	11,209	
		total	10,240	10,445	10,654	11,765	13,395	15,250	13,400
Dai Yen WWTP	Future	Dai Yen	6,934	7,073	7,215	7,967	9,071	10,328	9,100
Private WWTP		Hùng Thắng	316	323	329	363	414	471	
		Tuần Châu	2,097	2,139	2,182	2,409	2,743	3,123	
		total	2,413	2,462	2,511	2,773	3,157	3,594	
Isolated		Hà Khẩu	678	692	706	779	887	1,010	
		Việt Hưng	1,882	1,919	1,958	2,162	2,461	2,802	
		Dai Yen	1,734	1,768	1,804	1,992	2,268	2,582	
		total	4,294	4,380	4,467	4,933	5,616	6,394	
Sub-total Western Ha Long			**76,062**	**77,585**	**79,139**	**87,388**	**99,495**	**113,280**	
Eastern Ha Long									
Ha Khanh WWTP	Existing	Hồng Gai	8,452	8,621	8,794	9,711	11,056	12,588	
		Bạch Đằng	9,888	10,086	10,288	11,360	12,934	14,726	
		Yết Kiêu	10,571	10,783	10,999	12,145	13,828	15,744	
		Trần Hưng Đạo	9,944	10,143	10,346	11,425	13,008	14,810	
		Cao Xanh	16,538	16,869	17,207	19,001	21,633	24,630	
		Cao Thắng	10,687	10,901	11,119	12,278	13,979	15,916	
		Hồng Hải	19,717	20,112	20,515	22,653	25,791	29,365	
		Hà Khánh	0	0	0	0	0	0	
		total	**85,797**	**87,515**	**89,268**	**98,572**	**112,229**	**127,778**	**112,300**
Ha Phong WWTP (JICA)	Target	Hà Lầm	6,473	6,602	6,735	7,437	8,467	9,640	
		Hà Trung	4,861	4,958	5,057	5,584	6,358	7,239	
		Hồng Hà	16,697	17,031	17,372	19,183	21,841	24,867	
		Hà Tu	8,063	8,224	8,389	9,263	10,547	12,008	
		Hà Phong	5,971	6,091	6,213	6,860	7,811	8,893	
		total	**42,064**	**42,907**	**43,766**	**48,328**	**55,024**	**62,647**	**55,100**
Private WWTP		Yết Kiêu	0	0	0	0	0	0	
		Hồng Hà	0	0	0	0	0	0	
*Included in othe WWTP			0	0	0	0	0	0	
Isolated		Cao Thắng	7,124	7,267	7,413	8,185	9,319	10,610	
		Hà Lầm	4,315	4,402	4,490	4,958	5,645	6,427	
		Hà Trung	3,240	3,305	3,371	3,723	4,239	4,826	
		Hà Tu	5,375	5,483	5,593	6,176	7,031	8,005	
		Hà Phong	3,981	4,061	4,142	4,574	5,207	5,929	
		Hà Khánh	7,048	7,189	7,333	8,097	9,219	10,497	
			31,084	31,707	32,342	35,712	40,660	46,294	
Sub-total Eastern Ha Long			**158,945**	**162,128**	**165,375**	**182,612**	**207,913**	**236,720**	
Total in Ha Long			**235,007**	**239,714**	**244,514**	**270,000**	**307,409**	**350,000**	

Source: JICA Study Team

As a result of the population projection, the target populations in western and eastern Ha Long City are summarized in Table 4.2.3.

Table 4.2.3 Target Population in the Original F/S and Preliminary Review

	F/S in 2008		Preliminary Review	
	Area (ha)	Population in 2015	Area (ha)	Population in 2025
Western Area	283.14	45,332	713.2	39,300
Eastern Area	326.51	59,265	1,248.08	55,100 * 11,300 is covered by private WWTP

Note: The target area of F/S in 2008 shown in the above table was assumed to be too small and that of Preliminary Review was re-calculated by GIS software in this study.

Source: JICA Study Team

4.2.4 Projection of Wastewater Volume

Wastewater volume is calculated based on the population projection shown in Table 4.2.1. The unit wastewater volume and other parameters adopted in the project are summarized in Table 4.2.2.

Table 4.2.4 Unit Wastewater Volume

Item		Unit	Value	Remarks
A. Water Consumption	Domestic[*1]	Lpcd	180	-
	Non-domestic[*2]	Lpcd	18	10% of Domestic
	Total	Lpcd	198	-
B. Wastewater Generation Factor[*3]		%	90-95	
C. Infiltration Ratio		%	10	-
D. Daily Maximum Factor[*4]		-	1.3	= 1.15- 1.3

Note :
*1: City Master Plan in Halong City
*2: QCVN 01:2008 (for public work and administration)
*3: QCVN 01:2008
*4: TCVN 7957: 2008
Source: JICA Study Team

According to the proposed unit wastewater volume, the capacity of the WWTP is calculated as shown in Table 4.2.5. The required capacities of the WWTPs are 8,200 m^3/day (Ha Khau WWTP: western area) and 8,600 m^3/day (Ha Phong WWTP: eastern area) on average.

Table 4.2.5 Capacity of WWTPs Required in 2025

Item		Area	West		East		Note
		Situation	Existing	Planned	Existing	Planned	
		Donor	World Bank	JICA	World Bank	JICA	
		Unit	Bai Chay	Ha Khau	Ha Khanh	Ha Phong	
Target Year		–	2025	2025	2025	2025	
Area		ha		283.14		326.51	
Population in 2025	Population						
	Resident	capita	29,100	39,300	112,300	55,100	
	Tourist	capita	5,800	0	1,100	0	Bay Chay:20% Hon Gai: 1%
	Total		34,900	39,300	113,400	55,100	
	Covered by Private WWTP	capita			5,690	11,300	
					(CIENCO5)	(LICOGIx2)	
	Target Population						
	Resident	capita	29,100	39,300	106,610	43,800	
	Tourist	capita	5,800	0	1,100	0	Bay Chay:20% Hon Gai: 1%
	Total		34,900	39,300	107,710	43,800	
Wastewater Volume	Unit wastewater volume						
	Resident	liter/capita/day	180	180	180	180	Based on M/P
	Tourist	liter/capita/day	180	180	180	180	
	Public, Administration, Commercial	liter/capita/day	18	18	18	18	10% of domestic WW
	Industrial Zone	m3/ha	22	22	22	22	
	Water supply coverage	%	100%	100%	100%	100%	
	Collection coverage in resider	%	95%	95%	95%	90%	
	Wastewater volume						
	Resident	m3/day	4,976	6,720	18,230	7,096	
	Tourist	m3/day	992	0	188	0	
	Public and Administration	m3/day	597	672	1,842	710	
	Total		6,565	7,392	20,260	7,805	
	Inflow/Infiltration	m3/day	656	739	2,026	781	10% of Daily Average
	Wastewater Volume						
	Daily Average	m3/day	7,221	8,132	22,286	8,586	
	Daily Maximum	m3/day	9,388	10,571	28,972	11,161	1.3*Daily Average
	Hourly Maximum	m3/hour	508	573	1,569	605	1.3*Daily Maximum
	Hourly Maximum (Rainy Da	m3/hour	602	847	2,321	894	2.5*Daily Average
	Capacity of WWTP						
	Daily Average basis	m3/day	**7,300**	**8,200**	**22,300**	**8,600**	
	Daily Maximum basis	m3/day	**9,400**	**10,600**	**29,000**	**11,200**	
	existing capacity of WWTP	m3/day	3,500		7,200		
	proposed capacity of WWTP	m3/day		5,000		6,500	

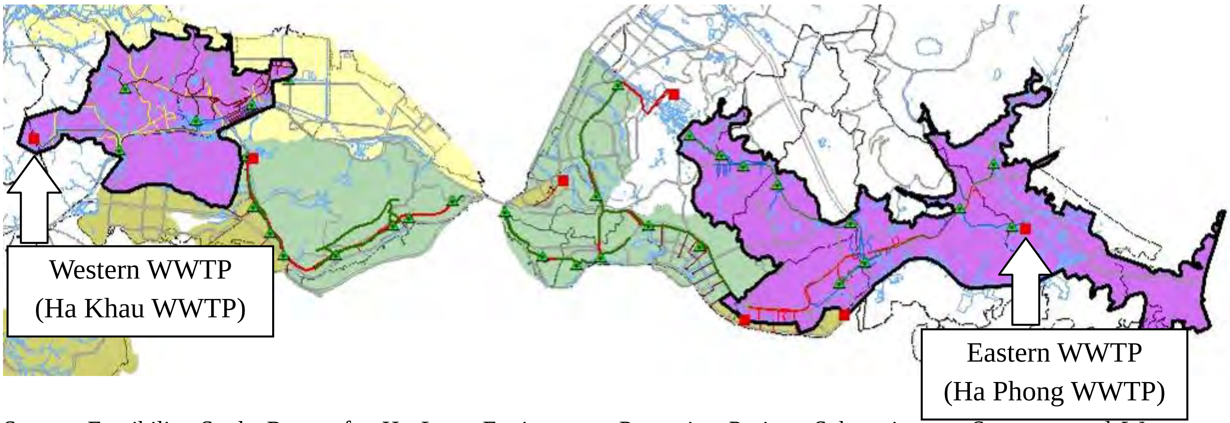
Source: JICA Study Team

4.3 Preliminary Plan of Sewerage System and Facilities

4.3.1 Wastewater Treatment Plant

(1) Location of Wastewater Treatment Plant

In general, a WWTP is located at a site with low elevation, such as the downstream of a river and/or along the seaside, in order to decrease the number of pumping stations. However, majority of the seaside in Ha Long City has already been developed as a tourism and/or residential zone and it is difficult to find an appropriate area for the WWTP there. In the city development master plan, the location of the WWTP was selected at the intermontane basin in the western area and at the agricultural area in the eastern area. The location of the WWTP is selected at the site stipulated under the land use plan in the city development master plan as shown in Figure 4.3.1.



Source: Feasibility Study Report for Ha Long Environment Protection Project, Sub-project on Sewerage and Wastewater Treatment in Ha Long City

Figure 4.3.1 Location of WWTP

1) Western Area

The proposed site of the WWTP, shown in Picture 4.3.1, is located at the intermontane basin in Ha Khau Ward. Its linear distance from the national road is about 1.5 km and the difference of elevation from the national road seems to be about 10 m. There is a planned city development area between the proposed site and the national road, and the project is expected to start in 2014 by Ha Long City. In the site and along the access road, not so much resettlement is expected.

Source: JICA Study Team

Picture 4.3.1 Proposed Site in the Western Area

2) Eastern Area

The proposed site of the WWTP, shown in Picture 4.3.2, is located in the agricultural area of Ha Phong Ward. There are city and industrial development area and resettlement area (transmigration site for persons affected by resettlement) in the southeastern side of the proposed site. In the site and along the access road, no resettlement is expected.

Source: JICA Study Team

Picture 4.3.2 Proposed Site in the Eastern Area

(2) Incremental Capacity

The Bai Chay WWTP is expected to be relocated to Ha Khau WWTP according to the city development master plan. The relocation will be carried out in the second phase of the project.

The incremental capacity of the Ha Khau WWTP is calculated so that 8,200 m^3/day (maximum of 10,600 m^3/day) is required in the first phase and 7,300 m^3/day (maximum of 9,400 m^3/day) is required in the second phase. Regarding the eastern area, 8,600 m^3/day (maximum of 11,200 m^3/day) is required in Ha Phong WWTP, as shown in Table 4.3.1.

Table 4.3.1 Incremental Capacity

		F/S in 2008		**Preliminary Review**	
1) Planning Condition					
Target year		2015		2025	
Unit wastewater volume	Domestic	120 Lpcd (=150 Lpcd*80%)		180 Lpcd	
	Public, etc.	—		18 Lpcd (10% of domestic)	
Collection coverage		75%		90-95%	
Inflow / infiltration		20% of daily average		10% of daily average	
Total unit wastewater volume		108 Lpcd		196-207 Lpcd	
2) Capacity of WWTP		Daily Average	Daily Maximum	Daily Average	Daily Maximum
	Western Ha Long (Ha Khau: 1st Phase)	5,000 m^3/day	-	8,200 m^3/day	10,600 m^3/day
	Western Ha Long (Bai Chay: 2nd Phase)	-	-	7,300 m^3/day	9,400 m^3/day
	Eastern Ha Long	6,500 m^3/day	-	8,600 m^3/day	11,200 m^3/day

Source: JICA Study Team

(3) Treatment Process

1) Inflow and Effluent Quality

The Japanese guideline on per capita pollution load is adopted for the estimation of inflow quality, since there is no Vietnamese standard. In addition, there is septic tank, which treats human waste (effluent from toilet), at all households and hotels in Ha Long City and the wastewater treatment in the septic tank is considered in setting the unit pollution load as explained below.

