Department of Public Works and Transport
Phnom Penh Capital City
Kingdom of Cambodia

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR SEWERAGE SYSTEM DEVELOPMENT
IN
THE PHNOM PENH CAPITAL CITY
IN THE KINGDOM OF CAMBODIA

August 2019

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.
in association with
NIPPON KOEI CO., LTD.
WATER AND SEWER BUREAU, CITY OF KITAKYUSHU

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to CTI Engineering International Co., Ltd., Nippon Koei Co., Ltd. and Water and Sewer Bureau, City of Kitakyushu.

The survey team held a series of discussions with the officials concerned of the Government of Cambodia, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Cambodia for their close cooperation extended to the survey team.

August, 2019

Megumi MUTO
Director General
Global Environmental Department
Japan International Cooperation Agency

SUMMARY

1. Outline of Cambodia

With an area of 181,000 km^2, the Kingdom of Cambodia had the population of about 14.7 million in 2013. Gross Domestic Product (GDP) per capita of Cambodia is US$ 1,390 in 2017. The climate of Cambodia is classified as tropical monsoon type, characterized by two seasons: dry and rainy season. The rainy season is normally from May to November.

After decades of civil wars, Cambodia started to reconstruct the country in the 1990's under a new coalition government with a market economy system. With the assistance of the international community, the Cambodian government has been actively promoting administrative and financial reforms and development of infrastructures. GDP growth rates per year have exceeded 7% stably since 2011. The Government of Cambodia (hereinafter referred to as "the GOC") has specified sustainable economic growth and industrial development as most important policy objective.

2. Background of the Project

Wastewater generated in Phnom Penh Capital City (hereinafter referred to as "PPCC"), the capital city of the Kingdom of Cambodia, has been increasing mainly due to rapid urbanization and population increase (from approximately 1.0 million in 1998 to 1.7 million in 2013). In general, the wastewater from PPCC is introduced to septic tanks in each household or business establishment. Supernatant liquid from the tanks are discharged to swamps/lakes through drainage pipe/channels and purified by natural purification function to some extent. However, the water environment in PPCC is seriously deteriorated due to the insufficient maintenance of the septic tanks, decrease of natural purification function in the swamps/lakes because of unregulated land reclamation and development. In particular, Cheung Aek Lake, the project area in this preparatory survey, decreases its area especially from 2003 to 2015 and thus deterioration of environmental and living condition of the people around the lake is accelerated.

The GOC places importance on construction and sustainable operation of facilities related to sewage management and drainage improvement in the major cities including PPCC in such national strategies as "National Strategic Development Plan (NSDP), 2014-2018" In addition, PPCC sets goals of "Prevention of water pollution" and "Promotion of sewage treatment" in "City Development Strategy (CDS), 2005" and sets priority on the development of sewerage facilities in the PPCC's city development plan of "White Book on Development and Planning of Phnom Penh, 2015".

Taking the above conditions into consideration, Japan International Cooperation Agency (hereinafter referred to as JICA), implemented "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area" from year 2014 to 2016, in response to the official request from the RGC. In this Study, Sewage Management and Drainage Improvement Master Plan (hereinafter referred to as M/P), was formulated for the target year of 2035. In the M/P, Cheung Aek Treatment Area, in which wastewater from central area of PPCC is currently discharged to Cheung Aek Lake through existing combined drainage pipes/channels, is set-up, applying off-site sewage treatment. Furthermore, phased implementation plan for the treatment area, which consists of short-term (up to 2020), medium-term (from 2021 to 2030) and long-term (from 2031 to 2040), is established.

This project aims to construct Sewage Treatment Plant (STP) and sewer (interceptor), based on the short-term program in the phased implementation plan in the M/P.

JICA conducted a preparatory survey on the Project. The preparatory survey team held a series of discussions with the officials concerned of the GOC. As a result of discussions, both sides confirmed that the items requested by the GOC for the Project are as shown in the Table below.

Description of Requested Components for the Project

Components	Detailed Contents (will be studied in the Preparatory Survey)
Construction of Sewage Treatment Plant (STP) (including Interception Facilities)	- Capacity: 5,000m^3 - Treatment method: Pre-treated Trickling Filtration (PTF)
Access Road/Sewer pipe from Trabek Pumping Station to STP	- Length: 2,000 m - Diameter of Sewer pipe: 500 mm

Note: Components and contents requested for the Project had been confirmed in Minutes of Discussions, signed on May 25, 2018.

3. Outline of the Survey/Design and Contents of the Project

JICA dispatched the Preparatory Survey Team to Cambodia from May 7 to July 8 and August 7 to October 7, 2018. In the Preparatory Survey, the urgency and necessity of the requested project were again recognized. The content and size of the Project, as well as its appropriateness and effect have been discussed and proposed in the draft final report of the Preparatory Survey, which was explained to the Cambodian side by an explanation team dispatched to Cambodia from May 15 to May 25, 2019. Both sides had agreed on the contents and the finalization of the Preparatory Survey Report.

3.1 Basic Design Policy

3.1.1 STP

(1) Target Wastewater Qualities to be treated

In principle, BOD and TSS are targeted for designing sewage treatment facilities. Influent BOD and TSS are set based on those in the M/P. Effluent BOD and TSS are set in accordance with effluent standard for Commercial Building, Borey, Satellite City and Resort or Recreation Center in the Sub-decree on the Management of Drainage and Wastewater Treatment System, because effluent standards for designing STP is not yet established in Cambodia.

Design water quality of T-N and T-P are not set in this Project because 1) no effluent standards for designing STP is established in Cambodia and 2) PTF, which is introduced in the Project is not applicable for removal of T-N and T-P independently. However, since PTF have capacity to remove T-N and T-P to some extent, JICA Survey Team estimates the possible level of effluent concentration of T-N and T-P employing simulation results.

(2) Wastewater Treatment Method

PPCC requested PTF to be applied in this Project, on the other hand, two method, namely, PTF and CASP, are recommended in the M/P (Both of the methods have the same score in the quantitative evaluation). Therefore, JICA survey team re-evaluates the PTF and CASP considering BOD removal efficiency, construction cost, operation cost, easiness of operation and maintenance and so on. As a result, PTF is selected as appropriate method in this Project.

(3) Sludge Treatment Method

PTF generates excess sludge in common with other wastewater treatment systems. Should sludge treatment system be not equipped in the facilities, stable operation of wastewater

treatment is impossible. Proper sludge treatment system is extremely important for wastewater treatment. Sludge treatment process is determined by conducting alternative study, including such processes as gravity sludge thickener, sludge drying bed, and dewatering by mechanical dehydrator to minimize quantity of sludge. In the alternative study, not only technical matter but also capital expenditures (CAPEX) and operating expenditures (OPEX) are considered. In addition, since global warming is recently focused, reduction of greenhouse gases is also analysed. As a result, sludge treatment system including gravity sludge thickener, digester and sludge drying beds, is selected in this Project.

(4) Landscaping Pond

Landscaping pond is installed to demonstrate the effect and benefit of the Project. The landscaping pond shall be designed considering future use as environmental education and enlightenment for the citizens. Therefore, the pond is designed to easily be visited, be useful and comfortable, and be operated with low O&M cost.

(5) Smooth Expansion

The capacity of STP of this Project is 5,000m^3/day, and it will be expanded up to 282,000m^3/day in accordance with long-term plan of the M/P. Therefore, the facilities in this Project (capacity of 5,000 m^3/day) are designed as much as possible not to be useless and will smoothly be expanded for the future capacity of the long-term plan.

3.1.2 Interception Facilities and Sewer Pipe

The design of interception facilities are determined considering workability, construction cost, wastewater volume, land use and so on. As for interception method, Fixed-type Interception is applied based on the alternative study of (i) Fixed-type Interception, and (ii) Float-type Interception. In the design of sewer pipe, pressure flow is applied based on the alternative study of (a) Gravity flow and (b) Pressure flow.

The acquisition of private land and house relocation often cause social conflicts. To avoid such conflicts, the right of way for the installation of sewer pipe shall be set within the public land (in which Access Road (Channel Maintenance Road) is constructed in this project) near existing drainage canal, which is located from Trabek Pumping Station to the STP site.

3.1.3 Reclamation

Construction site of STP designated by the GOC is located in the north-east part of Cheung Aek Lake. The STP site shall be reclaimed before construction of the STP to be higher than flood water level of Cheung Aek Lake. The bottom of the proposed area must be covered by sludge and organic sediments. Therefore, removal of these sludge and organic sediments shall be included in the Project. Moreover, analysis on the soil condition of lake bottom is conducted in order to evaluate the soil stabilization and consolidation, as well as select ground improvement method.

3.1.4 Soft Component Plan

PPCC has so far no experience of sewage management utilizing STP and no staff who has experience in operation and maintenance of STP; therefore, it is essential to train the staff of PPCC to guarantee sustainable operation of the STP constructed in this Project. Soft Components in this Project are proposed, considering technical and financial point of view.

3.2 Contents of the Project

The following structures shall be constructed by the Project as the Japanese assistance.

Contents of Construction in the Project

Facilities			Major Specifications
Interception Facilities			Gate and Pump: 3.9 m^3/min×15kW×2 units
Sewer Pipe(Interceptor)			Length: 1.86 km, Ductile Pipe (φ300)
Access Road (Channel Maintenance Road)			Length: 1.69 km, Car Road Width: 7.0 m, Walkway: 1.5 m
Sewage Treatment Plant			
	Wastewater Treatment Facilities	Reservoir Tank, Raw water Pump	Reservoir Tank : 140 m^3, Raw Water Pump: 5.1 m^3/min × 30kW×2 units Others : Screens, Mixer
		Floating Sponge Filter (FSF)	Area 24.0 m^2×Thickness: 0.6 m×2 tanks
		High-rate Trickling Filter (HTF)	Area 82.8 m^2×Thickness: 2.5 m×2 tanks
		Final Solid Liquid Separator (SLS)	Area 20.0 m^2×Thickness: 0.7 m×2 tanks
		Chlorination Tank	Chlorination Tank: 60 m^3
		Back Washing Water Storage Tank	Backwashing Water Storage Tank : Depth: 3.0 m×7.0 m×5.5 m Others: Mixer, Transfer Pump
		Primary Sedimentation Tank	Primary Sedimentation Tank : Depth:3.0 m×φ7.0 m Others : Sludge Scraper, Transfer Pump
	Sludge Treatment Facilities	Sludge Thickener	Gravity Thickener : Depth:4.0 m×φ5.5 m Others : Sludge Scraper, Transfer Pump
		Sludge Digestion Facilities	Primary Tank : Depth:11.0 m×φ7.5m Secondary Tank : Depth:10.0 m×φ7.5m Others : Gas Holder, Flare Stack, Sludge Transfer Pump
		Sludge Drying Beds	40 m^2×20 beds
Administration Building			Administration Room, Operation Room, Meeting Room, Electric Room, Laboratory, Workers Room
Transformer House			Electric Room
Structures for Exterior/Others			Landscaping Pond, Outfall, Gate and Fence, Yard piping and cabling, Pavement and Drainage

Contents of Soft Component in the Project

	Contents
Capacity Development in Operation and Maintenance of STP	Technical transfer and capacity development on O&M of STP, especially, wastewater treatment facilities, sludge treatment facilities, sludge management and water quality
Assistance for formulating Financial Plan for STP Management	Capacity development on preparation of financial plan, budget and expenditure management

4. Implementation Period and Project Cost

Implementation period of the Project is estimated to be 13 months for detailed engineering design, and 37 months for construction work including soft component.

The project cost to be borne by the recipient country is estimated to be about US$746,000 (83.6 million Japanese Yen, US$1.0 = JPY111.84).

The cost to be borne by the Japan's Grant Aid is not shown in this report due to the confidentially.

5. Project Evaluation

5.1 Relevance of the Project

Relevance of the Project is verified from the following viewpoints.

(1) Target Scale of Benefit

The number of direct beneficiary by the Project is approximately 19,000 people. Starting with this project, the improvement of water environment in PPCC is accelerated. In

addition, improvement of hygienic condition is expected due to reduction of incidence rate of waterborne disease, like diarrhea, typhoid and dysentery. Further, increase in price of people's property and/or asset value around the Project site, will be expected.

(2) Urgency of Improvement of Living Condition of the People

The area of Cheung Aek Lake, the project area of the preparatory survey, is decreasing especially from 2003 to 2015. The natural purification function is also affected due to rapid urbanization and population increase. Thus, deterioration of natural purification function of the lake is accelerated. Moreover, offensive odor from wastewater flowing into the lake seriously affects living condition of the people around the lake. Therefore, mitigation measures to improve the condition are urgently required.

(3) Consistency with Long-Term Development Programme

GOC places importance on construction and sustainable operation of facilities related to sewage management and drainage improvement in the major cities including PPCC in such national strategies as "National Strategic Development Plan (NSDP), 2014-2018" In addition, PPCC sets goals of "Prevention of water pollution" and "Promotion of sewage treatment" in "City Development Strategy (CDS), 2005" and sets priority on the development of sewerage facilities in the PPCC's city development plan of "White Book on Development and Planning of Phnom Penh, 2015". The White Book proposes the construction of wastewater treatment plant in Cheung Aek Lake. Thus, the relevance of the Project is high since the Project is consistent with the long-term development programme of the Cambodia and PPCC.

(4) Impact to Environment

Significant or permanent negative impact to natural and social environments are not expected by implementing the Project. In contrast, positive impact such as improvement of living and social environments by the construction of STP is expected.

(5) Consistency with Japan's Aid Policy and Objective

The Project is to be implemented based on the M/P formulated in "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area, JICA, December 2016". In addition, this Project applies Japanese unique wastewater treatment method of PTF, which is the first technology verified in the "International Technology Verification Program", conducted by Japan Sewage Works Agency. Thus, this Project is consistent with one of the Japanese aid policies of "Quality Infrastructure Investment".

5.2 Effectiveness

(1) Quantitative and Direct Effectiveness

19,000 project beneficiaries and reduction of BOD load discharged to the public waterbodies are expected by implementing the Project, as shown in the following table.

Indicators	Present (2018)	Future (2027) (3 years after completion of the project)
Sewered Population (person)	0	19,000
Amount of Wastewater Treated (m^3/day)	0	5,000
BOD Concentration (effluent water quality) (mg/L)	195	30

(2) Qualitative and Indirect Effectiveness

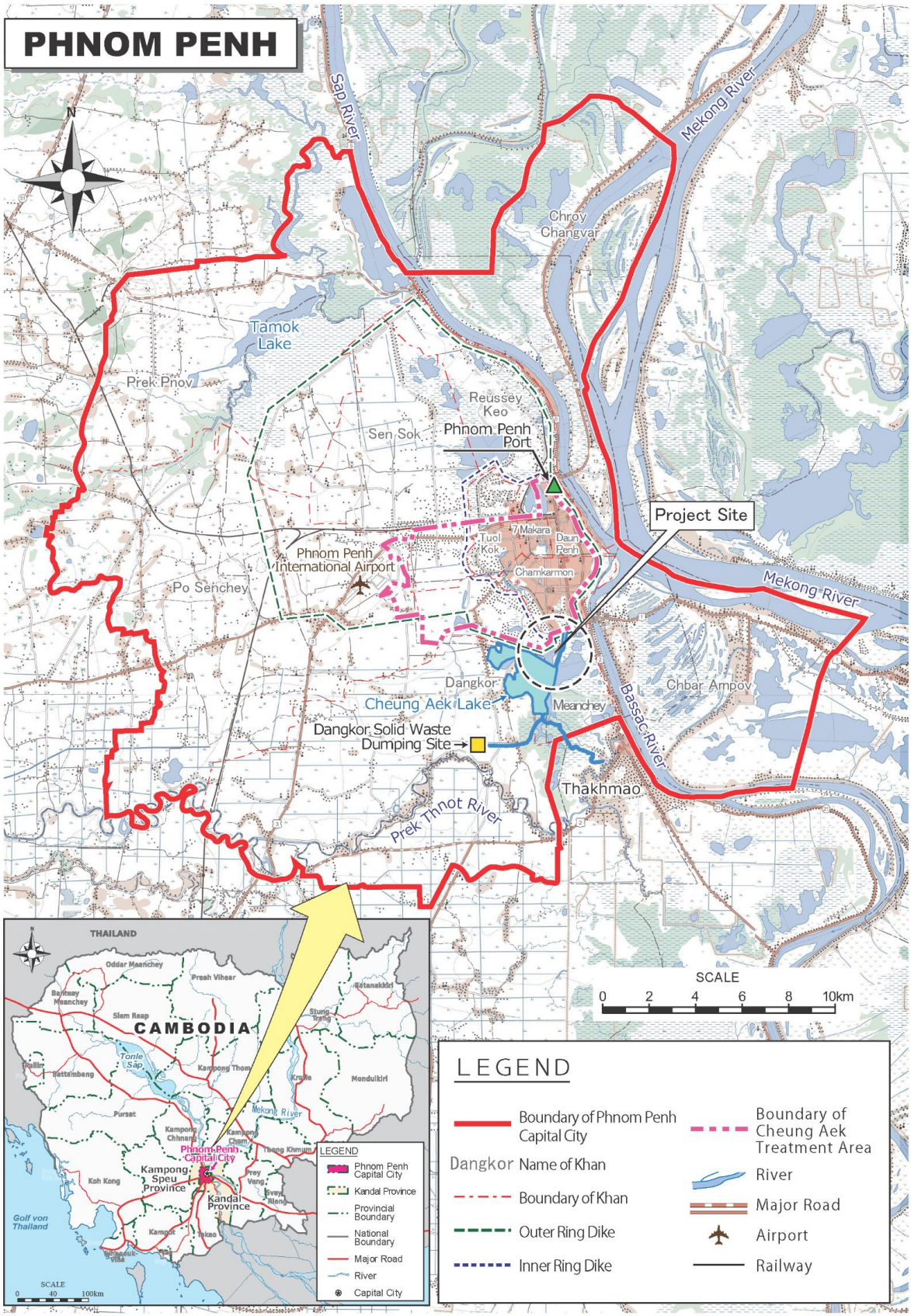
By implementing this Project, the following qualitative effectiveness for improving living and hygienic condition of the people are expected.

- Wastewater treatment facilities constructed in the Project contributes to improve the water quality of Cheung Aek Lake, mitigate offensive odor and thus improve living condition of the people around the Lake.
- Wastewater treatment facilities constructed in the Project decrease the waterborne disease. Thus, hygienic condition of the people around the Lake is improved.

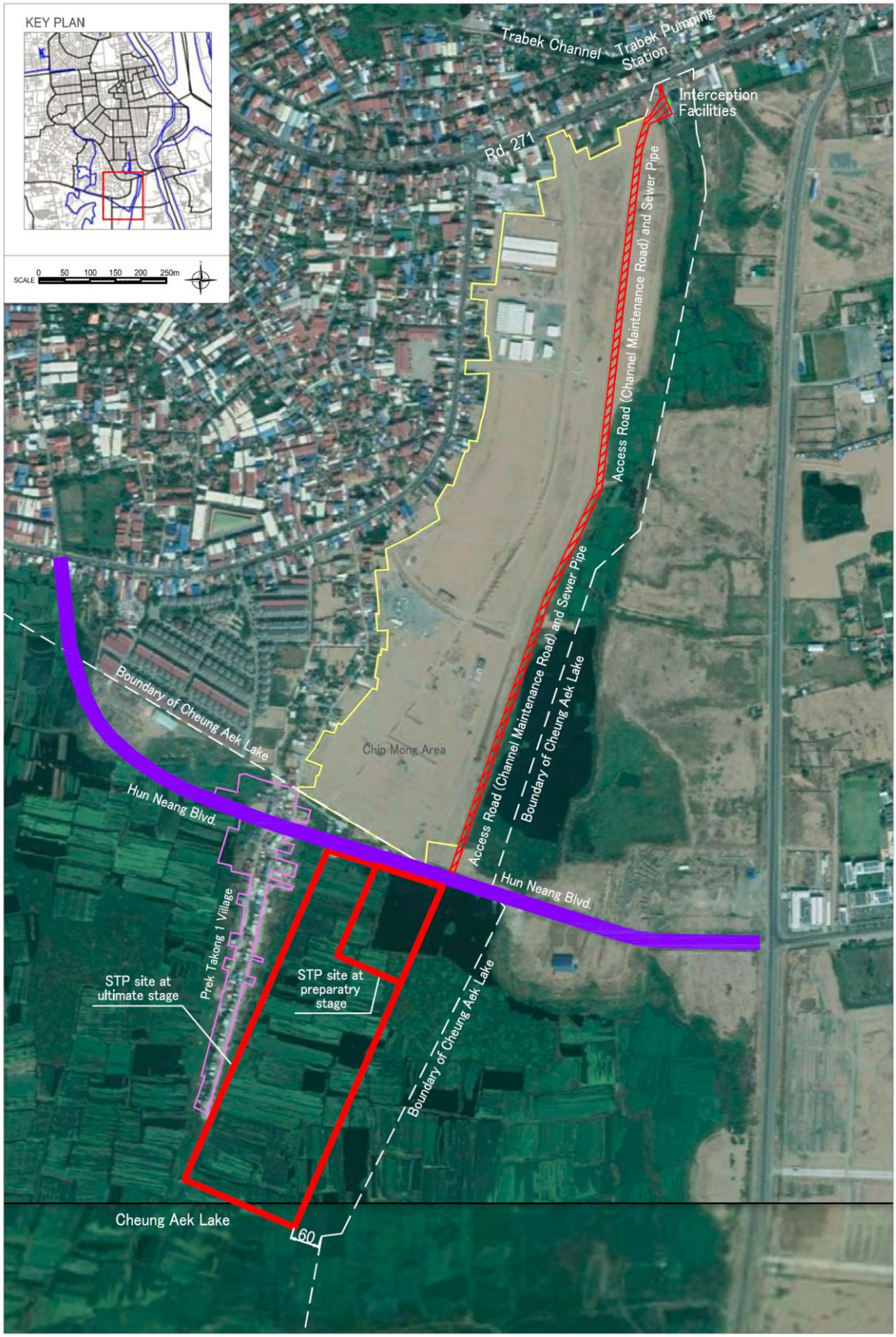
The above effectiveness contributes to accomplish the goals of "Prevention of water pollution" and "Promotion of sewage treatment" in City Development Strategy of PPCC.

5.3 Conclusion

As stated above, the Project has high relevance and effectiveness. Hence, it is desirable to execute the Project.



LOCATION MAP



LOCATION MAP

(ENLARGED MAP OF STP CONSTRUCTION SITE)

PERSPECTIVES

Interception Facilities

Sewage Treatment Plant

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Abbreviations and Acronyms

1. Organizations

ADB	Asian Development Bank
AASHTO	American Association of State Highway and Transportation Officials
CDC	Council for the Development of Cambodia
DEF	Department of Economy and Finance
DLMUPC	Department of Land Management, Urban Planning and Construction
DOAFF	Department of Agriculture, Forestry and Fisheries
DOE	Department of Environment
DOH	Department of Health
DOLVT	Department of Labor and Vocational Training
DOT	Department of Tourism
DOWRAM	Department of Water Resources and Meteorology
DPWT	Department of Public Works and Transport
DSO	Drainage Pumping Station and Sewage Treatment Plant Office
EDC	Electricité du Cambodge
EMA	External Monitoring Agency
GOC	Government of Cambodia
GDR	General Department of Resettlement
GOJ	Government of Japan
IRC	Inter-Ministrial Resettlement Committee
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
MEF	Ministry of Economic and Finance
MGRC	Municipality Grievance Redress Committee
MLMUPC	Ministry of Land Management, Urban Planning and Construction
MOAFF	Ministry of Agriculture, Forestry and Fisheries
MOE	Ministry of Environment
MOP	Ministry of Planning
MPWT	Ministry of Public Works and Transport
MRSC	Municipality Resettlement Sub-Committee
MOWRAM	Ministry of Water Resources and Meteorology
PDOE	Provincial Department of Environment
PGRC	Provincial Grievance Redress Committee
PIU	Project Implementation Unit
PMU	Project Management Unit
PPCA	Phnom Penh Capital Administration
PPCC	Phnom Penh Capital City
PPWSA	Phnom Penh Water Supply Authority
PRSC	Provincial Grievance Redress Committee
RGC	Royal Government of Cambodia
WB	World Bank

2. Others

AH	Affected Households
AG	Aboveground
A/P	Authorization to Pay
AP	Affected People
ARAP	Abbreviated Resettlement Plan
ASTM	American Society for Testing and Materials
ATP	Affordability To Pay
AV	Audio Visual

B/A	Banking Arrangement
BOD	Biochemical Oxygen Demand
BRP	Basic Resettlement Plan
CAPEX	Capital Expenditures
CASP	Conventional Activated Sludge Process
CBR	California Bearing Ratio
CDS	City Development Strategy
CFU	Colony Forming Unit
CH_4	Methane
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CR	Critically Endangered
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CSES	Cambodia Socio-Economic Survey
DCIP	Ductile Cast Iron Pipe
DG	Director General
DIMDM	Department of Internal Monitoring and Data Management
DMS	Detailed Measurement Survey
DO	Dissolved Oxygen
DP	Development Partner
DRP	Detail Resettlement Plan
EA	Executing Agency
EC	Electrical Conductivity
EF	Economic Fish
EIA	Environmental Impact Assessment
EL.	Elevation
EMA	External Monitoring Agency
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EN	Endangered
E/N	Exchange of Notes
FRP	Fiber Reinforced Plastics
FSF	Floating Sponge Filter
G/A	Grant Agreement
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRM	Grievance Redress Mechanism
H_2S	Hydrogen Sulfide
HDPE	High Density Polyethylene Pipe
HH	Household
HTF	High-rate Trickling Filter
IA	Implementing Agency
IEE	Initial Environmental Examination
IEIA	Initial Environment Assessment
IOL	Inventory of Losses
IRR	Internal Rate of Return
JEM	Standards of the Japan Electrical Manufacturers' Association
JIS	Japan Industrial Standards
LAR	Land Acquisition and involuntary Resettlement
LC	Least Concern
LCD	Liquid Crystal Display
LRP	Livelihood Restoration Plan
LWL	Low Water Level
M/M	Man-Month
M/P	Mater Plan

MPN	Most Probable Number
MPR	Monthly Poverty Rate
MOD	Minutes of Discussions
MOU	Memorandum of Understanding
NaClO	Sodium Hypochlorite
NGO	Non-Governmental Organization
NSDP	National Strategic Development Plan
NO_2	Nitrogen Dioxide
NT	Near Threatened
NTU	Nephelometric Turbidity Unit
O&M	Operation and Maintenance
OPEX	Operating Expenditures
PAM	Project Administration Manual
PC	Precast Concrete
PIB	Project Information Booklet
PIM	Project Implementation Manual
PM	Particulate Matter
PPC	Project Preparation Consultant
PS	Pumping Station
PTF	Pre-treated Trickling Filtration
RAP	Resettlement Action Plan
RCS	Replacement Cost Survey
Rd.	Road
RF	Resettlement Framework
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SES	Socio Economic Surveys
SLS	Final Solid Liquid Separator
SO_2	Sulfur Dioxide
SO_4	Sulfate
SOP	Standard Operating Procedures
SPT	Standard Penetration Test
SS	Suspended Solids
STD	Sexually Transmitted Diseases
STP	Sewage Treatment Plant
TDS	Total Dissolved Solid
T-N	Total Nitrogen
TOR	Terms of Reference
T-P	Total Phosphorus
TSP	Total Suspended Particles
TSS	Total Suspended Solid
UDRP	Updated Detailed Resettlement Plan
UG	Underground
URAP	Updated Resettlement Action Plan
USD	United States Dollar
UXO	Unexploded Ordnance
VP	Hard Vinyl Chloride Pipe
WG	Working Group

CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Background of the Project

Wastewater generated in Phnom Penh Capital City (hereinafter referred to as "PPCC"), the capital city of the Kingdom of Cambodia, has been increasing mainly due to rapid urbanization and population increase (from approximately 1.0 million in 1998 to 1.7 million in 2013). In general, the wastewater from PPCC is introduced to septic tanks in each household or business establishment. Supernatant liquid from the tanks are discharged to swamps/lakes through drainage pipe/channels and purified by natural purification function to some extent. However, the water environment in PPCC has seriously deteriorated due to the insufficient maintenance of the septic tanks, decrease of natural purification function in the swamps/lakes because of unregulated land reclamation and development. In particular, the area of Cheung Aek Lake, the project area in this preparatory survey, has been decreasing especially from 2003 to 2015 and thus deterioration of environmental and living conditions of the people around the lake has accelerated.

The Government of Cambodia (hereinafter referred to as GOC), places importance on construction and sustainable operation of facilities related to sewage management and drainage improvement in the major cities including PPCC in such national strategies as "National Strategic Development Plan (NSDP), 2014-2018" In addition, PPCC sets goals of "Prevention of water pollution" and "Promotion of sewage treatment" in "City Development Strategy (CDS), 2005" and sets priority on the development of sewerage facilities in the PPCC's city development plan of "White Book on Development and Planning of Phnom Penh, 2015".

Taking the above conditions into consideration, Japan International Cooperation Agency (hereinafter referred to as JICA), implemented "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area" from year 2014 to 2016, in response to the official request from the RGC. In this Study, Sewage Management and Drainage Improvement Master Plan (hereinafter referred to as M/P), was formulated for the target year of 2035. In the M/P, Cheung Aek Treatment Area, in which wastewater from central area of PPCC is currently discharged to Cheung Aek Lake through existing combined drainage pipes/channels, is set-up, applying off-site sewage treatment. Furthermore, phased implementation plan for the treatment area, which consists of short-term (up to 2020), medium-term (from 2021 to 2030) and long-term (from 2031 to 2040), is established.

This project aims to construct Sewage Treatment Plant (STP) and sewer (interceptor), based on the short-term program in the phased implementation plan in the M/P.

1.2 Contents of the Request

The preparatory survey team held a series of discussion with the officials of the GOC. Through a series of discussions, both sides confirmed that the items requested by the GOC for the Project are as shown in the following table.

Table R 1.2.1 Requested Components for the Project

Components	Detailed Contents (will be studied in the Preparatory Survey)
Construction of Sewage Treatment Plant (STP) (including Interception Facilities)	- Capacity: 5,000m^3 - Treatment method: Pre-treated Trickling Filtration (PTF)
Access Road[1]/Sewer pipe from Trabek Pumping Station to STP	- Length: 2,000 m - Diameter of Sewer pipe: 500 mm

Source: Survey Team

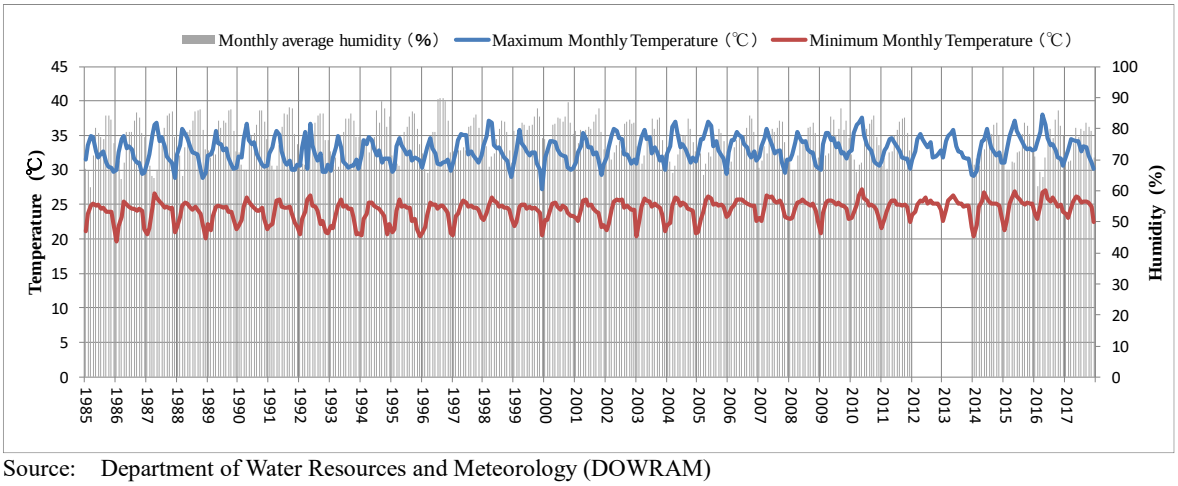
[1] "Access Road" is referred to as "Access Road (Channel Maintenance Road)" hereinafter, because the Access Road also functions as maintenance road of the discharge channel from Trabek Pumping Station.

1.3 Natural Conditions of the Project Area

(1) Meteorological Phenomena

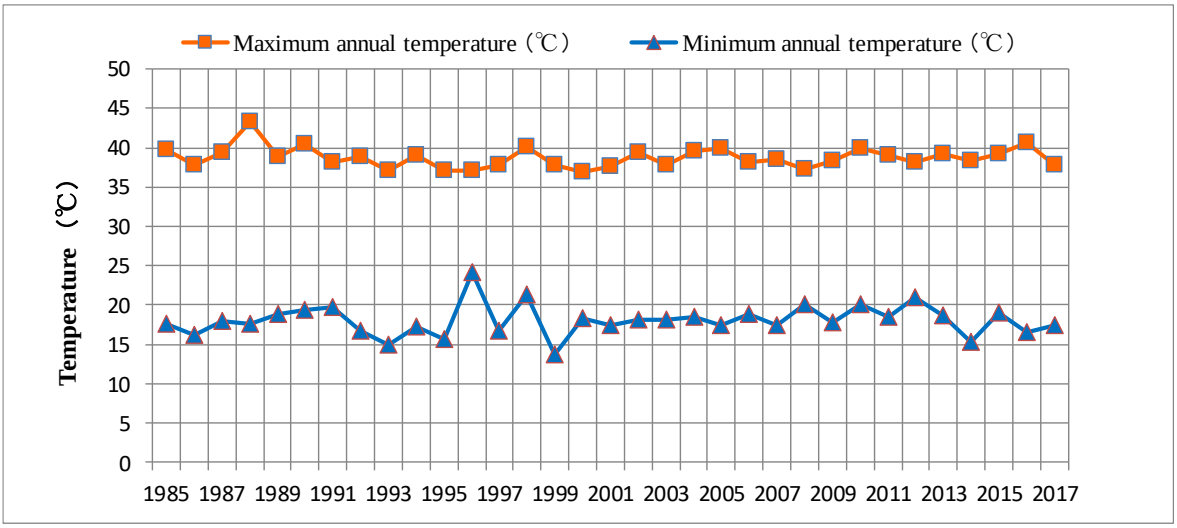
Meteorological data and water level of the Bassac River necessary for planning and designing are collected. Meteorological data is collected and analysed based on the data of Pochentong and Khmuonh stations managed by Department of Water Resources and Meteorology (DOWRAM). The collected items are 1) Temperature, 2) Humidity, 3) Rainfall and 4) Wind speed and direction. Water level of the Bassac River are collected from 2 stations, namely, Chaktomuk and Koh Khel Stations. Salient features of the data are as follows.

- Maximum and minimum monthly average temperatures are 38.0 degrees (2016) and 19.7 degrees (1986). Annual average of humidity is 77 % (see **Fig. R** 1.3.1). Annual maximum and minimum temperatures are 43.3 degrees (1988) and 13.7 degrees (1999) (see **Fig. R 1.3.2**).
- Average annual rainfall is approximately 1,520 mm (from 2006 to 2015), however the range of the annual rainfall is wide as maximum 1,939 mm (2008) and minimum 1,171 mm (2006). About 87% of annual rainfall is recorded in the rainy season (see Table R 1.3.1 and **Fig. R 1.3.3**).
- Maximum wind speed of 18 m/s is recorded in 2015 and 2016. In general, south or west wind is observed in the dry season. On the other hand, north or east wind is observed in the rainy season (see **Fig. R 1.3.5**).
- At Chaktomuk Station, which is nearest to the proposed STP site, maximum water level is EL.+10.18 m is recorded in 2000. Water level of Koh Khel Station, which is about 30 km downstream of STP site, was about 3 m lower than those of Chaktomuk Station (see **Fig. R 1.3.6**).



Source: Department of Water Resources and Meteorology (DOWRAM)

Fig. R 1.3.1 Maximum and Minimum Monthly Temperature and Monthly Average Humidity (1985-2017)



Source: Department of Water Resources and Meteorology (DOWRAM)

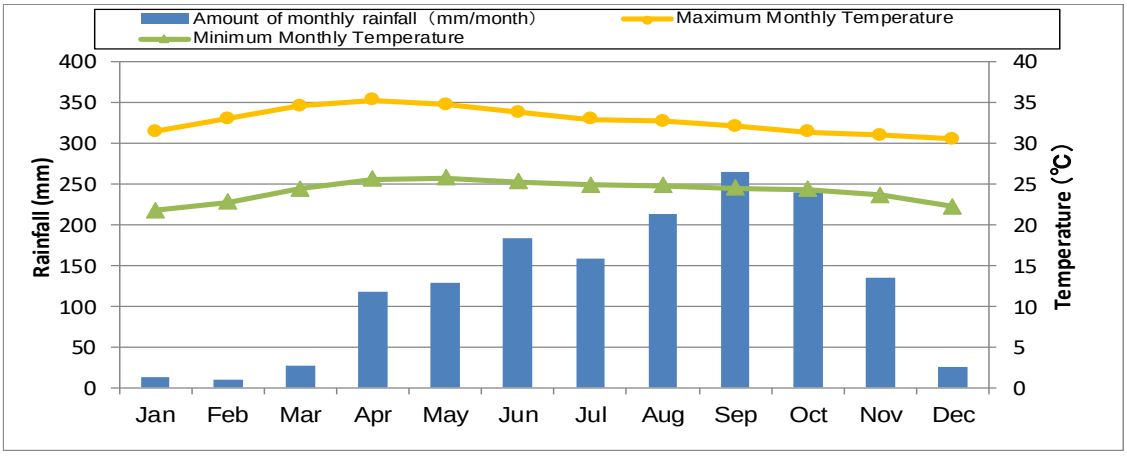
Fig. R 1.3.2 Annual Maximum and Minimum Temperature (1985-2017)

Table R 1.3.1 Amount of Monthly Rainfall (2006-2015)

Unit:mm/month

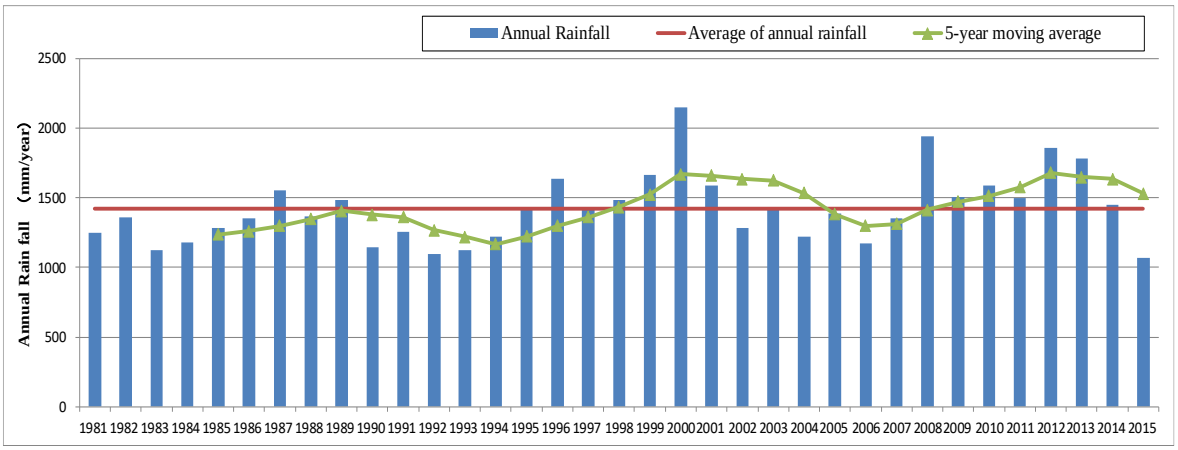
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Season	Dry				Rainy							Dry	
2006	0.1	42.1	32.8	66.4	84.0	92.0	124.8	274.2	228.2	190.9	12.4	23.0	1170.9
2007	0.0	0.0	32.7	39.9	192.4	258.3	135.7	263.6	155.1	212.1	63.2	0.0	1353.0
2008	74.1	0.6	112.0	83.4	197.3	219.1	169.6	289.6	290.2	259.4	190.7	52.7	1938.7
2009	0.0	14.6	7.1	270.5	241.7	148.6	111.8	267.9	300.2	108.2	33.5	0.0	1504.1
2010	25.4	0.0	35.6	55.9	26.9	254.3	84.1	233.0	324.3	387.1	94.3	69.9	1590.8
2011	0.8	0.0	11.4	130.9	131.4	113.3	227.8	249.7	244.4	311.9	67.0	7.0	1495.6
2012	27.0	41.0	28.8	77.8	185.8	94.3	283.2	177.6	455.8	116.6	350.4	22.0	1860.3
2013	0.0	0.0	2.0	182.2	143.4	350.8	189.8	0.0	139.2	413.8	303.8	56.2	1781.2
2014	0.0	6.1	13.8	147.1	44.8	198.8	190.8	194.4	274.7	215.3	148.4	13.3	1447.5
2015	2.6	0.0	2.9	124.5	33.9	99.9	74.1	190.5	245.6	185.0	92.4	13.3	1064.7
Average	**13.0**	**10.4**	**27.9**	**117.9**	**128.2**	**182.9**	**159.2**	**214.1**	**265.8**	**240.0**	**135.6**	**25.7**	**1520.7**

Source: Department of Water Resources and Meteorology (DOWRAM)



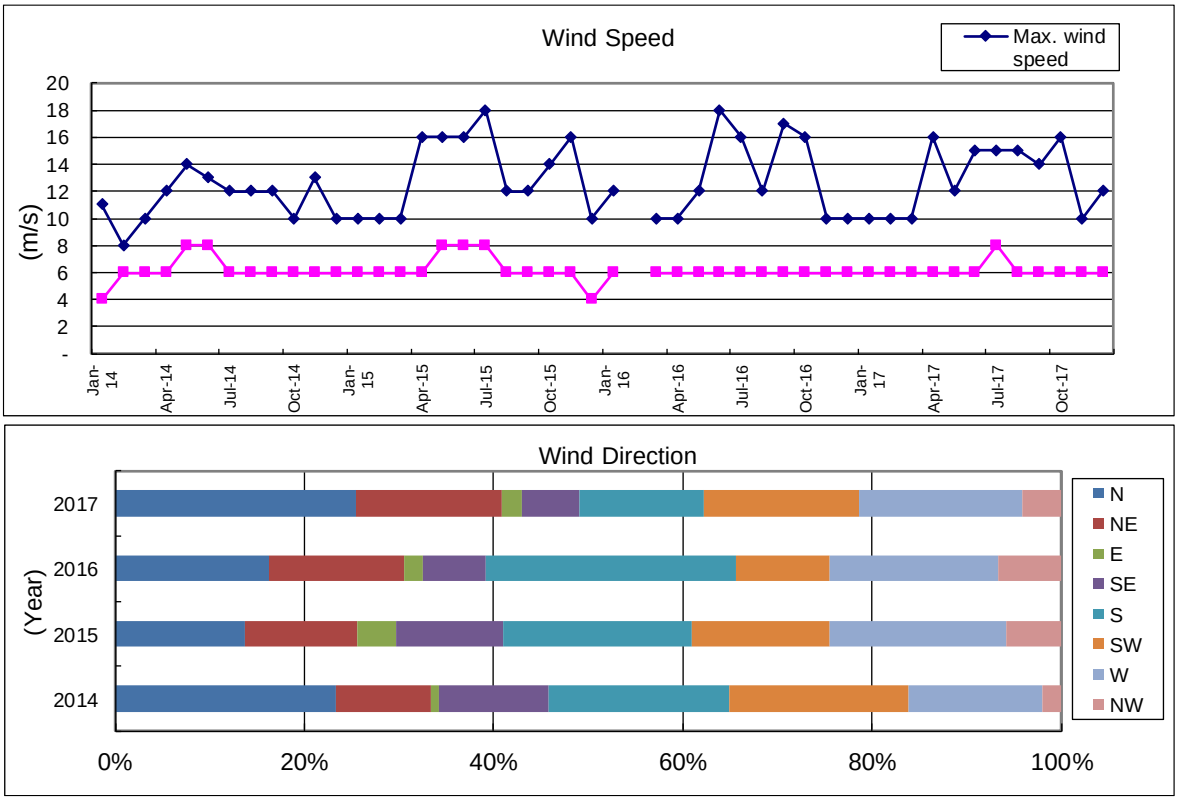
Source: Department of Water Resources and Meteorology (DOWRAM)

Fig. R 1.3.3 Amount of Monthly Rainfall (2006-2015)



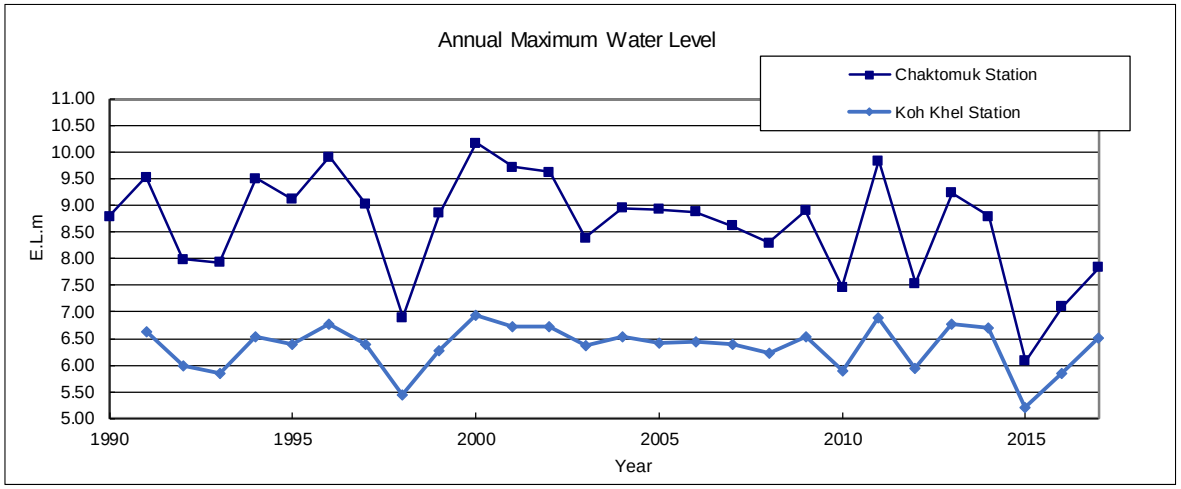
Source: Department of Water Resources and Meteorology (DOWRAM)

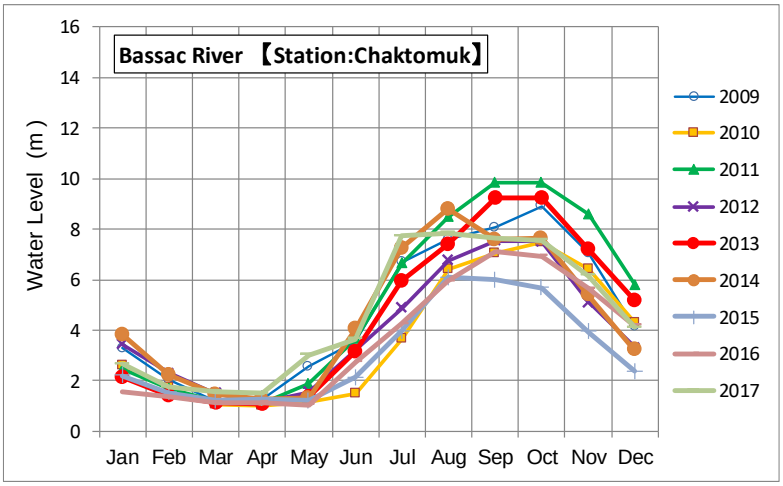
Fig. R 1.3.4 Secular Change of Annual Rainfall (1981-2015)

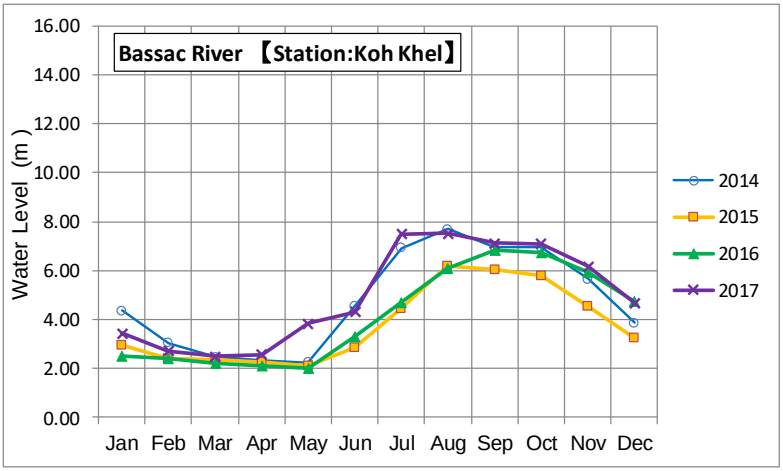


Source: Department of Water Resources and Meteorology (DOWRAM)

Fig. R 1.3.5 Wind Speed and Wind Direction (2014-2017)







Source: Ministry of Water Resources and Meteorology (MOWRAM)

Fig. R 1.3.6 Water Level of Bassac River

(2) Topographic Survey

Topographic surveys are conducted to collect the basic data for the design and planning of STP, sewer pipe as well as interception facilities. Conducted topographic surveys are as follows.

- Plan survey for in and around STP construction site in Cheung Aek Lake (survey area is shown in **Fig. R 1.3.7** by yellow line).
- Cross-Sectional Survey (including survey of thickness of sludge). The survey line is shown in **Fig. R 1.3.7** by pink line),

The outline of the survey is summarised in **Table R 1.3.2** and the location is shown in **Fig. R 1.3.7**. Condition of the survey is shown in **Photo R 1.3.1**.

Table R 1.3.2 Outline of Topographic Survey

Survey Item	Survey Location	Quantity
Plan Survey	All Site	Area = 147.0 ha
Cross-Sectional Survey	Around Outlet of Trabek Pumping Station	11 sections (L = 1,100 m)
	Downstream Channel of Trabek Pumping Station	18 sections (L = 8,540 m)
	STP Site	15 sections (L = 8,100 m)

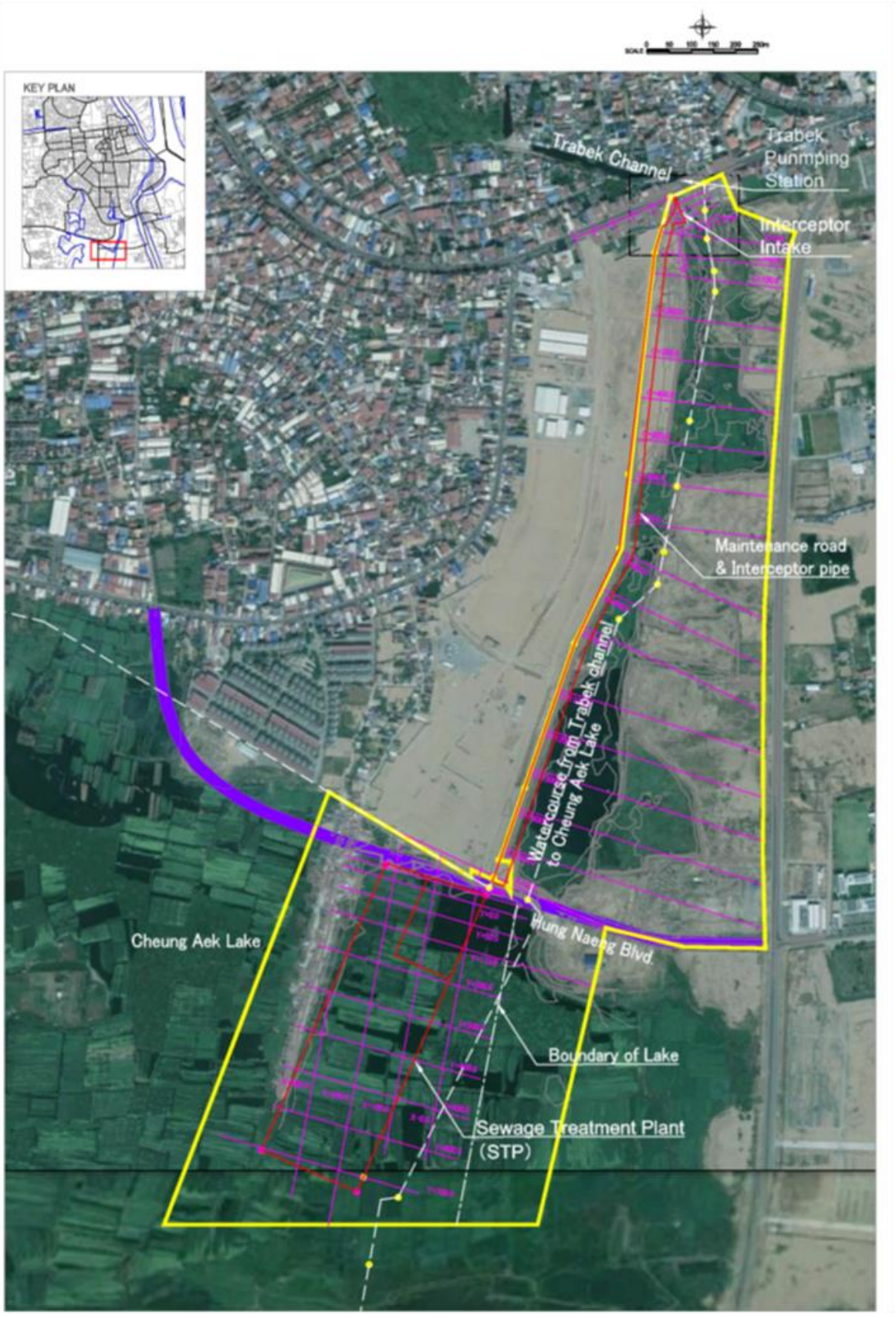
Source: Survey Team

Survey on Road

Survey on Water Surface

Source: Survey Team

Photo R 1.3.1 Site of Topographic Survey



Source: Survey Team

Fig. R 1.3.7 Location of Topographic Survey

(3) Geological Survey

Machine boring and laboratory test are conducted to clarify geological condition for the reclamation and foundation of STP, sewer pipe as well as interception facilities. The outline of the survey is described below. The location is shown in **Fig. R 1.3.8** and condition of the survey is shown in **Photo R 1.3.2**.

(a) Contents of Machine Boring and Laboratory Test

Machine boring is conducted at 5 locations. In the bore hole, in-situ tests are also carried out. The test items are as followings.

- Standard Penetration Test (SPT),
- Groundwater level survey,
- Sampling of every layer, and
- Geological boring log.

In conducting machine boring, disturbed samples and undisturbed samples are taken for laboratory tests from the bore hole. The test items are as followings.

[for Undisturbed Sample]

- Consolidation test,

[for Disturbed Sample]

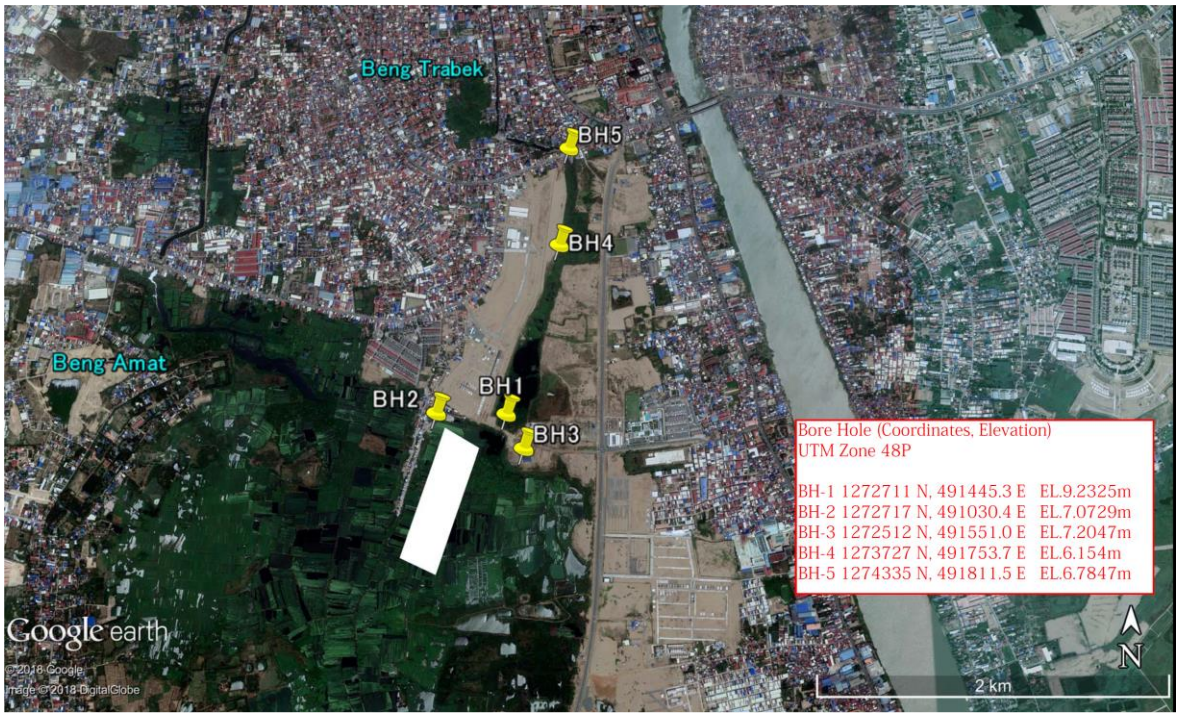
- Unit weight analysis,
- Grain size analysis,

Boring at Br. 4

Boring at Br. 4

Source: Survey Team

Photo R 1.3.2 Site of Geological Survey



Source: Survey Team

Fig. R 1.3.8 Location of Geological Survey

(b) Test Results

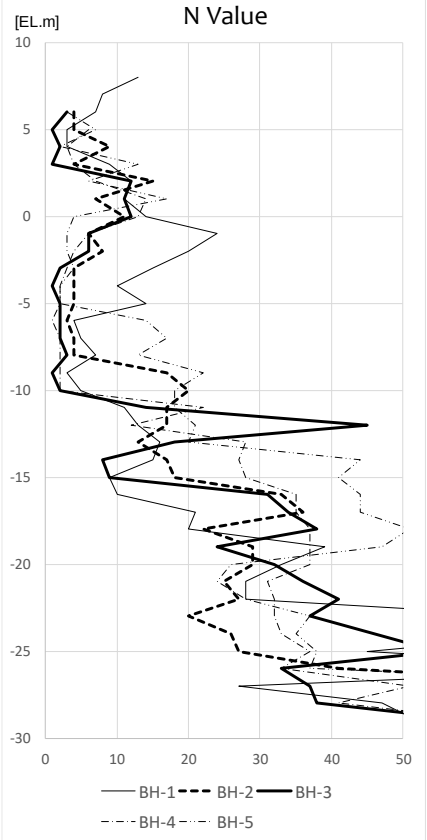


Fig. R 1.3.9 Result of SPT

Results of N-value obtained in the Standard Penetration Test (SPT) at 5 boring locations are shown in the figure on the left.

N-value of more than 10 are obtained at all the 5 locations in the elevation of deeper than EL. -10 m. On the other hand, soft soil layer is found in the elevation of less than EL. - 10 m.

Out of the borings of BH-1, BH-2 and BH-3, which are conducted near STP site, distribution of N-value at BH-1 and BH-2 are almost similar in the depth from EL. 0 m to EL. - 10 m. As a result, distribution of N-value of BH-1 and BH-2 represents geological feature around the STP site.

At BH-1 and BH-2 in the depth from EL. 0 m to EL. - 10 m, N-value of less than 10 are obtained. Therefore, analysis of land subsidence arising from land reclamation is conducted.

Results of laboratory tests at the boring locations are summarized below.

(c) Boring No.1

Table R 1.3.3 Results of Laboratory Test (Boring No.1: BH-1)

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m³	D.D KN/m³	M & C %	SAND %	GRAVEL %	C KN/m²	ϕ Deg.	MV m²/MN	CV m²/Sec	e_o Void Ratio	K m/sec	E KN/m²	Gs	ASTM	ASTM	N-VALUE 300mm
BH-1	1	D1	1.00-1.45	Top soil, silty well-graded fine to medium SAND (SM), Q-4, alluvia, loose to medium dense.	8.55	26.23	23.23	3.00	-4.89	-	-	10.30	89.70	0.00	-	-					5783	-	Silty-well-graded SAND	SM	13
		D2	2.00-2.45		17.44	27.32	24.21	3.11	-2.18	-	-	42.09	57.91	0.00							3227	-	Silty-well-graded SAND	SM	8
		U3	2.50-3.00		13.39	26.23	23.10	3.13	-3.10	14.43	12.72	57.52	42.48	0.00	2.39	24					-	2.66	Sandy lean CLAY	SM	-
	2	D4	3.00-3.45	Very loose becoming loose silty-well-graded fine to medium SAND (SM), Q-4, alluvia, saturation layer.	12.76	26.32	23.32	3.00	-3.52	-	-	7.34	92.66	0.00							2601	-	Silty-well-graded SAND	SM	7
		U5	3.50-4.00		15.22	26.32	23.40	2.92	-2.80	14.14	12.27	18.52	81.48	0.00	2.65	24							Silty-well-graded SAND	SM	
		D6	4.00-4.45		30.25	27.25	24.21	3.04	1.99	-	-	26.00	74.00	0.00							1058	-	Silty-well-graded SAND	SM	3
		D7	5.00-5.45		25.76	26.32	23.23	3.09	0.82	-	-	23.72	76.28	0.00							947	-	Silty-well-graded SAND	SM	3
		U8	5.50-6.00		27.64	26.40	23.65	2.75	1.45	13.71	10.74	25.38	74.62	0.00	0.53	23					-	2.66	Silty-well-graded SAND	SM	-
	3	D9	6.00-6.45	Stiff lean CLAY (CL), Q-4, alluvia, wet soil layer.	37.71	40.21	23.10	17.11	0.85			99.17	0.83	0.00							2565		Lean CLAY	CL	9
		D10	7.00-7.45		26.35	39.32	22.31	17.01	0.24	-	-	99.17	0.83	0.00							3161	-	Lean CLAY	CL	12
		U11	7.50-8.00		25.75	40.12	23.32	16.80	0.14	18.25	14.51	97.97	2.03	0.00	47.71	8	0.198	$1.57x10^{-6}$	0.77	$3.11x10^{-11}$	2047	2.69	Lean CLAY	CL	
		D12	8.00-8.45		19.02	40.12	22.22	17.90	-0.18			95.09	4.91	0.00							2668		Lean CLAY	CL	11
		D13	9.00-9.45		20.36	39.32	21.12	18.20	-0.04	-	-	95.87	4.13	0.00							3210	-	Lean CLAY	CL	14
		U14	9.50-10.00		17.18	40.12	21.21	18.91	-0.21	17.90	15.27	96.77	3.23	0.00	47.71	8	0.144	$4.86x10^{-6}$	0.60	$6.97x10^{-11}$	2394	2.70	Lean CLAY	CL	
	4	D15	10.00-10.45	Stiff becoming very stiff fat CLAY (CH), Q-4, alluvia.	21.57	55.32	25.25	30.07	-0.12			86.03	13.97	0.00							5227		Fat CLAY	CH	24
		U16	10.50-11.00		23.20	56.65	26.32	30.33	-0.10	20.40	16.56	98.62	1.38	0.00	54.07	5	0.114	$3.58x10^{-6}$	0.62	$4.09x10^{-11}$	2606	2.69	Fat CLAY	CH	-
		D17	11.00-11.45		23.01	54.12	24.21	29.91	-0.04	-	-	97.93	2.07	0.00	-	-					4167	-	Fat CLAY	CH	20
		D18	12.00-12.45		34.19	55.32	24.05	31.27	0.32			99.57	0.43	0.00							3003		Fat CLAY	CH	15
		U19	12.50-13.00		36.01	54.12	23.32	30.80	0.41	18.74	13.78	97.51	2.49	0.00	50.89	5					-	2.70	Fat CLAY	CH	-
	5	D20	13.00-13.45	Stiff lean CLAY (CL), Q-4, alluvia.	31.34	40.12	23.32	16.80	0.48			96.70	3.30	0.00							1932	-	Lean CLAY	CL	10
		U21	13.50-14.00		39.69	41.12	23.15	17.97	0.92	17.89	12.80	97.91	2.09	0.00	45.32	9	0.178	$1.06x10^{-7}$	1.19	$1.88x10^{-15}$	2316	2.69	Lean CLAY	CL	-
		D22	14.00-14.45		32.05	39.32	21.12	18.20	0.60			96.15	2.90	0.95							2606		Lean CLAY	CL	14
	6	D23	15.00-15.45	Soft becoming medium stiff lean CLAY (CL), bottom of pond, Q-4, alluvia, wet soil layer.	38.46	40.12	22.21	17.91	0.91			98.35	1.65	0.00							731	-	Lean CLAY	CL	4
		U24	15.50-16.00		35.17	40.25	20.88	19.37	0.74	13.74	10.17	97.67	2.33	0.00	13.52	9	0.152	$8.64x10^{-5}$	1.06	$1.32x10^{-13}$	1518	2.70	Lean CLAY	CL	-
		D25	16.00-16.45		38.34	39.32	22.34	16.98	0.94			94.37	5.63	0.00							883		Lean CLAY	CL	5
		U26	16.50-17.00		44.10	40.25	22.50	17.75	1.22	17.87	14.70	98.12	1.88	0.00	37.37	7	0.111	$9.71x10^{-6}$	1.01	$1.08x10^{-15}$	1269	2.69	Lean CLAY	CL	-
BH-1	6	D27	17.00-17.45	Soft becoming medium stiff lean CLAY (CL), bottom of pond, Q-4, alluvia, wet soil layer.	42.59	42.21	22.31	19.90	1.02	-	-	99.91	0.09	0.00	-	-					1195	-	Lean CLAY	CL	7
		D28	18.00-18.45		47.24	39.32	19.32	20.00	1.40	-	-	99.04	0.96	0.00							507	-	Lean CLAY	CL	3
		D29	19.00-19.45		52.71	40.32	22.31	18.01	1.69	-	-	99.96	0.04	0.00							814	-	Lean CLAY	CL	5
	7	D30	20.00-20.45	Stiff lean CLAY (CL), Q-4, alluvia.	74.86	39.32	22.10	17.22	3.06	-	-	98.43	1.57	0.00							1729	-	Lean CLAY	CL	11
		D31	21.00-21.45		21.83	39.39	21.05	18.34	0.04	-	-	92.84	6.21	0.95							1993	-	Lean CLAY	CL	13
		D32	22.00-22.45		22.59	40.40	23.40	17.00	-0.05			77.43	22.57	0.00							2395		Lean CLAY, with sand	CL	16
		D33	23.00-23.45		23.89	39.34	22.25	17.09	0.10	-	-	81.92	12.55	5.53							2198	-	Lean CLAY	CL	15
		D34	24.00-24.45		22.11	40.05	21.54	18.51	0.03	-	-	50.03	49.97	0.00							1298	-	Sandy lean CLAY	CL	9
		D35	25.00-25.45		21.78	39.20	22.25	16.95	-0.03			90.65	8.66	0.69							1413		Lean CLAY	CL	10
		U36	25.50-26.00		19.56	40.30	22.10	18.20	-0.14	18.26	12.40	91.55	8.18	0.26	45.32	9					-	2.69	Lean CLAY	CL	-
	8	D37	26.00-26.45	M. dense very clayey-well-graded fine to medium SAND.	13.19	32.23	18.32	13.91	-0.37	-	-	19.52	77.50	2.98	-	-					2894	-	Clayey-well-graded SAND	SC	21
		D38	27.00-27.45		13.10	32.05	19.97	12.08	-0.57			23.31	76.06	0.63							2707		Clayey-well-graded SAND	SC	20
	9	D39	28.00-28.45	Very Stiff becoming hard lean CLAY (CL) & sandy lean CLAY (CL), trace fine gravel, Q-4, alluvia.	16.14	39.32	19.32	20.00	-0.16			57.30	42.70	0.00							5172	-	Sandy lean CLAY	CL	39
		D40	29.00-29.45		19.96	40.05	20.20	19.85	-0.01			84.18	15.82	0.00							4304		Lean CLAY, with sand	CL	33
		D41	30.00-30.45		17.92	40.10	22.21	17.89	-0.24	-	-	96.71	3.29	0.00	-	-					3594	-	Lean CLAY	CL	28
		D42	31.00-31.45		14.09	36.32	24.24	12.08	-0.84			98.58	1.42	0.00							3537		Lean CLAY	CL	28
		U43	31.50-32.00		12.43	36.32	23.30	13.02	-0.83	19.91	16.35	99.23	0.77	0.00	55.66	8					-	2.70	Lean CLAY	CL	-
	10	D44	32.00-32.45	Very hard lean CLAY (CL), Q-4, alluvia.	9.06	35.25	22.20	13.05	-1.01			89.78	10.22	0.00							8437	-	Lean CLAY	CL	68
		D45	33.00-33.45		10.70	36.32	23.20	13.12	-0.95			88.37	11.63	0.00							8799		Lean CLAY	CL	72
	11	D46	34.00-34.45	M. dense very clayey-well-graded fine to medium SAND (SC), gravel, Q-4, alluvia.	8.35	35.54	16.16	19.38	-0.40			22.29	75.01	2.70							5425		Clayey-well-graded SAND	SC	45
		D47	35.00-35.45		8.73	33.20	15.32	17.88	-0.37			27.61	72.07	0.32							10326		Clayey-well-graded SAND	SC	87
		D48	36.00-36.45		12.47	34.15	16.65	17.50	-0.24			21.26	78.74	0.00							3171		Clayey-well-graded SAND	SC	27
	12	D49	37.00-37.45	Very hard lean CLAY (CL), Q-4, alluvia, trace fine gravel.	18.16	36.32	23.10	13.22	-0.37			90.13	9.87	0.00							5435		Lean CLAY	CL	47
		D50	38.00-38.45		13.89	36.25	24.21	12.04	-0.86			94.20	5.80	0.00							5934		Lean CLAY	CL	52
		D51	39.00-39.45		12.94	36.59	23.31	13.28	-0.78			76.95	23.05	0.00							5746		Lean CLAY, with sand	CL	51
		D52	40.00-40.45		13.09	37.18	22.34	14.84	-0.62			55.07	44.93	0.00							6008		Sandy lean CLAY	CL	54