Table 4.3.2 Pollution Load per Capita

	Source of Pollution Load[1)]		Pollution Load per Capita (Without Septic Tank)	Percent Reduction at Septic Tank[2)]	Pollution Load per Capita (With Septic Tank)
	Human Waste	Gray Water			
	gpcd	gpcd	gpcd	%	gpcd
	(i)	(ii)	(iii)=(i)+(ii)	(iv)	(v)=(iii)-(i)x(iv)
BOD	18	40	58	45	50
SS	20	25	45	60	33
T-N	9	2	11	25	8.8
T-P	0.9	0.4	1.3	15	1.2

1) Planning and Design Guideline for Sewerage System, Japan Sewage Works Association, 2009
2) Median ratio proposed in US EPA Design Manual: Onsite Wastewater Treatment and Disposal Systems, 1980
Source: JICA Study Team

According to the unit wastewater volume and unit pollution load, the inflow quality is calculated as shown in Table 4.3.3.

Regarding the effluent quality, design effluent quality shall be set considering i) Vietnamese standard, ii) Vietnamese design criteria, and iii) DONRE's proposal (EU standard). To meet EU standard, nitrate (N) and phosphate (P) treatment, i.e., advanced treatment, is needed but it costs much higher than the normal secondary treatment process. Meeting this EU standard will require additional investments and O&M cost that is more than 30% compared with Vietnamese standard. Therefore, it would be better for the environment to spend that extra cost to expand the capacity and coverage of the wastewater collection system to treat more wastewater. In this regard, a two-step approach was proposed. First, wastewater treatment plants will be built according to normal Vietnamese environment standard. After all wastewater treatment plants and collection systems are built, additional investments will be made one by one in upgrading the treatment plants. The effluent quality tentatively applied in the study is shown in Table 4.3.3 which requires BOD, SS and N treatment. The effluent quality will be decided during the detailed design phase.

Table 4.3.3 Inflow and Effluent Quality Applied in the Project (Tentative)

No.	Parameter	Unit	Inflow Quality	Effluent Quality				
				QCVN 14:2008	TCVN 7222:2002	Proposal in FS	Proposed by DONRE	Adopted in the Project
1	pH	-	-	5-9	6-9	6-9	6.5 – 9.5	6-9
2	BOD_5	mg/L	229	50	10-30	10-30	25	10-30
3	SS	mg/L	151	100	10-30	10-30	35	10-30
4	$N\text{-}NH_4$	mg/L	-	50	-	-	-	-
5	T-N	mg/L	40	-	15-30	15-30	10-15	15-30
6	T-P	mg/L	5	10	5-12	5-12	1-2	5-12
Note				National Standard	Design Standard (reference)			The necessity of P treatment will be monitored.

Source: JICA Study Team

2) Treatment Process

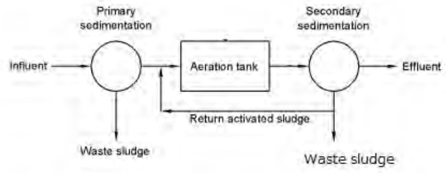
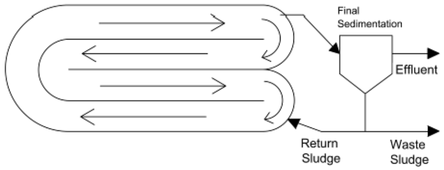
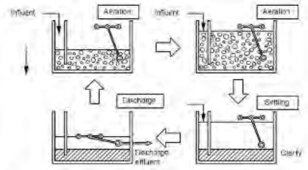
In Ha Long City, the sequencing batch reactor (SBR) process has been applied at all existing public WWTPs. The SBR process requires a simple structure for construction and is advantageous in terms of the removal of suspended solids and its expected removal of nitrogen and phosphorus. However, this method is not easy to operate, particularly, the control of influent water quality is not an easy task as compared with other treatment processes.

In this regard, other treatment processes such as the conventional activated sludge (CAS) and oxidation ditch (OD) are compared with the SBR process.

According to Table 4.3.4, in terms of O&M and cost, the OD process is recommended. However, in Ha Long City, the land for the WWTP is limited due to the expansion of the urban area, and the area for the WWTP cannot be secured. Therefore, the CAS method, which is more suitable for the combined sewerage system because of its capability to treat the CSO, is recommended among three treatment processes for all WWTPs considering the current situation in Ha Long City.

In addition, it is recommended that a new treatment process, “Pre-treated Trickling method (PTF)” which is piloting in Da Nang City shall be investigated in detailed design stage. The pilot plant of PTF process is now investigated in Kochi Prefecture in Japan where the lower temperature in winter season than Ha Long and Da Nang Cities. The most suitable method will be selected in detailed design phase.

Table 4.3.4 Comparison of Wastewater Treatment Process

<table>
<tr><th>Treatment Process</th><th>Conventional Activated Sludge (CAS)</th><th>Oxidation Ditch (OD)</th><th>Sequencing Batch Reactor (SBR)</th></tr>
<tr><td rowspan="2">Outline</td><td>
</td><td>
</td><td></td></tr>
<tr><td>- The wastewater flows into the primary sedimentation tank and large particle is removed.
- The wastewater is biologically treated by bacteria in the aeration tank.
- Solid-liquid separation is performed in the final sedimentation tank.</td><td>- The wastewater flows into the reaction tank directly and is biologically treated by bacteria
- Solid-liquid separation is performed in the final sedimentation tank.</td><td>- The wastewater flows into a single reactor, and the aeration, sedimentation and discharge of supernatant water are performed.
- Same process is periodically repeated.</td></tr>
<tr><td>Treatment capacity</td><td>Small scale ～ Large scale</td><td>Small scale～ Medium scale</td><td>Small scale～ Large scale</td></tr>
<tr><td>Difficulty of operation</td><td>Middle</td><td>Easiest in three processes</td><td>Most difficult to control</td></tr>
<tr><td>Treatment performance</td><td></td><td></td><td></td></tr>
<tr><td>Nitrate treatment (Expected effluent quality)</td><td>- 20 mg/L under conventional treatment.
- 15 mg/L when aeration control operation is applied at the upstream compartment of aeration tank</td><td>- 15 mg/L</td><td>- 20 mg/L under SBR
- 15 mg/L when the size of the SBR tank is much bigger to operate under low load condition</td></tr>
<tr><td>Phosphate treatment</td><td>- Theoretically, advanced treatment such as A_2O or AO process will be needed, although the effluent standard will be met without advanced process through the absorption in aeration tank.
- In case of high load, chemical treatment (flocculant) process shall be added.</td><td>- Chemical treatment (flocculant) or additional anaerobic tank is needed.</td><td>- Chemical treatment (flocculant) is needed.</td></tr>
<tr><td>First flush treatment (Stormwater) treatment)</td><td>- Peak flow during dry weather is treated through the whole treatment process.
- Remaining stormwater is treated during the sedimentation and disinfection process.</td><td>- Considering the planned intercepting rate, the hydraulic retention time is 12 hours during the stormwater inflow and the treatment is assumed to be fair.</td><td>- All stormwater cannot be sufficiently treated under the SBR system.
(Stormwater within the capacity of the regulation tank will be well treated.)</td></tr>
<tr><td>Adaptability for fluctuation – Volume</td><td>Medium</td><td>High</td><td>Low</td></tr>
<tr><td>Adaptability for fluctuation – Load</td><td>Medium</td><td>High</td><td>Low</td></tr>
<tr><td>Excess sludge volume</td><td>Much</td><td>Small</td><td>Much</td></tr>
<tr><td>Required area</td><td>Medium</td><td>Large</td><td>Small</td></tr>
<tr><td>Required cost*1</td><td>120</td><td>80</td><td>100</td></tr>
<tr><td rowspan="2">Evaluation</td><td>***Recommended***</td><td>***Not desirable***</td><td>***Not desirable***</td></tr>
<tr><td>○Medium-sized area is required.
○Stable effluent quality can be obtained.
△Expensive compared with other process.</td><td>×Large area for WWTP is needed.
◎Stable effluent can be obtained by the easiest O&M.</td><td>×The control of SBR is difficult due to quite low adoption of inflow change.
× The large regulation tank and stormwater sedimentation tank are required to deal with daily wastewater fluctuation and stormwater.</td></tr>
</table>

*1: Land reclamation cost, land acquisition cost, and resettlement cost are NOT included.
Source: JICA Study Team

(4) Disinfection Process

1) Outline

The targets of disinfection are bacteria, virus, and protozoa. For the safety of treated water, the number of *Escherichia coli* (*E. Coli*) is applied as the indicator because large number of *E. Coli* is detected in the feces of humans and livestock, and *E. Coli* can survive in water for long time, which means that *E. Coli* can cover the feasibility of danger by other pathogenic organisms. Therefore, the reduction of the detection number of *E. Coli* to less than the target number is obligated. These days, the application of ultraviolet (UV) disinfection and ozone disinfection is increasing due to environmental protection as an alternative to chlorine disinfection.

2) Type of Disinfection

a) Chlorination

a-1) Sodium Hypochlorite (Liquid)

Chlorination is most common in the world. Disinfection by sodium hypochlorite is getting popular due to the simple facilities of chemical storage tank and injection pump.

a-2) Calcium Hypochlorite /Chlorinated Isocyanuric Acid (Solid)

In case of using sodium hypochlorite for small-scale WWTP, there is possibility that problems in injection pumps and pipes occur due to their small diameter. Therefore, the tablet type of calcium hypochlorite or chlorinated isocyanuric acid is applied to contact with treated water. Also, in case of small inflow, e.g., during the beginning of the WWTP operation, tablet type is utilized.

b) UV Disinfection

Although chlorination is more widespread than other disinfection methods, UV disinfection is becoming common for small/medium-scale WWTPs in terms of environmental protection. The UV disinfection method also has advantages including O&M such as avoiding unnecessary chemical addition, short disinfection time, and simple facilities.

c) Ozone Disinfection

Ozone is quite an important disinfectant like sodium hypochlorite, and its sterilizing effect is quite high. The ozone disinfection system requires large space, and the cases where the deodorization and decolorization system is integrated with the ozone disinfection system are common.

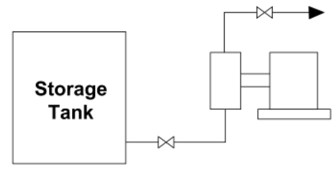
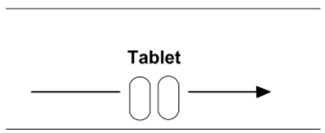
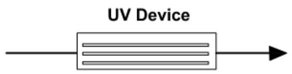
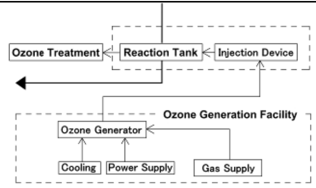
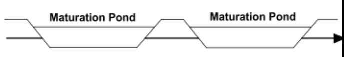
d) Maturation Pond

The maturation pond is mainly applied as a part of the wastewater treatment process in developing countries, which usually consists of anaerobic pond, facultative pond, and maturation pond. Its purpose is finishing the treated water including stabilization and disinfection. In addition, although several algae and nutrients are removed in the maturation pond, there are some cases wherein many algae grow in the maturation ponds.

3) Study on Disinfection Processes

The comparison of disinfection processes is shown in Table 4.3.5. In this case, the wastewater is discharged into the natural environment after the treatment. Therefore, advanced treatment and disinfection for decolorization and deodorization which result in expensive costs are not required. However, the number of *E. Coli* shall be securely decreased. Therefore, chlorination is preferable in terms of cost and disinfection performance. And disinfection by sodium hypochlorite is selected due to the medium to small scale of the WWTPs.

Table 4.3.5 Comparison of Disinfection Processes

	Chlorine Disinfection		UV Disinfection	Ozone Disinfection	Maturation Pond
	Sodium Hypochlorite (Liquid)	Calcium Hypochlorite (Solid)			
Description					
	The enzyme is deactivated by the injection of sodium hypochlorite	The enzyme is deactivated by the contact of tablets of calcium hypochlorite/chlorinated isocyanuric acid with treated water.	DNA of bacteria is affected and its replication is prevented by the irradiation of UV.	The plasma-like cell wall and nucleic acid are directly demolished by ozone injection.	The treated water is disinfected by UV of sunlight.
Disinfection Performance	Not effective to deactivate protozoa and several virus.	Not effective to deactivate protozoa and several virus.	Effective to deactivate protozoa and virus. Performance depends on the characteristics of treated water including SS and water temperature.	Effective to deactivate protozoa and virus and for deodorization and decolorization.	Unstable effect due to fluctuation of sunlight. Not effective to deactivate protozoa and several virus.
Capacity of WWTPs	Small ～ Large	Small	Small ～ Medium	Small ～ Medium	Small
Residual Disinfection Effect	Active	Active	No Effect	No Effect	No Effect
Influence to Environment	Concern on residual chlorine and trihalomethane	Concern on residual chlorine and trihalomethane	No Influence	No Influence	Low
Contact Time	Long	Long	Short	Long	Quite Long
Required Area	Small ～ Medium	Small (unnecessary)	Small (unnecessary)	Large	Largest among all methods
O&M	Easy O&M due to simple facilities	In case of small treatment capacity of the WWTPs, O&M is easy.	Easy O&M due to simple facilities and operation and no replacement of chemicals	Experience and skills are required.	Easiest due to no facilities
Initial Cost O&M Cost	Cheap	Cheap	Expensive	Expensive	Cheapest
Evaluation	**Suitable**	**Not applicable**	**Not applicable**	**Not applicable**	**Not applicable**
	◎Common method in the world ○Cheap Cost, Easy O&M, △Concern about environmental influence	×Not suitable for WWTPs with medium-small capacity	× Expensive cost	◎High disinfection performance × Expensive cost	◎ Easiest O&M ×Large area and low disinfection performance.

Source: JICA Study Team

(5) Sludge Treatment

For almost all WWTPs in Vietnam, either planned or operating, sludge treatment is achieved by mechanical dewatering followed by disposal to landfill site.

In general, there are four typical sludge treatment processes, namely: 1) sludge drying bed, 2) mechanical dewatering facility, 3) digestion tank for reduction and stabilization of sludge, and 4) incinerator for maximizing the reduction of sludge amount. The mechanical dewatering process is recommended, due to the following reasons based on the comparison study as shown in Table 4.3.6:

- The sludge drying bed is applied in Bai Chay WWTP. However, if it is applied in the new WWTP, large area (300 m for each side) is required for the buffer zone to prevent offensive odor. Therefore, it is unrealistic to apply this process following the current Vietnamese standard.
- After the sludge drying bed, the mechanical dewatering is the cheapest and easiest method.
- Digestion and incineration require difficult operation and high O&M cost.

Table 4.3.6 Comparison of Alternatives of Sludge Treatment Process

	1) Sludge Drying Bed	**2) Mechanical Dewatering**	**3) Digestion + Dewatering**	**4) Dewatering + Incineration**
1) Construction Cost	Lowest	Relatively low	Relatively expensive	Very expensive
2) O&M Cost	Lowest	Relatively low	Relatively expensive	Very expensive
3) Difficulty of O&M	Easiest	Relatively easy	Relatively difficult	Difficult
4) Offensive Odor	No measure for mitigation	Measures are available	Measures are available	Measures are available
5) Required Area	More than 20 times of other options	Not large	Not large	Not large
6) Amount of Sludge Generated	Reduced by drying	Reduced by dewatering	Reduced by digestion	Reduced by incineration (largest reduction)
7) Adoption	Bai Chay WWTP	Adopted in Kim Lien, Truc Bach, North Thang Long, Hai Phong and HCMC WWTPs	Adopted in some small projects	No record of adoption in Vietnam
Total Evaluation	Not Recommendable	Best Option	Not Recommendable	Not Recommendable

Source: JICA Study Team

After the completion of WWTPs with capacity of 8,200 m^3/day, 7,300 m^3/day, and 8,600 m^3/day, about 2,900 kg/day of dry sludge will be generated in total under full operation. The dry sludge is proposed to be disposed at the landfill site constructed under the WB project.

Screw press dewatering system is recommended considering the difficulties of operation and the operation costs of the belt filter press and centrifuge systems. Appropriate mechanical dewatering facility will be selected during the detailed design phase.

(6) Deodorization Process

1) Outline

Although the WWTP plays an important role to support the comfortable life in the urban area, it is regarded as unsanitary facility by the inhabitants and they often complain about the odor from the WWTP. Therefore, adequate countermeasures against odor are required to harmonize with the living environment around the WWTPs.

Because the odor from the WWTPs contains the variety of odorous substance , appropriate countermeasures according to each condition are essential. In general, countermeasures such as covering, dilution, allocation and direction of facilities, and deodorization are applied.

2) Target Facilities for Deodorization

a) Grid Chamber

The opening shall be closed as much as possible, and the coverings for the sand removal machine and screen shall be installed. The deodorization will be carried out by adsorption resulting from the negative pressure inside the grid chamber.

b) Sludge Thickening and Dewatering Facilities

The part of the sludge that is exposed to the atmosphere shall be covered. Same countermeasure is implemented for the belt comber for the transportation.

3) Type of Deodorization

a) Activated Carbon Adsorption Method

Through this method, the odor is physically adsorbed through the absorption tower filled with activated carbon. Although this method is widely applied due to the high efficiency of deodorization and easy maintenance, the cost of construction and O&M is expensive compared with the other methods. Therefore, environmental condition, odor density, and combination with other methods shall be considered in the application.

b) Biological Method

Through this method, the odor is removed by oxidative decomposition from metabolism. Recently, the miniaturization of devices and increase of deodorization efficiency are implemented through the development of matrix with excellent microorganism immobilization. This method is widely applied due to easy O&M, low cost, and adoption of odor with various concentrations.

c) Chemical Washing Method

Through this method, the odor is removed by irreversible chemical reaction between odor components and chemicals.

The general combinations of chemicals are shown hereunder.

- Water washing + oxidant (sodium hypochlorite) + mixture solution of alkali (caustic soda)
- Acid washing (sulfuric acid) + mixture solution of acids and alkalis
- Ozone + sodium thiosulfate

d) Soil Filter Method

Through this method, the odor is removed by oxidative decomposition from metabolism in the soil with high air permeability. The adoptability of fluctuation of odor concentration is low and 3-5 m^2 of area per treated air is required. The cost of construction and maintenance is low and in addition, no machinery facility is required. In case of increase in the soil bed pressure, although cultivation, replacement of soil, and routine works including weeding are required, the soil bed can be utilized as open space.

4) General Deodorization Process

The following systems are commonly applied:

- Process A – Activated Carbon System
- Process B – Bio-filter and Activated Carbon System
- Process C – Chemical Washing and Activated Carbon System
- Process D – Soil Filter and Activated Carbon System

The deodorization systems above are different in terms of effect, cost, and applicable conditions. Therefore, it is necessary to select the most suitable system for the WWTP considering the odor level and scale.

5) Study of Process

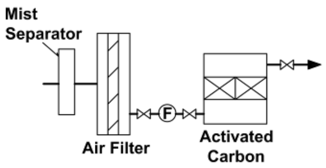
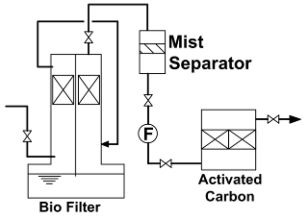
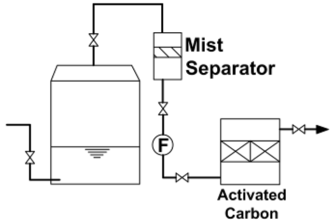
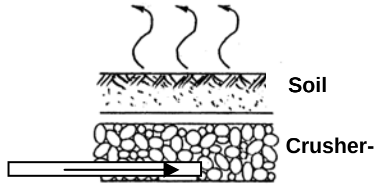
There are several offensive odor sources in the WWTP and they can be divided into two types of sources by odor intensity level. The high intensity odor source is from sludge treatment facilities. On the other hand, the low intensity odor sources are from inlet pump facility, grit chamber facility, and primary sedimentation tank. It is recommended that the mitigation measures for offensive odor for two types of sources are considered separately, because their scales are large enough to select separate measures in the WWTP. This will lead to better operation, lesser O&M cost, and enhanced output.

As shown in Table 4.3.7, soil filter is applied to the deodorization for the lift pump facility, grit chamber facility, and primary sedimentation tanks in Process D while bio-filter and activated carbon is applied for the sludge treatment facility in Process B because of the following reasons:

The density of odorous substances from the lift pump facility, grit chamber facility, and primary sedimentation tanks is low. Therefore, natural bio-filter can deodorize adequately.

The density of odorous substances from sludge treatment facilities is high, and natural bio-filter cannot deodorize such substances properly. Activated carbon system requires frequent replacement of activated carbon, which makes it costly. Bio-filter and activated carbon system and chemical washing and activated carbon system can reduce the frequency of replacement of activated carbon. In addition, the former method is more cost-effective and easy to operate and maintain.

Table 4.3.7 Comparison of Deodorization Process

	Activated Carbon System	Bio-filter and Activated Carbon System	Chemical Washing and Activated Carbon System	Natural Bio-filter System
Description				
	The odorous substance is removed by physical adsorption of activated carbon.	This system consists of biological filter unit and activated carbon unit. The frequency of changing the activated carbon can be reduced by chemical reaction in the chemical washing unit installed in the fore stage.	This system consists of chemical washing unit and activated carbon unit. The frequency of changing the activated carbon can be reduced by chemical reaction in the chemical washing unit installed in the fore stage.	The odorous substance is removed by absorption and oxidative decomposition by microorganisms in the soil.
Performance	Adequate removal performance for odorous substance with high density	Higher removal performance than Process-A due to the combination of biological and physical treatments.	Higher removal performance than Process-A due to the combination of chemical and physical processes.	It cannot treat odorous substances with high density. However, it has been proven that it has enough capacity to treat substances with low density.
Required Area	Smallest area is required.	Larger area than Process-A is required.	Larger area than Process-B is required due to necessity of larger number of accessory machines.	Although the largest area is required, it can be located in an open area outside the facilities.
Maintenance	Maintenance is easiest. However, frequency of change of activated carbon is so high, which results in expensive maintenance cost.	Easier maintenance than Process-C. Maintenance cost is cheaper than Process-A.	Most difficult maintenance due to various kinds of pumps and controlling equipment, as well as the storage, handling and disposal of chemicals. The maintenance cost is more expensive than Process-A and Process-B.	Watering, lawn mowing, and weeding are necessary, which are easy and cheap work. Cultivating and pH control are necessary in case of head increase and soil oxidization, respectively. Cost of maintenance works including all of the above is lowest.
	Frequency of change of activated carbon High odor condition: Every six months Low odor condition: Every year	Frequency of change of activated carbon High odor condition: Every year Low odor condition: Every two years	Frequency of change of activated carbon High odor condition: Every year Low odor condition: Every two years	
Cost	Initial cost is lower than Process-B and Process-C. However, total cost including O&M cost is at the same level as Process-B.	Initial cost is the highest among the four processes. However, total cost including O&M cost is at the same level as Process-A.	Both the initial cost and O&M cost are the most expensive among the four processes.	Both the initial cost and O&M cost are lower than the other systems.
Evaluation	Not Applicable	Applicable for Sludge Treatment Facility (Final decision to be done in D/D stage)	Not Applicable	Applicable for Grit Chamber and Primary Sedimentation Tank (Final decision to be done in D/D stage)
	○Enough performance to treat high density of odorous substance △Frequent change of activated carbon is necessary.	○Enough performance to treat high density of odorous substance ○Easy maintenance	○Enough performance to treat high density of odorous substance ×Expensive cost and difficult O&M	△Low applicability to high density of odorous substances ◎Easiest maintenance and cheapest cost