Source: Survey Team

(d) Boring No.2

Table R 1.3.4 Results of Laboratory Test (Boring No.2: BH-2)

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m³	D.D KN/m³	M & C %	SAND %	GRAVEL %	C KN/m²	ϕ Deg.	MV m²/MN	CV m²/Sec	e_o Void Ratio	K m/sec	E KN/m²	Gs	ASTM	ASTM	N-VALUE 300mm
BH-2	1	D1	1.00-1.45	Top soil, silty well-graded fine to medium SAND (SM), Q-4, alluvia, very loose.	20.69	26.90	23.32	3.58	-0.73	-	-	16.57	83.43	0.00	-	-					1790	-	Silty-well-graded SAND	SM	4
		D2	2.00-2.45		20.17	27.32	24.21	3.11	-1.30	-	-	8.99	91.01	0.00							1635	-	Silty-well-graded SAND	SM	4
		U3	2.50-3.00		19.32	26.32	23.55	2.77	-1.53	14.00	11.73	11.29	88.71	0.00	1.59	23					-	2.66	Silty-well-graded SAND	SM	-
	2	D4	3.00-3.45	Soft to stiff brown lean CLAY (CL), Q-4, alluvia, wet soil layer.	26.49	40.10	22.00	18.10	0.25	-	-	97.79	2.21	0.00							3390	-	Lean CLAY	CL	9
		U5	3.50-4.00		29.97	39.30	21.14	18.16	0.49	18.79	14.46	95.73	4.27	0.00	53.27	7	0.252	$7.48x10^{-8}$	0.85	$1.89x10^{-10}$	1278		Lean CLAY	CL	
		D6	4.00-4.45		31.31	39.32	21.12	18.20	0.56	-	-	99.08	0.92	0.00							1322	-	Lean CLAY	CL	4
	3	D7	5.00-5.45	Medium stiff becoming stiff fat CLAY (CH), Q-4, alluvia.	29.60	56.56	25.25	31.31	0.14	-	-	99.84	0.16	0.00							4423	-	Fat CLAY	CH	15
		U8	5.50-6.00		31.64	56.56	25.10	31.46	0.21	18.86	14.33	98.13	1.87	0.00	49.30	5	0.183	$2.62x10^{-9}$	0.80	$4.78x10^{-11}$	2389	2.70	Fat CLAY	CH	-
		D9	6.00-6.45		30.46	56.30	24.65	31.65	0.18			97.88	2.12	0.00							1900		Fat CLAY	CH	7
		D10	7.00-7.45		32.47	55.64	24.50	31.14	0.26	-	-	99.24	0.76	0.00							2764	-	Fat CLAY	CH	11
		U11	7.50-8.00		37.09	55.54	24.50	31.04	0.41	18.73	13.66	97.51	2.49	0.00	47.71	8	0.211	$2.13x10^{-9}$	0.98	$4.48x10^{-11}$	2160	2.69	Fat CLAY	CH	
		D12	8.00-8.45		31.25	56.64	23.23	33.41	0.24			98.89	1.11	0.00							1472		Fat CLAY	CH	6
		D13	9.00-9.45		30.66	55.80	24.21	31.59	0.20	-	-	99.67	0.33	0.00							1890	-	Fat CLAY	CH	8
		U14	9.50-10.00		66.90	53.23	24.25	28.98	1.47	17.87	10.71	99.88	0.12	0.00	38.16	5	0.450	$3.23x10^{-8}$	1.83	$1.45x10^{-10}$	800	2.70	Fat CLAY	CH	
		D15	10.00-10.45		48.31	56.32	23.23	33.09	0.76			98.81	1.19	0.00							922		Fat CLAY	CH	4
	4	U16	10.50-11.00	Soft dark-gray lean CLAY (CL), bottom of pond, Q-4, alluvia, wet soil layer.	38.18	39.30	22.65	16.65	0.93	13.74	9.94	94.37	5.63	0.00	13.52	7	0.246	$9.34x10^{-9}$	1.22	$2.30x10^{-10}$	870	2.69	Lean CLAY	CL	-
		D17	11.00-11.45		39.55	39.32	23.15	16.17	1.01	-	-	94.24	5.76	0.00	-	-					877	-	Lean CLAY	CL	4
		D18	12.00-12.45		40.95	38.12	22.21	15.91	1.18			98.13	1.87	0.00							838		Lean CLAY	CL	4
		U19	12.50-13.00		42.09	38.23	21.12	17.11	1.23	13.75	9.67	99.47	0.53	0.00	14.31	5	0.215	$7.33x10^{-8}$	1.16	$1.57x10^{-10}$	619	2.69	Lean CLAY	CL	-
		D20	13.00-13.45		39.47	39.30	21.12	18.18	1.01			98.84	1.16	0.00							606	-	Lean CLAY	CL	3
		U21	13.50-14.00		38.26	39.32	20.54	18.78	0.94	14.88	10.76	99.11	0.89	0.00	19.08	5					-	2.70	Lean CLAY	CL	-
		D22	14.00-14.45		43.17	39.32	20.21	19.11	1.20			99.39	-99.39	100.00							773		Lean CLAY	CL	4
		D23	15.00-15.45		73.53	40.32	22.10	18.22	2.82			97.79	1.28	0.93							746	-	Lean CLAY	CL	4
		U24	15.50-16.00		56.50	40.12	23.23	16.89	1.97	13.91	8.89	98.06	1.94	0.00	15.11	7					-	2.69	Lean CLAY	CL	-
	5	D25	16.00-16.45	Very stiff lean CLAY (CL), Q-4, alluvia.	95.47	39.98	22.50	17.48	4.17			97.60	2.40	0.00							3020		Lean CLAY	CL	17
		U26	16.50-17.00		65.28	39.32	23.20	16.12	2.61	18.25	12.31	96.89	3.11	0.00	54.07	8					-	2.69	Lean CLAY	CL	-

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m³	D.D KN/m³	M & C %	SAND %	GRAVEL %	C KN/m²	ϕ Deg.	MV m²/MN	CV m²/Sec	e_o Void Ratio	K m/sec	E KN/m²	Gs	ASTM	ASTM	N-VALUE 300mm
BH-2	6	D27	17.00-17.45	Medium dense very clayey-well-graded fine to medium SAND (SC), gravel, Q-4, alluvia.	21.07	32.23	22.00	10.23	-0.09	-	-	32.40	67.48	0.11	-	-					3439	-	Clayey-well-graded SAND	SC	20
		D28	18.00-18.45		20.08	33.20	22.54	10.66	-0.23	-	-	35.34	64.66	0.00							2840	-	Clayey-well-graded SAND	SC	17
		D29	19.00-19.45		20.69	36.20	22.21	13.99	-0.11	-	-	29.95	70.05	0.00							2762	-	Clayey-well-graded SAND	SC	17
		D30	20.00-20.45		20.55	35.88	22.08	13.80	-0.11	-	-	30.66	69.34	0.00							2060	-	Clayey-well-graded SAND	SC	13
		D31	21.00-21.45		20.08	35.25	22.80	12.45	-0.22	-	-	32.00	68.00	0.00							2623	-	Clayey-well-graded SAND	SC	17
		D32	22.00-22.45		15.86	35.31	22.31	13.00	-0.50			16.33	82.75	0.93							2711		Clayey-well-graded SAND	SC	18
	7	D33	23.00-23.45	Dense clayey-well-graded medium SAND (SC), gravel.	13.83	33.60	18.32	15.28	-0.29	-	-	19.25	77.89	2.86							4845	-	Clayey-well-graded SAND	SC	33
		D34	24.00-24.45		11.97	35.26	18.27	16.99	-0.37	-	-	19.25	80.75	0.00							5169	-	Clayey-well-graded SAND	SC	36
		D35	25.00-25.45		13.66	35.23	19.32	15.91	-0.36			14.39	82.68	2.93							3099		Clayey-well-graded SAND	SC	22
		U36	25.50-26.00		11.41	44.00	22.00	22.00	-0.48	21.22	17.67	12.43	84.56	3.02	3.45	37					-	2.68	Clayey-well-graded SAND	SC	-
	8	D37	26.00-26.45	Very Stiff becoming hard lean CLAY (CL) & lean CLAY (CL), with sand, trace fine gravel, Q-4, alluvia.	22.29	40.41	24.21	16.20	-0.12	-	-	96.50	3.12	0.37	-	-					3999	-	Lean CLAY	CL	29
		D38	27.00-27.45		21.18	40.10	23.20	16.90	-0.12			96.89	3.11	0.00							3923		Lean CLAY	CL	29
		D39	28.00-28.45		21.69	39.32	23.97	15.35	-0.15			83.87	16.13	0.00							3322	-	Lean CLAY, with sand	CL	25
		D40	29.00-29.45		23.01	40.10	24.32	15.78	-0.08			86.12	13.88	0.00							3522		Lean CLAY	CL	27
		D41	30.00-30.45		21.50	40.12	23.32	16.80	-0.11	-	-	85.13	14.87	0.00	-	-					2568	-	Lean CLAY	CL	20
		D42	31.00-31.45		21.71	39.32	23.10	16.22	-0.09			75.96	24.04	0.00							3279		Lean CLAY, with sand	CL	26
		U43	31.50-32.00		20.93	40.00	18.32	21.68	0.12	19.55	17.21	78.70	21.30	0.00	57.25	11					-	2.70	Lean CLAY, with sand	CL	-
		D44	32.00-32.45		21.26	39.90	22.10	17.80	-0.05			65.33	34.67	0.00							3350	-	Lean CLAY, with sand	CL	27
	9	D45	33.00-33.45	Very hard lean CLAY (CL), Q-4, alluvia.	19.29	37.12	21.05	16.07	-0.11			70.47	29.53	0.00							5000		Lean CLAY, with sand	CL	41
		D46	34.00-34.45		21.58	36.36	19.32	17.04	0.13			77.97	21.84	0.18							10193		Lean CLAY, with sand	CL	85
		D47	35.00-35.45		20.99	36.97	20.20	16.77	0.05			75.74	19.89	4.36							10162		Lean CLAY, with sand	CL	86
	10	D48	36.00-36.45	Very hard sandy lean CLAY (CL), with sand, Q-4, alluvia, trace fine gravel, bed rock layer.	20.48	37.18	19.65	17.53	0.05			54.02	22.85	23.13							11645		Lean CLAY, with sand	CL	100
		D49	37.00-37.45		15.40	38.12	20.21	17.91	-0.27			56.32	24.14	19.54							11713		Lean CLAY, with sand	CL	102
		D50	38.00-38.45		21.11	39.30	19.19	20.11	0.10			55.48	22.03	22.48							13026		Lean CLAY, with sand	CL	115
		D51	39.00-39.45		9.30	40.10	20.21	19.89	-0.55			66.97	23.31	9.72							11738		Lean CLAY, with sand	CL	105
		D52	40.00-40.45		9.56	39.39	19.34	20.05	-0.49			73.08	25.19	1.73							11147		Lean CLAY, with sand	CL	101

Source: Survey Team

(e) Boring No.3

Table R 1.3.5 Results of Laboratory Test (Boring No.3: BH-3)

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m³	D.D KN/m³	M & C %	SAND %	GRAVEL %	C KN/m²	ϕ Deg.	MV m²/MN	CV m²/Sec	e_o Void Ratio	K m/sec	E KN/m²	Gs	ASTM	ASTM	N-VALUE 300mm
BH-3	1	D1	1.00-1.45	Top soil, silty well-graded fine to medium SAND (SM), Q-4, alluvia, Very loose.	17.89	26.99	23.20	3.79	-1.40	-	-	7.06	92.94	0.00	-	-					1346	-	Silty-well-graded SAND	SM	3
		D2	2.00-2.45		27.06	26.89	23.31	3.58	1.05	-	-	6.88	93.12	0.00							424	-	Silty-well-graded SAND	SM	1
		U3	2.50-3.00		26.52	26.26	23.60	2.66	1.10	13.59	10.74	6.82	93.18	0.00	2.12	22					-	2.66	Silty-well-graded SAND	SM	-
		D4	3.00-3.45		44.41	27.24	24.10	3.14	6.47	-	-	16.33	83.67	0.00							776	-	Silty-well-graded SAND	SM	2
		U5	3.50-4.00		36.36	26.20	23.23	2.97	4.42	13.40	9.82	33.12	66.88	0.00	1.43	23							Silty-well-graded SAND	SM	
	2	D6	4.00-4.45	Very soft lean CLAY.	40.20	36.23	21.12	15.11	1.26	-	-	99.67	0.33	0.00							344	-	Lean CLAY	CL	1
	3	D7	5.00-5.45	Stiff lean CLAY (CL), Q-4, alluvia.	22.85	36.64	22.21	14.43	0.04	-	-	97.58	2.42	0.00							3582	-	Lean CLAY	CL	12
		U8	5.50-6.00		19.37	36.90	22.10	14.80	-0.18	19.13	16.03	97.69	2.31	0.00	42.94	8	0.213	$2.12x10^{-8}$	0.81	$4.51x10^{-11}$	94	2.70	Lean CLAY	CL	-
	4	D9	6.00-6.45	Medium stiff becoming stiff fat CLAY (CH), Q-4, alluvia.	27.67	58.58	26.26	32.32	0.04			98.91	1.09	0.00							3018		Fat CLAY	CH	11
		D10	7.00-7.45		26.29	58.32	25.65	32.67	0.02	-	-	99.50	0.50	0.00							3061	-	Fat CLAY	CH	12
		U11	7.50-8.00		26.14	56.32	24.11	32.21	0.06	18.26	14.48	99.59	0.41	0.00	47.71	5	0.653	$4.83x10^{-8}$	1.85	$3.15x10^{-10}$	673	2.69	Fat CLAY	CH	
		D12	8.00-8.45		31.59	53.23	24.21	29.02	0.25			99.76	0.24	0.00							1507		Fat CLAY	CH	6
	5	D13	9.00-9.45	M.Stiff black organic SOIL, fat SILT (OH).	121.35	80.12	46.32	33.80	2.22	-	-	87.64	12.36	0.00							1480	-	Fat Silty, organic SOIL	MH	6
		U14	9.50-10.00		127.83	88.32	50.50	37.82	2.04	9.19	4.03	97.14	2.86	0.00	9.54	5					-	2.62	Fat Silty, organic SOIL	MH	
	6	D15	10.00-10.45	Very soft becoming soft dark-gray lean CLAY (CL), bottom of pond, Q-4, alluvia, wet soil layer.	35.03	36.65	23.23	13.42	0.88			85.59	14.41	0.00							495		Lean CLAY	CL	2
		U16	10.50-11.00		41.88	36.99	22.21	14.78	1.33	12.58	8.87	98.32	1.68	0.00	11.13	5	0.186	$6.33x10^{-8}$	1.04	$1.18x10^{-10}$	955	2.69	Lean CLAY	CL	-
		D17	11.00-11.45		37.55	40.12	23.15	16.97	0.85	-	-	96.84	3.16	0.00	-	-					251	-	Lean CLAY	CL	1
		D18	12.00-12.45		37.88	36.20	23.21	12.99	1.13			98.48	1.52	0.00							481		Lean CLAY	CL	2
		U19	12.50-13.00		36.79	36.20	23.10	13.10	1.04	12.73	9.31	99.68	0.32	0.00	11.13	5	0.237	$6.28x10^{-8}$	1.12	$1.49x10^{-10}$	757	2.70	Lean CLAY	CL	-
		D20	13.00-13.45		39.25	36.65	22.21	14.44	1.18			99.64	0.36	0.00							474	-	Lean CLAY	CL	2
		U21	13.50-14.00		44.58	36.99	22.15	14.84	1.51	12.40	8.58	99.33	0.67	0.00	12.72	5					-	2.70	Lean CLAY	CL	-
		D22	14.00-14.45		45.62	37.12	21.10	16.02	1.53			99.63	0.14	0.24							468		Lean CLAY	CL	2
		D23	15.00-15.45		45.60	36.20	22.21	13.99	1.67			98.98	1.02	0.00							685	-	Lean CLAY	CL	3
		U24	15.50-16.00		52.14	36.32	22.97	13.35	2.19	13.40	8.81	99.45	0.55	0.00	14.31	8	0.155	$6.25x10^{-8}$	1.27	$9.69x10^{-11}$	1164	2.69	Lean CLAY	CL	-
		D25	16.00-16.45		45.82	36.64	21.12	15.52	1.59			99.84	0.16	0.00							236		Lean CLAY	CL	1
		U26	16.50-17.00		36.02	36.65	20.21	16.44	0.96	12.08	8.95	98.14	1.86	0.00	9.54	5					-	2.70	Lean CLAY	CL	-

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m³	D.D KN/m³	M & C %	SAND %	GRAVEL %	C KN/m²	ϕ Deg.	MV m²/MN	CV m²/Sec	e_o Void Ratio	K m/sec	E KN/m²	Gs	ASTM	ASTM	N-VALUE 300mm
BH-3	6	D27	17.00-17.45	Very soft lean CLAY .	54.69	37.10	22.64	14.46	2.22	-	-	99.33	0.67	0.00	-	-					450	-	Lean CLAY	CL	2
	7	D28	18.00-18.45	M. dense becoming dense clayey-well-graded fine to medium SAND.	18.50	32.23	21.12	11.11	-0.24	-	-	17.11	82.89	0.00							3026	-	Clayey-well-graded SAND	SC	14
		D29	19.00-19.45		17.26	34.12	20.21	13.91	-0.21	-	-	39.88	60.12	0.00							9576	-	Clayey-well-graded SAND	SC	45
		D30	20.00-20.45		18.81	35.20	19.32	15.88	-0.03	-	-	21.45	75.43	3.12							3795	-	Clayey-well-graded SAND	SC	18
	8	D31	21.00-21.45	Medium stiff lean CLAY (CL), Q-4, alluvia.	23.91	40.12	24.10	16.02	-0.01	-	-	94.59	5.17	0.24							1676	-	Lean CLAY	CL	8
		D32	22.00-22.45		22.59	39.32	23.10	16.22	-0.03			97.33	2.67	0.00							1862		Lean CLAY	CL	9
	9	D33	23.00-23.45	Hard lean CLAY, with sand.	23.42	40.11	22.54	17.57	0.05	-	-	84.96	15.04	0.00							6308	-	Lean CLAY, with sand	CL	31
	10	D34	24.00-24.45	Dense well-graded SAND.	12.28	32.23	16.32	15.91	-0.25	-	-	40.96	59.04	0.00							6843	-	Silty-well-graded SAND	CL	34
	11	D35	25.00-25.45	Very Stiff to hard lean CLAY (CL) to sandy lean CLAY (CL), gravel, Q-4, alluvia.	11.31	35.25	18.32	16.93	-0.41			52.42	47.58	0.00							7566		Sandy lean CLAY	CL	38
		U36	25.50-26.00		11.34	35.18	18.18	17.00	-0.40	18.93	15.97	55.32	44.68	0.00	47.71	8					-	2.70	Sandy lean CLAY	CL	-
		D37	26.00-26.45		14.62	36.26	22.21	14.05	-0.54	-	-	76.50	19.36	4.13	-	-					4735	-	Lean CLAY, with sand	CL	24
		D38	27.00-27.45		18.08	35.80	21.12	14.68	-0.21			90.93	9.07	0.00							6245		Lean CLAY	CL	32
		D39	28.00-28.45		14.45	36.36	21.54	14.82	-0.48			73.82	26.18	0.00							6955	-	Lean CLAY, with sand	CL	36
	12	D40	29.00-29.45	Dense clayey-well-graded medium SAND (SC), gravel.	14.98	32.20	18.18	14.02	-0.23			15.83	84.17	0.00							7842		Clayey-well-graded SAND	SC	41
		D41	30.00-30.45		15.74	32.23	23.20	9.03	-0.83	-	-	14.50	85.50	0.00	-	-					7011	-	Clayey-well-graded SAND	SC	37
		D42	31.00-31.45		12.81	35.23	18.20	17.03	-0.32			14.66	64.78	20.56							8632		Clayey-well-graded SAND	SC	46
		U43	31.50-32.00		15.46	36.99	18.32	18.67	-0.15	20.90	18.78	13.11	86.89	0.00	4.24	40					-	2.67	Clayey-well-graded SAND	SC	-
	13	D44	32.00-32.45	Hard becoming very hard lean CLAY (CL) & lean CLAY (CL), with sand, trace fine gravel, Q-4, alluvia.	16.65	40.12	19.19	20.93	-0.12			97.19	2.81	0.00							10224	-	Lean CLAY	CL	55
		D45	33.00-33.45		21.10	36.32	20.10	16.22	0.06			84.33	7.03	8.64							6085		Lean CLAY	CL	33
		D46	34.00-34.45		14.39	36.26	21.12	15.14	-0.44			94.28	5.72	0.00							6761		Lean CLAY	CL	37
		D47	35.00-35.45		14.16	36.36	20.21	16.15	-0.37			73.30	26.10	0.61							6883		Lean CLAY, with sand	CL	38
	14	D48	36.00-36.45	Very hard lean CLAY (CL), Q-4, alluvia, trace fine gravel, bed rock layer.	13.65	36.99	19.32	17.67	-0.32			84.48	15.52	0.00							10767		Lean CLAY, with sand	CL	60
		D49	37.00-37.45		9.89	36.56	20.21	16.35	-0.63			92.04	7.96	0.00							16541		Lean CLAY	CL	93
		D50	38.00-38.45		10.40	36.99	19.19	17.80	-0.49			69.11	30.89	0.00							10060		Lean CLAY, with sand	CL	57
		D51	39.00-39.45		14.18	37.15	20.10	17.05	-0.35			73.04	26.96	0.00							7532		Lean CLAY, with sand	CL	43
		D52	40.00-40.45		18.93	40.12	21.12	19.00	-0.12			81.47	18.53	0.00							9032		Lean CLAY, with sand	CL	52

Source: Survey Team

(f) Boring No.4

Table R 1.3.6 Results of Laboratory Test (Boring No.4: BH-4)

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m^3	D.D KN/m^3	M & C %	SAND %	GRAVEL %	C KN/m^2	ϕ Deg.	MV m^2/MN	CV m^2/Sec	e_o Void Ratio	K m/sec	E KN/m^2	Gs	ASTM	ASTM	N-VALUE 300mm
BH-4	1	D1	1.00-1.45	Top soil, silty well-graded SAND.	33.09	26.32	23.23	3.09	3.19	-	-	5.85	94.15	0.00	-	-					2677	-	Silty-well-graded SAND	SM	6
		D2	2.00-2.45	Soft becoming medium stiff lean CLAY (CL), Q-4, alluvia.	43.75	36.20	23.31	12.89	1.59	-	-	97.75	2.25	0.00							1220	-	Lean CLAY	CL	3
		U3	2.50-3.00		32.30	36.32	22.21	14.11	0.72	14.40	10.88	96.27	-96.27	100.00	14.31	5					-	2.70	Lean CLAY	CL	-
	2	D4	3.00-3.45		31.28	36.65	24.10	12.55	0.57	-	-	98.06	1.94	0.00							1494	-	Lean CLAY	CL	4
		U5	3.50-4.00		24.33	39.32	23.20	16.12	0.07	14.06	11.31	96.45	3.55	0.00	14.31	5							Lean CLAY	CL	
		D6	4.00-4.45		24.99	35.26	23.32	11.94	0.14	-	-	98.77	1.23	0.00							2268	-	Lean CLAY	CL	7
		D7	5.00-5.45		22.98	56.90	26.26	30.64	-0.11	-	-	95.01	4.99	0.00							4567	-	Fat CLAY	CH	14
	3	U8	5.50-6.00	Stiff fat CLAY (CH), Q-4, alluvia.	26.35	56.32	25.65	30.67	0.02	19.20	15.20	97.81	2.19	0.00	54.07	5	0.213	$3.93x10^{-8}$	0.80	$8.36x10^{-11}$	1941	2.72	Fat CLAY	CH	-
		D9	6.00-6.45		28.02	56.32	25.25	31.07	0.09			96.02	3.98	0.00							4285		Fat CLAY	CH	13
	4	D10	7.00-7.45	M.Stiff black organic SOIL, fat SILT (OH).	91.91	85.32	45.45	39.87	1.17	-	-	95.64	4.36	0.00							2006	-	Fat Silty, organic SOIL	MH	6
		U11	7.50-8.00		82.71	88.32	45.65	42.67	0.87	9.25	5.06	92.71	7.29	0.00	17.49	3	0.420	$2.37x10^{-8}$	2.58	$9.97x10^{-10}$	854	2.63	Fat Silty, organic SOIL	MH	
		D12	8.00-8.45	Very soft becoming soft dark-gray lean CLAY (CL), bottom of pond, Q-4, alluvia, wet soil layer.	35.03	36.32	23.32	13.00	0.90			95.17	4.83	0.00							1300		Lean CLAY	CL	4
		D13	9.00-9.45		38.91	36.36	22.21	14.15	1.18	-	-	98.23	1.77	0.00							944	-	Lean CLAY	CL	3
		U14	9.50-10.00		30.38	36.56	22.65	13.91	0.56	13.40	10.28	84.54	15.46	0.00	12.72	5					-	2.69	Lean CLAY, with sand	CL	
		D15	10.00-10.45		35.25	35.20	21.01	14.19	1.00			81.11	18.89	0.00							614		Lean CLAY, with sand	CL	2
		U16	10.50-11.00		32.61	36.23	20.21	16.02	0.77	12.39	9.34	79.33	20.67	0.00	12.72	5					-	2.70	Lean CLAY, with sand	CL	-
		D17	11.00-11.45		35.29	36.64	21.01	15.63	0.91	-	-	74.71	25.29	0.00	-	-					596	-	Lean CLAY, with sand	CL	2
		D18	12.00-12.45		35.80	37.15	19.32	17.83	0.92			93.03	6.97	0.00							297		Lean CLAY	CL	1
	5	U19	12.50-13.00		31.74	37.18	20.20	16.98	0.68	12.74	9.67	96.82	3.18	0.00	11.13	5					-	2.70	Lean CLAY	CL	-
		D20	13.00-13.45		35.39	36.32	20.21	16.11	0.94			85.44	14.56	0.00							564	-	Lean CLAY	CL	2
		U21	13.50-14.00		32.85	36.23	21.12	15.11	0.78	12.89	9.71	84.99	15.01	0.00	12.72	5	0.156	$6.68x10^{-8}$	0.96	$1.04x10^{-10}$	1074	2.69	Lean CLAY, with sand	CL	-
		D22	14.00-14.45		38.86	36.97	19.32	17.65	1.11			95.27	4.73	0.00							550		Lean CLAY	CL	2
		D23	15.00-15.45		52.50	36.99	19.99	17.00	1.91			99.70	0.30	0.00							538	-	Lean CLAY	CL	2
		U24	15.50-16.00		47.72	36.99	20.11	16.88	1.64	12.75	8.63	98.52	1.48	0.00	9.54	5					-	2.70	Lean CLAY	CL	-
		D25	16.00-16.45		35.05	37.12	20.21	16.91	0.88			99.47	0.53	0.00							526		Lean CLAY	CL	2
		U26	16.50-17.00		32.86	35.26	19.98	15.28	0.84	12.75	9.43	98.05	1.95	0.00	9.54	5					-	2.70	Lean CLAY	CL	-

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m^3	D.D KN/m^3	M & C %	SAND %	GRAVEL %	C KN/m^2	ϕ Deg.	MV m^2/MN	CV m^2/Sec	e_o Void Ratio	K m/sec	E KN/m^2	Gs	ASTM	ASTM	N-VALUE 300mm
BH-4	6	D27	17.00-17.45	Medium dense very clayey-well-graded fine to medium SAND (SC), gravel, Q-4, alluvia.	16.65	32.23	19.32	12.91	-0.21	-	-	22.67	77.33	0.00	-	-					5507	-	Clayey-well-graded SAND	SC	22
		D28	18.00-18.45		17.59	35.12	21.12	14.00	-0.25	-	-	16.62	83.38	0.00							2947	-	Clayey-well-graded SAND	SC	12
		D29	19.00-19.45		17.58	33.23	18.87	14.36	-0.09	-	-	13.33	86.67	0.00							6719	-	Clayey-well-graded SAND	SC	28
		D30	20.00-20.45		20.67	34.15	19.28	14.87	0.09	-	-	12.24	87.76	0.00							6354	-	Clayey-well-graded SAND	SC	27
		D31	21.00-21.45		20.24	35.23	20.21	15.02	0.00	-	-	10.89	89.11	0.00							6466	-	Clayey-well-graded SAND	SC	28
	7	D32	22.00-22.45	Dense very clayey-well-graded fine to medium SAND (SC), gravel, Q-4, alluvia.	21.79	34.15	19.32	14.83	0.17			13.53	86.47	0.00							7933		Clayey-well-graded SAND	SC	35
		D33	23.00-23.45		18.89	34.15	19.19	14.96	-0.02	-	-	11.76	88.24	0.00							7795	-	Clayey-well-graded SAND	SC	35
		D34	24.00-24.45		16.27	35.26	20.21	15.05	-0.26	-	-	18.45	81.55	0.00							8101	-	Clayey-well-graded SAND	SC	37
		D35	25.00-25.45		20.91	34.15	19.65	14.50	0.09			19.19	80.81	0.00							7969		Clayey-well-graded SAND	SC	37
		U36	25.50-26.00		16.34	34.80	19.28	15.52	-0.19	19.55	16.63	22.18	77.82	0.00	0.80	35					-	2.66	Clayey-well-graded SAND	SC	-
	8	D37	26.00-26.45	Hard lean CLAY (CL), Q-4, alluvia.	23.37	40.12	23.23	16.89	0.01	-	-	97.61	2.04	0.35	-	-					7844	-	Lean CLAY	CL	37
		D38	27.00-27.45		21.98	40.25	22.32	17.93	-0.02			71.10	28.90	0.00							6474		Lean CLAY, with sand	CL	31
		D39	28.00-28.45		23.62	36.26	21.54	14.72	0.14			70.25	29.75	0.00							6584	-	Lean CLAY, with sand	CL	32
	9	D40	29.00-29.45	Dense clayey-well-graded medium to coarse SAND (SC), gravel.	21.06	32.23	19.32	12.91	0.13			16.35	83.48	0.17							6489		Clayey-well-graded SAND	SC	32
		D41	30.00-30.45		11.19	34.15	16.23	17.92	-0.28	-	-	16.99	74.13	8.88	-	-					6598	-	Clayey-well-graded SAND	SC	33
		D42	31.00-31.45		17.39	33.29	19.32	13.97	-0.14			17.88	80.45	1.67							7295		Clayey-well-graded SAND	SC	37
		U43	31.50-32.00		17.40	33.60	18.97	14.63	-0.11	19.90	16.46	17.41	82.38	0.21	5.57	36					-	2.66	Clayey-well-graded SAND	SC	-
		D44	32.00-32.45		23.91	33.26	17.19	16.07	0.42			29.75	69.69	0.56							6422	-	Clayey-well-graded SAND	SC	33
		D45	33.00-33.45		11.90	33.20	18.31	14.89	-0.43			38.49	51.39	10.12							9789		Clayey-well-graded SAND	SC	51
	10	D46	34.00-34.45	Very hard lean CLAY (CL), Q-4, alluvia, trace fine gravel.	22.58	35.35	19.23	16.12	0.21			92.54	7.46	0.00							7774		Lean CLAY	CL	41
		D47	35.00-35.45		16.70	35.64	20.21	15.43	-0.23			90.19	9.81	0.00							11604		Lean CLAY	CL	62
		D48	36.00-36.45		18.74	34.00	21.15	12.85	-0.19			85.25	14.75	0.00							9803		Lean CLAY	CL	53
		D49	37.00-37.45		17.44	35.16	20.25	14.91	-0.19			85.61	14.39	0.00							10783		Lean CLAY	CL	59
		D50	38.00-38.45		18.62	35.23	21.12	14.11	-0.18			71.35	28.65	0.00							13005		Lean CLAY, with sand	CL	72
		D51	39.00-39.45		16.16	36.32	19.19	17.13	-0.18			55.77	44.23	0.00							12682		Sandy lean CLAY	CL	71
		D52	40.00-40.45		16.58	35.15	20.20	14.95	-0.24			69.09	30.91	0.00							13425		Lean CLAY, with sand	CL	76

Source: Survey Team

(g) Boring No.5

Table R 1.3.7 Results of Laboratory Test (Boring No.5: BH-5)