Source: JICA Study Team

(7) Layout Plan of WWTP

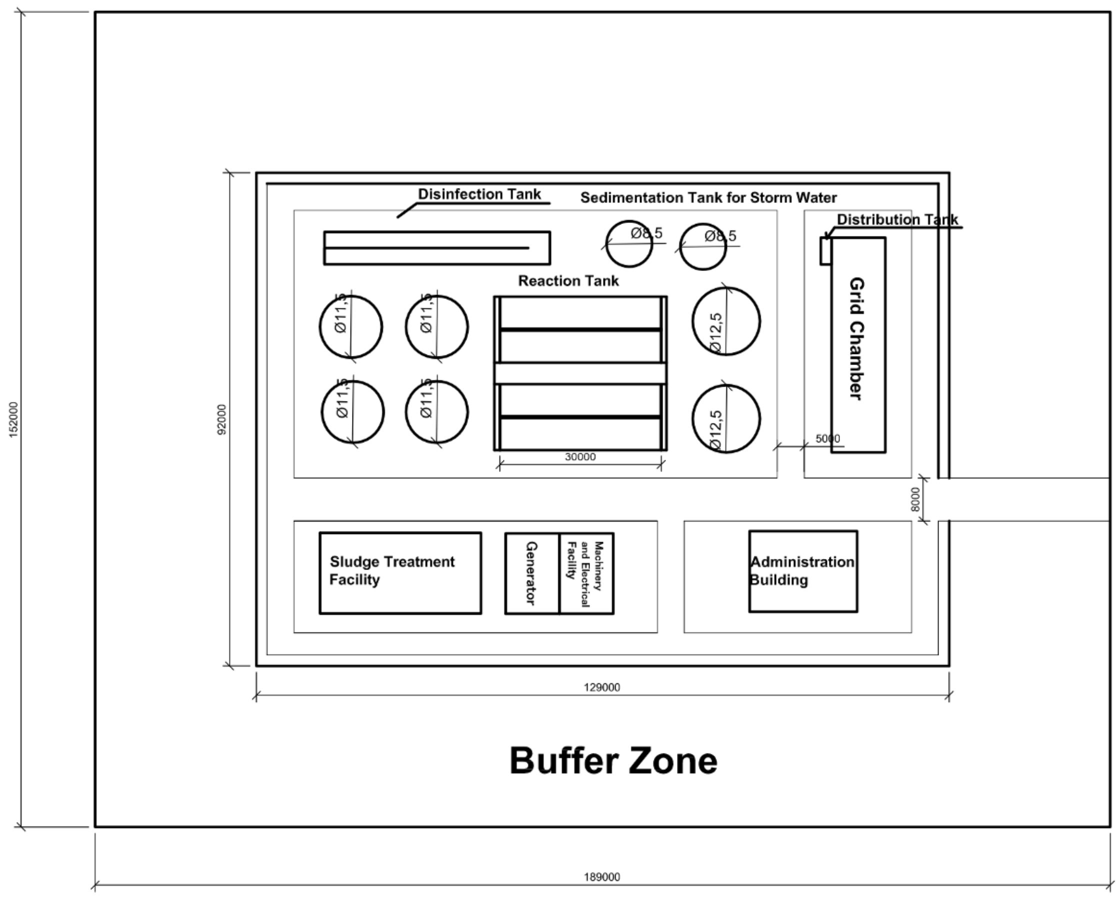
According to the National Technical Regulation on Domestic Wastewater (QCVN-07:2010/BXD) shown in Table 4.3.8, buffer zone is required around the WWTPs and PSs to prevent the negative impact of odor on the neighboring residents. The WWTPs with capacity of 5,000-50,000 m^3/day, which have odor treatment system and mechanical sludge treatment system, shall have 30 m of buffer zone.

Table 4.3.8 National Technical Regulation on Domestic Wastewater

No.	Items	Buffer zone (m) based on capacity (×1000 m^3/day)			
		<0.2	0.2-5	5-50	>50
1	**Pumping Station**	15	20	25	30
2	**Wastewater Treatment Plant**				
a	Physical treatment (combined with sludge drying bed)	100	200	300	400
b	Biological treatment (combined with sludge drying bed)	100	150	300	400
c	Biological treatment without sludge drying bed (combined with sludge drying equipment, sludge treatment, odor treatment and covered construction)	10	15	30	40
d	Underground sewerage filter yard	100	150	300	500
e	Sewerage farming, agriculture	50	200	400	1000
f	Biological pond	50	200		
g	Sewerage oxidation channel	50	150		

Source: JICA Study Team

Including the buffer zone, the layout plan of the Ha Phong WWTP is shown in Figure 4.3.2.



Source: JICA Study Team

Figure 4.3.2 Layout Plan of Ha Phong WWTP

Table 4.3.9 General Information of Ha Phong WWTP

General	
Treatment Process	CAS process
Wastewater Flow	8,600 m^3/day
Treatment Capacity	6,500 m^3/day
Required Area for WWTP	1.2 ha
Required Area including Buffer Zone	2.9 ha
Facilities	
Grit Chamber	
Sedimentation Tank for Stormwater	ϕ 8.5×2
Primary Sedimentation Tank	ϕ 12.5×2
Reaction Tank	6 m×5 m×30 m×4 units
Final Sedimentation Tank	ϕ 11.5×4
Disinfection Tank	3 m×2 m×30 m

Source: JICA Study Team

4.3.2 Collection System

(1) Type of Collection System

Interceptor system is applied for the project according to the city development master plan.

(2) Route of Sewer Main (Interceptor)

The route of the sewer main (interceptor) is basically the same as the proposed sewer main route in the local F/S. The route of the sewer main and branch sewer shall be investigated carefully during the next detailed design stage (revision of feasibility study).

The following are proposed in this stage:

- Sewer main and branch sewer and pumping station shall be installed to cover the entire target area. The following areas shall be covered:
  - Residential area in Hung Thang Ward (expanded area);
  - Residential area in Ha Khau Ward, which is a dense low-lying area near the sewer main; and
  - Residential areas in Cao Thang, Ha Lam, and Ha Trung wards where sewer main and/or branch sewer have not been installed.
- Interceptors which are connected to the combined sewer shall be proposed to prevent pollution load during wet weather.
- The capacity of the pumping station shall be revised according to the revision of wastewater volume.

(3) Construction Method of Sewer Mains

The construction method of sewer pipe is basically open cut method considering the construction cost; however, the application of pipe-jacking method shall be investigated during the detailed design stage.

4.3.3 Drainage System

The drainage system shall be investigated during the detailed design stage. The runoff calculation shall be carried out in order to satisfy the design criteria for Grade I cities.

The dredging and replacement/repair of existing drainage channel shall be investigated during the detailed design stage as well.

4.4 Quantities of Construction Work

Basically, the construction work quantities were estimated according to the existing F/S and additional construction work was preliminary estimated in the study. The summary of construction work in the project is shown in Table 4.4.1.

Table 4.4.1 Quantities of Construction Work

Item	Unit	Area of Ha Khau WWTP	Area of Ha Phong WWTP	Total
1. WWTP	m^3/day	7,500 [9,800]	8,600 [11,200]	16,100 [21,000]
2. Pumping Station	nos.	8	10	18
3. Collection Network				
Interceptor (gravity)	m	10,335	13,962	24,317
Interceptor (pressure)	m	7,688	9,601	17,289
Diversion chamber	nos.	10	19	29
House connection	nos.	6,120	8,246	14,366
4. Drainage System				
Circular pipe	m	842	357	1,199
Box culvert	m	2,301	984	3,285
Roadside gutter	m	12,555	10,527	23,082
Outlet	nos.	25	2	27
Rain inlet	nos.	694	297	991
Third level culvert	m	78,953	33,836	112,789
Dredging	m^3	14,727	6,306	21,033

Source: JICA Study Team

4.5 Preliminary Project Cost Estimates

4.5.1 Review of Construction Cost Estimates in Original Feasibility Study

The construction cost estimated in the feasibility study is summarized in Table 4.5.1.

Table 4.5.1 Project Cost Proposed in Local F/S (Estimated in 2008)

Item	Cost	Ratio
Construction cost	USD 38,830,502	60%
Sewer pipe	*(USD 9,816,838)*	*(15%)*
Manhole type pumping station	*(USD 3,181,095)*	*(5%)*
WWTP	*(USD 11,600,693)*	*(18%)*
Drainage pipe	*(USD 14,231,876)*	*(22%)*
Equipment for O&M	USD 1,809,175	3%
Compensation cost	USD 1,280,261	2%
Project management	USD 376,458	1%
E/S services	USD 5,343,616	8%
Other cost	USD 3,159,650	5%
Contingency	USD 13,291,020	21%
Total	**USD 64,090,680**	**100%**

Source: Feasibility Study Report for Ha Long Environment Protection Project, Sub-project on Sewerage and Wastewater Treatment in Ha Long City

4.5.2 Preliminary Construction Cost Estimated in this Study

The construction cost is revised in this study due to the following conditions:

- **Construction cost**
  - **Capacity:** The capacities of WWTP and PS are revised.
  - **Quantity:** The additional collection system (interceptors and combined sewer) was set tentatively. Also, the quantity of drainage works proposed in the local F/S was applied.
  - **Unit Price:** The unit price set in 2008 was updated to that of 2014 by utilizing the quotations for some facilities and referring to the unit price of another sewerage project.
- **Equipment cost, Compensation cost:** Unit price is updated from the local F/S.
- **Project management cost:** Set according to JICA's condition.
- **Engineering service cost:** Estimated according to the manning schedule.
- **Contingencies:** Physical contingency and price contingency are applied according to JICA's condition.

The estimated construction cost is USD 61 million and the total project cost including VAT is about USD 127 million as shown in Table 4.5.2. The revised cost is about double compared with the originally estimated cost. Considering the price escalation from 2008 to 2014, which is about 2.1 times over the entire period, the estimated cost seems to be reasonable.

Table 4.5.2 Project Cost (Revised in 2014)

USD= JPY 102.6
VND=JPY 0.00487735

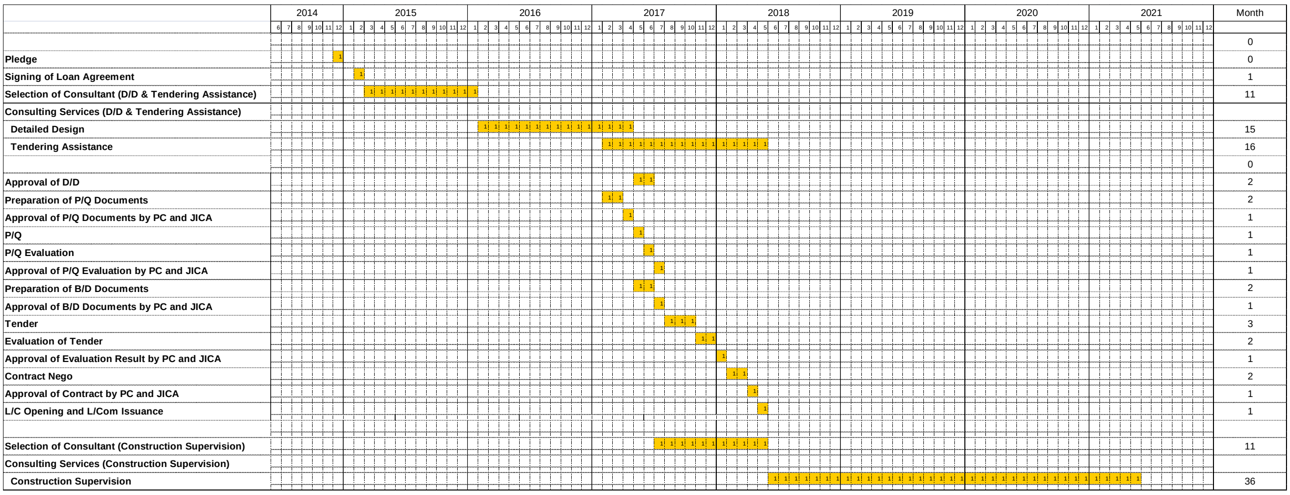
No.	Content	Total Value after Tax		
		JPY	VND	USD
A	***Construction Cost***	***4,502,993,265***	***923,245,285,844***	***43,888,823***
1	Construction of rain water channels	1,759,873,916	360,825,610,999	17,152,767
2	Construction of wastewater sewers	2,743,119,350	562,419,674,846	26,736,056
	Construction of sewers for wastewater collection	*1,628,518,857*	*333,893,983,151*	*15,872,503*
	Construction of wastewater pumping stations	*215,324,712*	*44,147,861,994*	*2,098,681*
	Construction of wastewater treatment plant	*899,275,781*	*184,377,829,700*	*8,764,871*
B	***Equipment Cost***	***1,730,917,579***	***354,888,715,326***	***16,870,542***
1	Equipment for pumping stations	162,437,941	33,304,527,469	1,583,216
2	Equipment for WWTP	1,279,001,610	262,232,727,857	12,465,903
3	Equipment for management and operation	289,478,028	59,351,460,000	2,821,423
	Total Cost of Construction, Installation + Equipment	**6,233,910,844**	**1,278,134,001,170**	**60,759,365**
C	***Cost of site clearance, compensation***	***225,333,714***	***46,200,000,000***	***2,196,235***
D	***Cost of project management***	***780,376,497***	***160,000,000,000***	***7,606,009***
E	***Cost of consulting for construction investment***	***1,704,920,040***	***349,558,459,728***	***16,617,154***
F	***Other costs***	***945,209,091***	***193,795,501,290***	***9,212,564***
G	***Contingencies***	***2,359,526,526***	***483,771,929,825***	***22,997,335***
	Total Investment Cost	**12,249,276,712**	**2,511,459,892,013**	**119,388,662**
	VAT	**815,645,804**	**167,231,239,133**	**7,949,764**
	Grand Total	**13,064,922,516**	**2,678,691,131,146**	**127,338,426**

Source: JICA Study Team

4.6 Preliminary Implementation Plan

According to WDPMU's plan, the operation of the new sewerage system shall start in 2021. The proposed implementation schedule of the first phase project is shown in Table 4.6.1

Table 4.6.1 Implementation Schedule of the First Phase Project



Source: JICA

4.7 Operation and Management of WWTPs

After the completion of the project, there will be four public WWTPs and three private WWTPs in Ha Long City. In addition, the number of PSs and length of pipelines and channels will increase. Therefore, the organization for the management of sewerage system shall be improved to carry out the O&M of the sewerage system more effectively.

Regarding the O&M of WWTPs, currently the operators of URENCO continuously stay at the Bai Chay and Ha Khanh WWTPs and patrol three private WWTPs. Likewise, the classification of WWTPs for effective operation are recommended. Considering the capacity of WWTPs, the staff of Ha Khau WWTP shall manage the WWTPs in the western area and the staff of Ha Khanh WWTP shall manage the public and private WWTPs in the eastern area through patrol as shown in Table 4.7.1. In order to monitor small WWTPs, SCADA system shall be needed.

Table 4.7.1 Classification of WWTPs

Western Area		Eastern Area	
Central WWTP	**Monitored and Patrolled**	**Central WWTP**	**Monitored and Patrolled**
Ha Khau WWTP	(Bai Chay WWTP)	Ha Khanh WWTP	Ha Phong WWTP
			WWTP of CIENCO5
			WWTP-1 of LICOGI
			WWTP-2 of LICOGI

Source: JICA Study Team

The details of the comprehensive sewerage management scheme will be studied in the F/S stage.

4.8 Capacity Development

The O&M for the WWTPs with CAS process requires an operator with adequate skills and experience. Thus, the capacity development of operators shall be correctly implemented. Currently, although the small WWTPs with CAS process constructed by private company are operating, the operation of the plant is not sufficiently carried out so far. Therefore, the development of operators is essential for all the WWTPs with CAS process that are operating in Ha Long City.

The capacity development for staff of WDPMU and relevant organizations is essential to manage the sewerage system sustainably in Ha Long City.

From the detailed design phase, the staff of WDPMU shall join the consultant’s team and study the process and knowhow of planning and design of sewerage system through on-the-job-training. In addition, study tour to Japan is required to learn the technologies and appropriate management method especially for the WWTPs.

In addition, JICA is planning to establish the training center in Hanoi for the concerned Vietnamese public and private staff to develop their capacity on sewerage development and management. Therefore, Ha Long City including the staff of URENCO shall utilize this scheme to accelerate the capacity development.

Appendix: Revised Sewerage Development Plan

The preliminary review of the local F/S was carried out in two phases. The result of first preliminary review is shown in Chapter IV and that of second one is shown in this Appendix. The target of the first preliminary review is the review of local F/S excluding the World Bank project area. On the other hand, the review of local F/S and improvement of World Bank project area were carried out in the second preliminary review.

1. Background of the Revision

Quang Ninh Province and Ha Long City have been requested to improve the water environment in Ha Long Bay. They planned to improve the coverage ratio of sewerage system in Ha Long City, which is about 30% as of 2014, and the sewerage development at the neighboring region of the existing sewered area was proposed in the feasibility study carried out by the local consultant in 2008. The proposed project was in the shortlist for JICA ODA loan and JICA is planning to provide financial and technical assistance for the project.

2. Current Issues in the Existing Sewered Area

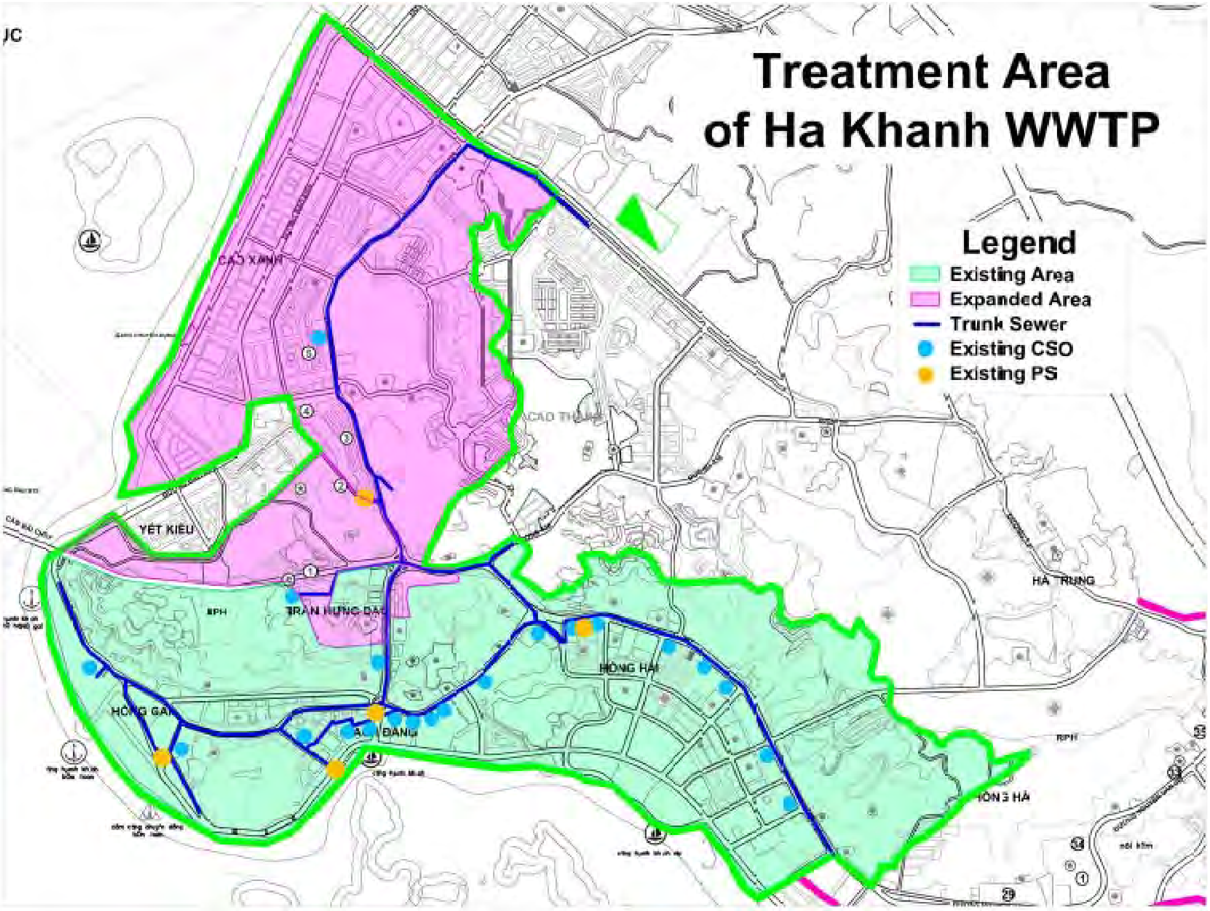
2.1 Low Coverage in Hon Gai Area (Eastern Area)

The inflow of Ha Khanh WWTP is much less than its capacity. The average inflow in 2014 is less than 5,000 m^3/day although the capacity of the WWTP is 7,200 m^3/day. The existing interceptors do not cover the entire treatment area of the WWTP and a certain ratio of the wastewater in the area is not collected by the interceptors.

According to the F/S report of the WB project, the target area of sewerage development in Hon Gai area (eastern area) includes six wards, namely: Hong Gai, Yet Kieu, Tran Hung Dao, Bach Dang, Cao Xanh, and Hong Hai wards. Cao Thang Ward with population of 17,811 persons as of 2013 is excluded from the target area of the project although it is located nearby Ha Khanh WWTP. In addition, the collection ratio and coverage ratio for the planning parameter are 75% and 60%, respectively, which means that only 45% of the wastewater generated in the target area is collected and treated in the Ha Khanh WWTP.

Based on the drawings of the existing facilities, the diversion chambers (CSO points) were constructed mainly to collect the wastewater from the coastal area, i.e., Hong Gai, Bach Dang, and Hong Hai wards, and partially from the Tran Hung Dao Ward. Therefore, the wastewater from the remaining area, i.e., Yet Kieu Ward, Cao Xanh Ward, and certain part of Tran Hung Dao Ward, are discharged without treatment. The population in the actual covered area is about 43,000 (56% of target area) and about 33,000 (44% of target area) in the uncovered area as of 2013.

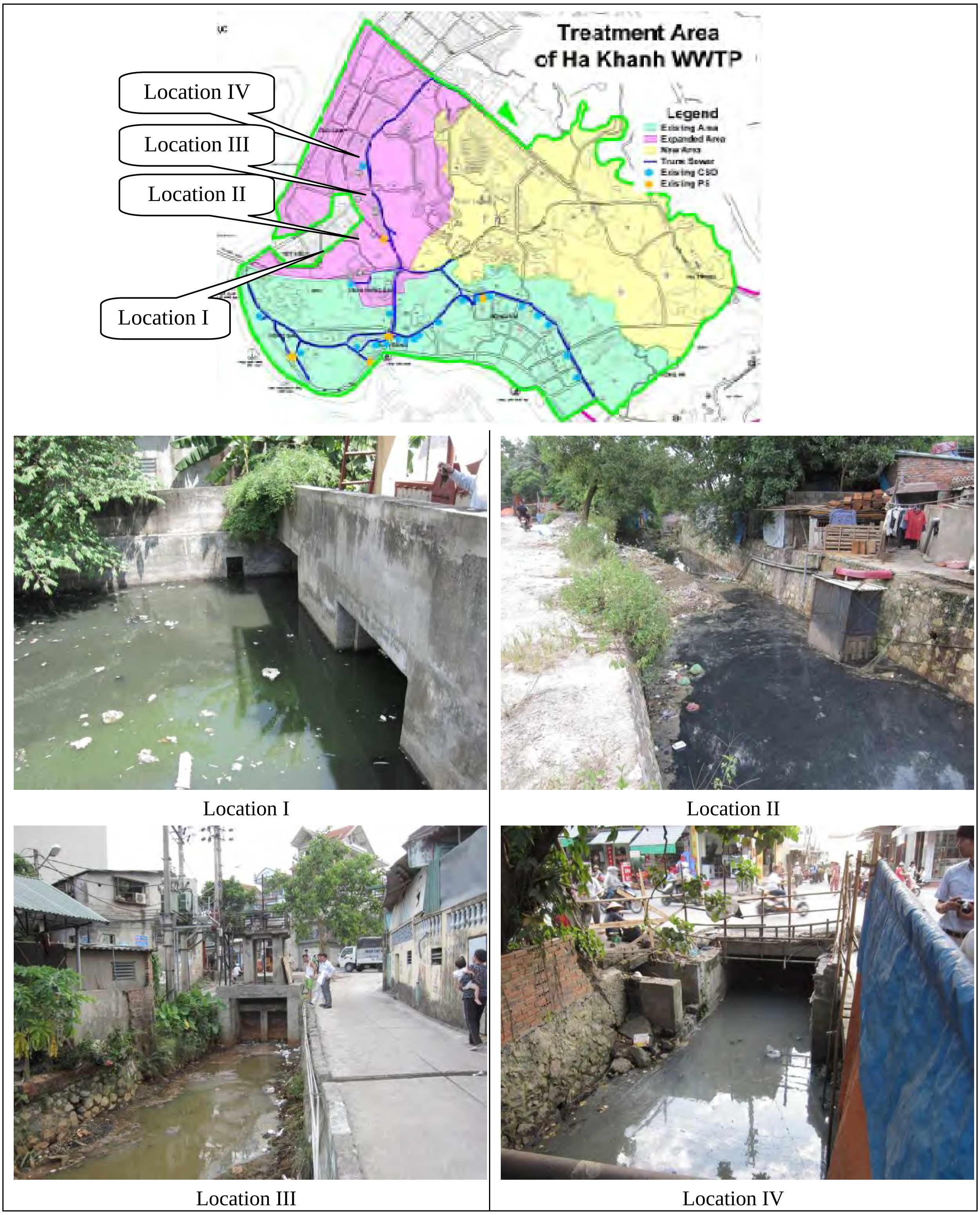
The locations of the diversion chambers (CSO points) and the catchment area covered (indicated in light blue) and uncovered (indicated in purple) by the existing sewerage system are shown in Figure A2.1.



Source: JICA Study Team

Figure A2.1 Actual Sewered Area in the World Bank Project

The development of Ha Khanh WWTP and its interceptors was carried out as the second phase of the sewerage project using the surplus budget of the first phase of the sewerage project in Bai Chay area. Therefore, the budget of the second phase project was not enough to cover the whole area and the remaining area and Cao Thang Ward shall be sewered urgently to improve the water environment of Ha Long Bay. In the unsewered area, the uncollected wastewater is discharged to the sea through rivers and/or ponds as shown in Picture A2.1.