BOREHOLE	STRATUM	SAMPLE	DEPTH INTERVAL	DESCRIPTION OF STRATA	Water Content	ATTEBERG LIMIT				DENSITY OF SOILS		PARTICLE SIZE DISTRIBUTION			Direct Shear Test		Consolidation Test					SPECIFIC GRAVITY	Group Name	Group Symbol	S.P.T TEST
No	No	No	(M).	N°	W %	L.L%	P.L%	IP	IL	B.D KN/m³	D.D KN/m³	M & C %	SAND %	GRAVEL %	C KN/m²	ϕ Deg.	MV m²/MN	CV m²/Sec	e_o Void Ratio	K m/sec	E KN/m²	Gs	ASTM	ASTM	N-VALUE 300mm
BH-5	1	D1	1.00-1.45	Top soil, silty well-graded SAND, Loose	25.67	26.23	23.23	3.00	0.81	-	-	25.15	74.85	0.00	-	-					1346	-	Silty-well-graded SAND	SM	3
		D2	2.00-2.45		26.94	27.12	24.21	2.91	0.94	-	-	21.33	78.67	0.00							2800	-	Silty-well-graded SAND	SM	7
		U3	2.50-3.00		26.27	26.23	23.32	2.91	1.01	14.87	11.78	45.05	54.95	0.00	0.00	26					-	2.67	Silty-well-graded SAND	SM	-
	2	D4	3.00-3.45	Very soft lean CLAY, wet soil layer.	66.50	40.12	23.23	16.89	2.56	-	-	87.04	12.96	0.00							743	-	Lean CLAY	CL	2
		U5	3.50-4.00		61.83	39.32	23.32	16.00	2.41	14.69	9.08	87.69	12.31	0.00	13.52	7	0.169	$7.83x10^{-8}$	0.75	$1.32x10^{-10}$	2517	2.70	Lean CLAY	CL	
	3	D6	4.00-4.45	Medium stiff to stiff lean CLAY (CL), Q-4, alluvia.	27.82	39.32	24.21	15.11	0.24	-	-	97.96	2.04	0.00							4264	-	Lean CLAY	CL	13
		D7	5.00-5.45		29.54	40.12	23.32	16.80	0.37	-	-	96.73	3.27	0.00							1892	-	Lean CLAY	CL	6
		U8	5.50-6.00		30.26	40.54	23.10	17.44	0.41	17.12	13.15	96.51	3.49	0.00	31.80	8					-	2.70	Lean CLAY	CL	-
	4	D9	6.00-6.45	Stiff fat CLAY (CH), Q-4, alluvia.	26.67	59.32	25.25	34.07	0.04			99.54	0.46	0.00							5125		Lean CLAY	CH	17
	5	D10	7.00-7.45	Very soft becoming soft lean CLAY, bottom of pond, Q-4, alluvia, wet soil layer.	38.46	36.32	23.23	13.09	1.16	-	-	86.23	13.77	0.00							1173	-	Lean CLAY	CL	4
		U11	7.50-8.00		87.95	36.32	22.62	13.70	4.77	13.36	7.11	85.94	14.06	0.00	13.52	7	0.420	$2.18x10^{-8}$	1.60	$9.18x10^{-11}$	641	2.69	Lean CLAY	CL	
		D12	8.00-8.45		37.33	36.32	23.21	13.11	1.08			91.48	8.52	0.00							856		Lean CLAY	CL	3
		D13	9.00-9.45		62.27	36.36	22.21	14.15	2.83	-	-	96.48	3.52	0.00							794	-	Lean CLAY	CL	3
		U14	9.50-10.00		36.24	36.65	21.14	15.51	0.97	13.74	10.09	95.50	4.50	0.00	13.52	7	0.186	$8.69x10^{-9}$	0.86	$1.61x10^{-10}$	868	2.69	Lean CLAY	CL	
		D15	10.00-10.45		36.24	35.20	21.12	14.08	1.07			99.37	0.63	0.00							987		Lean CLAY	CL	4
		U16	10.50-11.00		28.64	36.32	20.21	16.11	0.52	13.21	10.27	97.91	2.09	0.00	13.52	7					-	2.69	Lean CLAY	CL	-
		D17	11.00-11.45		24.70	36.32	22.10	14.22	0.18	-	-	98.13	1.87	0.00	-	-					467	-	Lean CLAY	CL	2
		D18	12.00-12.45		24.72	35.26	18.32	16.94	0.38			98.61	1.39	0.00							439		Lean CLAY	CL	2
		U19	12.50-13.00		32.85	36.32	19.32	17.00	0.80	12.58	9.47	55.90	44.10	0.00	11.13	5	0.094	$1.91x10^{-9}$	0.67	$1.80x10^{-11}$	3085	2.69	Sandy lean CLAY	CL	-
	6	D20	13.00-13.45	Stiff to very stiff sandy lean CLAY (CL), Q-4, alluvia, wet soil layer.	13.52	35.26	22.23	13.03	-0.67			51.50	48.50	0.00							2824	-	Sandy lean CLAY	CL	14
		U21	13.50-14.00		16.94	36.23	22.15	14.08	-0.37	18.24	15.59	51.14	48.86	0.00	46.91	7					-	2.69	Sandy lean CLAY	CL	-
		D22	14.00-14.45		17.15	36.36	21.10	15.26	-0.26			64.35	34.10	1.55							3257		Lean CLAY, with sand	CL	17
		D23	15.00-15.45		17.23	36.32	19.32	17.00	-0.12			71.61	28.39	0.00							2383	-	Lean CLAY, with sand	CL	13
		U24	15.50-16.00		20.15	36.64	20.14	16.50	0.00	18.25	15.19	70.30	29.70	0.00	52.48	5					-	2.70	Lean CLAY, with sand	CL	-
	7	D25	16.00-16.45	Very stiff fat CLAY (CH), Q-4, alluvia.	28.04	58.58	22.30	36.28	0.16			95.06	4.94	0.00							3858		Fat CLAY	CH	22
		U26	16.50-17.00		27.03	58.97	22.31	36.66	0.13	20.40	14.98	94.22	5.78	0.00	58.84	8					-	2.69	Fat CLAY	CH	-
BH-5	7	D27	17.00-17.45	Very stiff fat CLAY.	12.88	58.65	23.25	35.40	-0.29	-	-	82.43	17.57	0.00	-	-					3040	-	Fat CLAY, with sand	CH	18
	8	D28	18.00-18.45	Medium dense very clayey-well-graded fine to medium SAND, gravel.	16.17	33.32	18.32	15.00	-0.14	-	-	45.24	54.76	0.00							2933	-	Clayey-well-graded SAND	SC	18
		D29	19.00-19.45		16.27	35.20	18.39	16.81	-0.13	-	-	40.58	59.42	0.00							3307	-	Clayey-well-graded SAND	SC	21
		D30	20.00-20.45		16.17	34.15	18.97	15.18	-0.18	-	-	43.55	56.45	0.00							3053	-	Clayey-well-graded SAND	SC	20
	9	D31	21.00-21.45	Dense very clayey-well-graded fine to medium SAND, gravel.	15.89	35.25	19.58	15.67	-0.24	-	-	27.38	71.06	1.55							6504	-	Clayey-well-graded SAND	SC	44
		D32	22.00-22.45		16.45	34.12	18.97	15.15	-0.17			13.66	86.34	0.00							5895		Clayey-well-graded SAND	SC	41
		D33	23.00-23.45		17.29	35.11	20.40	14.71	-0.21	-	-	13.13	86.87	0.00							6160	-	Clayey-well-graded SAND	SC	44
		D34	24.00-24.45		15.80	36.23	18.33	17.90	-0.14	-	-	12.25	87.75	0.00							6008	-	Clayey-well-graded SAND	SC	44
	10	D35	25.00-25.45	Hard to very hard lean CLAY.	15.99	40.10	19.32	20.78	-0.16			98.01	1.99	0.00							6797		Lean CLAY	CL	51
		U36	25.50-26.00		15.08	44.00	22.00	22.00	-0.31	20.42	17.58	96.82	3.18	0.00	73.15	11					-	2.67	Lean CLAY	CL	-
		D37	26.00-26.45		17.08	39.39	20.21	19.18	-0.16	-	-	97.15	2.85	0.00	-	-					6124	-	Lean CLAY	CL	47
	11	D38	27.00-27.45	Very stiff becoming hard fat CLAY.	17.21	59.65	25.65	34.00	-0.25			90.38	9.62	0.00							3321		Lean CLAY	CH	26
		D39	28.00-28.45		17.73	60.20	26.32	33.88	-0.25			92.86	7.14	0.00							3004	-	Lean CLAY	CH	24
		D40	29.00-29.45		19.82	59.65	25.65	34.00	-0.17			91.17	8.83	0.00							3433		Lean CLAY	CH	28
		D41	30.00-30.45		19.46	56.65	21.12	35.53	-0.05	-	-	86.90	13.10	0.00	-	-					4445	-	Lean CLAY	CH	37
	12	D42	31.00-31.45	Dense very clayey-well-graded fine to medium SAND, gravel.	20.80	32.23	18.23	14.00	0.18			32.53	67.47	0.00							4128		Clayey-well-graded SAND	SC	35
		U43	31.50-32.00		17.31	40.00	18.32	21.68	-0.05	20.40	17.59	32.85	67.15	0.00	1.59	39					-	2.69	Clayey-well-graded SAND	SC	-
		D44	32.00-32.45		19.72	32.05	18.32	13.73	0.10			46.89	53.11	0.00							4402	-	Clayey-well-graded SAND	SC	38
	13	D45	33.00-33.45	Hard sand lean CLAY.	19.14	36.65	18.97	17.68	0.01			51.34	48.66	0.00							4213		Sandy lean CLAY	CL	37
	14	D46	34.00-34.45	Very dense very well-graded medium to coarse SAND, gravel.	8.09	32.05	17.28	14.77	-0.62			27.77	68.61	3.62							10949		Clayey-well-graded SAND	SC	98
		D47	35.00-35.45		8.15	32.65	17.17	15.48	-0.58			27.59	71.67	0.74							10225		Clayey-well-graded SAND	SC	93
	15	D48	36.00-36.45	Very hard lean CLAY, gravel.	17.79	40.10	23.23	16.87	-0.32			92.78	5.18	2.05							5527		Lean CLAY	CL	51
		D49	37.00-37.45		18.31	39.32	22.21	17.11	-0.23			97.59	2.41	0.00							5657		Lean CLAY	CL	53
		D50	38.00-38.45		16.65	40.12	22.40	17.72	-0.32			89.59	9.20	1.21							6728		Lean CLAY	CL	64
		D51	39.00-39.45		15.95	38.38	19.32	19.06	-0.18			92.83	7.17	0.00							6219		Lean CLAY	CL	60
		D52	40.00-40.45		13.00	38.98	20.25	18.73	-0.39			75.85	18.29	5.86							6439		Lean CLAY, with sand	CL	63

Source: Survey Team

(4) Water Level Survey

Water level survey is conducted to clarify water level around STP construction site. Survey results are employed to design ground level of STP site and hydraulic profile of sewage treatment facilities in STP. Outline of water level survey is summarized in **Table R 1.3.8**. Survey location is shown in **Fig. R 1.3.10** and condition of the survey is shown in **Photo R 1.3.3**.

Table R 1.3.8 Outline of Water Level Survey

Period	Frequency
From June 2018 to August 2018, from November 2018 to March 2019	Once per week
From September 2018 to October 2018	Three times per week

Source: Survey Team

Source: Survey Team

Fig. R 1.3.10 Location of Water Level Survey

Site at WG1

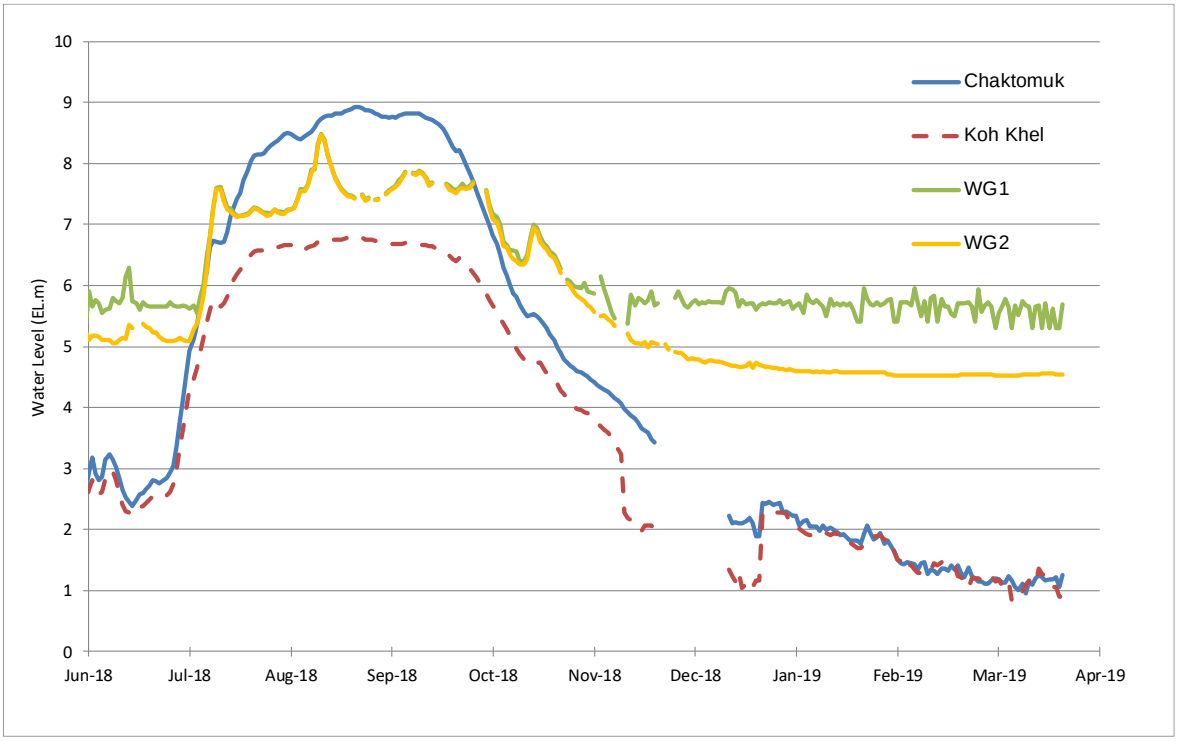
Site at WG2

Source: Survey Team

Photo R 1.3.3 Site of Water Level Survey

Results of water level at WG1 and WG2 are shown in **Fig. R 1.3.11**, with water level at Chaktomuk and Koh Khel stations as a reference. Maximum water level of EL. +8.48 m was recorded at WG1 in August 2018, and minimum water level of EL. +4.53 m was recorded at WG2 in March 2019.

In general, water level at WG1 and WG2 are higher than those of Chaktomuk and Koh Khel stations in the dry season. On the other hand, water level at WG1 and WG2 are lower than those of Chaktomuk and Koh Khel stations in the rainy season. This result shows that the water level of Cheung Aek Lake is affected by outer water level.



Note: Data from December 2018 to March 2019 at Chaktomuk and Koh Khel stations are those from December 2017 to March 2018, because the data are not available.
Source: Survey Team

Fig. R 1.3.11 Result of Water Level Survey

(5) Water Quality and Sediment Analysis

Water quality and sediment analysis is conducted to clarify water quality and contamination of heavy metals in the sediment in and around STP construction site, as well as drainage channels including Trabek Channel. Survey results are employed to design sewage and sludge treatment facilities in STP. Outline of the survey is summarized in **Table R 1.3.9**. Survey location is shown in **Fig. R 1.3.12** and condition of the survey is shown in **Photo R 1.3.4**. The survey results are summarized in **Table R 1.3.10**.

- BOD, TSS: high BOD was observed in the dry season (December 2018), with the maximum of 215 mg/L at W-2. Maximum BOD at W-1a and W-1b, which are located near the interception facilities in the project, was 185 mg/L (observed in December 2018). TSS at W-1a and W-1b varies from 42 mg/L (observed in August 2018) to 296 mg/L (observed in December 2018). The low TSS in August arises from stormwater in the rainy season.

- T-N, T-P and heavy metals: these parameters are monitored as a reference, because these parameters are not targeted to remove in the sewage treatment plant in this project. As for T-N, minimum and maximum values were recorded at 16.1 mg/L and 44.8 mg/L. Minimum and maximum of T-P were recorded at 1.27 mg/L and 6.0 mg/L. All of the heavy metals were not detected or do not exceed water quality standard[2].

- Sediment: the standard for sediment in the water is not available. Therefore, the monitoring results are compared with the standard for solid waste "Prakas No. 387:Standards of the quantity of toxic chemicals or hazardous substances contained in hazardous waste which is allowed to be disposed in sanitary landfills". As a result, all the data do not exceed the standard.

Table R 1.3.9 Outline of Water Quality and Sediment Analysis

Contents	Water Sampling and Analysis	Sediment Sampling and Analysis
Sampling Location	W-1a: Wastewater discharge point (Intake point of the Trabek Pumping Station) W-2b: Wastewater discharge point (Discharge point of the Trabek Pumping Station) W-2: Trabek Drainage Channel (St. 288) W-3: Tumpun Pumping Station W-4: Tumpun Drainage Channel W-5: Proposed construction site of Sewage Treatment Plant	S-1: Wastewater discharge point (In the vicinity of the Trabek Pumping Station) S-2: Proposed construction site of Sewage Treatment Plant
Analysis Parameter	● pH, DO, T-BOD, S-BOD, T-COD_{Cr}, S-COD_{Cr}, TSS, T-N, NH_4-N, T-P, Total Coliform ● Heavy Metal (Cadmium(Cd), Lead(Pb), Mercury(Hg), Selenium(Se), Arsenic(As), Hexavalent Chrome(Cr^{6+}))	● Heavy Metal (Cadmium(Cd), Lead(Pb), Mercury(Hg), Selenium(Se), Arsenic(As), Hexavalent Chrome(Cr^{6+}))

[2] Samples monitored in this survey deem to be not river/lake water but wastewater, considering monitoring locations. Therefore, the monitoring results are compared with the standard for "Public Water Area and Sewer" in the "Effluent Standard for Public Water Areas or Sewer", MOE.

Contents	Water Sampling and Analysis	Sediment Sampling and Analysis
Term	Rainy Season：June 2018 Dry Season：December, 2018	Fine weather in June 2018

Source: Survey Team

Source: Survey Team

Fig. R 1.3.12 Location of Water Quality Survey

Site at W-1(S-1)

Site at W-5(S-2)

Source: Survey Team

Photo R 1.3.4 Site of Water Quality Survey

Table R 1.3.10 Results of Water Quality and Sediment Analysis

No	Item	Standard	Unit	W-1 a	W-2	W-3	W-4	W-5	W-1 a		W-1 b		W-1 a	W-1 b	W-2	W-3	W-4	W-5
									taken in AM	taken in PM	taken in AM	taken in PM						
Date of Monitoring				18 June 2018					22 August 2018				13 December 2018					
1	Water Quality Analysis																	
1	pH	5.0-9.0	-	6.99	7.21	7.17	7.26	7.10	6.95	7.09	7.18	7.26	6.86	6.99	7.21	7.14	7.16	6.99
2	DO	> 1.0	mg/L	2.30	2.20	2.40	2.10	2.30	2.30	2.20	2.50	2.60	2.10	2.30	2.30	2.20	2.10	2.50
3	T-BOD_5	< 80	mg/L	85	93	98	78	83	115	155	180	145	135	185	215	190	170	185
4	S-BOD5	N/A	mg/L	47	55	56	49	47	63.0	65.0	61.0	59.0	65	69	71	73	68	67
5	T-COD_{Cr}	< 100	mg/L	160	170	180	150	160	210	280	270	260	285	355	425	395	370	375
6	S-COD_{Cr}	N/A	mg/L	145	160	170	138	135	195	260	245	240	215	265	340	340	290	310
7	TSS	< 120	mg/L	66	86	84	110	56	62.0	46.0	42.0	68.0	152	296	196	104	340	172
8	T-N	N/A	mg/L	16.5	17.5	16.1	17.4	16.4	26.0	27.5	28.0	27.2	35	43	37.8	44.8	38.5	25.2
9	NH_4-N	< 7	mg/L	12.6	14.0	8.4	11.2	9.8	11.2	12.6	14.0	11.8	7.8	9.1	7.7	9.8	8.0	6.3
10	NO_2	N/A	mg/L	0.10	0.10	0.10	0.10	0.10	0.03	0.03	0.03	0.03	0.09	0.07	0.08	0.07	0.07	0.03
11	NO_3	< 20	mg/L	0.41	0.38	0.57	0.41	0.79	0.20	0.20	0.20	0.20	0.74	0.69	0.72	0.70	0.69	0.53
12	T-P	N/A	mg/L	1.27	1.55	1.75	1.60	1.89	1.43	1.35	1.34	1.40	6.00	4.25	5.25	5.50	3.25	3.00
13	Cadmium(Cd)	< 0.5	mg/L	ND	ND	ND	0.024	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14	Lead(Pb)	< 1.0	mg/L	ND	0.100	ND	0.450	0.065	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	Mercury(Hg)	< 0.05	mg/L	0.038	ND	ND	0.041	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16	Selenium(Se)	< 0.5	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
17	Arsenic(As)	< 1.0	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18	Chromium (Cr^{6+})	< 0.5	mg/L	0.026	0.019	0.013	0.022	0.029	0.013	0.016	0.019	0.022	0.160	0.220	0.430	0.190	0.300	0.140
19	Total Coliform	N/A	CFU/100mL	5.2E+03	4.8E+05	5.9E+05	5.4E+05	5.6E+03	1.3E+07	1.6E+07	2.0E+07	2.3E+07	2.1E+07	2.5E+07	1.9E+07	2.4E+07	1.1E+06	2.2E+06
20	E. coli	N/A	CFU/100mL	4.8E+02	3.7E+04	4.1E+04	4.7E+04	3.9E+03	1.2E+07	1.4E+07	1.9E+07	2.2E+07	1.6E+07	1.4E+07	1.3E+07	1.2E+07	9.9E+05	8.2E+05

No	Item	Refer-ence[1)]	Unit	S-1	S-2
Date of Monitoring				18 June 2018	
2	Sediment Analysis				
2.1	Analysis (Dissolution)				
1	Cadmium(Cd)	< 5	mg/kg	0.29	0.23
2	Lead(Pb)	< 420	mg/kg	0.19	2.40
3	Mercury(Hg)	< 10	mg/kg	1.33	0.45
4	Selenium(Se)	< 100	mg/kg	ND	ND
5	Arsenic(As)	< 40	mg/kg	0.67	1.15
6	Chromium (Cr^{6+})	< 380	mg/kg	1.35	4.29
2.2	Analysis (Acid Digestion)				
1	Cadmium(Cd)	< 5	mg/kg	1.12	1.41
2	Lead(Pb)	< 420	mg/kg	3.92	7.22
3	Mercury(Hg)	< 10	mg/kg	3.58	1.71
4	Selenium(Se)	< 100	mg/kg	0.11	0.10
5	Arsenic(As)	< 40	mg/kg	1.41	1.59
6	Chromium (Cr^{6+})	< 380	mg/kg	3.02	6.15

Note 1) : Prakas No. 387:Standards of the quantity of toxic chemicals or hazardous substances contained in hazardous waste which is allowed to be disposed in sanitary landfills

Source: Survey Team

(6) Water Quality Monitoring Data of PPCC

Water quality in and around PPCC is monitored by MOE once a month. According to the data of MOE from January 2010 to December 2017, water quality is monitored at 9 points (Point A to I from 2010 to 2013, as well as Point A to H and J from 2014 to 2017) as shown in **Table R 1.3.11** and **Fig. R 1.3.13** with the parameters of pH, TSS, BOD, COD, T-N, T-P and Cr^{6+}.

Of the nine points, 5 points (A, B, C, D and E) are monitored to meet "Water Quality Standard at River" and other 4 points (F, G, H, I and J) are monitored to meet "Effluent Standard for Public Water Area and Sewer". Results of analysis in **Fig. R 1.3.14** and **Fig. R 1.3.15**, and minimum, maximum and average at each monitoring point is summarised in **Table R 1.3.12**.

In addition, present conditions of water quality at monitoring points of 1) Point H (Trabek), at which wastewater is introduced to the proposed STP and 2) Point C (Prek Thnot River, Thakhmao Bridge), at which accumulated water in Cheung Aek Lake is currently discharged and treated water in the proposed STP will be finally discharged, are enumerated below.

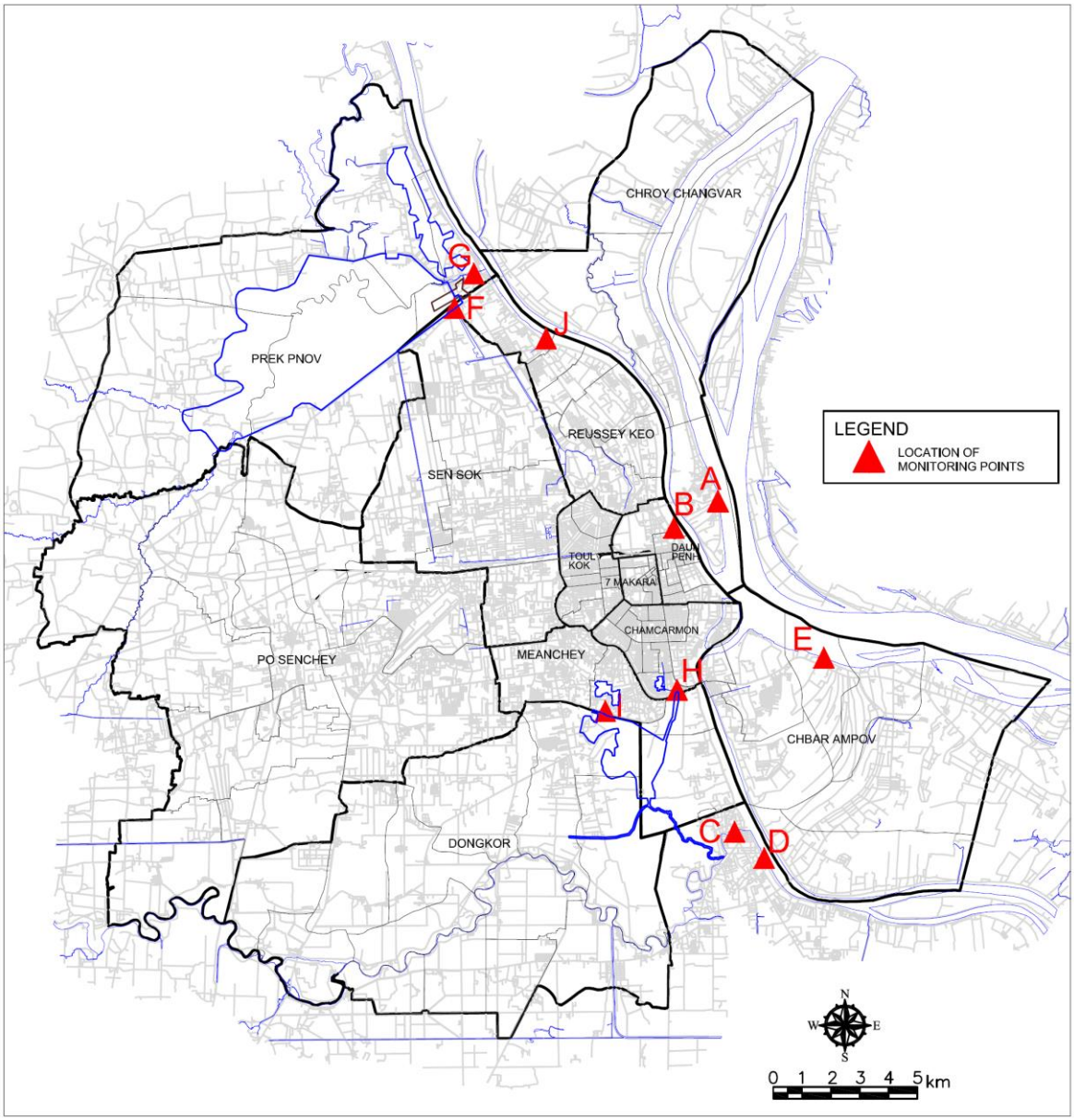
- At Point C (Prek Thnot River, Thakhmao Bridge), at which wastewater from Cheung Aek Lake is discharged: highest BOD_5 was recorded in the dry season with values ranging from 40 mg/L to 70 mg/L in the past several years. On the other hand, TSS ranges from about 80 mg/L to 130 mg/L in the past several years. In the rainy season, high T-N was observed with values ranging from 6 to 9 mg/L. T-P ranges from 1.0 mg/L to 2.0 mg/L.

- At Point H (Trabek), at which wastewater is introduced to the proposed STP: highest BOD_5 was recorded in the 9 monitoring points with average of about 208 mg/L. In particular, values of last 3 years were higher than those of others. In general, TSS ranges from 120 mg/L to 220 mg/L. High T-N was recorded in the rainy season with values from 12 mg/L to 18 mg/L. T-P ranges from 1.0 mg/L to 3.0 mg/L. No Cr^{6+} data exceeds the discharge criteria (0.5 mg/L).

Table R 1.3.11 Monitoring Points by MOE and Available Data

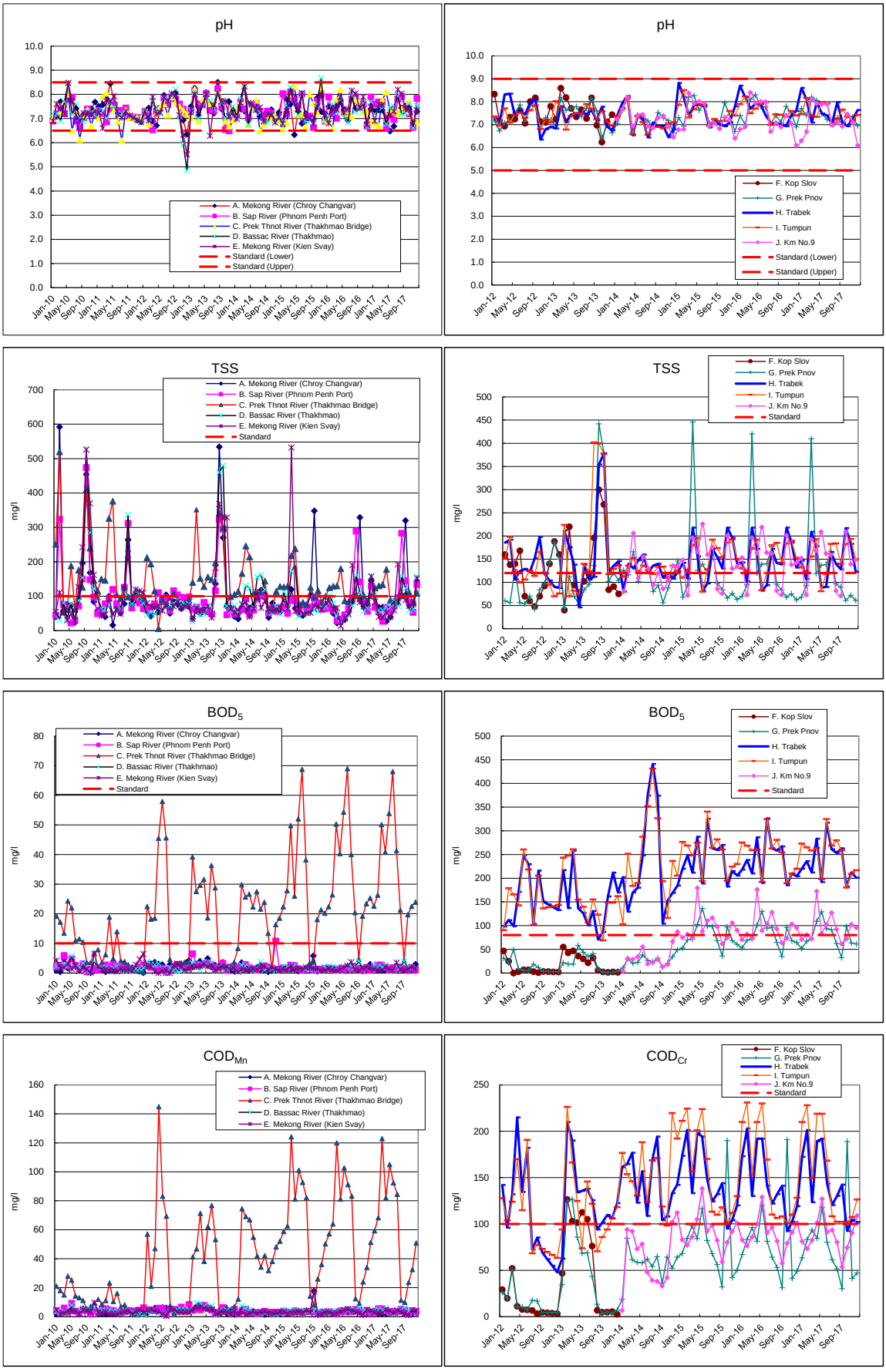
No.	Monitoring Points	Available Data
A	Mekong River (Chroy Changvar)	Data: January 2010 to December 2017
B	Sap River (Phnom Penh Port)	
C	Prek Thnot River (Thakhmao Bridge)	
D	Bassac River (Thakhmao)	
E	Mekong River (Kien Svay)	
F	Kop Slov	January 2012 to December 2013
G	Prek Pnov	January 2012 to December 2017
H	Trabek	Ditto
I	Tumpun	Ditto
J	Km. No.9	January 2014 to December 2017

Source: MOE, Survey Team



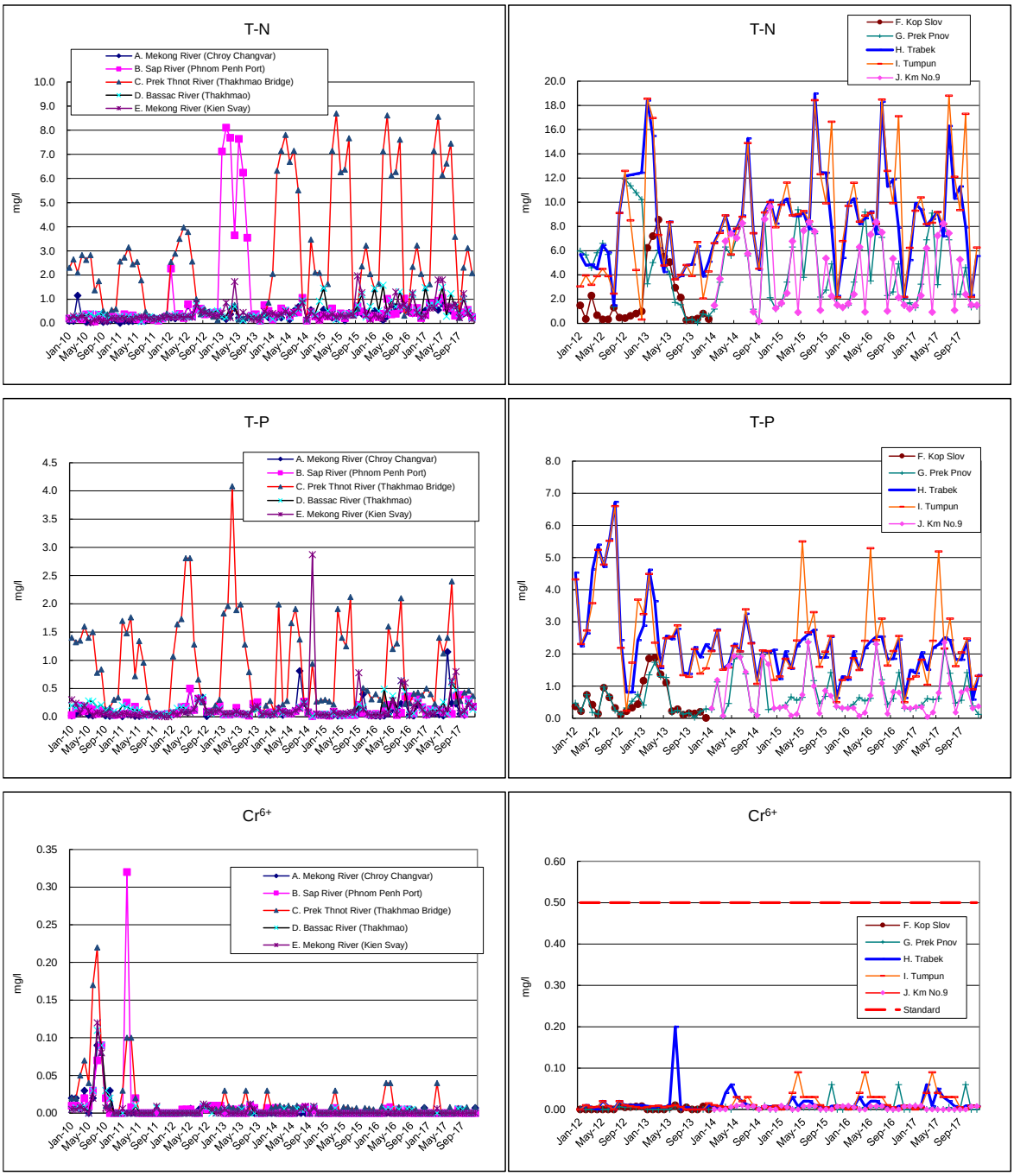
Source: MOE, Survey Team

Fig. R 1.3.13 Monitoring Points by MOE



Source: MOE, Survey Team

Fig. R 1.3.14 Analysis Result of Monitoring by MOE (1/2)