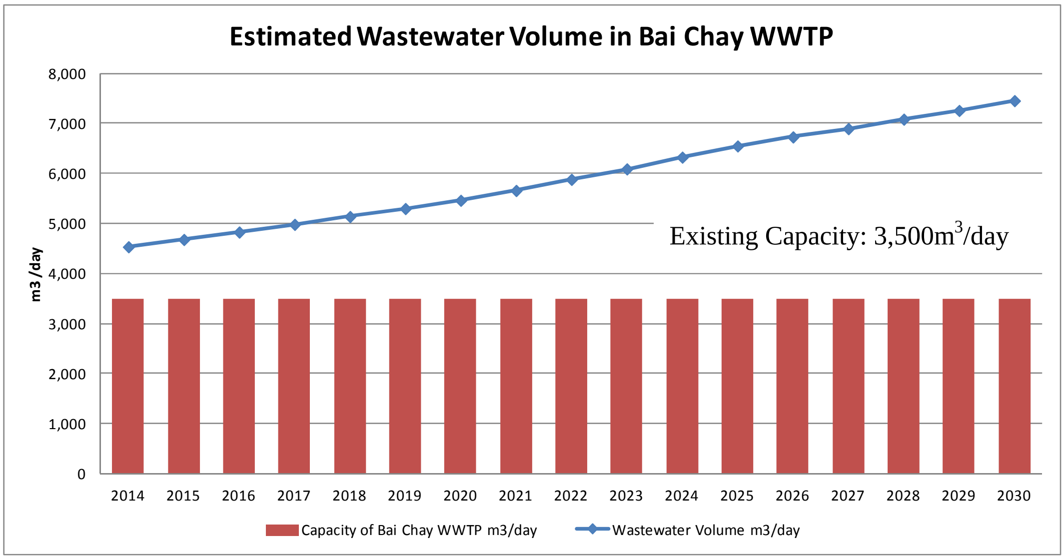
Source: JICA Study Team

Picture A2.1 Uncollected Wastewater in the Target Area of Ha Khanh WWTP

2.2 Insufficient Capacity of Bai Chay WWTP

The inflow volume to the Bai Chay WWTP is about 3,500 m^3/day, which is the same as the capacity of the

WWTP, because the excess amount of wastewater is not collected by the WWTP. The wastewater volume calculated based on the current population and estimated by the current and future water consumption in the treatment area in 2014 is about 4,500 m^3/day and it is expected to increase continuously as shown in Figure A2.2. The wastewater volume in 2025 in the Bai Chay treatment area will increase up to 6,500 m^3/day according to the population growth, increase of tourists, and economic development. The wastewater volume exceeds the existing capacity of Bai Chay WWTP and the excess amount of wastewater may be discharged to the sea without treatment.



Source: JICA Study Team

Figure A2.2 Expected Wastewater Volume to Bai Chay WWTP

In addition, the existing WWTP applies SBR for wastewater treatment and maturation pond for disinfection. Regarding the SBR in Bai Chay WWTP, the capacity of the regulation pond (equalization tank) is 220 m^3, which corresponds to about 1.5 hours of daily average flow. However, the peak inflow during the wet weather is three times as much as that during the dry weather. Therefore, the regulation pond is insufficient during the wet weather and the existing SBR system can be operated appropriately only during the dry weather. However, the effluent quality can satisfy the Vietnamese regulation because the quality of inflow is not so serious. Moreover, the maturation pond functions well only during sunny days and it shall be improved so as not to be affected by the weather condition.

In order to improve the above conditions, the capacity of the WWTP shall be expanded and the facilities shall be improved. Ha Long City is planning to relocate the existing Bai Chay WWTP because it is adjacent to the future tourist zone stipulated in the city development master plan in order to prevent the negative impact to the tourists. Therefore, the existing WWTP shall be replaced with the new WWTP which is planned to be constructed in Ha Khau area.

2.3 Insufficient Condition of Tidal Gates

Some tidal gates are broken and/or not maintained appropriately as shown in Picture A2.2.

Tidal Gate in Bai Chay

Tidal Gate in Hon Gai

Source: JICA Study Team

Picture A2.2 Current Situation of Tidal Gates

The operation of the pumping station is stopped during high tide and heavy rain in Bai Chay area to prevent sea water intrusion to the WWTP. This is due to the poor condition of the tidal gates and because sea water easily comes into the interceptors during high tide. Therefore, the wastewater entering the sewerage system during high tide is directly discharged to the sea without appropriate treatment.

3. Proposed Sewerage Plan

3.1 Basic Strategy

Firstly, the sewerage project proposed by Quang Ninh Province and Ha Long City involves sewerage development in the outskirts of Ha Long City. However, it is desirable that the existing sewered area of Ha Khanh WWTP will be improved first in order to improve the water environment of Ha Long Bay more appropriately and accurately. The population in the treatment area of Ha Khau WWTP is about 75,000 and the improvement of this dense area is indispensable.

Secondly, the treatment area of Ha Khanh WWTP shall be expanded to include Cao Thang Ward, which is not covered by any centralized sewerage system, and Ha Lam and Ha Trung wards considering the geological features.

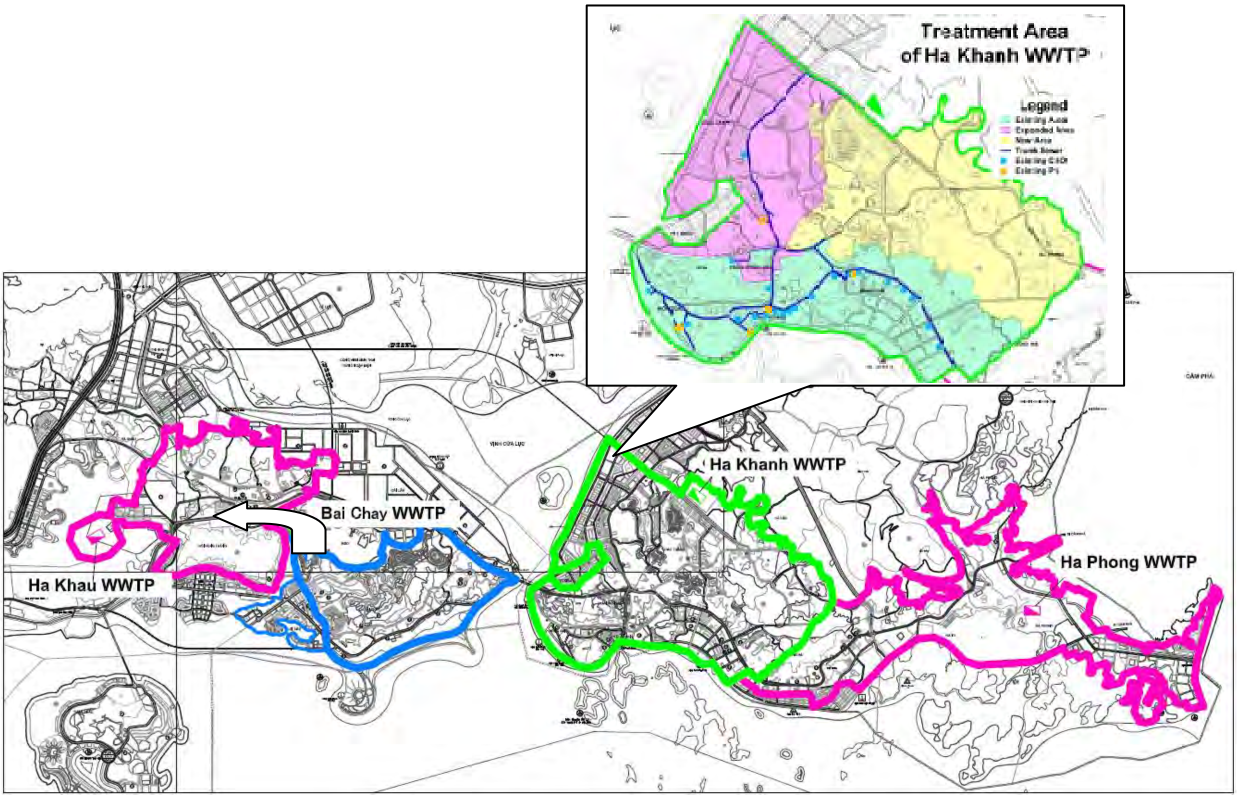
Thirdly, since Bai Chay WWTP is planned to be relocated by 2025, the treatment area of the existing Bai Chay WWTP and the newly developed area (treatment area of Ha Khau WWTP) shall be integrated to maximize the efficiency of the project. In addition, the treatment area of Ha Khau WWTP shall be expanded to Hung Thang Ward, which is the neighboring region of the main interceptor of Ha Khau treatment area. Generally, the financial efficiency in a huge WWTP is higher than in a small WWTP and the integration and expansion are assumed to be financially efficient.

3.2 Target Year

The target year for the proposed sewerage plan is set in 2025 which is about ten years later from the commencement of the project (L/A). The sewerage system of the project is expected to start operation around 2021.

3.3 Area

Considering the geographical features, the hilly area along the national road in Ha Lam Ward and Ha Trung Ward is transferred to the area of the Ha Khanh WWTP. The proposed area allocation is shown in Figure A3.1.



Note: Bai Chay WWTP will be relocated to the proposed Ha Khau WWTP.

Source: JICA Study Team

Figure A3.1 Treatment Area in Each WWTP in Ha Long City

3.4 Type of Collection System

The development of the collection system will be carried out step-by-step. The first phase is the development of the interceptor which is the trunk sewer of the combined sewer system. The second phase is the development of the branch sewer for upgrading to the separated sewer system. The upgrading to the separated sewer system requires huge amount of investment; hence, it is not desirable to adopt the separated sewer system in Ha Long City considering that further sewerage development is expected in Quang Ninh Province.

3.5 Required Capacity of WWTPs

According to the population projection and the planning parameter in Grade I cities, the required capacities of the WWTPs were calculated. The population projection is shown in Table A3.1 and the capacities of the WWTPs are shown in Table A3.2.