Source: MOE, Survey Team

Fig. R 1.3.15 Analysis Result of Monitoring by MOE (2/2)

Table R 1.3.12 Minimum, Maximum and Average at Monitoring Points

Location		pH (-)	TSS (mg/L)	BOD (mg/L)	COD_{Mn} (mg/L)	COD_{Cr} (mg/L)	T-N (mg/L)	T-P (mg/L)	Cr^{6+} (mg/L)
A. Mekong River (Chroy Changvar)	Min	6.33	16.0	0.1	1.4	-	0.01	0.01	ND
	Max	8.50	592.0	5.8	17.6	-	1.15	1.15	0.090
	Average	7.35	97.9	1.7	3.6	-	0.35	0.10	0.021
B. Sap River (Phnom Penh Port)	Min	6.49	22.0	0.2	1.4	-	0.08	0.01	ND
	Max	8.24	474.0	10.8	9.3	-	8.11	0.50	0.320
	Average	7.36	94.3	2.1	4.0	-	0.86	0.12	0.021
C. Prek Thnot River (Thakhmao Bridge)	Min	6.09	5.8	0.2	1.3	-	0.13	0.03	ND
	Max	8.38	520.0	69.0	145.0	-	8.69	4.08	0.220
	Average	7.31	137.8	21.2	40.8	-	2.72	0.87	0.024
D. Bassac River (Thakhmao)	Min	4.85	22.0	0.1	0.8	-	0.07	0.01	ND
	Max	8.67	526.0	5.8	9.4	-	1.58	0.64	0.110
	Average	7.33	97.4	1.9	4.0	-	0.49	0.13	0.015
E. Mekong River (Kien Svay)	Min	5.52	14.0	0.0	0.6	-	0.04	0.00	ND
	Max	8.47	532.0	6.5	17.6	-	1.97	2.87	0.120
	Average	7.37	99.5	1.7	3.5	-	0.44	0.15	0.017
Standard for A. to E.		6.5-8.5	<100	<10	-	-	-	-	<0.05
F. Kop Slov	Min	6.24	40.0	0.7	-	2.6	0.26	0.01	ND
	Max	8.59	300.0	54.8	-	126.4	8.56	1.88	0.010
	Average	7.49	129.1	16.4	-	35.4	2.08	0.56	0.007
G. Prek Pnov	Min	6.41	42.0	1.0	-	3.4	0.09	0.03	ND
	Max	8.30	446.0	136.2	-	191.0	11.93	2.38	0.060
	Average	7.40	122.9	49.6	-	60.0	4.50	0.70	0.011
H. Trabek	Min	6.35	46.0	70.9	-	47.9	1.48	0.58	ND
	Max	8.82	378.0	441.0	-	215.0	18.98	6.73	0.200
	Average	7.43	147.0	207.7	-	136.0	8.48	2.31	0.017
I. Tumpun	Min	6.56	70.0	68.9	-	63.5	0.32	0.23	ND
	Max	8.51	402.0	431.3	-	231.0	18.80	6.60	0.090
	Average	7.43	150.4	219.7	-	141.0	8.47	2.40	0.019
J. Km No.9	Min	6.09	71.0	4.0	-	6.7	0.18	0.04	ND
	Max	8.40	226.0	179.5	-	138.2	9.64	2.36	0.010
	Average	7.25	141.3	80.1	-	83.0	4.15	0.73	0.008
Standard for F to I.		5.0-9.0	<120	<80	-	<100	-	-	<0.5

ND: Not Detected
Source: MOE, Survey Team

In addition, effluent from factories has been monitored by MOE. The number of monitored factories in 2017 was 28 factories, 16 of which are in Phnom Penh with six monitoring parameters, pH, TSS, BOD_5, COD_{Cr}, Oil & Grease, NH_3. Based on the monitoring data, one factory exceeded COD_{Cr} discharge criteria and one factory exceeded pH discharge criteria, both of which are located in PPCC.

1.4 Environmental and Social Considerations

1.4.1 Environmental Impact Assessment

1.4.1.1 Outline of the Project having an Environmental Impact

Outline of the Project having an environmental impact are as summarised in **Table R 2.1.1**.

1.4.1.2 Basic Information of Environmental and Social Situation

(1) Natural Environment

(a) Geology

In terms of geological conditions of Cambodia, almost all of the land is situated on relatively-new ground, such as quaternary sedimentary rocks and unconsolidated sediments. Relatively old soil such as the upper Jurassic-cretaceous sedimentary unit, exists in the northeast area. Lower-middle Jurassic sedimentary units are situated in the southwest part of Cambodia. Phnom Penh is mainly located on quaternary sedimentary rocks.

(b) Soil

Geologic structure of the Mekong Delta region, where the Study Area is situated, had been formed in Precambrian to Holocene ages. Old Alluvium was formed in deltaic shape between the Pliocene and Pleistocene by the Mekong and its tributaries and then Holocene deltaic alluvium was formed. The Holocene Alluvium, mainly consisting of unconsolidated silt and clay with some lenses of sand, virtually blankets the entire delta. The Holocene Alluvium in and around the Study Area generally has a thickness of less than 25 m.

The Holocene Alluvium differs from the Old Alluvium in having a generally finer texture, almost no laterite, and a relative abundance of shell and lignite layers. The surface geological condition of PPCC is characterised by the sandy mud covered on base terrane inclined from west to east, as well as soft clay layer at some places.

(c) Hydrology

The water level of the Mekong River is measured at Chrauy Changva Station, while that of the Sap River is measured at Chaktmuk and Phnom Penh Port stations by MOWRAM. The highest water level of Bassac and Sap rivers is generally recorded during August to October. Among annual highest water level in recent 5 years (2009-2013), the highest water level of Bassac River is 9.84 m (2011) and lowest level is 7.47 m (2010). On the other hand, water level during March to May is very low (1.2 m). Annual variation of the river water levels sometimes reaches approximately 8.0 m.

The river flows have seasonal fluctuations: the maximum flow of the Mekong River is more than 30,000 m^3/s during the rainy season when it counterflows towards Sap River.

(d) Air Quality

Available air quality monitoring as secondary information is still limited in Cambodia. According to the results of the monitoring of ambient air pollution (Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014,), CO, NO_2 and SO_2 values are within the standard. However, the dust parameters of particulate matters (PM 2.5, PM 10) are very high. The trend found in the record in 2001 was high Total Suspended Particles (TSP).

(e) Water Quality

Water quality in and around PPCC is monitored by MOE once a month (see **Section 1.3**).

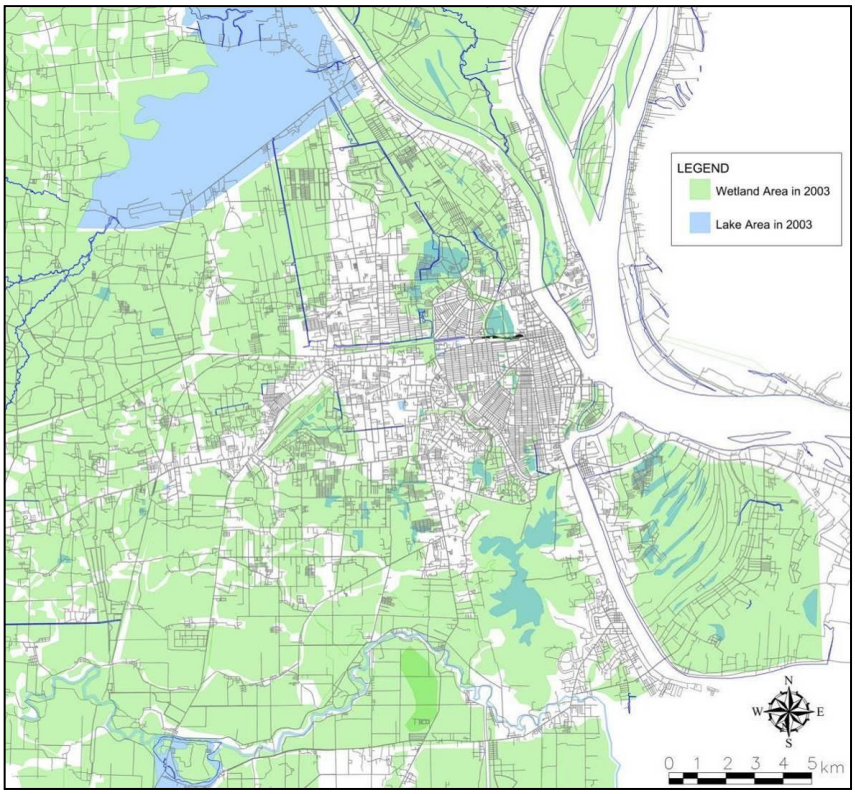
(f) Ecosystem

Cambodia accommodates more than 135 species of mammals, 599 species of birds, 173 species of reptiles, 72 species of amphibians, 350 species of moths and butterflies, 955 fresh and marine fish and aquatic species, and more than 4,500 vascular plant species (2014, The Fifth National Report to the Convention on Biological Diversity). Located at the middle Cambodia, Phnom Penh also has similar potential for biodiversity. Among the species, 74 vertebrate animal and 23 plant species were listed as endangered species in the Red List in the IUCN at 2011.

(2) Social Environment

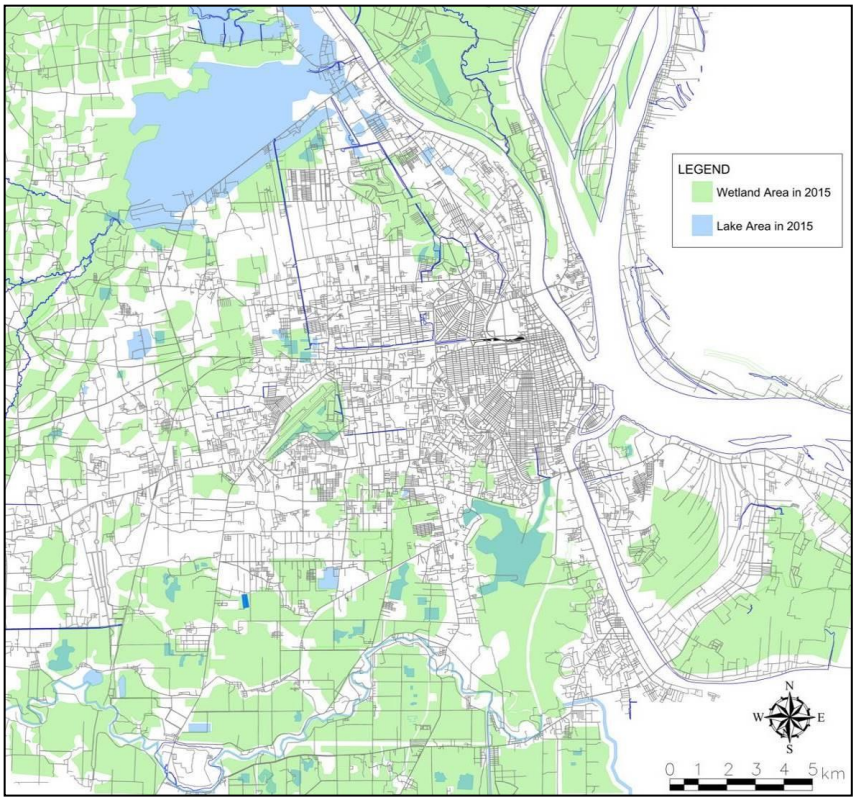
(a) Land Use

As the urban development Master Plan of PPCC, the "White Book on Development and Planning of Phnom Penh" was issued in October 2007 (hereinafter referred to as "White Book"). In the White Book, the land use plan for the target year 2035 was formulated based on land use in 2004. The land use plan was approved in the committee for land management and urban planning for the capital, which was established in accordance with a Royal Decree, and finally approved with the issuance of sub-decree dated on 23rd December 2016. As for actual land use of PPCC, lake and swamp area the area decreased almost by half due to urbanization and industrialization in PPCC, as shown in **Fig. R 1.4.1** and **Fig. R 1.4.2**, which present lakes and swampy areas in the years of 2003 and 2015.



Source: Final Report of the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area

Fig. R 1.4.1 Area of Lakes and Swamps in Phnom Penh (2003)



Source: Final Report of the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area

Fig. R 1.4.2 Area of Lakes and Swamps in Phnom Penh (2015)

(b) Economy

Although the average total monthly income by household in Cambodia dropped in the year 2011, the income increased as a whole. The average monthly total income by household was 1,236 thousand Riels (approximately 309 USD based on the exchange rate 1UD=4thousand Riels) per household in 2013 with about 20% of annual growth rate (average monthly total income growth by household was 21.3% from 2012 to 2013).

As with the national trend, in PPCC, the average total monthly income by household slightly dropped in 2011 and the average in 2013 was 2,517 thousand Riels (about 625 USD based on the exchange rate 1UD=4thousand Riels). Annual growth rate from 2012 to 2013 was 33.5 %. The total household income in PPCC was about twice as high as that in the national average

(c) Ethnic Group

People in Cambodia consist of Khmer (90%), Vietnamese (5%), Chinese (1%) and other ethnic groups (4%). Among the other ethnic groups, Cham, Thai, Lao and Khmer Loeu have comparatively high populations. Based on the recent sampling of the Cambodia Socio-Economic Survey (CSES), the population of Khmer accounts for more than 97%.

(d) Road

In parallel with the economic development, traffic flow has become heavy in PPCC. The traffic volume in PPCC is 60 to 90 thousand vehicles/day. Seventy-five percent of the traffic consists of motorcycles.

(e) Solid Waste

There are three waste management companies in PPCC; namely, 1) CINTRI: collection and transport of domestic waste; 2) Carom: collection and dispose of industrial waste; and 3) Red Cross Phnom Penh: burning of hazardous waste (waste from hospitals). PPCC is managing the landfill site in Dangkor District. Capacity of the site is approximately 31.4 ha. The landfill site of industrial waste is managed by the Carom in Po Senchey District in an area of approximately 5 ha. Also, the following facts are identified.

- The waste collection business registration system has been established. As for solid waste collection, CINTRI Co. Ltd., among the waste collection businesses, has been granted an exclusive contract.
- Transported volume of solid waste is 1,800 to 2,000 t/day, and disposal cost at the Dangkor Landfill Site is about 0.75USD/t.
- Segregation (combustible waste, garbage, non-combustible waste) has not been carried out in PPCC.

(f) Sanitation and Livelihood

The Cheung Aek Lake is used for flood control and natural wastewater treatment lagoon of Phnom Penh before flowing into Bassac River. Swamp area, seasonal land area and permanent water body in the lake have been used by the people for the cultivation of aquatic plants and animal husbandry and fisheries.

1.4.1.3 Legal Framework of Environmental and Social Considerations

(1) Legislation and Legal Procedure for Environmental and Social Considerations in Cambodia

(a) Legislation

Relative laws and regulations for Environmental and Social Considerations in Cambodia are below;

Table R 1.4.1 Relative Laws and Regulations for Environmental and Social Considerations in Cambodia

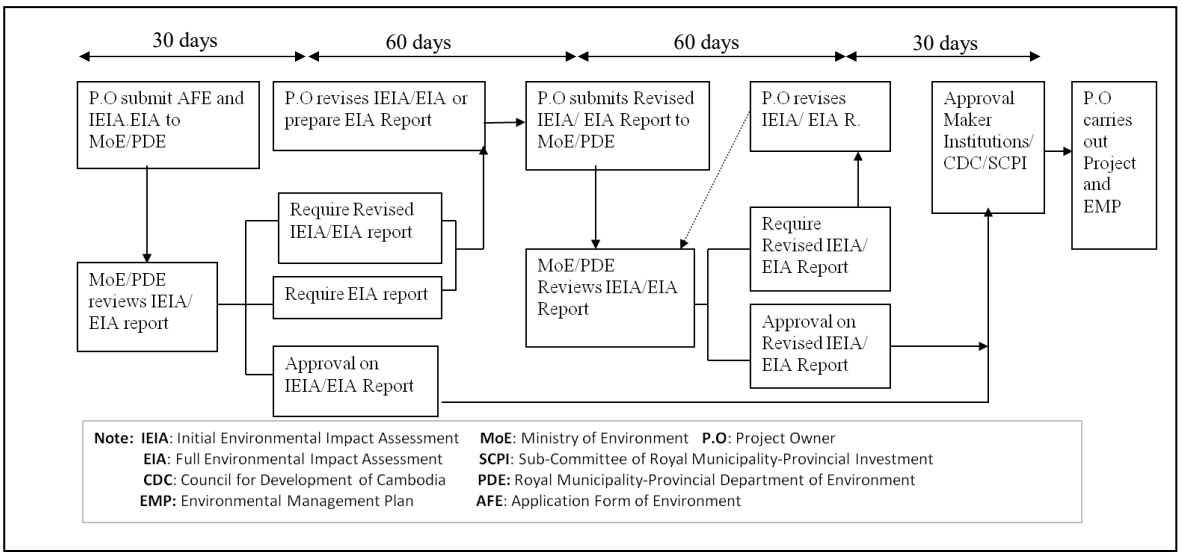
No.	Legislation	Description
1.	Royal Decree Constitution of the Kingdom of Cambodia (September 24, 1993)	The constitution was stated the Khmer language is official use in the kingdom of Cambodia. All persons, individually or collectively, shall have the rights to own property.
2	Royal Decree NS-PKM-1296/36, 1996, Law on Environmental Protection and Natural Resource Management (18 November 1996)	As the principal law on environmental protection, the law provides for a national environment policy, national and regional environment plans, assessment of impact on the environment of projects and activities, management of natural resources, monitoring, data collection and inspection, and participation of the public in relation to the environment.
3.	No. 07 NS/RKM/2008, Protected Areas Law (Royal Decree No. NS/RKM/2008/007)	This Law provides for the management, conservation and development of natural protected areas to ensure the conservation of biodiversity and guarantee the use of natural resources in a sustainable manner consisting of 11 Chapters divided into 66 articles.
4.	Anukret (Sub-decree) No. 72 ANRK.BK, 1999, on Environmental Impact Assessment (EIA) Process (11 August 1999)	This Sub-decree provides the detailed guidelines for implementation of the IEIA/EIA Process.
5.	Anukret (Sub-decree) No.27 ANRK/BK/1999, on Water Pollution Control, 1999 (April 6, 1999)	This Sub-decree regulates activities that cause pollution in public water areas in order to sustain good water quality so that the protection of human health and the conservation of biodiversity are ensured.
6.	Anukret (Sub-decree) No.36 ANRK.BK. in 1999, on Solid Waste Management, 1999	This Sub-decree regulates solid waste management to ensure the protection of human health and the conservation of biodiversity.
7.	Anukret (Sub-decree) No. 42 in 2000, on the Control of Air Pollution and Noise Disturbance, 2000 (July 10, 2000)	This Sub-decree provides for the management, prevention and control of air and noise pollution, detailing in the Annexes the threshold values for emissions, outlaying the procedures and legal requirements to limit and provide for the pollutants.
8.	Anukret (Sub-decree) No. 123ANRK.BK. in 2009, on determining the type of fishery products, which are endangered in 2009	This Sub-decree identifies endangered fish and aquatic species in Cambodia as Cr, En and Vu. The aquatic species identified by the sub-decree are protected.
9.	Prakas (Declaration) No.020 in 2007, January, 2007 of MOAFF on Classification and List of Wildlife Species.	Declaration identifies endangered wildlife species (Mammals, Reptile and birds) as Critically Endangered (Cr), Rare (R) and Moderately Exist species in Cambodia. The Cr and R species are protected species.

No.	Legislation	Description
10.	Prakas(Declaration) No. 376 BRK.BST, 2009 on General Guideline for conducting IEIA1/EIA Reports, 2009	Declaration on General Guideline for Preparing Initial Environmental Impact Assessment (IEIA) and EIA Reports was issued by the Ministry of Environment (MOE) in 2009.
11.	Prakas (Joint Declaration) between MOE and MEF No. 745 MEF/MOE 2000, on Determination of Service Fee for EIA reviewing and Monitoring (20th October 2000)	This declaration provides the fee for the environmental services. The fees are determined depending on the categories. The categories are Industrial, Agriculture, Tourism, and Infrastructure.
12.	Prakas (Declaration) No. 1033, 1994, on Protected Areas, 1994	This "Prakas" (Declaration) of the Ministry of the Environment prohibits a series of acts in natural protected areas in the sense of Royal Decree of 1 November, 1993 on the Protection of Natural Areas.
13.	Prakas (Declaration) No. 230 in 2005, on the Delegation of Power of Decision-Making on Project Development to the Provincial Department of Environment, 2005	Declaration on the Delegation of Power of Decision-Making on Project Development to the Provincial Department of Environment (PDOE), 2005,
14.	Prakas (Declaration) No.215 in 2014, Sep. MOE	Declaration on the Registration of Selected Local Consultant Companies for conducting IEIA and EIA study. As of Jan. 2016, there are 13 national registered consultants companies for IEIA/EIA study.

Source: Survey Team based on English Translation supplemented by JICA env. Profile 2013, Faolex, ADB (2014) Integrated Urban Environmental Management in the Tonle Sap Basin Project – Kampong Chhnang Urban Area Environment Improvements

(b) Procedure of IEIA/EIA

As shown in the flowchart below, the DPWT firstly submits the Environment Application Form together with his IEIA/EIA report to the competent authority, which means, the MOE. After the MOE has reviewed the report, it may require the DPWT to revise the report or implement further study. Should the environmental study fulfil the requirement of the authority, the report is approved and forwarded to the CDC (Cambodia Development Council) or Sub-Committee of Royal Municipality, Provincial Department of Environment for the approval of succeeding project implementation.



Source: Declaration on General Guidelines for Conducting Initial and Full Environmental Impact Assessment Reports

Fig. R 1.4.3 Flowchart of the IEIA/EIA Process for National Level Projects

(c) Project Subject to the Provisions on Environmental Impact Assessment (EIA)

In Sub-decree No. 72, projects required an Initial Environmental Impact Assessment (IEIA), almost equivalent to IEE, or EIA are categorized as A; Industry, B; Agriculture, C; Tourism and D; Infrastructure in 'Sub-degree on Environmental Impact Assessment Process, Aug. 1999'. In the Sub-degree, wastewater treatment plans are categorized as Industry. According to MOE, all size of wastewater treatment planes requires to carry out full EIA.

Also, in Sub-decree No.230 issued in 1999, Article 1 mentions that DOE would manage a project having a project cost of not more than US Doller 2 million. The MOE is responsible for a project with a project cost of more than US Doller 2 million.

(d) Comparison between Cambodian Regulations and JICA Guidelines

The Project is classified as Category B as per JICA Guidelines requiring only IEE level environmental assessment. On the other hand, this Project is required to conduct EIA study by environmental legislation in Cambodia. The Gap between the Environmental legislation in Cambodia and JICA Guidelines are compared in **[Appendices] 6.1**.

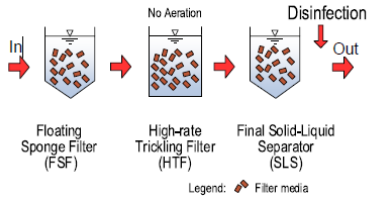
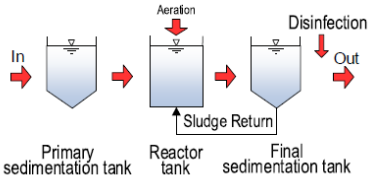
(2) Preparation of EIA Study

In accordance with Cambodian regulation, full EIA study is required as the project includes the construction of STP. Taking account of Cambodian regulation and JICA Guidelines for Environmental and Social Considerations (hereinafter referred to as "JICA Guidelines"), a comparison of alternative plans and scoping of potential impact items was conducted. Based on the scoping, the Terms of Reference (TOR) for the EIA study was prepared.

1.4.1.4 Comparison of Alternative Plans

STP is a core facility of the Project and thus the Project compared alternatives of STP including without project. As a result, Pre-treated Trickling Filtration (PTF) was evaluated as the most adequate facility. The comparison is shown in **Table R 1.4.2**.

Table R 1.4.2 Comparison of Alternative Plan on STP Construction in the Project

Item	Alternative 1	Alternative 2	No Project
	Pre-treated Trickling Filtration (PTF)	Conventional Activated Sludge Process (CASP)	Current Condition
Outline of Treatment Methods			-
	This is Japanese new technology upgrading trickling filter by introducing new filter media	Most popular sewage treatment method using mechanical equipment. Higher treatment performance in pollution load	

Item	Alternative 1	Alternative 2	No Project
	Pre-treated Trickling Filtration (PTF)	Conventional Activated Sludge Process (CASP)	Current Condition
		reduction is achieved but energy consumption is bigger than PTF.	
Technical Aspects	- Capacity: 5,000m^3/day - Land Requirement: <3.0 ha - BOD Removal Rate: < 30 mg/L - No aeration is required and thus energy consumption is smaller than that of CASP. - O&M is easier than that of CASP.	- Capacity: 5,000m^3/day - Land Requirement: <3.5 ha - BOD Removal Rate: < 15 mg/L - This method requires aeration in the reactor and thus energy consumption is much bigger than that of PTF. - O&M is more difficult than that of PTF. - Moreover, highly skilled technique in required for operation.	-
Cost (Ratio)[1)]	- Construction Cost: 0.9 - O&M Cost: 0.68	- Construction Cost: 1 - O&M Cost: 1	- No cost
Natural Environment	- Filter bed can be easily washable and thus prevent flies from filter bed. - Water quality will be slightly improved - In the proposed project area, there is no inundated forest and protected area, and the land use are water area or landfill, so the negative impact on natural environment is expected to be low.	- Treatment performance is higher than that of PTF. - The same as on the left	- As Cheung Aek Lake is being reclaimed year by year, and the area of the lake is shrinking. Therefore, negative impact caused by discharge of wastewater is getting more significant, and it will be serious for natural environment.
Social Environment	- Land Requirement is smaller (3 ha) than CASP. - People will lose their part of income from growing of swamp morning glory, water mimosa and water celery.	- Land Requirement is larger (3.5 ha) than PTF. - The same as on the left	- As Cheung Aek Lake is being reclaimed year by year, and the area of the lake is shrinking. Therefore, wastewater discharged caused infectious deceases and lower production of vegetables.
Pollution	- Filter bed can be easily washable and thus prevent offensive odor generation - Sanitary waste form staff and workers (during construction and O&M) - Sludge from the STP may pollute surrounded solid waste disposal site.	- Worse odor generation than that of PTF - The same as on the left	- As Cheung Aek Lake is being reclaimed year by year, and the area of the lake is shrinking. In the situation, water, ground water and sediment, and offensive odor, are getting worse.
Provisional Rating	+++	++	+

Note 1: Ratio of STP construction and O&M cost in comparison with CASP based on cost estimation in "the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area"
Note 2: Scores in "Evaluation" are on a three-level descending system of "+++" to "+"
Source: Survey Team

After selecting the PTF, three alternatives of STP site in Cheung Aek Lake are studied (**Fig. R 1.4.4**):

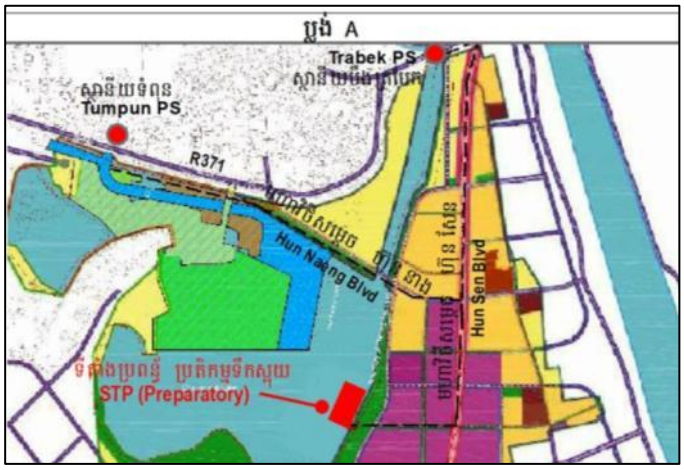
i) Plan A is located in Cheung Aek Lake area about 700 m far from Hun Neang Boulevard, which is being constructed (by the PPCC), by taking the wastewater from Trabek pumping station.

ii) Plan B is located in Cheung Aek Lake area next to Hun Neang Boulevard, which is being constructed, by taking the wastewater from Boeung Trabek pumping station.

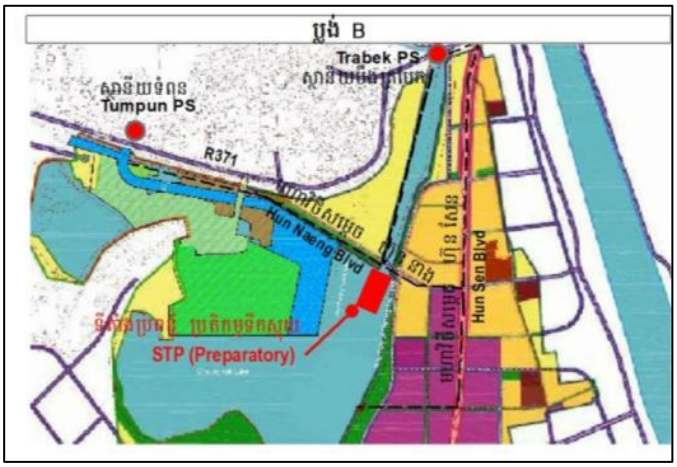
iii) Plan C is located in Cheung Aek Lake area around 200m from Rd. 371 by taking the

wastewater from Tumpun pumping station.

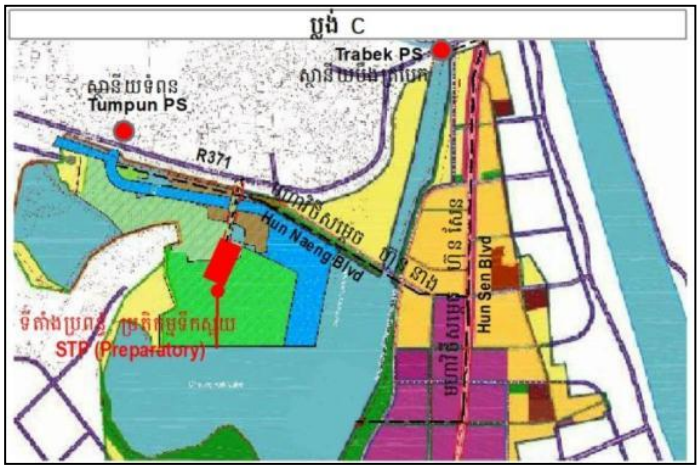
Based on technical and economic comparisons for environmental and social impacts, plan B is better than plan A and C and has been selected as shown in **Table R 1.4.3**.



Plan A



Plan B



Plan C

Fig. R 1.4.4 Options for Locations of STP in Phnom Penh

Table R 1.4.3 Comparison of Location for STP

	Option A		Option B		Option C	
Construction Cost						
Reclamation of STP Site	STP site is distant from Lake shore so that the cost and duration of construction will be greater, due to extra volume of reclamation and special technique for ground improvement.	C	Compared to Plan A and C, the site is closer to the land which is already reclaimed so that the cost and duration of construction will be smaller.	B	STP site is distant from Lake shore so that the cost and duration of construction will be greater, due to extra volume of reclamation and special technique for ground improvement.	(B)
Access Road	Hun Sen Blvd is used as Access Rd. Reclamation is needed for 0.8km or around from STP to Hun Sen Blvd, which can be converted to an Arterial Rd in CBD.	B	A part of already reclaimed area will be used as Access Rd. Reclamation is needed for only 0.1km or around to the nearest coast, so that it will be least costly among the three.	A	Reclamation is needed for 0.6km or around from STP to Rd371. A bridge over the canal is needed so that it will be most costly among the three.	Access Road
Interceptor Pipe For Preparatory Project	The intake of wastewater 5,000 m³/day for the preparatory project should be changed from Tumpun to Trabek so that tunneling under water is not required. Pipes will be the longest among the three but less costly than Plan C, which needs under-canal tunneling.	B	Least costly among the three since pipes are shorter than Plan A and under water tunneling is not required like C. If the intake point is changed from Tumpun to Trabek and a part of reclaimed area is be used for pipe route, the piping cost become even smaller.	A	Most costly among the three since tunneling is required to go under canal.	C
Interceptor Pipe For Future Extension	Interceptor pipes, diameter of 2,200mm from Tumpun 1,650mm from Trabek, are planned in the future extension plan. The length of those pipes will be the longest among the three.	B	Interceptor pipes, diameter of 2,200mm from Tumpun 1,650mm from Trabek, are planned in the future extension plan. The length of those pipes will be the longer than the Plan C, but under water tunneling is not required.	A	Interceptor pipes, diameter of 2,200mm from Tumpun 1,650mm from Trabek, are planned in the future extension plan. The length of those pipes will be the shortest but they need to go under canal which makes this plan most expensive.	C
Social Impact						
Resettlement	STP site and Access road are within the boundary of the Lake, although there is still possibility of resettlement due to illegal habitats.	B	STP site is within the boundary of the Lake, although there is still possibility of resettlement due to illegal habitats. Construction of Access road doesn't require resettlement since a part of the already reclaimed land will be used for it.	B	Resettlement process is required for residences located around the connecting point of Access road and Rd371. STP site is within the boundary of the Lake , although there is still possibility of resettlement due to illegal habitats.	C
Visual Impact	STP site and urban development area are segregated by water body but it will affect the sight from high-rise buildings in CBD.	C	STP site and urban development area are segregated by water body and plantation can be a countermeasure to ease visual impact from low-rise residential area.	B	STP site and urban development area are neighboring directly so that not only the plantation wall but green-belt should be applied to ease visual impact from neighboring area.	C
Deodorization	STP site and urban development area are segregated by water body so that deodorization equipment can be less costly.	B	STP site and urban development area are segregated by water body so that deodorization equipment can be less costly.	B	STP site and urban development area are neighboring directly so that deodorization equipment can be costly.	C
Overall Evaluation	Less expensive than Plan C when Hun Sen Blvd is used for the pipe route. Visual Impact is considerable.	B	Least expensive with the least social impact, most recommended.	A	Most expensive with higher impact to social, not recommended.	C

1.4.1.5 Scoping and TOR

(1) Scoping

The Project was reviewed in light of the JICA Guidelines. The scoping result is summarized in the following table.