Table A3.1 Population Projection for the Target Year 2025

				Statistic Data	Forecast→	→	→	Target Year		
					1.020	1.020	1.020	1.026	1.026	
			Ward	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**Target Population**
Western Ha Long						1		1.257		
Bai Chay WWTP	Existing		Bãi Cháy	**22,180**	**22,624**	**23,077**	**25,483**	**29,013**	**33,033**	**29,100**
Ha Khau WWTP (JICA)	Target		Giếng Đáy	13,815	14,092	14,374	15,872	18,071	20,575	
			Hà Khẩu	10,175	10,379	10,587	11,690	13,310	15,154	
		Incremental	Hùng Thắng	4,745	4,745	4,745	4,745	4,745	4,745	
			total	**28,736**	**29,216**	**29,706**	**32,308**	**36,126**	**40,474**	**36,200**
Viet Hung WWTP	Future		Bãi Cháy	0	0	0	0	0	0	
			Giếng Đáy	0	0	0	0	0	0	
			Hà Khẩu	2,713	2,768	2,823	3,117	3,549	4,041	
			Việt Hưng	7,526	7,677	7,831	8,647	9,845	11,209	
			total	10,240	10,445	10,654	11,765	13,395	15,250	13,400
Dai Yen WWTP	Future		Dai Yen	6,934	7,073	7,215	7,967	9,071	10,328	9,100
Private WWTP			Hùng Thắng	1,582	1,708	1,838	2,524	3,531	4,678	
			Tuần Châu	2,097	2,139	2,182	2,409	2,743	3,123	
			total	3,679	3,847	4,020	4,933	6,274	7,801	
Isolated			Hà Khẩu	678	692	706	779	887	1,010	
			Việt Hưng	1,882	1,919	1,958	2,162	2,461	2,802	
			Dai Yen	1,734	1,768	1,804	1,992	2,268	2,582	
			total	4,294	4,380	4,467	4,933	5,616	6,394	
Sub-total Western Ha Long				**76,062**	**77,585**	**79,139**	**87,388**	**99,495**	**113,280**	
Eastern Ha Long										
Ha Khanh WWTP	Existing	Original	Hồng Gai	8,452	8,621	8,794	9,711	11,056	12,588	
			Bạch Đằng	9,888	10,086	10,288	11,360	12,934	14,726	
			Trần Hưng Đạo	4,972	5,072	5,173	5,712	6,504	7,405	
			Hồng Hải	19,717	20,112	20,515	22,653	25,791	29,365	
			Hà Khánh	0	0	0	0	0	0	
			subtotal	43,029	43,891	44,770	49,436	56,285	64,084	56,300
		Improved	Yết Kiêu	10,571	10,783	10,999	12,145	13,828	15,744	
			Trần Hưng Đạo	4,972	5,072	5,173	5,712	6,504	7,405	
			Cao Xanh	16,538	16,869	17,207	19,001	21,633	24,630	
			subtotal	32,081	32,724	33,379	36,858	41,965	47,779	42,000
		subtotal in existing area		75,110	76,614	78,149	86,294	98,250	111,863	98,300
	Incremental (Newly Developed)		Cao Thắng	10,687	10,901	11,119	12,278	13,979	15,916	
			Hà Lầm	6,473	6,602	6,735	7,437	8,467	9,640	
			Hà Trung	2,430	2,479	2,529	2,792	3,179	3,619	
			subtotal	19,590	19,982	20,382	22,507	25,625	29,175	25,700
			total	**94,700**	**96,596**	**98,531**	**108,801**	**123,875**	**141,038**	**123,900**
Ha Phong WWTP (JICA)	Target		Hà Trung	2,430	2,479	2,529	2,792	3,179	3,619	
			Hồng Hà	16,697	17,031	17,372	19,183	21,841	24,867	
			Hà Tu	8,063	8,224	8,389	9,263	10,547	12,008	
			Hà Phong	5,971	6,091	6,213	6,860	7,811	8,893	
			total	**33,161**	**33,825**	**34,503**	**38,099**	**43,378**	**49,388**	**43,400**
Private WWTP			Yết Kiêu	0	0	0	0	0	0	
			Hồng Hà	0	0	0	0	0	0	
*Included in othe WWTP				0	0	0	0	0	0	
Isolated			Cao Thắng	7,124	7,267	7,413	8,185	9,319	10,610	
			Hà Lầm	4,315	4,402	4,490	4,958	5,645	6,427	
			Hà Trung	3,240	3,305	3,371	3,723	4,239	4,826	
			Hà Tu	5,375	5,483	5,593	6,176	7,031	8,005	
			Hà Phong	3,981	4,061	4,142	4,574	5,207	5,929	
			Hà Khánh	7,048	7,189	7,333	8,097	9,219	10,497	
				31,084	31,707	32,342	35,712	40,660	46,294	
Sub-total Eastern Ha Long				**158,945**	**162,128**	**165,375**	**182,612**	**207,913**	**236,720**	
Total in Ha Long				**235,007**	**239,714**	**244,514**	**270,000**	**307,409**	**350,000**	

Source: JICA Study Team

Table A3.2 Capacity of WWTPs in 2025

Item		Area	West			East					
		Situation	Existing	Planned		Existing		Inclemental	Total	Planned	
		Donor	World Bank	JICA		World Bank (sewered)	JICA (new)	JICA		JICA	
		Unit	Bai Chay	Ha Khau	BaiChay+ Ha Khau		Ha Khanh			Ha Phong	Note
Target Year		–	2025	2025		2025				2025	
Area		ha		283.14						326.51	
Population in 2025	Population										
	Resident	capita	29,100	36,200		56,300	42,000	25,700		43,400	
	Tourist	capita	5,800	0		1,100	0	0		0	Bay Chay:20% Hon Gai: 1%
	Total		34,900	36,200		57,400	42,000	25,700		43,400	
	Covered by Private WWTP	capita					5,690			11,300	
							(CIENCO5)			*(LICOGIx2)*	
	Target Population										
	Resident	capita	29,100	36,200	65,300	56,300	36,310	25,700	118,310	32,100	
	Tourist	capita	5,800	0	5,800	1,100	0	0	1,100	0	Bay Chay:20% Hon Gai: 1%
	Total		34,900	36,200	71,100	57,400	36,310	25,700	119,410	32,100	
Wastewater Volume	Unit wastewater volume										
	Resident	liter/capita/day	180	180	180	180	180	180	180	180	Based on M/P
	Tourist	liter/capita/day	180	180	180	180	180	180	180	180	
	Public, Administration, Commercial	liter/capita/day	18	18	18	18	18	18	18	18	10% of domestic WW
	Water supply coverage	%	100%	100%	100%	100%	100%	100%	100%	100%	
	Collection coverage in resider	%	95%	95%	95%	95%	95%	90%		90%	
	Wastewater volume										
	Resident	m3/day	4,976	6,190	11,166	9,627	6,209	4,163	20,000	5,200	
	Tourist	m3/day	992	0	992	188	0	0	188	0	
	Public and Administration	m3/day	597	619	1,216	982	621	416	2,019	520	
	Total		6,565	6,809	13,374	10,797	6,830	4,580	22,207	5,720	
	Inflow/Infiltration	m3/day	656	681	1,337	1,080	683	458	2,221	572	10% of Daily Average
	Wastewater Volume										
	Daily Average	m3/day	7,221	7,490	14,711	11,877	7,513	5,038	24,427	6,292	
	Daily Maximum	m3/day	9,388	9,737	19,125	15,440	9,767	6,549	31,755	8,180	1.3*Daily Average
	Hourly Maximum	m3/hour	508	527	1,036	836	529	355	1,720	443	1.3*Daily Maximum
	Hourly Maximum (Rainy Day	m3/hour	602	780	1,532	1,237	783	525	2,545	655	2.5*Daily Average
	Capacity of WWTP										
	Daily Average basis	m3/day	**7,300**	**7,500**	**14,800**	**11,900**	**7,500**	**5,100**	**24,500**	**6,300**	
	Daily Maximum basis	m3/day	**9,400**	**9,800**	**19,200**	**15,500**	**9,800**	**6,600**	**31,900**	**8,200**	
	existing capacity of WWTP	m3/day	3,500			7,200					
	proposed capacity of WWTP	m3/day		5,000						6,500	

Source: JICA Study Team

3.6 Incremental Capacity in the Project

In the Ha Khau and Ha Phong WWTPs, the incremental capacity is the same as the required capacity. In the Ha Khanh WWTP, the required capacity of the improved area in the target area of the WB project (Yet Kieu Ward, Cao Xanh Ward, and certain part of Tran Hung Dao Ward) and the expanded area in this project (Cao Thang, Ha Lam, and Ha Trung wards) will be constructed. As a result of the study, the incremental capacities of the WWTPs were set as shown in Table A3.3.

Table A3.3 Incremental Capacity of WWTPs

	Unit	Ha Khau	Bai Chay	Ha Khanh	Ha Phong
Existing Capacity	m^3/day		3,500 [3,500]	7,200 [7,200]	
Incremental Capacity	m^3/day	14,800 [19,200]	0	12,600 [16,400]	6,300 [8,200]
Total Capacity	m^3/day	14,800 [19,200]	0	19,800 [23,600]	6,300 [8,200]
Required Capacity	m^3/day			24,500 [31,900]	
Note		Including the capacity of Bai Chay WWTP	Replaced by Ha Khau WWTP	The balance of the required and total capacity will be constructed in future.	

Note: Daily average capacity and daily maximum capacity are indicated. Daily maximum capacity is indicated in [ ].
Source: JICA Study Team

3.7 Layout Plan of WWTPs

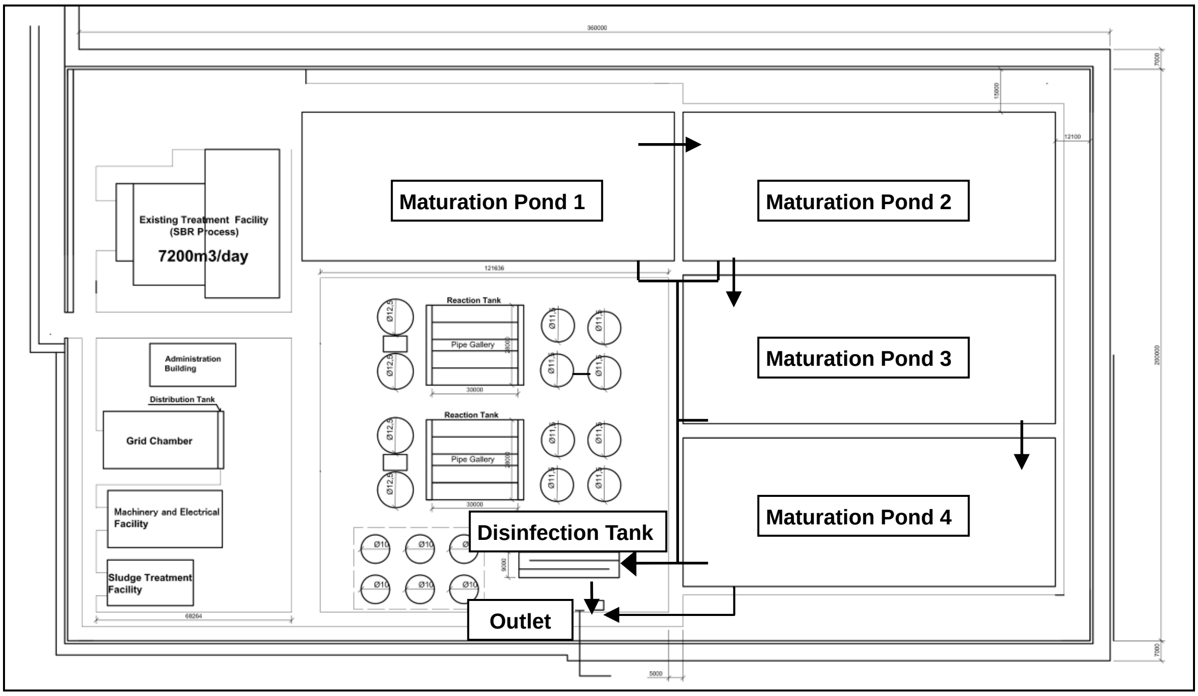
3.7.1 Ha Khanh WWTP

In order to expand the existing WWTP in Ha Khanh WWTP, the area of maturation ponds shall be utilized for the construction of incremental treatment plant. To prevent additional land acquisition near the existing WWTP, it was recommended to utilize the area of the existing maturation pond in the operation manual of the WWTPs provided by WB. There are six maturation ponds in the existing WWTP, but four maturation ponds are required according to the hydraulic calculation. Therefore, it is recommended to utilize the area of two maturation ponds for the development of the incremental treatment plant. For the backup of the disinfection process during cloudy and wet weather, the effluent of the maturation pond can be connected to the new disinfection system. The layout plan is proposed as shown in Figure A3.2.

Table A3.4 Required Capacity of Maturation Pond

	Current	Revised
Inflow	7,200 m^3/day	
HRT	5 days	
Required Volume	36,000 m^3	
Water Depth	1.5 m	
Length: L1	125 m (in consideration of hypotenuse)	
Length: L2	47.5 m (in consideration of hypotenuse)	
Water Depth	1.5 m	
Volume per Pond	8,906 m^3	
Number of Pond	6	**4**
Total Volume	53,436 m^3	**35,624** m^3

Source: JICA Study Team



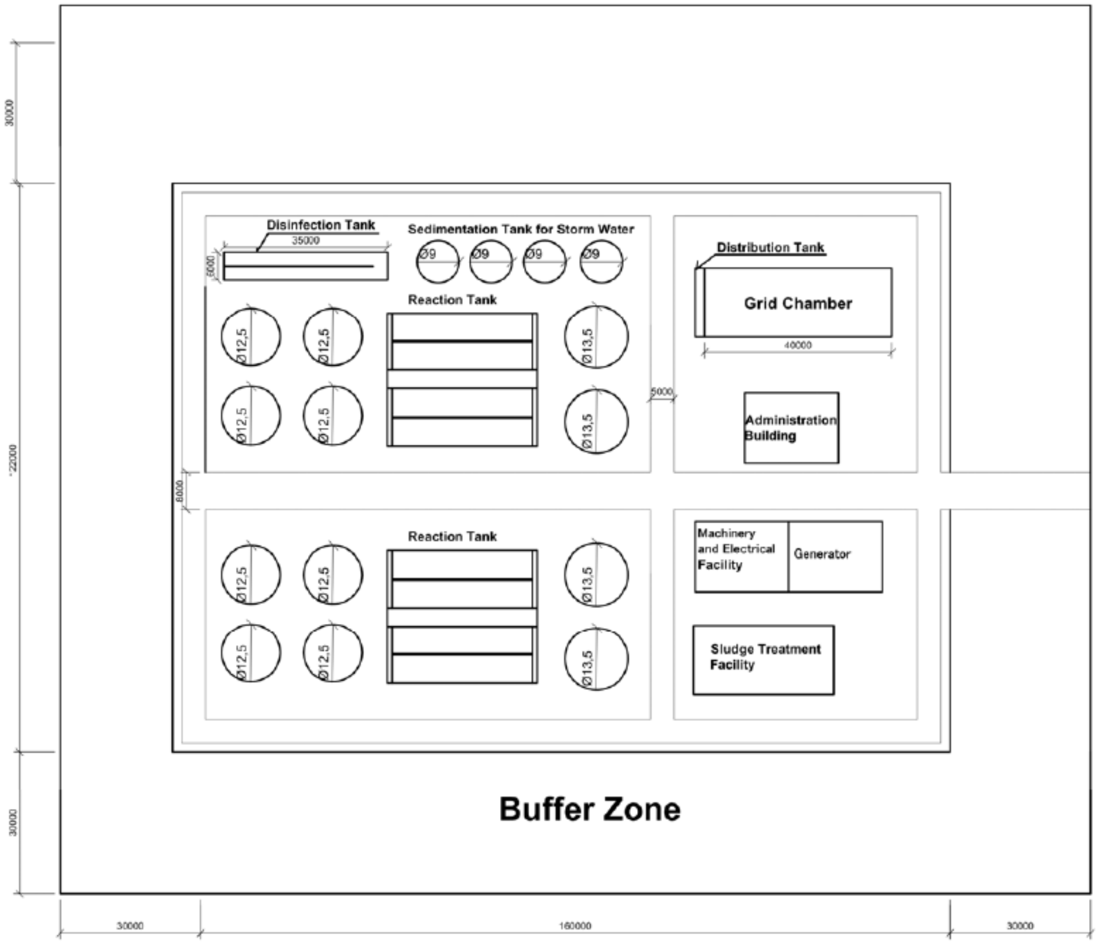
Source: JICA Study Team

Figure A3.2 Layout Plan of New Treatment Facilities in Ha Khanh WWTP

When the additional expansion of the Ha Khanh WWTP or renewal of existing SBR plant is needed in the future, the utilization of the existing maturation pond will be investigated.