Table R 1.4.4 Possible Adverse Impact (Pollution and Natural Environment)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
I. Pollution and Natural Environment				
1	Air Pollution, Dust Generation	B-	D	Construction Landfill for STP and Access Road (Channel Maintenance Road) (including sewer pipe) will generate dust. Operation Air pollution is not predicted.
2	Offensive Odor	D	D	Construction Construction of STP and Access Road (Channel Maintenance Road) (including sewer pipe) will not cause offensive odor Operation Offensive odor is not generated due to the adopted sewage treatment method (PTF) in STP.
3	Noise	B-	D	Construction Construction equipment may cause offensive noise. Operation Noise will be little as the pollution source is small pump and far enough from neighbor houses.
4	Vibration	B-	D	Construction Construction equipment may cause vibration effects on nearby structure. Operation Vibration will be little as the pollution source is small pump and STP will be far enough from neighbor houses.
5	Water Pollution	B-	C-	Construction Landfill for STP and Access Road (Channel Maintenance Road) (including sewer pipe) may increase TSS. Operation Sludge treatment may cause slight negative impact to residents adjacent to STP but the impact is unknown.
6	Soil Pollution	B-	D	Construction Landfill for STP and Access Road (Channel Maintenance Road) (including sewer pipe) entail agitation of sediment, and it may affect surrounding water quality. Operation Soil is not generated or discharged.
7	Solid Waste	B-	D	Construction Construction work will generate solid waste. Operation Solid waste (sludge) will be limited and properly treated.
8	Soil Erosion and Slope Failure	B-	D	Construction Construction work of STP and Access Road (Channel Maintenance Road) (including sewer pipe) may cause soil erosion and slope failure. Operation

No.	Potential Impacts	Construction Stage	Operation Stage	Description
				Impact is not expected.
9	Protected Area	D	D	Construction and Operation There is no protected area near the project site.
10	Ecosystem	C-	C-	Construction and Operation Endangered species may inhabit in the area and be affected by the project.
11	Ground Subsidence	D	D	Construction and Operation Ground subsidence is not expected if construction is properly done.
12	Geology and Topography	B-	D	Construction Digging and backfilling land to construct the STP may change geography. Operation No adverse impact is expected because the land will be stable according to the project design.
13	Hydrology	C-	D	Construction Water flow by pumping from Trabek pumping station is not expected. Operation No adverse impact is expected.

Legend : A +/-: Significant positive (+)/negative (-) impact is expected.
B +/-: Some positive (+)/negative (-) impact is expected.
C +/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the survey progresses.
D: No impact is expected.

Source: Survey Team

Table R 1.4.5 Possible Adverse Impact (Social Environment)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
II. Social Environment				
1	Land Acquisition and Involuntary Resettlement	B-	D	Construction Some parts of STP site are currently used to cultivate water morning glory and other aquatic plants. There is a reclaimed site along the Access Road (Channel Maintenance Road) near Trabek Pumping Station for a business purpose. Both are carried out in public state land and illegal activities, but compensations may be necessary. Operation The action will be completed.
2	Poor People	D	D	Construction and Operation There are poor people depending on this land plant crop without possess the land. However, they will continue the agricultural activity at the alternative land and receive compensation.
3	Water Use	B-	B+	Construction Prek Takong 1 community uses water of Cheung Aek Lake not only for cultivation but also for washing and bathing. Operation Sewage treatment will improve water quality.
4	Road	B-	D	Construction During the construction stage, sewer pipe may pass crossing under the Rd. 271 near Trabek Pumping Station. Operation There will be no obstacle for traffic.
5	Accident	B-	D	Construction Accidents during the construction can be considered in operation of vehicle and machine. Operation

No.	Potential Impacts	Construction Stage	Operation Stage	Description
				Accidents will be little with normal operation.
6	Sanitation	D	B+	Construction Effect to sanitation is little. Operation Water quality in bacteriological parameters may be improved, and positive impact to the sanitation is expected.
7	Risk of Public Health and Welfare	B-	C-	Construction Many laborers will be employed for the construction. There may be a potential of infectious diseases. Operation Accident by operation may happen.
8	Livelihood/Income	B-	D	Construction Some illegal cultivation areas (mainly water morning glory) on Cheung Aek Lake for STP site are affected. Operation Farmers will produce crop in alternative cultivation areas
9	Existing Social Infrastructure and Service	B-	B+	Construction Same as No.4 “Road” in this Table. Operation Improvement of social service by the treatment of wastewater is expected.
10	Landscape	C-	C-	Construction Road may be dirty with the spill of soil and cement. Operation Road may be dirty with dried sludge spill.
11	Ethnic Minority People	D	D	Construction and Operation There are no ethnic minority people living in the Project area.
12	Migration	D	D	Construction and Operation Migrants are 1% at present in Prek Takong 1 village. The Project will not affect them because STP will totally improve living environment.
13	Gender	B±	D	Construction Women living near the project site will be given the job opportunities, but will be given only light work. Operation Job opportunity is limited and impact is little.
14	Children’s Right	D	D	Construction and Operation Employment of children is legally prohibited.
15	Working Condition	B+	D	Construction During the construction stage, there will be opportunities for local people to be employed in the construction works. Operation Employees will be limited.
16	Destruction/Disturbance to Items or Places of Cultural and Archeological Heritage	D	D	Construction and Operation There will be no destruction or disturbance of cultural and archeological heritage.
17	Climate Change	B-	D	Construction CO_2 emission will be expected with the use of machinery. Operation CO_2 emission is little because sludge will be properly treated.

Legend : A +/-: Significant positive (+)/negative (-) impact is expected.
B +/-: Some positive (+)/negative (-) impact is expected.
C +/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the survey progresses.
D: No impact is expected.

Source: Survey Team

1.4.1.6 TOR

Based on the scoping in **Table R 1.4.4** and **Table R 1.4.5**, TOR for EIA study is listed in the following table.

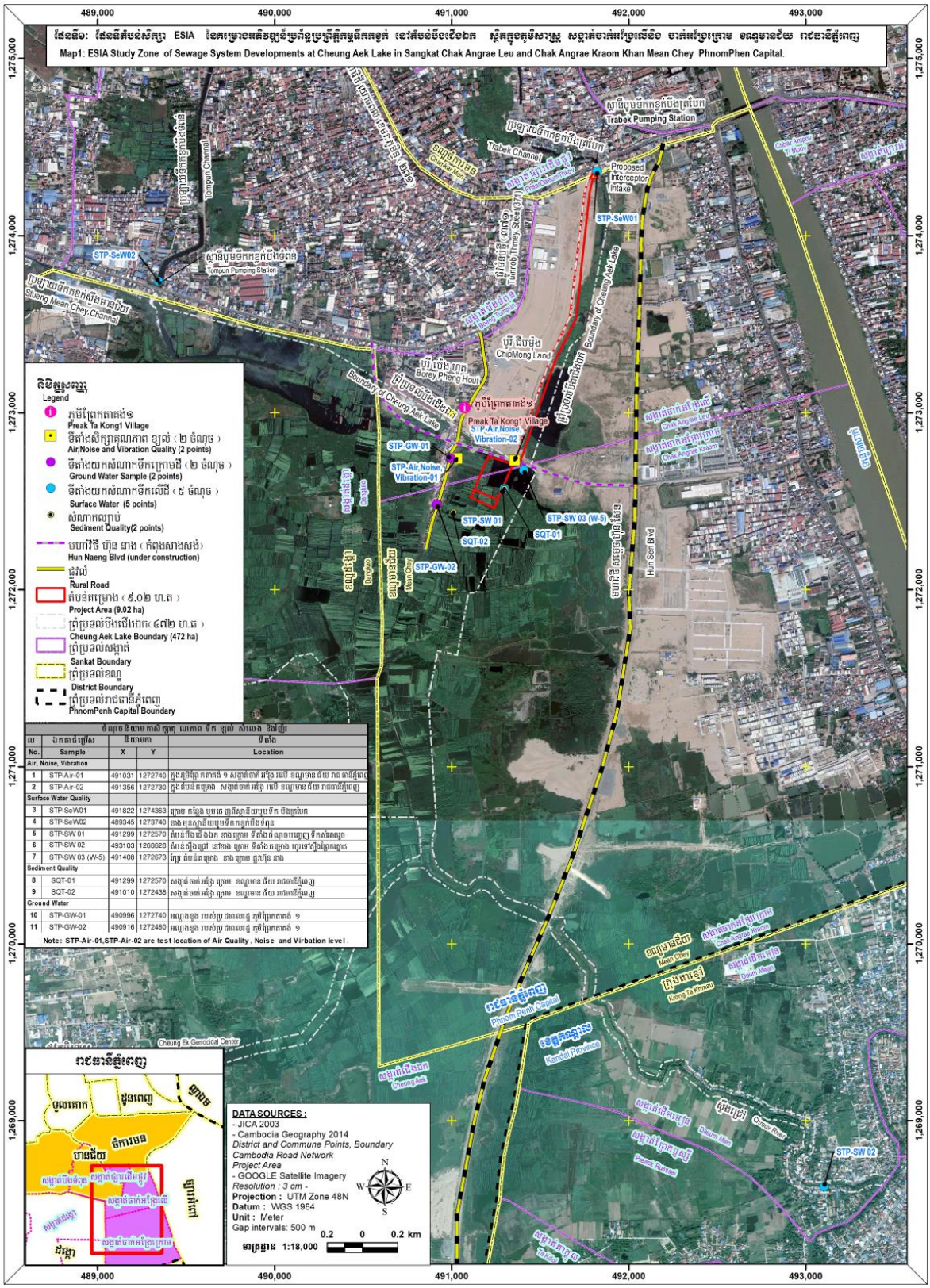
Table R 1.4.6 TOR for EIA Study

Item	Remarks
1. Study of Legal/Institutional/Policy Framework	-
2. Identification of Project Overview and Component	-
3. Baseline survey for Natural Environment	-
1) Meteorological Study	Select the nearest station point to the project site
2) Survey of Flora and Fauna	Survey area will be in and around the construction point.
3) Survey of Geology and Topography	
4) Survey of Soil	
5) Survey of Hydrology	
6) Survey of Air Quality	
7) Survey of Water and Ground Water Quality	
8) Survey of Noise and Vibration	
9) Survey of Solid Waste	
4. Baseline Survey for Social Environment	-
1) Demographical Study	Population, population distribution, population density and gender of relevant region in and around the project site.
2) Survey of Community Structure	
3) Survey of Road Traffic and Vehicle Movement	Near Trabek Pumping Station on Yothapol Khemarak Phonmin Blvd (Rd.271)
4) Survey of Livelihood/Income	Including income and poverty analysis.
5) Survey of Land Acquisition and Resettlement	-
6) Survey of Water Use and Sanitation	-
7) Survey of Public Health and Welfare	-
8) Survey of Working Accident	Occupation and wage
9) Survey of Landscape	Language, ethnic group, religion, heritage
5. Determination of Alternatives	Including zero option
6. Environment and Social Impact Analysis	-
7. Environment and Social Impact Assessment	-
8. Establishment of Mitigation Measures and Cost Estimation for the Mitigation	-
9. Establishment of Environment Management and Monitoring Plan	-
10. Gender Survey	-
11. Holding Stakeholder Meeting	One stakeholder meeting will be held for the project.
Facilitation for EIA procedure and approval	-
12. Reporting	-

Source: Survey Team

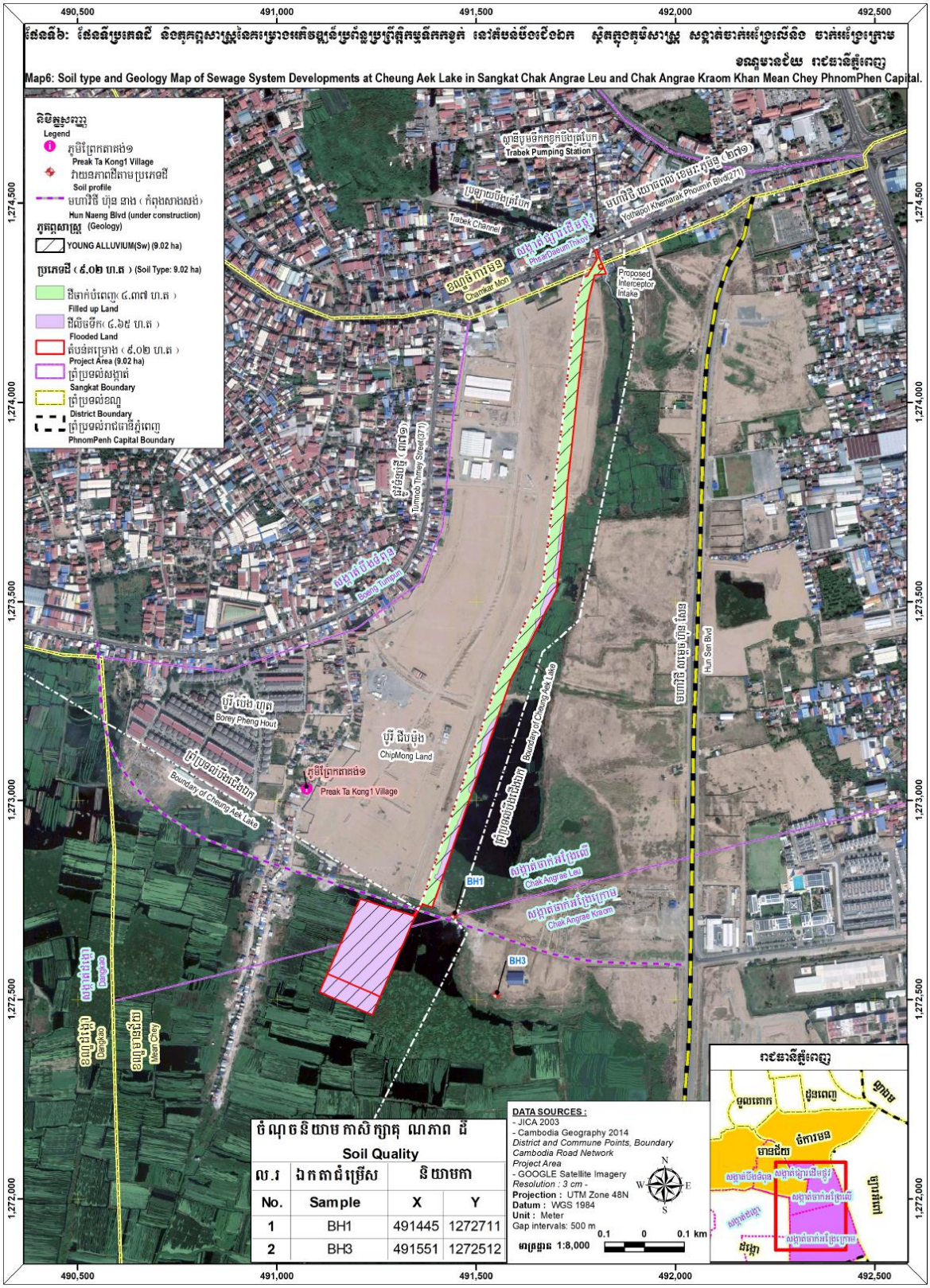
1.4.1.7 Survey Results for Environmental and Social Considerations

Environmental and social surveys were conducted through literature, interview and field research. The result and evaluation are described below. Sampling stations of the field research are shown in **Fig. R 1.4.5** to **Fig. R 1.4.7**.



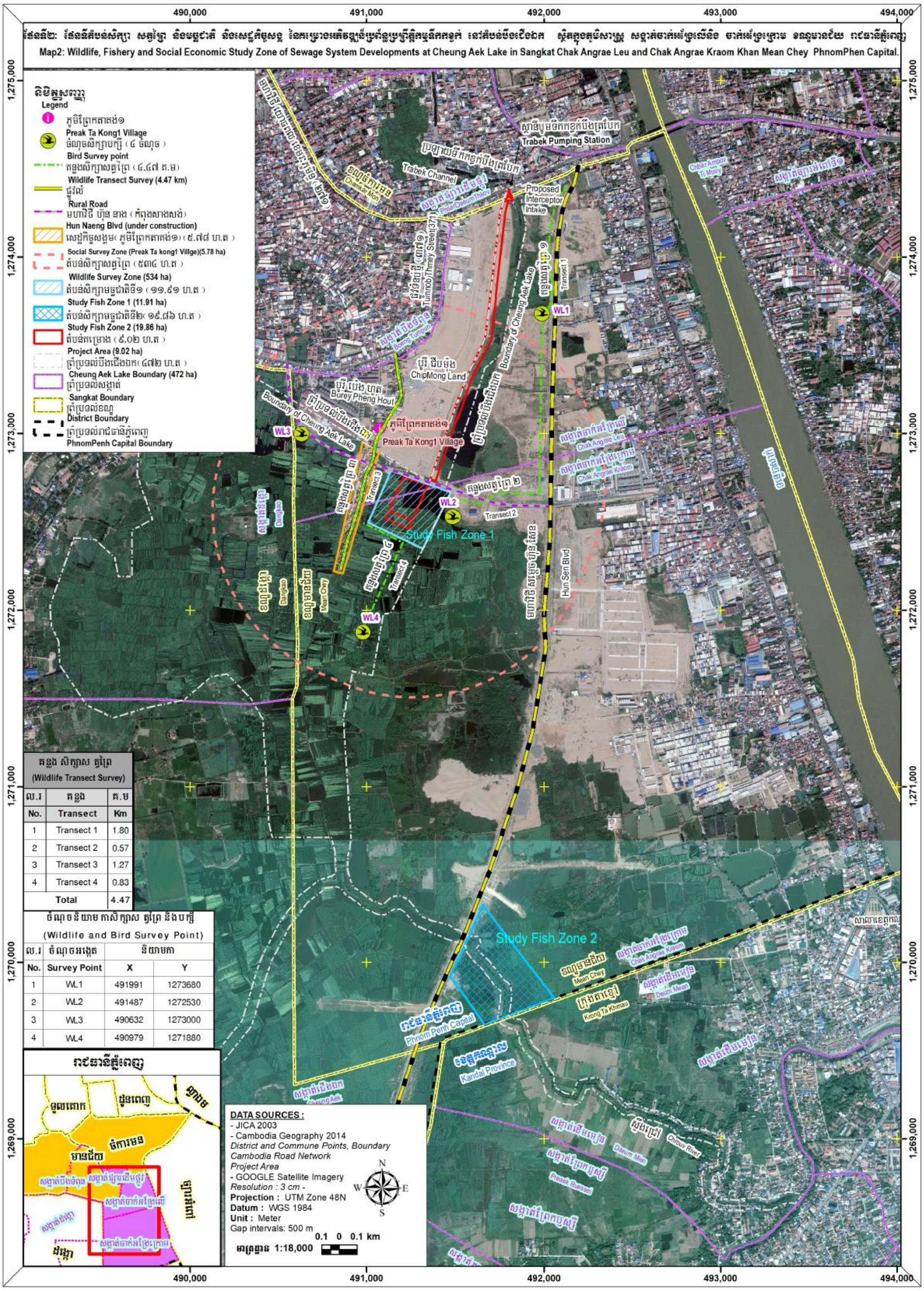
Source: Survey Team

Fig. R 1.4.5 Sampling Stations (Air, Water, Noise, Vibration, Sediment)



Source: Survey Team

Fig. R 1.4.6 Sampling Stations (Soil Profile, Hydrology)



គន្លង សិក្សាស ត្វព្រៃ (Wildlife Transect Survey)

No.	Transect	Km
1	Transect 1	1.80
2	Transect 2	0.57
3	Transect 3	1.27
4	Transect 4	0.83
	Total	4.47

ចំណុចនីយាមកាសិក្សាស ត្វព្រៃ និងបក្សី (Wildlife and Bird Survey Point)

No.	Survey Point	X	Y
1	WL1	491991	1273680
2	WL2	491487	1272530
3	WL3	490632	1273000
4	WL4	490979	1271880

Source: Survey Team

Fig. R 1.4.7 Sampling Stations (Birds, Fish)

(1) Meteorology (Basic Information)

In Phnom Penh, the average maximum temperature of period of 5 years (2013-2017) was 30.06^{0}C. Average minimum temperature in the same period was 27.63^{0}C. Average temperature of 1 year was 28.85^{0}C. The maximum temperature was 40.70^{0}C in April 2016, and the minimum temperature was 16.50^{0}C in February 2016 and 2017. For rainfall, the average for period of 5 years (2013-2017) was 1,496.10 mm. The maximum rainfall was 449.20 mm in October 2016. About humidity in Phnom Penh at the same period of time, the average humidity was 74.86%. The maximum humidity was 85.94% in October 2016 and minimum humidity was 61.38% in February 2016. Wind speed in Phnom Penh had an average of 11.8 m/s in the same period of time. The maximum wind speed was 18 m/s in September 2016. Evaporation in Phnom Penh in these 5 years was 11,078.8 mm with the yearly average of 2,215.76 mm. The monthly maximum evaporation was 277.60 mm in April 2016. The monthly minimum was 136.20 mm in March 2014.

(2) Hydrology

According to data from drilling test in hole BH1 and BH3 near project area, there is confined aquifer that formed by rain and river water absorbed into soil, and upper layer is unconfined aquifer that flow into pond, canals and lake and through soil and rock at the bottom. It is absorbed into the under layer and create the Confined Aquifer. In project area, there are 2 layers of Confined Aquifer. First layer is about 21 m to 26 m depth and second layer is about 32 m to 37 m depth (ground water is located in fine sand and medium sand). According to interview with the well digger, the water sample taken from the first well (sample number STP-GW-01) is about 40 m depth and static level (from the bottom to water surface) is 3 m to 4 m and flow rate is 1 to 5 m^3/h. The aquifers are deep enough and impact by the project is little.

[Prediction]

As for surface water, there is water way from the Trabek pumping station to the project site. The depth (from the bottom to water surface) is 3 m to 4 m. The flow rate is 1 to 5 m^3/s but recently the water way is narrower due to illegal reclamations. In the situation, the Project may cause additional impact with dumping excavated sediment during construction as it may block the flow of surface water and lead to flooding.

(3) Geology and Topography

(a) Geology

Based on geological map published by U.S Department of the Interior, year 1977 (Geological Survey Water Supply Paper 1608-P), overlaid with geological map of department of geography that is supported by JICA in 2003, geography of the project area

has 1 type of YOUNG ALLUVIUM (Sw), which was formed in Q4 of Senozoic Era about 11.7 thousand years ago. This area, around 50 to 70 m depth, has sandstone and mudstone with dark red color that was formed by the heat.

[Prediction]

No impact by the Project is predicted with above condition.

(b) Topography

Geographically, the project is located in Cheung Aek Lake and is almost flat with bottom elevation of the Lake is 1.4 m to 3.7 m above sea level. Highest land near the project area is Rd. 271 with 10.72 m above sea level.

[Prediction]

The predicted impact is change of topography due to the digging and backfilling land to construct STP.

(4) Air Quality

Air quality testing done in 2 locations collaborated with the laboratory of Ministry of Environment (MOE) for 24 hours on the day is not holiday or national ceremony day.

According to the results of the air quality analysis, conducted in October 2018, at Location1, level of CO, NO_2, SO_2, O_3, TSP and Pb is still lower than the standard of MOE. However, PM10 and PM2.5 exceeds the standard, which is caused by the emission of gases and dust from vehicle travelling on road and boulevard nearby.

Table R 1.4.7 Result of air Quality Analysis in Project Area (studied on 30 October 2018)

No.	Parameters	Unit	Result	Standard	Method	Duration
1	CO	mg/m³	1.490	**20**	Method Carbon Monoxide Passive Dositube	8 hours
2	NO_2	mg/m³	0.017	**0.1**	Method Saltzman	24 hours
3	SO_2	mg/m³	0.014	**0.3**	Method Pararosaniline	24 hours
4	O_3	mg/m³	0.000	**0.2**	Method Professional Gas Detector GT-901 03	1 hours
5	TSP	mg/m³	0.182	**0.33**	Method Weight Concentration Measuring	24 hours
6	PM10	mg/m³	0.061	**0.05**	Method Weight Concentration Measuring	24 hours
7	PM2.5	mg/m³	0.037	**0.025**	Method Weight Concentration Measuring	24 hours
8	Pb	mg/m³	ND	**0.005**	Method 3500 Pb C (HNO3.HCI Digestion)	24 hours
9	H_2S	mg/m³	ND	**0.001**	Method Hydrogen Sulide Detector Tube (Gastec No 4UK)	(*)

Source: Laboratory of Ministry of Environment. Standard: Table 1 of Annex of Prakas number 116 PK/BS Adopted on 11 April 2018, MOE

Location 2, level of CO, NO_2, SO_2, O_3, TSP Pb PM10 and PM2.5 is lower than standard of MOE. However, H_2S exceeds the standard, which is caused by the septage thrown by collectores into the water nearby.

Table R 1.4.8 Result of Air Quality Analysis in Prek Takong 1 Village (studied on 31 October 2018)

No.	Parameters	Unit	Result	Standard	Method	Duration
1	CO	mg/m³	2.720	**20**	Method Carbon Monoxide Passive Dositube	8 hours
2	NO_2	mg/m³	0.020	**0.1**	Method Saltzman	24 hours
3	SO_2	mg/m³	0.016	**0.3**	Method Pararosaniline	24 hours
4	O_3	mg/m³	0.000	**0.2**	Method Professional Gas Detector GT-901 03	1 hours
5	TSP	mg/m³	0.094	**0.33**	Method Weight Concentration Measuring	24 hours
6	PM10	mg/m³	0.047	**0.05**	Method Weight Concentration Measuring	24 hours
7	PM2.5	mg/m³	0.019	**0.025**	Method Weight Concentration Measuring	24 hours
8	Pb	mg/m³	ND	**0.005**	Method 3500 Pb C (HNO3.HCI Digestion)	24 hours
9	H_2S	mg/m³	2.740	**0.001**	Method Hydrogen Sulide Detector Tube (Gastec No 4UK)	(*)

Source: Laboratory of Ministry of Environment.

[Prediction]

From the above results, increases of dust during construction period, caused by passing trucks and reclamation, are considered. However, the impact would be slight, since total amount of sand and soil is small. Negative impact during operation period is not predicted. No additional H_2S will be generated.

(5) Soil (Sediment)

Based on Crocker's Soil type map of 1963, scale 1/1,000,000, in project area with 9.02 ha, there is 1 type of soil, Alluvial Lithosols. However, according to site study in September 2018, in project area of Access Road (Channel Maintenance Road) site of 4.37 ha is sand that was filled up for building, which is not so fertilized. Other 4.65 ha is Lake land.

STP construction site is located on Cheung Aek Lake with the depth of water around 1 m to 3.5 m. The soil samples are taken from the bottom of the lake to study the quality. The study was done in 2 locations near the project area and 7 parameters were analyzed. The first point was selected near the sources of sewage from Trabek canal in Sangkat Chak Angre Krom, Khan Mean Chey. The Second point is located near STP construction area nearby Prek Takong 1 village, Sangkat Chak Angre Krom, Sangkat Chak Angre Krom, Khan Mean Chey.

Based on the result of soil (sediment) quality analysis on 2 locations in **Table R 1.4.9**, Arsenic (As) is the toxic substance and it exceeded the standard of Ministry of Environment at the location nearby outlet of Trabek pumping station (location 1). Other parameters and all parameters of second location did not exceed the standard.

Table R 1.4.9 Soil Quality Analysis Result (Sediment Quality) in Project Area

No.	Parameters	Unit	Standard	Sample Number		Method
				SQT01	SQT02	
1	Arsenic (AS)	mg/kg-dry	<15	17.16	4.48	Method 3500-Aa D, (HNO3, HCL digestion)
2	Cadmium (Cd)	mg/kg-dry	<0.8	0.13	0.06	Method 3500-Cd C, (HNO3, HCL digestion)
3	Chromium (Cr)	mg/kg-dry	<100(Cr^{-6})	18.60	14.22	Method 3500-Cr C, (HNO3, HCL digestion)
4	Iron (Fe)	mg/kg-dry	-	2,121.16	2,774.34	Method 3500-Fe C,

No.	Parameters	Unit	Standard	Sample Number		Method
				SQT01	SQT02	
						(HNO3, HCL digestion)
5	Lead (Pb)	mg/kg-dry	<85	14.30	10.24	Method 3500-Pb C, (HNO3, HCL digestion)
6	Mercury (Hg)	mg/kg-dry	<0.3	0.02	0.008	Method 3500-Hg B, (HNO3, HCL digestion)
7	Selenium (Se)	mg/kg-dry	<0.7	ND	0.10	Method 3500-Se I, (HNO3, HCL digestion)

Source: Laboratory of Ministry of Environment (tested on 24 October 2018). Standard: The standard of toxic chemicals or hazards that may allowed in the soil (Ministry of Environment, No. 387 PK/BS adopted on 30 September 2015 annex 2

[Prediction]

The spill of fuel and lubricant and dumping of waste on the soil (sediment) is predicted to cause soil quality pollution. Land clearing, excavating and backfilling may cause erosion. More, the dumping of spoiled soil (sediment) digging from the bottom of the lake may slide into the lake.

(6) Surface Water and Ground Water

(a) Surface Water

According to the water quality testing result at downstream end of Trabek Pumping Station Discharge Channel (location of STP-SW01 or STP-SW-03 (W-5)) and Steung Chrov (Cheung Aek Lake) (location of STP-SW-02) in the following table, the sample STP-SW01 shows that the water quality during the rainy season has 2 parameters (DO, Oil and Grease) which exceeded the effluent standard for public water area and sewer of MOE. On the other hand, Sample STP-SW03 (W-5) that was studied by JICA Survey Team shows that the water quality during the rainy season has 2 parameters (BOD_5, COD) which exceeded the standard.

Table R 1.4.10 Testing Result of Surface Water Quality at Downstream End of Trabek Pumping Station Discharge Channel (24 October 2018)

No	Parameters	Unit	MOE Standard	Sample Number	
				STP-SW01	STP-SW03 (W-5) (By JICA)
1	pH	No Unit	5-9	6.68	7.10
2	Temperature	ºC	<45	30	NA
3	Total Dissolved Solid (TDS)	mg/l	<2,000	271.00	NA
4	Total Suspended Solid (TSS)	mg/l	<120	70.00	56.00
5	Dissolved Oxygen (DO)	mg/l	>1.0	0.30	2.30
6	Biochemical Oxygen Demand (BOD_5)	mg/l	<80	43.00	83.00
7	Chemical Oxygen Demand (COD)	mg/l	<100	58.00	160
8	Oil and Grease	mg/l	<15	17.73	NA
9	Detergent	mg/l	<15	6.88	NA
10	Sulphate (SO_4)	mg/l	<500	32.00	NA
11	Total Nitrogen (T-N)	mg/l	NA	13.20	NA
12	Total Phosphorus (T-P)	mg/l	NA	3.80	NA
13	Lead (Pb)	mg/l	<1.0	0.0006	0.065
14	Arsenic (As)	mg/l	<1.0	0.00	ND
15	Cadmium (Cd)	mg/l	<0.5	ND	ND

No	Parameters	Unit	MOE Standard	Sample Number	
				STP-SW01	STP-SW03 (W-5) (By JICA)
16	Iron (Fe)	mg/l	<20	0.32	NA
17	Mercury (Hg)	mg/l	<0.05	0.0006	ND
18	Total Coliform	MPN/100ml	NA	$1.5x10^4$	$5.6x10^3$

Source: Survey Team

Table R 1.4.11 Testing Result of Surface Water Quality at Steung Chrov (Cheung Aek Lake) (23 October 2018)

No	Parameters	Unit	MOE Standard	Sample Number
				STP-SW02
1	pH	No Unit	6.5-8.5	6.90
2	Temperature	°C	NA	30.7
3	Total Dissolved Solid (TDS)	mg/l	NA	186.00
4	Total Suspended Solid (TSS)	mg/l	1-15	32.00
5	Dissolved Oxygen (DO)	mg/l	2.0-7.5	2.30
6	Biochemical Oxygen Demand (BOD_5)	mg/l	NA	14.70
7	Chemical Oxygen Demand (COD)	mg/l	<8	26.00
8	Oil and Grease	mg/l	NA	6.27
9	Detergent	mg/l	NA	2.27
10	Sulphate (SO_4)	mg/l	NA	26.00
11	Total Nitrogen (TN)	mg/l	0.6-1.0	9.30
12	Total Phosphorus (TP)	mg/l	0.005-0.05	3.10
13	Lead (Pb)	mg/l	<0.01	0.001
14	Arsenic (AS)	mg/l	<0.01	0.00
15	Cadmium (Cd)	mg/l	<0.001	ND
16	Iron (Fe)	mg/l	NA	0.53
17	Mercury (Hg)	mg/l	<0.0005	0.0005
18	Total Coliform	MPN/100ml	<1,000	$2.4x10^4$

Source: Survey Team

- Water quality at downstream end of Trabek Pumping Station Discharge Channel (location of STP-SW01 or STP-SW-03 (W-5)): water in this area is from Trabek pumping station that has the level of DO, BOD_5, COD, Oil and Grease, exceed the standard of MOE. Low DO is coming from high BOD_5, COD that absorb DO, leading to impact on fish livelihood. T-N, T-P and Total Coliform are due to pollutants exists in public drainage from toilet and kitchen.

- Water quality at Steung Chrov (Cheung Aek Lake) (location of STP-SW-02): Steung Chrov receives the water from Cheung Aek Lake and the water flows into Steung Prek Thout and then discharged to Bassac River. According to the consultation with the representative of Department of Water Resource and Meteorology, when the water level of Mekong River rises up, the water flows into Chueng Aek Lake from September to November. For example, during the rainy season in 2018, water in Mekong River rose up and flowed into Cheung Aek Lake in September and water in Cheung Aek Lake flows into Steung Chrov in the middle of October. This water quality - when water from Cheung Aek Lake flows into the downstream - shows that TSS, COD, T-N, T-P, and Total Coliform exceeds the standard of MOE.