3.7.2 Ha Khau WWTP

The Ha Khau WWTP will be constructed at the location of the intermontane basin and there is not so much residence around the proposed site of the WWTP. The layout plan of the Ha Khau WWTP is proposed as shown in Figure A3.3. The required area is about 2.1 ha without buffer zone and 4.2 ha including buffer zone. The necessity of the buffer zone shall be negotiated with the related organizations considering that the neighboring area of the Ha Khau WWTP is a green belt according to the city development master plan.

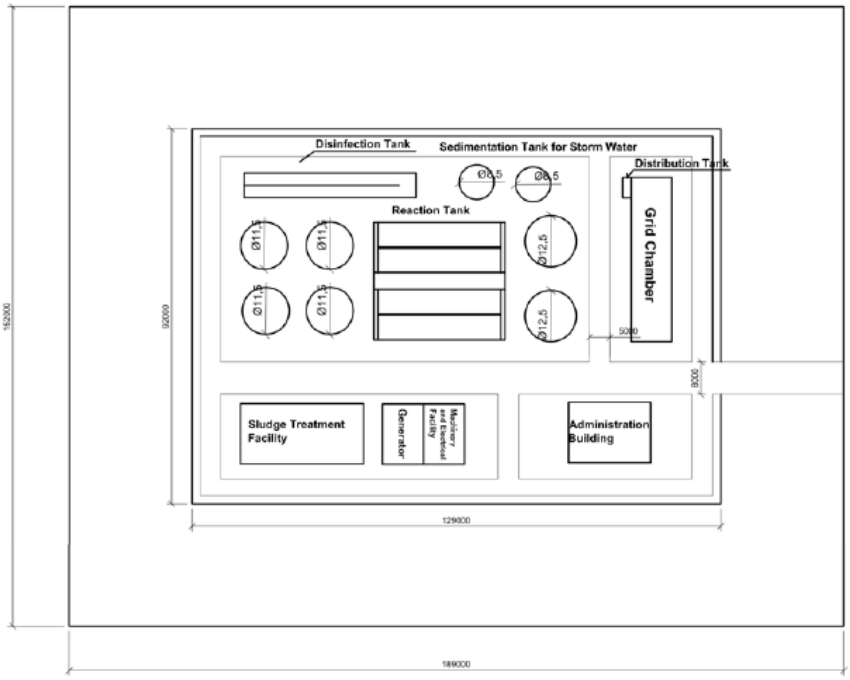


Source: JICA Study Team

Figure A3.3 Layout Plan of Ha Khau WWTP

3.7.3 Ha Phong WWTP

The Ha Phong WWTP is located at the existing agricultural area and the surrounding area will be developed as a residential area according to the city development master plan. The layout plan of the Ha Phong WWTP is proposed as shown in Figure A3.4. The required area is about 1.2 ha without buffer zone and 2.9 ha including buffer zone. In this WWTP, a buffer zone, mechanical sludge treatment system, and some deodorization process will be needed to prevent the negative impact to the surrounding area.



Source: JICA Study Team

Figure A3.4 Layout Plan of Ha Phong WWTP

3.8 Improvement of Collection Network

3.8.1 Hon Gai Centre Ward in the Eastern Area

This area includes the central wards of Hon Gai, where drainage system and wastewater treatment system will be built by the WB project, including Hong Gai, Bach Dang, Tran Hung Dao, and Hong Hai wards; part of the Hong Ha Ward; areas along the Cao Thang Road, Ha Lam Road, and Yet Kieu Road, which belong to Cao Thang, Cao Xanh, and Yet Kieu wards and part of Ha Lam Ward.

However, the domestic wastewater of some residential areas has not been collected and transmitted to the wastewater treatment plant in Ha Khanh. Therefore, there is a need to develop the wastewater collection system in the remaining areas.

The purpose of the study is to improve the existing wastewater collection system in Hon Gai Centre Ward area. There are six areas that need to improve the sewerage system as follows:

(1) Gieng Don Residential Area

- Location: along Tran Hung Dao Road and Loong Toong Market; belong to Tran Hung Dao Ward
- Catchment area: collect wastewater by sewer along Le Lai Street, To Hien Thanh Street, and then connect to box culvert along Yet Kieu Lake, discharge to the sea through existing pumping station at Yet Kieu Lake.
- Proposal to construct CSO 01 at the end point of the existing box culvert, discharge to existing pumping station.

(2) Cao Thang Road Area

- Location: residential area along Cao Thang Road, from Yet Kieu Road to Cao Xanh Road
- Catchment area: collect wastewater by sewer along Cao Thang and then connect to box culvert along Yet Kieu Lake, discharge to the sea through existing pumping station at the Yet Kieu Pond.
- Proposal of CSO: use the same CSO 01 at the end point of the existing box culvert, discharge to existing pumping station.

(3) Bridge No.1 Stream Area

- Location: residential along Cao Xanh Road, from Cao Thang Road to Bridge No. 1 stream; belong to Cao Xanh Ward
- Catchment area: collect wastewater by Bridge No. 1 stream and then connect to box culvert across Cao Xanh Road (at existing PS6), discharge to the lake through existing stone masonry open channel.
- Proposal to construct CSO 02 at the end of the existing stone masonry open channel connected to the lake.
- Proposal to improve the interceptor pipeline at Bridge No. 1 stream area.

(4) Bridge No. 2 Stream Area

- Location: residential along Bridge No. 2 stream; belong to Cao Xanh Ward.
- Catchment area: collect wastewater by Bridge No. 2 stream and then connect to box culvert across Cao Xanh Road and discharge to the lake.
- Proposal to construct CSO 03 at the end of existing box culvert connected to the existing lake.
- Proposal to construct CSO 04 at the end point of the residential area, discharge to the existing lake.
- Proposal to improve the interceptor pipeline at Bridge No. 2 stream area and residential area at the downstream of Bridge No. 2 stream.

(5) Bridge No. 3 Stream Area

- Location: residential area along Bridge No. 3 stream; belong to Cao Xanh Ward.
- Catchment area: collect wastewater by Bridge No. 3 stream and then connect to box culvert across Cao Xanh Road and discharge to the sea.
- Proposal to construct CSO 05 at the residential area (about 50 m from Cao Xanh Road).

(6) Pho Moi Residential Area

- Location: residential in Pho Moi area; belong to Tran Hung Dao Ward.

- Catchment area: collect wastewater by sewer along Dang Ba Hat Street and box culvert along Yet Kieu Lake, discharge to the sea through PS at the Yet Kieu Lake.

- Proposal to construct CSO 06 at the end point of existing box culvert to PS.

3.8.2 Other Wards in the Eastern Area

This includes Ha Lam, Ha Tu, Ha Trung, Ha Phong, and Hong Ha wards where drainage channels have not been constructed.

The drainage and wastewater collection systems in these areas will be constructed simultaneously to bring wastewater to two concentrated treatment plants located in the Ha Khanh and Ha Phong areas.

3.8.3 Western Area

The drainage and wastewater treatment system in the Bai Chay Ward was constructed in the World Bank project.

In Tuan Chau Ward s and majority of Hung Thang Ward, drainage system and wastewater treatment systems will be constructed through projects of new urban development areas.

In the remaining areas including Ha Khau and Gieng Day wards and part of the existing residential areas of Hung Thang Ward, a comprehensive drainage and wastewater collection system that will connect to the concentrated treatment plant located in Ha Khau should be built.

3.9 Quantities of the Construction Works

Basically, the quantities of the construction works were estimated based on the existing F/S and additional construction work was preliminary estimated in this study. The summary of construction work under the project is shown in Table A3.5.

Table A3.5 Quantities of the Construction Works

Item	Unit	Area of Ha Khau WWTP	Area of Ha Khanh WWTP	Area of Ha Phong WWTP	Total
1. WWTP	m^3/day	14,800 [19,200]	12,600 [16,400]	6,300 [8,200]	33,700 [43,800]
2. Pumping Station	nos.	9	4	6	19
3. Collection Network					
Interceptor (gravity)	m	10,335	5,000	13,962	29,317
Interceptor (pressure)	m	10,688	5,000	9,601	25,289
Diversion chamber	nos.	10	6	19	35
House connection	nos.	6,120	2,061	6,185	14,366
4. Drainage System					
Circular pipe	m	842	0	357	1,199
Box culvert	m	2,301	0	984	3,285
Roadside gutter	m	12,555	0	10,527	23,082
Outlet	nos.	25	0	2	27
Rain inlet	nos.	694	0	297	991
Third level culvert	m	78,953	0	33,836	112,789
Dredging	m^3	14,727	0	6,306	21,033

Source: JICA Study Team

3.10 Preliminary Cost Estimates

The construction cost is revised in this study based on the conditions indicated in Clause 4.4. The estimated construction cost is USD 86 million and the total project cost including VAT is about USD 154 million as shown in Table A3.6.

Table A3.6 Project Cost (Revised in 2014)

USD 1= JPY 102.6
VND 1 =JPY 0.00487735

No.	Content	Total Value After Tax		
		JPY	**VND**	**USD**
A	***Construction Cost***	***5,744,375,867***	***1,177,765,016,908***	***55,988,069***
1	Construction of rain water channels	1,759,873,916	360,825,610,999	17,152,767
2	Construction of wastewater sewers	3,984,501,951	816,939,405,909	38,835,302
	Construction of sewers for wastewater collection	*1,883,400,248*	*386,152,121,014*	*18,356,728*
	Construction of wastewater pumping stations	*292,978,096*	*60,069,076,331*	*2,855,537*
	Construction of wastewater treatment plant	*1,808,123,607*	*370,718,208,564*	*17,623,037*
B	***Equipment Cost***	***3,083,726,022***	***632,254,002,011***	***30,055,809***
1	Equipment for pumping stations	221,018,564	45,315,268,109	2,154,177
2	Equipment for WWTP	2,573,229,431	527,587,273,902	25,080,209
3	Equipment for management and operation	289,478,028	59,351,460,000	2,821,423
	Total Cost of Construction, Installation + Equipment	**8,828,101,889**	**1,810,019,018,919**	**86,043,878**
C	***Cost of site clearance, compensation***	***225,333,714***	***46,200,000,000***	***2,196,235***
D	***Cost of project management***	***780,376,497***	***160,000,000,000***	***7,606,009***
E	***Cost of consulting for construction investment***	***1,704,920,040***	***349,558,459,728***	***16,617,154***
F	***Other costs***	***985,793,344***	***202,116,459,891***	***9,608,122***
G	***Contingencies***	***2,359,526,526***	***483,771,929,825***	***22,997,335***
	Total Investment Cost	**14,884,052,011**	**3,051,665,868,362**	**145,068,733**
	VAT	**923,292,440**	**189,301,947,085**	**8,998,952**
	Grand Total	**15,807,344,451**	**3,240,967,815,447**	**154,067,685**

Source: JICA Study Team