- [Reference 1 : estimated concentration of Hg in the sludge from the STP] Though

monitoring results of Hg does not exceed MOE standards, in case that the water including concentration of Hg (0.0006 mg/L), observed at STP-SW01, is treated in the STP, Suspended Solid (SS) will become sludge adhering Hg. Under the assumption that 60%[3] of Suspended Solid will become sludge adhering Hg, the concentration of Hg in the sludge is expected at about 0.36[4] mg/kg. Comparing the concentration with one of international standard (Japanese standard of soil pollution) of 15 mg/kg, it is still less than the standard value.

- [Reference 2 : estimated concentration of Pb in the sludge from the STP] Though **monitoring results of Pb does not exceed the MOE standard**, in case that the water including Pb (0.065 mg/L), observed at STP-SW03 (W-5), is treated in the STP, SS will become sludge adhering Pb. As with the Hg, under the assumption that 60% of SS will become sludge adhering Pb, the concentration of Pb in the sludge is expected at about 39[5] mg/kg. Comparing the concentration with one of international standard (Japanese standard of soil pollution) of 150 mg/kg, it is still less than the standard value.

[Prediction]

Pollution into Cheung Aek Lake nearby the project area may slightly increase by the construction activities such as soil work (clearing and filling land and pumping the water), and concrete work. Surface water quality in operation phase may deteriorate, if maintenance of STP is not enough, which leads to the loss of treated capacity and re-pollute Cheung Aek Lake.

(b) Ground Water

Table R 1.4.12 Testing Result of Groundwater Quality (23 October 2018)

No	Parameters	Unit	MOE Standard	Sample Number	
				STP-GW01	STP-GW02
1	pH	No Unit	6.5-8.5	6.78	6.90
2	Turbidity	NTU	5	0.00	14.00
3	Electrode Conductivity (EC)	µS/Cm	500-1500	734.00	981.00
4	Total Dissolved Solid (TDS)	mg/l	800	283.00	366.00
5	Total Hardness (as $CaCO_3$)	mg/l	300	93.50	117.00
6	Chloride (Cl^-)	mg/l	250	10.00	17.00
7	Fluoride (F)	mg/l	1.5	0.26	0.28
8	Nitrate (NO_3)	mg/l	50	1.40	0.60
9	Sulfate (SO_4)	mg/l	250	0.59	20.00
10	Iron (Fe)	mg/l	0.3	0.10	0.32
11	Arsenic (As)	mg/l	0.05	0.01	0.01

[3] 60% is based on the design removal rate of SS in the STP [=(205 mg/L-80 mg/L)÷205 mg/L×100]

[4] Estimated amount of Hg in sludge per day is 0.0006 mg/L×60%×5,000 m^3/day (treated water per day)×1,000 L/m^3=1,800 mg/day. The sludge produced in STP is about 5 to 10 m^3(≒5,000 to 10,000 kg/day). Thus, 0.36 mg/kg at maximum (=1,800 mg/day÷5,000 kg/day), is obtained.

[5] Estimated amount of Pb in sludge per day is 0.065 mg/L×60%×5,000 m^3/day (treated water per day)×1,000 L/m^3=195,000 mg/day. The sludge produced in STP is about 5 to 10 m^3(≒5,000 to 10,000 kg/day). Thus, 39 mg/kg at maximum (=195,000 mg/day÷5,000 kg/day), is obtained.

No	Parameters	Unit	MOE Standard	Sample Number	
				STP-GW01	STP-GW02
12	Mercury (Hg)	mg/l	0.001	0.0003	0.0002
13	Chromium (Cr)	mg/l	0.05	ND	ND
14	Manganese (Mn)	mg/l	0.1	0.20	0.20
15	Aluminum (Al)	mg/l	0.2	0.14	0.14
16	Cadmium (Cd)	mg/l	0.003	ND	0.0006
17	Total Coliform	MPN/100ml	0	0.00	0.00
18	E-coli	MPN/100ml	0	0.00	0.00

Source: Survey Team

- Turbidity of sample 2: STP-GW02 exceeds 5 NTU because Iron ion become Iron (III) Oxide (rust), causing difficulty of clothes washing. If the water is too turbid, it will stain the clothes with color. However, Turbidity doesn't harm health if there is no toxic metal oxide in this water.
- Iron (Fe) of sample 2: STP-GW02 with 0.32 mg/l is caused by the Iron ion reacted with Oxygen and became Iron (III) Oxide in the earth layer especially in the sediment from river. It leads to the difficulty in clothes washing, but it isn't harmful to human health.
- Manganese (Mn) is also heavy metal. It was found in sample 2: STP-GW02 as well, but its concentration is normally less than Iron. Using water with Manganese ion is not good for drinking, so people decided not to drink this type of water. When we wash clothes with the water with Manganese iron in, it will stain on clothes with black spot. Generally, Fe and Mn also block the filter of the well.

[Prediction]

The Project doesn't affect the ground water quality.

(7) Noise and Vibration

(a) Noise

According to the results of noise measurement at zone 1 in project area, from morning (6:00) to evening (18:00), the average noise is 45.01dB, lower than standard (standard is 60dB). However, from 15:00 to 16:00, the noise exceeds the standard because of the bridge construction along Hun Neang Boulevard. Similarly, from 18:00 at the evening to 23:00 at night, the average noise is 44.76dB, which is lower than standard (standard is 50dB). However, from 22:00 to 23:00, the noise exceeds the standard because the noise from generator at the bridge construction site. The bridge construction will end within a year. At the night time from 23:00pm to the dawn at 5:00am, the average noise was 45.43dB, but sometimes higher than standards (standard is 45dB), due to the trucks on Hun Sen boulevard.

[Prediction]

There will be some disturbance to the people and birds living around the project area (Borey Chip Mong Group and Prek Takong 1 village) by the noise from the machinery, vehicle, generator and other construction activities.

Table R 1.4.13 Result of Noise Measurement in Project Area (studied on 30 October 2018)

Time	Duration	Noise Level dB(A) (30 October 2018) X=0491356 Y=1272730				Mean
		LAeq	Standard (Leq)	Lmax	Lmin	
Day	6:00-7:00	44.6	60	49.3	38.8	Mean=45.01
	7:00-8:00	46.4		56.8	39.8	
	8:00-9:00	44.2		61.4	38.1	
	9:00-10:00	45.8		56.1	38.4	
	10:00-11:00	42.6		51.3	37.7	
	11:00-12:00	44.8		65.1	34.1	
	12:00-13:00	40.0		54.1	34.4	
	13:00-14:00	43.0		57.8	35.7	
	14:00-15:00	40.5		54.2	33.9	
	15:00-16:00	64.6		92.4	36.6	
	16:00-17:00	42.3		57.4	34.1	
	17:00-18:00	41.3		55.4	34.8	
Evening	18:00-19:00	43.4	50	55.9	35.4	Mean=44.76
	19:00-20:00	40.6		52.6	33.9	
	20:00-21:00	42.7		56.2	35.8	
	21:00-22:00	45.0		50.9	42.7	
	22:00-23:00	52.1		63.2	41.1	
Night	23:00-00:00	67.2	45	88.3	39.1	Mean=45.43
	00:00-1:00	42.2		58.7	30.1	
	1:00-2:00	48.5		59.7	29.0	
	2:00-3:00	33.1		48.2	29.2	
	3:00-4:00	34.9		49.1	29.3	
	4:00-5:00	52.7		64.1	37.0	
	5:00-6:00	39.4		51.1	33.4	
24 hours Average		**45.1**		**58.7**	**35.5**	

Source: Survey Team

Table R 1.4.14 Result of Noise Measurement in Prek Takong 1 Village (studied on 31 October 2018)

Time	Duration	Noise Level dB(A) (31 October 2018) X=0491031 Y=1272740				Mean
		LAeq	Standard (Leq)	Lmax	Lmin	
Day	6:00-7:00	46.4	60	60.1	39.4	Mean=49.12
	7:00-8:00	48.3		65.3	37.1	
	8:00-9:00	48.7		64.2	38.0	
	9:00-10:00	76.4		105.4	39.6	
	10:00-11:00	52.7		73.9	37.5	
	11:00-12:00	42.6		62.0	34.8	
	12:00-13:00	39.5		55.5	33.0	
	13:00-14:00	46.8		72.2	37.1	
	14:00-15:00	50.6		69.6	35.7	
	15:00-16:00	47.5		61.9	37.4	
	16:00-17:00	45.4		58.1	38.0	
	17:00-18:00	44.5		66.6	38.4	
Evening	18:00-19:00	55.4	50	58.4	42.2	Mean=58.16
	19:00-20:00	58.6		61.6	56.2	
	20:00-21:00	60.9		85.1	45.1	
	21:00-22:00	58.2		73.0	54.5	
	22:00-23:00	57.7		64.3	53.9	
Night	23:00-00:00	52.8	45	82.1	40.5	Mean=46.66

Time	Duration	Noise Level dB(A) (31 October 2018) X=0491031 Y=1272740				Mean
		LAeq	Standard (Leq)	Lmax	Lmin	
	00:00-1:00	46.7		58.1	38.3	
	1:00-2:00	45.4		59.4	38.5	
	2:00-3:00	45.2		60.2	33.7	
	3:00-4:00	41.9		60.3	34.6	
	4:00-5:00	49.8		62.0	39.4	
	5:00-6:00	44.8		60.8	36.9	

Source: Survey Team

(b) Vibration

According to result of vibration measurement at both locations, its level is below the standard of MOE (see the following table).

[Prediction]

There will be slight disturbance to the people and birds living around the project area (Borey Chip Mong Group and Prek Takong 1 village) by the vibration from the machinery, vehicle, generator and construction activities.

Table R 1.4.15 Result of Vibration Measurement in Project Area (studied on 30 October 2018)

Time	Duration	Vibration Level dB (30 October 2018) X=0491356 Y=1272730				Mean
		Leq	Standard Laeq	Lmax	Lmin	
Day	6:00-7:00	17.4	65	24.4	14.9	17.758
	7:00-8:00	17.3		33.8	15.1	
	8:00-9:00	17.2		23.6	15.4	
	9:00-10:00	21.7		45.0	13.1	
	10:00-11:00	15.5		21.7	13.8	
	11:00-12:00	15.8		24.5	14.3	
	12:00-13:00	18.2		26.9	16.9	
	13:00-14:00	23.1		45.4	11.4	
	14:00-15:00	15.5		19.1	13.3	
	15:00-16:00	15.7		23.2	13.9	
	16:00-17:00	16.9		25.1	14.9	
	17:00-18:00	18.8		26.0	17.7	
Night	18:00-19:00	18.1	60	33.0	14.0	18.058
	19:00-20:00	15.3		18.5	14.1	
	20:00-21:00	15.5		24.7	14.1	
	21:00-22:00	18.5		40.9	11.5	
	22:00-23:00	22.7		47.3	11.6	
	23:00-00:00	15.8		30.6	13.7	
	00:00-1:00	15.4		17.1	14.0	
	1:00-2:00	18.9		26.7	17.6	
	2:00-3:00	18.9		26.8	13.0	
	3:00-4:00	17.8		23.9	15.8	
	4:00-5:00	17.4		24.4	14.9	
	5:00-6:00	22.4		33.9	13.0	
24 hours Average		**17.9**		**28.6**	**14.3**	

Source: Survey Team

Table R 1.4.16 Result of Vibration Measurement at Prek Takong 1 Village (studied on 31 October, 2018)

Time	Duration	Vibration Level dB (31 October 2018) X=0491031 Y=1272740				Mean
		Leq	Standard Laeq	Lmax	Lmin	
Day	6:00-7:00	13.3	65	26.1	11.4	14.808
	7:00-8:00	13.1		20.8	11.5	
	8:00-9:00	13.2		30.1	11.4	
	9:00-10:00	27.8		48.9	11.6	
	10:00-11:00	16.0		41.0	11.0	
	11:00-12:00	12.7		16.6	11.2	
	12:00-13:00	13.2		31.1	11.1	
	13:00-14:00	14.5		29.7	11.4	
	14:00-15:00	13.7		28.5	11.6	
	15:00-16:00	13.6		27.0	11.3	
	16:00-17:00	13.4		28.9	11.4	
	17:00-18:00	13.2		28.8	11.5	
Night	18:00-19:00	12.9	60	22.3	11.4	15.283
	19:00-20:00	12.9		24.6	11.3	
	20:00-21:00	12.8		16.4	11.4	
	21:00-22:00	29.4		55.6	11.4	
	22:00-23:00	12.8		17.9	11.3	
	23:00-00:00	16.4		45.6	11.6	
	00:00-1:00	12.9		22.9	11.5	
	1:00-2:00	16.2		34.5	11.5	
	2:00-3:00	12.9		33.7	11.1	
	3:00-4:00	16.9		39.7	11.5	
	4:00-5:00	13.2		26.5	11.4	
	5:00-6:00	14.1		30.6	11.5	
24 hours Average		**15.0**		**30.3**	**11.4**	

Source: Survey Team

(8) Ecosystem

(a) Plants and Habitat of Wildlife

In the project area, there are aquatic crop of local people, includes Swamp morning glory *(IpoMOEa aguatica)*, Water celery (*Oenanthe Javanica),* Water mimosa *(Neptunia oleracea)* Common water hyacinth (*Eichhornia crassipes),* Water Reed (*Cynodon dactylon),* and *Colocasia escula var.aquatilis* that are the habitats of fishes. Furthermore, in Cheung Aek Lake near the project area (1 km around the project area), there are a lot of common duckweed (*Lemna minor)* which is source of food for fish and other small plants such as *Phoenix paludosa, Eichhornia crassipes, Catharanthus roseus, Canmelina, Marsilia quatrifolia, Salifolia* and so on.

About 500 m to 1 km away from project area to the south-east, there are some flooded forest plants in the Lake, including *Barringionia asiatica, Peltophorum pterocarpum, Combretum trifoliatum,* Deum Kontuy Antung, Deum Treng, *Cynodon dactylon, Hymnocardia wallichii, Bridelia avata Var Curtisis, Oxycerus longifora, Lxora cunefolia varwarians, Cochlopermun religiosum, Morinda persicaefoia,* Deum Krokhub Prey, *Cyperus Kyllingia nemoralis, Gmelina asiatica, Mimosa pigra L, Croton caudanus,*

Croton joufra, Seshania javanica, Deum Ombuoh, Deum Sondaek Khmoach, *Derris trifilia, Inhnocarpus frutescens,* Deum Sav Mao Prey are the habitats for amphibians, birds and fishes as well as the breeding sites.

(b) Mammal

There are only 2 main mammals found in the project area. Animals in the Prakas No 020 PK/KSK dated on January 25, 2007 of the Ministry of Agriculture, Forestry and Fisheries (MOAFF) are not found and the mammal in CITES annex are also not found. Moreover, the threated species animals in IUCN Red List are also not found in and around the project area.

Table R 1.4.17 Name of Mammals in and around the Project Area (22 October 02 November 2018)

No.	Scientific Name	English Name	Prakas No. 020 PK/KSK (January 25,2007)	CITES	IUCN	Interviewing	Survey Team
1	*Herpestes javanicus*	Small Asian Mongoose			LC	✓	
2	*(Order: CHIROPTERA)*	Bats				✓	

Source: Survey Team

(c) Birds

43 species of birds are found in and around the project area, 3 are found species in the CITES annex; 2 species in annex II such as Black-shouldered Kite (*Elanus coeruleus) and* Barn Owl (*Tyto alba)* and 1 species in annex III is Cattle Egret (*Bubulcus ibis).* The birds in the Prakas No 020 PK/KSK dated on January 25, 2007 of MOAFF are not found. A bird Green Sandpiper (*Tringa guttifer*) in the threated species animals in IUCN Red List is found.

Table R 1.4.18 Name of Birds in and around the Project Area (October 22-November 08, 2018)

Nº	Scientific Name	English name	Prakas No. 020 PK/KSK (January 25, 2007)	CITES	IUCN	Interviewing	Survey Team
1	*Hemixos flavala*	Ashy Bulbul			LC	□	
2	*Anthus rufulus*	Paddyfield Pipit			LC	□	□
3	*Dicaeum ignipectus*	Fire-breasted Flowerpecker			LC	□	
4	*Phylloscopus plumbeitarsus*	Two-barred Wabler				□	
5	*Saxicola caprata*	Pied Bushchat			LC	□	□
6	*Ploceus philippinus*	Baya Weaver			LC	□	□
7	*Prinia inormata*	Plain Prinia			LC	□	□
8	*Prinia hodgsonii*	Grey-breasted Prinia			LC	□	
9	*Acrocephalus orientalis*	Oriental Reed Wabler				□	□
10	*Orthotomus sutorius*	Common Tailorbird			LC	□	□
11	*Passer montanus*	Eurasian Tree Sparrow			LC	□	□
12	*Passer domesticus*	House Sparrow			LC	□	□
13	*Pycnonotus goiavier*	Yellow-vented Bulbul			LC	□	□

Nº	Scientific Name	English name	Prakas No. 020 PK/KSK (January 25, 2007)	CITES	IUCN	Interviewing	Survey Team
14	*Megalurus palustris*	Striated Grassbird			LC	□	
15	*Anhinga melanogaster*	Oriental Darter			NT	□	
16	*Dicrurus aeneus*	Bronzed Drongo			LC	□	□
17	*Dicrurus macrocercus*	Black Drongo			LC	□	□
18	*Alcedo atthis*	Common Kingfisher			LC	□	
19	*Bubulcus ibis*	Cattle Egret		III	LC	□	□
20	*Ardeola bacchus*	Javan Pond Heron			LC	□	□
21	*Porphyrio*	Purple Swamphen			LC	□	□
22	*Gallicrex cinerea*	Watercock			LC	□	
23	*Gallinula chloropus*	Common Moorhen			LC	□	
24	*Gallinula chloropus*	White-breasted Waterhen			LC	□	□
25	*Porzana cinerea*	White-browed Crake			LC	□	□
26	*Dendrocygna javanica*	Lesser Whistling Duck			LC	□	
27	*Tringa guttifer*	Green Sandpiper			EN	□	
28	*Gelochelidon nilotica*	Gull-billed Tern			LC	□	□
29	*Centropus sinensis*	Greater Coucal			LC	□	□
30	*Streptopelia chinensis*	Spotted Dove			LC	□	
31	*Geopelia striata*	Zebra Dove			LC	□	□
32	*Rhipidura javanica*	Pied Fantail			LC	□	□
33	*Apus affinis*	House Swift			LC	□	□
34	*Apus pacificus*	Fork-tailed Swift			LC	□	
35	*Cypsiurus balasiensis*	Asian Palm Swift			LC	□	
36	*Hirundo rustica*	Barn Swallow			LC	□	□
37	*Merops viridis*	Blue-throated Bee-eater			LC	□	□
38	*Crypsirina temia*	Racket-tailed Treepie			LC	□	□
39	*Acridotheres tristis*	Common Myna			LC	□	□
40	*Elanus coeruleus*	Black-shouldered Kite		II	LC	□	□
41	*Tyto alba*	Barn Owl		II	LC	□	
42	*Cacomantis merulinus*	Plaintive Cuckoo			LC	□	□
43	*Lanius cristatus*	Brown Shrike			LC		□

Source: Survey Team

(d) Reptile and Amphibians

There are 20 species of reptiles and amphibians and the species in CITES annex II 2 species include Common Ratsnake (*Ptyas mucosus*) and Burmese Python *(Python molurus bivittatus).* The species under the sub-decree No 123 ANK/BK dated on August 12, 2009 of MOAFF and IUCN Red List are not found.

Table R 1.4.19 Name of Reptile and Amphibians in and around the Project Area (22 October 08 November 2018)

Nº	Scientific Name	English Name	Sub-decree No 123	CITES	IUCN	Interview	Survey Team
1	*Calotes versicolor*	Garden Fence Lizard					
2	*Acrochordus granulatus*	File Snake			LC		
3	*Enhydris*	Rainbow Water Snake			LC		
4	*Erpeton tentaculatus*	Tentacled snake			LC		
5	*Amphiesma stolata*	Striped Keelback					
6	*Boiga cyanea*	Green Cat Snake					
7	*Elaphe radiata*	Radiated Ratsnake					
8	*Oligodon taeniatus*	Striped Kukri Snake					
9	*Ptyas mucosus*	Common Ratsnake		II			
10	*Python molurus bivittatus*	Burmese Python		II			
11	*Xenochrophis piscator*	Chequered Keelred					
12	*Gekko gecko*	Tokay Gecko					
13	*Hemidactylus frenatus*	Spiny-tailed House Gecko					
14	*Scincella reevesii*	Speckled Leaf-litter Skink					
15	*Sphenomorphus indicus*	Indian Forest Skink					
16	*polypedates cf. leucomystax*	Common Tree Frog			LC		
17	*Duttaphrynus melanostictus*	Common Asian Toad					
18	*Kaloula pulchra*	Banded Bullfrog			LC		
19	*Fejervarga limnocharis*	Rice Field Frog					
20	*Hoplobatrachus tigerinus*	Tiger Frog			LC		

Source: Survey Team

(e) Fish

A total of 52 species are found in the study area. Zone 1, Cheung Aek Lake in and near project area, has 13 species (6 species are found by on-site fishing). Zone 2, Steung Chrov area, has 52 species (28 species are found by on-site fishing). Two threatened species in sub-decree No 123 ANK/BK dated on August 12, 2009 was found, includes Isok barb *(Probarbus jullien) and* Giant barb *(Catlocarpio siamensis)*. There are critical endangered species under IUCN Red List of Giant barb *(Catlocarpio siamensis)* and 2 endangered species; Isok barb *(Probarbus jullien) and* Iridescent shark-catfish *(Pangasius Hypophthalmus).* The fish fished in both zones are summarized in the following table.

Table R 1.4.20 Fish Species found in the Project Area (19 October – 30 November 2018)

Nº	English name	Scientific Name	Family Name	Economic Fish (EF) May 2005	sub-decree No 123	IUCN	Interview	On-site Study (zone 1 and 2)
1	Siamese glassfish	*Parambassis siamensis*	AMBASSIDAE			LC	Zone 1	
2	Climbing perch	*Anabas testudineus*	ANABANTIDAE	EF			Zone 1 and 2	Zone 1 and 2
3		*Mystus atrifasciatus*	BAGRIDAE	EF		LC	Zone 2	
4	Striped catfish	*Mystus multiradiatus*	BAGRIDAE	EF		LC	Zone 1 and 2	
5	Striped catfish	*Mystus mysticetus*	BAGRIDAE	EF		LC	Zone 1 and 2	Zone 1 and 2
6		*Hemibagrus spilopterus*	BAGRIDAE	EF		LC	Zone 2	Zone 2

Nº	English name	Scientific Name	Family Name	Economic Fish (EF) May 2005	sub-decree No 123	IUCN	Interview	On-site Study (zone 1 and 2)
7	Talking gourami	*Trichopsis pumila*	BELONTIIDAE			LC	Zone 1 and 2	
8	Croaking gourami	*Trichopsis vittata*	BELONTIIDAE			LC	Zone 1 and 2	
9	Common Snakehead	*Channa striata*	CHANNIDAE	EF		LC	Zone 1 and 2	Zone 2
10	Nile tilapia	*Oreochromis niloticus*	CICHLIDAE			NT	Zone 1 and 2	Zone 2
11	Walking catfish	*Clarias batrachus*	CLARIIDAE	EF		LC	Zone 1 and 2	Zone 1 and 2
12	Broad head catfish	*Clarias macrocephalus*	CLARIIDAE	EF		NT	Zone 1 and 2	
13	Giant barb	*Catlocarpio siamensis*	CYPRINIDAE		Cr, National Fish	CR	Zone 2	
14	Mekong barb	*Cyclocheilichthys repasson*	CYPRINIDAE			LC	Zone 2	
15	Cyclocheilichthys Tapiensis	*Cyclocheilichthys lagleri*	CYPRINIDAE			LC	Zone 2	
16	Siamese long fin carp	*Labiobarbus siamensis*	CYPRINIDAE			LC	Zone 2	
17		*Crossocheilus reticulatus*	CYPRINIDAE			LC	Zone 2	
18	Pale rasbora	*Rasbora aurotaenia*	CYPRINIDAE			LC	Zone 2	Zone 2
19	Striped flying bard	*Esomus metallicus*	CYPRINIDAE			LC	Zone 2	
20		*Hampala macrolepidota*	CYPRINIDAE	EF		LC	Zone 2	Zone 2
21		*Henicorhynchus caudimaculatus*	CYPRINIDAE				Zone 2	Zone 2
22	Siamese mud Carp	*Henicorhynchus siamensis*	CYPRINIDAE	EF			Zone 2	
23	Tiny scale barb	*Thynnichthys thynnoides*	CYPRINIDAE	EF		LC	Zone 2	
24	Tawes	*Barbodes gonionotus*	CYPRINIDAE	EF		LC	Zone 2	Zone 2
25	Mad barb	*Leptobarbus hoeveni*	CYPRINIDAE	EF			Zone 2	
26	Black sharkminnow	*Morulius chrysophekadion*	CYPRINIDAE	EF		LC	Zone 2	Zone 2
27	Silver sharkminnow	*Osteochilus hasselti*	CYPRINIDAE	EF		LC	Zone 2	
28		*Parachela oxygastroides*	CYPRINIDAE			LC	Zone 2	Zone 2
29		*Paralaubuca typus*	CYPRINIDAE			LC	Zone 2	Zone 2
30	Isok barb	*Probarbus jullieni*	CYPRINIDAE		Cr	EN	Zone 2	
31		*Puntioplites proctozysron*	CYPRINIDAE	EF			Zone 2	Zone 2
32	Spotted barb	*Systomus binotatus*	CYPRINIDAE				Zone 2	Zone 2
33	Puntius Simus	*Puntius orphoides*	CYPRINIDAE	EF			Zone 2	
34	Marbled sleeper	*Oxyeleotris marmorata*	ELEOTRIDAE	EF		LC	Zone 2	Zone 2
35	freshwater	*Xenentodon*	BELONIDAE			LC	Zone 2	

Nº	English name	Scientific Name	Family Name	Economic Fish (EF) May 2005	sub-decree No 123	IUCN	Interview	On-site Study (zone 1 and 2)
	garfish	*cancila*						
36	Stripe-nosed Halfbeak	*Zenarchopterus buffonis*	HEMIRAMPHIDAE				Zone 2	Zone 2
37	Peacock eel	*Macrognathus siamensis*	MASTACEMBELIDAE	EF		LC	Zone 2	
38	Shortspine eel	*Macrognathus taeniagaster*	MASTACEMBELIDAE	EF		LC	Zone 2	
39	Tiretrack spiny eel	*Mastacembelus armatus*	MASTACEMBELIDAE	EF		LC	Zone 2	
40	Catopra	*Pristolepis fasciata*	NANDIDAE	EF		LC	Zone 2	Zone 2
41	Bronze featheback	*Notopterus*	NOTOPTERRUS	EF		LC	Zone 2	Zone 2
42	Moon light gourami	*Trichogaster microlepis*	BELONTIIDAE	EF			Zone 1 and 2	Zone 1 and 2
43	Threespot gourami	*Trichogaster trichopterus*	BELONTIIDAE	EF		LC	Zone 1 and 2	Zone 1 and 2
44	Snakeskin gourami	*Trichogaster pectoralis*	BELONTIIDAE	EF			Zone 1 and 2	Zone 1 and 2
45		*Pangasius larnaudii*	PANGASIIDAE	EF		LC	Zone 2	Zone 2
46		*Pangasius bocourti*	PANGASIIDAE	EF		LC	Zone 2	Zone 2
47	Iridescent shark-catfish	*Pangasius hypophthalmus*	PANGASIIDAE	EF		EN	Zone 2	Zone 2
48	Butter catfish	*Ompok bimaculatus*	SILURIDAE	EF		NT	Zone 2	Zone 2
49		*Wallago attu*	SILURIDAE	EF		NT	Zone 2	Zone 2
50	Swamp eel	*Monopterus albus*	SYNBRANCHIDAE			LC	Zone 1 and 2	
51	Yellow pufferfish	*Tetraodon turgidus*	TETRAODONTIDAE			LC	Zone 2	Zone 2
52	Induan Carp	*Labeo rohita*	CYPRINIDAE			LC	Zone 2	Zone 2

Source: Survey Team

[Prediction]

As there are some species inhabiting in the project site, direct damage and loss of habitat for common species, are predicted. However, the scale of the project is small, species that inhabit at STP site is limited, and the species commonly inhabit around the STP site. Regarding endangered species (fish), the species are reported by interview survey in Zone 2. The area is 3km far from the project site and DO at project site is less than 0.5 mg/l. Therefore, the species cannot inhabit near the project area and negative impact to the ecosystem including endangered species is not predicted.

(9) Solid Waste

According to the study at the dumping site in Prek Takong 1 village, Chak Angre Leu, Khan Mean Chey, 1 m^3 of waste has an average weight of 115 kg, consisting of biodegradable waste (vegetable, fruit, food, paper…) (36.41%), non-hazardous waste (shellfish's shell,

snail's shell, wood pieces…) (2.90%), Scrap of glasses or porcelain or brick (7.5%), hazardous waste-plastic (bottle, plastic bag, plastic pipe…) (33.12%), and other hazardous waste (garment, tire and rubber waste, metal, batteries, lamp, medical waste, e-waste…) (20.07%).

Table R 1.4.21 Waste Composition at the Dumping Site (studied in November 2018)

No	Location	Sample	Village	Coordinate plane	Weight of waste 20cm^3 (kg)	Bio-degradable waste 20cm3(kg)	non-hazardous waste 20cm3(kg)	Glass/ porcelain/ brick 20cm3(kg)	Plastic 20cm^3 (kg)	Other hazardous waste 20cm^3(kg)
1	1	1	Prek Takong 1	X: 490960 Y:1272857	2.68	1.1	0.2	0.3	0.98	0.1
2		2	Prek Takong 1		2.85	0.85	0	0	1	1
3		3	Prek Takong 1		3.1	2.55	0.2	0	0.35	0
4	2	4	Prek Takong 1	X:490992 Y:1272772	2.6	0.9	0	0	0.8	0.9
5		5	Prek Takong 1		1.8	0.5	0.2	0	0.85	0.25
6		6	Prek Takong 1		0.95	0.1	0	0	0.7	0.15
7	3	7	Prek Takong 1	X:491034 Y:1272740	1.75	0.7	0	0	0.85	0.2
8		8	Prek Takong 1		2.05	0.33	0	0.25	0.52	0.95
9		9	Prek Takong 1		2.9	0.5	0	1	0.8	0.6
Average waste density					**2.30**	**0.84**	**0.07**	**0.17**	**0.76**	**0.46**
Waste density in 1m^3					**115**	**41.8**	**3.3**	**8.6**	**38.1**	**23.1**
Total %					**100%**	**36.41%**	**2.90%**	**7.50%**	**33.12%**	**20.07%**

Source: Survey Team

According to the study, waste management is available along the concrete road or any road the waste collection truck can access. In the study area, there is no solid waste management (waste). In Prek Takong 1 village, collection services are only available on the main roads. The concrete road from Rd. 371 to the end of the road, about 600 m long, which has the waste collection services, is targeted for the social economic study. From the end of this concrete road to the waterfront, there is no waste collection service. Structures are built in water (flooded in the rainy season) and people throw the waste/trash under or to the side or at the back of their structures and some throw waste into the available land near the structures.

[Prediction]

Solid waste (e.g. concrete fragment, iron scrap and timber fragment by the construction) management is obligated to the Project, and solid waste management system has been established in the Project. Therefore, issues of solid waste (proper collection and dumping) are basically not predicted. However, waste released by workers at the site spread from the living space to outside.

(10) Demographical Study

Two Sangkat, namely, Sangkat Chak Angre Leu and Sankat Chak Angre Krom, are located near the project area. Sangkat Chak Angre leu is the nearest to the project area with the population of 4,093 families with 19,633 people.

Table R 1.4.22 Statistics of Citizens living in Sangkat Chak Angre Leu

No.	Village	Total Family	Total Population	Female	18 years old and older	18 years old and older (female)
1	Prek Ta Nu	557	2,572	1,344	1,880	996
2	Prek Ta Nu 1	513	2,448	1,232	1,525	806
3	Prek Ta Nu 2	400	1,763	923	1,213	647
4	Prek Takong	512	2,290	1,131	1,461	764
5	Prek Takong 1	549	2,808	1,402	1,756	906
6	Prek Takong 2	753	3,735	1,895	2,553	1,338
7	Prek Takong 3	611	2,965	1,531	2,026	1,060
8	Phum 7	198	1,052	549	643	347
Total		**4,093**	**19,633**	**10,007**	**13,057**	**6,864**

Source: Data from authority of Sangkat Chak Angre Leu, 2018

(11) Community Structure

According to the data from the study of socio-economic in Prek Takong 1 village, the 135 family heads have education level from Grade 5 to Grade 12 and there are also some illiterate. Among the 135 family heads, there are 82 men and 8 women who can read and write Khmer, equal to 67%. There are 32 men and 11 women, who cannot read and write Khmer. In sum, 33% of households cannot read and write Khmer.

(12) Road

The existing roads infrastructures in the project area are: Rd. 271 to Kbal Thnorl headed to Hun Sen Boulevard (60 m road), which is connected to intersection of Hun Neang Blvd. (30 m Road).

[Prediction]

There can be minor impact on Rd. 271 by the transport of construction material such as soil, sand, rock and steel from other place using heavy truck which damage the road. There can be minor impact on the daily traffic and transport of the people live along the Rd. 271 with congestion.

(13) Livelihood and Income

Based on the analysis on the income using data from the interview with 135 family heads, the sources of incomes in Prek Takong 1 village are the aquatic crops (Morning glory, Celery and Water Mimosa) (29.38%), payment from daily work (constructors, freelance…) (23.56%), sales (18.67%) and so forth.

[Prediction]

The project will affect the aquatic vegetable planting of 7 users. This may decrease their income. If there is no tracking of their livelihood after the compensation, some users can use the compensation wrongly or they may not obtain benefit from the lost revenue program.

They are supposed to be hired as employee of the Project, but contractors may overlook the

TOR of the contract that requires them to choose the workers from the local community near the project site.

Table R 1.4.23 Source of Monthly Incomes (USD) of the interviewed Family near the Project Area (October to November 2018)

Village	Number of family	Officers (salary)	Company/NGO worker (salary)	Factory worker (salary)	Worker (no monthly salary)	Small scale sale	Driver (taxi, moto-taxi, remorque)	Farmer (aquatic crops)	Animal feeding	Fishing (Cheung Aek Lake)	Others	Total income of family/month
Prek Takong 1	135	$2,068	$5,182	$1,835	$12,779	$10,128	$2,710	$15,933	$58	$1,078	$2,462	$54,231
Total (%)		3.81%	9.55%	3.38%	23.56%	18.67%	5.00%	29.38%	0.11%	1.99%	4.54%	100%

Source: Survey Team

(14) Land Acquisition and Resettlement

In the area of 9.02 ha (Access Road (Channel Maintenance Road) site/sewer installation area: 5.24 ha, STP: 3.78 ha), there are 2 HHs who have structures/buildings illegally where nobody is living. Therefore, **involuntary resettlement doesn't occur**. One of the 2 HHs has 2 buildings (type 2f) with a total area of 106.2 m^2, total awning area of 156.8 m^2, bathroom 7.8 m^2, and temporary shelter of worker (type 2a) 73.4 m^2. Moreover, there are fruit trees - 47 trees/cluster in total; including 37 mango trees and 10 banana cluster. The other has brick fence (100mm) of Chip Mong Group with the size of 90 m^2 and double underground drainage pipe of Chip Mong Group with a length of 36 m. In the project area, there are lands that plant the aquatic crop in about 3.67 ha, which is used illegally by 7 HHs that have rented from 6 illegal land occupants will be affected by the Project. Out of the total of 22 AHs, 15 HHs are illegal land occupants and 7 HHs are users. Although the land occupation and use are illegal, compensation will be necessary, based on JICA environment and social guideline.

Table R 1.4.24 Affected HHs in the Project Site

No	village	Total HHs	Total people	Affected HHs	Illegal land occupant	Users
1	Prek Takong 1	549	2,808	22	15	7
Total		549	2,808	22	15	7

Source: Survey Team

Table R 1.4.25 Real Estate Affected by the Project

Type of structure	Roof	Wall	Floor	Column	Story	Affected area (m^2)	Affected HH
House 2f	Zinc	Brick	Mortar	Concrete	Single	106.20	1
Awning (1+2)	Zinc	None	Mortar	Iron	Single	156.80	
Bath room	Zinc	Brick	Tile	Iron	Single	7.80	
Shelter (2a)	Zinc	Wood and cloth	Wooden	Pole	Single	73.40	
Brick Fence, 100 mm (Chip Mong Group)						90.00	1
Brick Bund Wall, 200 mm (Chip Mong Group)						120	1
Total Affected HHs							2

Source: Survey Team

Table R 1.4.26 Affected Crops

Tree	Unit	Total
Mango	Tree	37
Banana	Cluster	10
Total		47

Source: Survey Team

(15) Water Use and Sanitation

In Prek Takong 1 in Sangkat Chak Angre Leu, which is near the project area, there are some people who use water (for bathing, laundry, cooking and drinking) from the city water supply and some use water from their well. In Prek Takong 1 village, the main water sources are the clean water from PPWSA (84%) followed by drilled well (16%).

Table R 1.4.27 Water Use of the People in the Village

No.	Village	Interviewed families	Case of water use	Water use of the interviewed families %			
				Drilled well	%	Clean water supply	%
1	Prek Takong 1	135	136	22	16%	114	84%

Source: Survey Team

Data obtained from interviews with 135 families shows that 89% of them have toilet and remaining have no toilet and have a wash by open defecation or use neighbor's toilet.

Table R 1.4.28 Toilet Utilize of the interviewed Families

No.	Village	Sangkat	Interviewed families	Toilet	%	No Toilet	%
1	Prek Takong 1	Chak Angre Leu	135	120	89%	15	11%
		Total	135	120	89%	15	11%

Source: Survey Team

[Prediction]

There can be slight impact on the clean water pipe for the people living near the outlet of the Trabek pumping station which can affect their daily water use.

(16) Public Health and Welfare

The Chiefs of Sangkat Chak Angre Leu and Cha Angre Krom stated that in the Sangkat Chak Angre Krom have 4 health centers with 60 rooms and 30 Doctors. In Sangkat Chak Angre Leu, there is no health post or health center. When the villagers get sick, they go to a health center in Sangkat Chak Angre Krom. In case of serious illness, they go to Khmer-Soviet Friendship Hospital, the nearest hospital of the project area.

Table R 1.4.29 Statistic of Health Center and Hospital in the Project Area

No.	Sangkat	Khan	Health post			Health center		
			Building	Room	Doctor	Building	Room	Doctor
1	Chak Angre Leu	Mean Chey	0	0	0	0	0	0
2	Chak Angre Krom	Mean Chey	0	0	0	4	60	30
		Total	0	0	0	4	60	30

Source: Data from authority of Sangkat Chak Angre Leu, 2018

[Prediction]

The following impacts are predicted during construction.

i. Project's workers' health and work safety

- In/near project area, the contaminated water will affect the welfare of staff-workers contacting the water directly or indirectly. The illnesses that can occur are diarrhea, typhoid fever, skin diseases and respiratory infection caused by the bad odor.
- The work incident caused by the neglect or not following the safety and risk management plan.

ii. Public health

- The people living near the project area can get STDs and other communicable disease from the staff-workers who come from the other area.
- Impact on public health by the trafficking or trading of drugs by some staff-workers.
- Traffic accident caused by the construction material transportation.

(17) Accident

According to National Road Safety Committee, in September 2018, there were 250 traffic accidents in Cambodia, which affected 461 people, in which there were 131 deaths (28.42%), 249 serious injuries (54.01%) and 81 slightly injuries (17.57%). The traffic accident also damaged 461 vehicles in total, as shown in the following table.

Table R 1.4.30 Traffic Accident Data in Cambodia

No.	Type of Vehicle	Number	Percentage
1	Motorcycle	271	58.79%
2	Car	121	26.25%
3	Truck	49	10.63%
4	Other	20	4.34%
Total		461	100.0%

Source: National Road Safety Committee, 2018

[Prediction]

Eventual event can occur during construction phase by the neglect of work safety and not following the safety and risk management plan and not checking the vehicle properly while driving.

(18) Landscape

In and around the project area, Cheung Aek Lake receives wastewater from Phnom Penh and people plant vegetables on the Lake such as Water Morning Glory and Celery and so on. Roads around the project site are dusty due to solid waste.

[Prediction]

The roads may be dirty by trucks conveying material (construction) and sludge (operation) in the Project.

(19) Gender

Gender equality is not a serious issue nowadays.

[Prediction]

However, the gender issue can be happened is the discrimination toward women and the disabled when they apply for job.

1.4.1.8 Impacts Evaluation

Based on the survey results and according to Guidelines, impacts are summarized in **Table R 1.4.31** and **Table R 1.4.32**. The negative impact of this project is considered small.

Table R 1.4.31 Impact Evaluation (Pollution and Natural Environment)

No.	Impact items	Construction Stage	Operation Stage	Description
I. Pollution and Natural Environment				
1	Air Pollution	B-	N/A	Construction • Machinery exhaust dust. • Traffic congestion in construction area leads to more exhaust emission. • Trucks make dust along the road when transport the material.
2	Noise	B-	N/A	Construction • There will be some disturbance to the people and birds living around the project area (Borey Chip Mong Group and Prek Takong 1 village) by the noise from the machinery, vehicle, generator and construction activities such as earth fill and pile driving.
3	Vibration	B-	N/A	Construction • There will be some disturbance to the people and birds living around the project area (Borey Chip Mong Group and Prek Takong 1 village) by the vibration from the machinery, vehicle, generator and construction activities such as earth fill and pile driving.
4	Water Pollution	B-	B±	Construction • The water become turbid because of the construction such as dredging and reclamation. • Pollute the surface water by the leak of oil from the machinery and vehicle in the construction site. Operation • Surface water quality may be deteriorated by poor maintenance which leads to the loss of treated capacity and re-pollute Cheung Aek Lake. • STP will reduce the water pollution in comparing to pre-construction.
5	Soil Pollution	B-	N/A	Construction • Spill of fuel and lubricant and dumping of waste on the soil may cause soil pollution. • Spill and leak of all types of oils may cause soil pollution
6	Solid Waste	B-	N/A	Construction • Solid waste (e.g. concrete fragment, iron scrap and timber fragment by the construction) management is obligated to the Project, and solid waste management system has been established in the Project.

No.	Impact items	Construction Stage	Operation Stage	Description
				Therefore, issues of solid waste (proper collection and dumping) are basically not predicted. • However, waste by the workers at the site may be released from their living space to outside.
7	Soil Erosion and Slope Failure	B-	N/A	Construction • Land clearing, excavating and backfilling may cause erosion. • Dumping of spoiled soil digging from the bottom of the lake may slide into the lake. • Landfill can slide into the lake near the project. • The project will purchase the landfill soil from licensed provider (the license is given by the Ministry of Mines and Energy. If the provider deals with river sand, the provider also requires the license given by the Ministry of Water Resources and Meteorology. EIA study is requited for establishment of the business of sand and soil collection with excavation depth of more than 4 m). Amount of soil for reclamation in the project is estimated at about 250,000 m^3. Candidate licensed providers for purchasing the soil are located in the southern part of PPCC (one provider is located near the boundary of Kandar Province and the other is located near Bassac River). Operation • Flood will not flow into the STP.
8	Ecosystem	B-	D	Construction • Construction activities, especially the soil work, may increase turbidity and reduce the dissolved oxygen. • Some aquatic birds live there and hunting and trading of these animal by the staff-worker may happen. • Endangered species are reported by interview survey in Zone 2. The area is 3 km far from the project site and DO at the project site is about 0.3 mg/l. Therefore, the species cannot inhabit near the project area and negative impact to the endangered species is not predicted. Operation • Water quality will be improved and negative impact to ecosystem is not considered.
9	Geology and Topography	B-	N/A	Construction and Operation • There can be the change in topography and the erosion in the project area, caused by land clearing, excavating and backfilling.
10	Hydrology	B-	N/A	Construction and Operation • Project may cause impact with dumping excavated sediment as it may block the flow of surface water and lead to flooding.

Legend : A +/-: Significant positive (+)/negative (-) impact is expected.
B +/-: Some positive (+)/negative (-) impact is expected.
C +/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the survey progresses.
D: No impact is expected.

Source: Survey Team

Table R 1.4.32 Possible Adverse Impact (Social Environment)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
II. Social Environment				
1	Land Acquisition and Involuntary Resettlement	B-	N/A	Construction • This project is in the Cheung Aek Lake area of the 520 ha in sub-decree No. 124 ANK/BK dated on 03 September 2008 as the public state land and in the sub-decree No. 168 ANK/BK dated on 13 December 2018 about changing of Cheung Aek Lake area in Khan Mean Chey and Khan Dangkor of Phnom Penh Capital City and Takhmao town of Kandal province, 190,736 m^2 (19.0736 ha), to the private state land to the Administrative of Phnom Penh Capital City for development of the sewage treatment system. • Basic Resettlement Plan (BRP) of the project in March 2019 shows that there are 22 AHs. • 7 users (using area of 3.67 ha) will lose their agricultural income (illegal) in the STP site. • In the Access road (Channel Maintenance Road)/Sewer (5.24 ha) site, there are 9 illegal land occupants in which 2 illegal land occupants have filled land illegally (total of 1.82 ha) and also have 3 structures and 47 fruit trees illegally. • 15 illegal land occupants' occupation, are out of target of compensation except compensation for buildings/Structures and Trees/Plants managed by 2 AHs at the Access Road (Channel Maintenance Road)/Sewer site. The details are described in "1.4.2.3 (3) Inventory of Affected Assets (a) Land"
2	Water Use	B-	B+	Construction • There can have negative impact on the clean water pipe of the people living near the outlet of the Trabek pumping station, which can affect their daily water use. Operation • Positive effect is expected with the improvement of people's life by the treated wastewater.
3	Road	B-	N/A	Construction • There can be impact on Rd. 271 by the transport of construction material such as soil, sand, rock and steel from other places using heavy truck, which damages the road. • There can be the impact on the daily traffic and transport of the people's life along Rd. 271 with congestion.
4	Accident	B-	N/A	Construction • Accidents can occur due to the neglect of work safety and not following the safety and risk management plan.
5	Sanitation	N/A	B+	Operation • Positive effect is reduction of waterborne disease after the treatment of wastewater.
6	Risk of Public Health and Welfare	B-	B±	Construction [Project's workers' health and work safety] • In/near project area, the contaminated water will affect the welfare of staff-workers contacting the water directly or indirectly. Illnesses that can occur are diarrhea, typhoid fever, skin diseases and respiratory infection caused by the bad odor. • Work incident caused by the neglect or not

No.	Potential Impacts	Construction Stage	Operation Stage	Description
				following the safety and risk management plan. [Public health] • The people living near the project area can get STDs and other communicable disease from the staff-workers who come from the other area. • Impact on public health by the trafficking or trading of drugs by some staff-workers. Operation • Positive effect is reduction of waterborne disease after the treatment of wastewater.
7	Livelihood/Income	B-	N/A	Construction • The project will affect the aquatic vegetable planting of 7 users, decreasing their living standard. If there is no tracking of their livelihood after the compensation, some users can use the compensation wrongly or they may not obtain benefit from the lost revenue program.
8	Existing Social Infrastructure and Service	B-	B+	Construction Same as "No.3 Road" Operation Improvement of social service by the treatment of wastewater.
9	Landscape	B-	B-	Construction Road may be dirty with the spill of soil and cement from trucks. Operation Road may be dirty with dried sludge spilled from trucks.
10	Gender	B-	N/A	Construction • Gender equality is not a serious issue nowadays, but the gender issue can be happened through discrimination toward women and the disabled when they apply for a job.
11	Employment Opportunity	B+	N/A	Construction • The project is planning to recruit up to 50 staff. They are supposed to be hired as employee of the Project, but contractors may overlook the TOR of the contract that requires them to hire workers from the local community near the project site.
12	Climate Change	B-	N/A	Construction • CO_2 emission caused by the use of machinery.

Legend : A +/-: Significant positive (+)/negative (-) impact is expected.
B +/-: Some positive (+)/negative (-) impact is expected.
C +/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the survey progresses.
D: No impact is expected.

Source: Survey Team

1.4.1.9 Mitigation Measures

Mitigation measures of the significant environmental and social impacts are as described in **Table R 1.4.33**.

Table R 1.4.33 Mitigation Measures

No.	Environmental Items	EMP	Implementing agency	Responsible Agency	Cost
Construction					
1.	Air pollution	• The contractor will have to educate the staff-workers to understand the sanitation, not to practice open defecation and keep waste in the storage. • Wet (sprinkle water) the constructing Access Road (Channel Maintenance Road) regularly (the dirt road, at least 4 times per day, 7 AM, 11 AM, 1:30 PM and 4 PM that are the busy time) and cover well the soil, sand, rock and cements when transported. • Contractor will educate the staff-worker about the risk of fire from the kitchen and welding as well as the fuel storage and other flammable material. • Cleaning of tires of dump truck, which are utilized for transporting soil and sand, will be implemented. • Soil and sand in the dump trucks' rear deck will be covered by plastic sheet. • The dump truck will adhere its allowable load	Contractor	PPCC/DPWT	Included in construction cost. Total estimated cost is $7,200.
2.	Water Pollution	• In the construction phase, the consultants chosen for the Project will monitor carefully in soil works and concrete works as well as water pumping. • The consultant must ensure that the contractor has educated the staff-workers about the sanitation not to practice open defecation and must keep waste in the storage which will be built in the temporary accommodation. • Contractor must take the strong measure in wastewater management by building a temporary toilet far away from the lake and installing the pipes with a depth of 1.5 to 2 m with a diameter of 0.5 m, as well as collecting solid waste to dump in a safe location without harming the environment. • In order to manage the waste efficientlly, the contractor will have to put up the sign of "Do not dump the waste" and so on in and near the project area in Khmer and English.	Contractor	PPCC/DPWT	Included in construction cost. Total estimated cost is $13,600.

No.	Environmental Items	EMP	Implementing agency	Responsible Agency	Cost
		• Fuel storage must be built according to the technical standard and make sure that there is no spill and leak of the fuel to the environment. • Contractors must follow the sub-degree No. 235 ANK/BK about the management of sewerage system dated on 25th December, 2017. • In case that the contractor does not follow the guideline and mitigation measure as described, the consultant must report DPWT and JICA to take contraction of budget for restoring environment.			
3.	Soil pollution	• Contractors will have to construct the fuel storage according to the national technical standard to ensure no spill or leak of fuel into the soil. • Furthermore, they must maintain the machinery and generator not to spill or leak fuel into the soil. The parking lot of vehicle and machinery must have concrete floor. • The contractors will have to manage all kind of waste properly: not to pour the old lubricant on the land and keep other waste safe by implementing solid-liquid waste management plan.	Contractor	PPCC/DPWT	Included in construction cost
4.	Noise/Vibration	• Contractor will use the machinery and vehicle with the exhaust pipe installing a qualified resonator and silent generator causing slight noise and not disturbing neighbors. • Contractors will educate the staff-workers not to create loud noise at the rest time and at night.	Contractor	PPCC/DPWT	Included in construction cost. Total estimated cost is $4,800.
5.	Soil Erosion and Slope Failure	• The consultant chosen by JICA will monitor the embankment, canal and spoiled soil dumping to prevent the erosion and ensure that there will be proper grass plantation at all site as stated in TOR. • The dumping of soil mixed with water from the bottom of the lake will be monitored not to slide into Cheung Aek Lake. Sludge and water taken out will be stored in the pit of 5m x 5m x 2m (width x length x depth) in order to settle sludge and	Contractor	PPCC/DPWT	Included in construction cost

No.	Environmental Items	EMP	Implementing agency	Responsible Agency	Cost
		dewater and finally fill back sludge into the pit. Do not dump the mixture of sludge and water into Cheung Aek Lake in/near the project area to prevent pollution.			
6.	Ecosystem	• Monitoring team must ensure that contractors have consulted with the Department of Environment and Ministry of Agriculture, Forestry and Fisheries to educate the staff-workers to love the wildlife and prevent hunting and trading the wild animal illegally. • Contractors must pay high attention to environmental protection by implementing the solid-liquid waste management plan and build the bathroom and toilet, installing pipe with 0.5 m of diameter, 1.5 to 2 m depth according to the number of workers not to drain the wastewater to the lake directly or build the toilet on the water. • The contractor will have to manage all kind of waste by storing them at a safe place according to the technical standard and CINTRI which is in charge of conveying the waste to the disposal site. • Educate the staff-workers to dump solid-liquid waste especially fuel and lubricant at the safety place.	Contractor	PPCC/DPWT	Included in construction cost
7.	Resettlement	• Project has already set the Basic Resettlement Plan (BRP) in 2019. The BRP will be implemented by the MEF as the leader and other relevant Ministry including the DPWT is the member for resolving the effects caused by the project. • DPWT will work with MEF to monitor and track the impact on the aquatic crop to ensure that AHs have restored their living standard better than before the project. • No living house will be affected, except one guarding house to be relocated. The project will compensate the cost of structure and transportation allowance to the AHs. Other affected secondary structures (fence and awning) and trees will also be compansated. Income restoration program will be	Inter-ministerial Resettlement Committee (IRC)	MEF	Included in preparation cost. The total estimated cost is 60,198USD (excluding land cost)

No.	Environmental Items	EMP	Implementing agency	Responsible Agency	Cost
		established during detail design stage by General Department of Resettlement.			
8.	Employment	• The monitoring team chosen by JICA will ensure that the contractors employ the people from the local community when they apply for job. • Contractors must follow the Labor Law of Kingdom of Cambodia by setting work hours per day of 8 hours equal to 46 hours per week (article 137 of Labor Law). If there are works during the holiday or national ceremony day, the employers must provide them the overtime pay and increase 50% for the daytime works and 100% for the nighttime works (article 139 of Labor Law).	Contractor	PPCC/DPWT	Included in construction cost
9.	Water Use	• Must solve the issue immediately by installing another pipe to replace the old system and ensure that there is no problem on the daily water use of the people.	Contractor	PPCC/DPWT	Included in construction cost
10.	Road	• The monitoring team will ensure that the contractors will access the road and use the truck as stated in TOR which has described above. • In case that there is damage of the road by the transportation of construction material, DPWT will be responsible for repairing the road.	Contractor	PPCC/DPWT	Included in construction cost
11.	Safety and Public Health	• To reduce the impact on health and safety of the staff-workers and public health and safety, the contractors must implement the mitigation measure as follows: • Educate staff and workers about both sanitation, self-protection from the social disease, and drinking of sterilized water or fresh water (bottle water). • Educate staff and workers about how to protect themselves and prevent disease in every 6 months. • Reserve the medicine to prevent and treat the diseases. • Build the toilets with septic tank far from water sources. • Provide clean water for temporary accommodation before stay of staff and worker or start of construction. • Construct the first aid room with adequate medicine for treating	Contractor	PPCC/DPWT	Included in construction cost

No.	Environmental Items	EMP	Implementing agency	Responsible Agency	Cost
		injuries. This mean, DPWT will implement the safety and risk management plan and the planning for accommodation, health and hygiene of project staff-workers. • Cooperate with the local authority to educate the staff-workers not to commit the sex trafficking (human trafficking) and drugs trafficking.			
Operation					
1.	Topography	• The DPWT, will have to prepare machinery to clean the soil that falls into the waterway and take the soil to store at the safe place and immediately repair the damaged part. The place that had fallen must be planted with grass or trees or covered with mortar, keeping the hole to drain water properly.	PPCC/DPWT	PPCC/DPWT	Included in operation and maintenance cost. Total cost for erosion protection is $15,000.
2.	Water Pollution	• DPWT, will have the staff trained by JICA to maintain the project and reserve the tool, spare parts and budget to repair the faciliteis to run normally treatment process. • DPWT cooperate with the laboratory of MOE to check and monitor the surface water quality at 3 locations. Location 1 is on the upstream of intake from Trabek pumping station with the coordinate X=0491822; Y=1274363. Location 2 is in Cheung Aek Lake, downstream of the outlet of treated sewage in Sangkat Chak Angre Krom, Khan Mean Chey, with the coordinate X=0491299; Y=1272570. Location 3 is in Steung Chrov, downstream of the project area, where the water flows into Steung Prek Thnot in Sangkat Deum Mean, Takmao town, Kandal Province with the coordinate X=0493103; Y=1268628. The water quality testing is done at least twice per year, in March (the dry season) and September (the rainy season) and the data will be stored in Microsoft Excel for the analysis purpose in the future. • The DPWT will pay close attention to waste management. • DPWT must maintain the treatment system regularly not to stop the process of treatment and have the budget plan for the	PPCC/DPWT	PPCC/DPWT	Included in operation and maintenance cost. Total WQT cost is $13,500.

No.	Environmental Items	EMP	Implementing agency	Responsible Agency	Cost
		system maintenance.			
3.	Ecosystem	• Pay close attention to the environmental protection. Thus, the staff-workers will not eat or trade aquatic birds.	PPCC/DPWT	PPCC/DPWT	Included in operation and maintenance cost
4.	Water Use	• Pay close attention to managing all kinds of solid-liquid waste including the maintenance of the treatment system, and improving water quality of Cheung Aek Lake and quality of vegetables planted by locals.	PPCC/DPWT	PPCC/DPWT	Included in operation and maintenance cost
5.	Safety and Public Health	• In this phase, the DPWT will follow the waste management plan. Treated dried sludge via truck must be well covered when transported not to harm the environment and society. After sludge thickening digestion, the sludge is dried up at sludge drying bed. After that, the sludge is transported by truck to damping sites. • DPWT will work with local authorities to prevent any accidents for STP operation.	PPCC/DPWT	PPCC/DPWT	Included in operation and maintenance cost

Source: Survey Team

1.4.1.10 Environmental Monitoring Plans

The environmental monitoring plan during construction and operation is shown below.

Table R 1.4.34 Monitoring Plan

Resource	Monitoring Locations	Methodology and Parameters	Monitoring Cycles	Responsible/ implementing Institutions	Monitoring Institutions
1. Project Before Construction Phase					
1.1 Socio-economy resource					
Resettlement	− Along the Access Road (Channel Maintenance Road) and sewerage treatment plant − Prek Takong 1 village	− The monitoring of compensation of resettlement and grievance redress	Once every 6 months	1. IRC-WG, IRC 2. DPWT 3. Local authorities	1. MoE 2. MEF 3. DoE 4. DLMUPC
2. Project Construction Phase					
2.1 Physical resource					
Soil erosion and slope failure	− Sand provider	− Confirmation of license issued by Ministry of Mines and Energy and Ministry of Water Resources and Meteorology	Before construction	1. DPWT 2. contractor	1. Ministry of Mines and Energy 2. Ministry of Water Resources and Meteorology
Topography	− Building construction site − Access Road (Channel Maintenance Road) − Protection dike construction site	− The monitoring of the topography and the erosion at the infrastructure construction site	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DoAFF 4. Local authority

Resource	Monitoring Locations	Methodology and Parameters	Monitoring Cycles	Responsible/ implementing Institutions	Monitoring Institutions
	− Spoiled soil dumping site	− The monitoring of erosion at the road, protection dike's embankment and spoiled soil dumping site			
Hydrology	− Canal from Trabek pumping station − Wastewater way, downstream of the drainage to Hun Neang road	− Monitoring of the obstruction of the flow of pumped wastewater	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DOWRAM 4. Local authority
Surface water quality	3 Sample locations near the project area − Location 1: X=0491822, Y=1274363 − Location 2: X=0491299, Y=1272570 − Location 3: X=0493103, Y=1268628 − Solid-liquid waste storage	− Monitoring of the water quality on the parameters: temperature; pH; Turbidity, TDS; TSS; DO; BOD; COD; SO_4; TN; TP; Pb and Total Coliform − Monitoring of solid-liquid waste management	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DOWRAM 4. Local authority
Soil quality	− Infrastructure construction site, generator and machinery storage − Temporary shelter of staff-workers	− Monitoring of solid-liquid waste management − Monitoring of the spill, leak of fuel on the soil.	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DOWRAM 4. DoAFF 5. Local authority
Air Quality	− Infrastructure construction site − Access Road (Channel Maintenance Road) − Temporary shelter of staff-workers − 2 location of air quality testing: location 1 X=0491356, Y=1272730, location 2 X=0491031, Y=1272740	− Monitoring of the material transportation on Rd. 271 − Monitoring of the odor condition at construction sites − Monitoring of air quality parameters: TSP; CO; NO_2; SO_2, O_3, PM10, PM2.5 and H_2S	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DoT 4. Local authority
Noise and vibration	− Infrastructure construction site − Road construction site from Rd. 271 to construction site − Temporary shelter of staff-workers − Noise and vibration testing locations are the same as air quality testing locations	− Monitoring of the noise and vibration from the material transportation, the operation of any machinery, generator and vehicle. − Monitoring of noise and vibration (Unit: dB)	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DoT 4. Local authority
2.2 Biological resources					
Ecosystem (Fish)	− Cheung Aek Lake near project area − Temporary shelter of staff-workers	− Monitoring of solid-liquid waste management − Monitoring of the water quality on the parameters temperature; pH;	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DOWRAM 4. DoAFF 5. Local authority

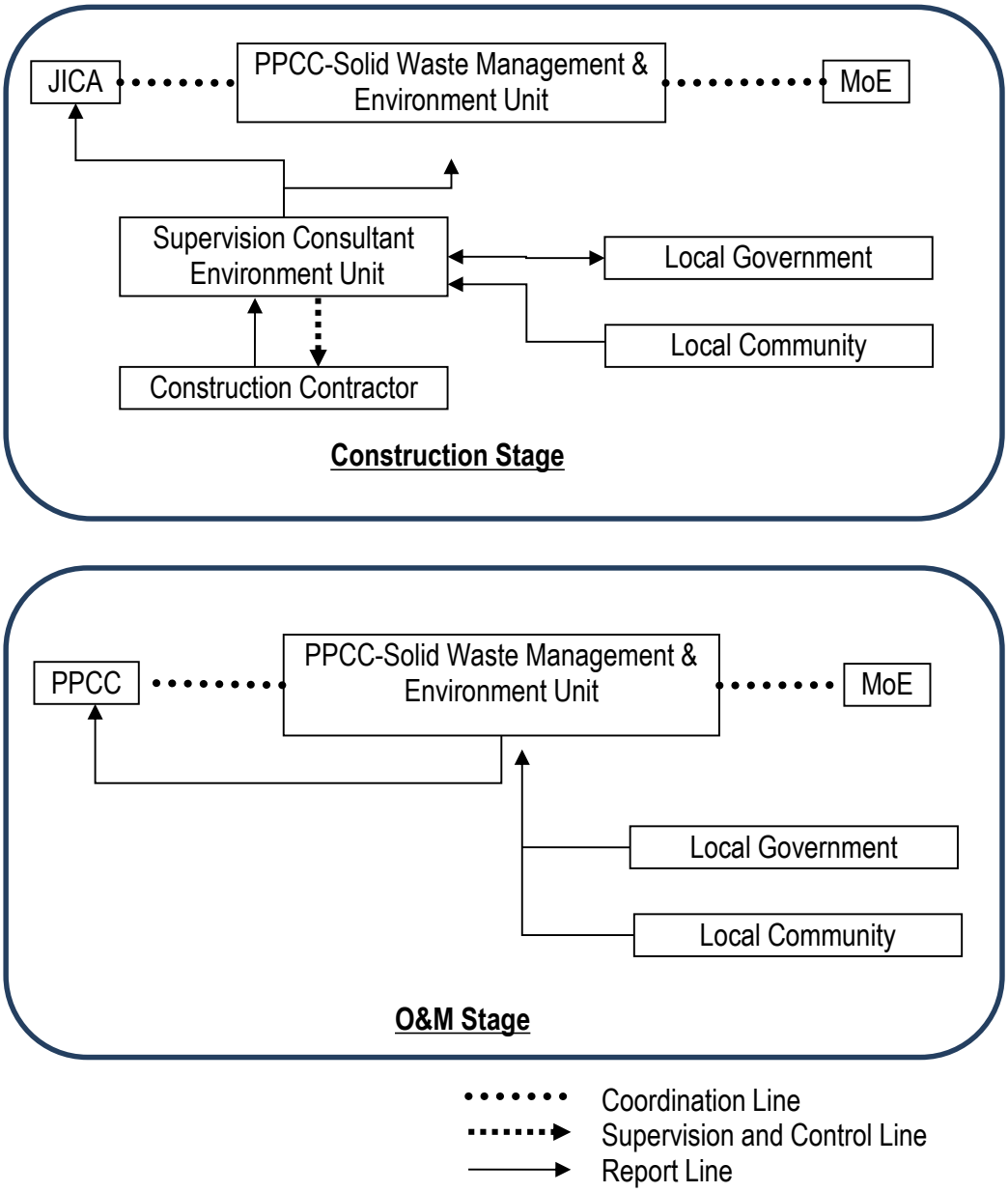
Resource	Monitoring Locations	Methodology and Parameters	Monitoring Cycles	Responsible/ implementing Institutions	Monitoring Institutions
		Turbidity, TDS; TSS; DO; BOD; COD; SO_4; TN; TP; Pb Total Coliform			
Ecosystem (Birds)	− Temporary shelter of staff-workers	− Monitoring of the crime on wildlife especially the aquatic birds	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DoAFF 4. Local authority
2.3 Socio-economic resources					
Resettlement	− Resident of AHs, lose their income in Prek Takong 1 village. − Area of 19.0736 ha for construction and expansion of the STP	− Monitoring of the livelihood of AHs (7HHs), lose their income. − Monitoring to ensure that no encroachment to the STP area.	Once every 6 months	1. DPWT 2. Local authority	1. MoE 2. MEF 3. DoE 4. DLMUPC 5. DOWRAM
Livelihood, occupations of the local community and gender	− Prek Takong 1 village − Temporary shelter of staff-workers	− Monitoring of the staff-worker selection by prioritize the locals, gender equality as well as the disability − Monitoring of work safety	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DoLVT 4. Local authority.
Road	− Rd. 271, Hun Sen Blvd. (60m) and Hun Neang Blvd. − Access Road (Channel Maintenance Road)	− Monitoring of the transportation (speed and load) − Monitoring of the parking − Monitoring of the repair of damaged road by the project	Once every 3 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DPWT 4. Local authority (local traffic police)
Public Health and Safety	− Infrastructure construction site − Generator, vehicle and machinery storage − Temporary shelter of staff-workers − First aid room	− Monitoring of solid-liquid waste management at temporary shelter − Monitoring of the clean water supply and sanitation − Monitoring of the safety equipment and work safety − Monitoring of the first aid room	Once every 3 months	1. DPWT 2. contractor	1. MoE 2. MOT 3. DoE 4. DoLVT 5. DoH 6. Local authority
3. Project Operation Phase					
3.1 Physical Resources					
Surface water quality	− 3 Sample locations near the project area − Location 1: X=0491822, Y=1274363 − Location 2: X=0491299, Y=1272570 − Location 3: X=0493103, Y=1268628 − Solid-liquid waste storage and filter system cleaning site	− Monitoring of the water quality on the parameters: temperature; pH; Turbidity, TDS; TSS; DO; BOD; COD; SO_4; TN; TP; Pb and Total Coliform − Monitoring of solid-liquid waste management − Monitoring of the filter system cleaning	Once every 6 months	1. DPWT 2. contractor	1. MoE 2. DoE 3. DOWRAM 4. Local authority

Resource	Monitoring Locations	Methodology and Parameters	Monitoring Cycles	Responsible/ implementing Institutions	Monitoring Institutions
Air quality	− Treatment plant, filtering facilities − Sludge storage − Solid-liquid waste storage	− Monitoring of solid-liquid waste management − Monitoring of air quality parameters: TSP; CO; NO_2; SO_2, O_3, PM10, PM2.5 and H2S − Monitoring of odor from waste storage and along the Access Road (Channel Maintenance Road).	Once every 6 months	1. DPWT	1. MoE 2. DoE 3. DoT 4. Local authority
Noise and vibration	− Treatment plant, at mechanic room, pumping room.	− Monitoring of the noise and vibration in the operation by measuring its level at the locations same as air quality testing locations	Once every 6 months	1. DPWT	1. MoE 2. DoE 3. DoT 4. Local authority
3.2 Biological Resources					
Ecosystem (Fish)	− Cheung Aek Lake near the project area	− Monitoring of the water quality on the parameters: temperature ; pH; Turbidity, TDS; TSS; DO; BOD; COD;SO_4 ; TN; TP; Pb and Total Coliform − Monitoring of solid-liquid waste management Note: Comparing the increasing of fish species near the project area. Before the project, study team caught only 6 species.	Once every 6 months	1. DPWT	1. MoE 2. DoE 3. DOWRAM 4. DoAFF 5. Local authority
3.3 Socio-economic Resources					
Resettlement (living standard of affected household monitor)	− Residential of the 7HHs who are affected by project	− Monitoring of the living standard of the people who get their aquatic crop by ensuring that they will have a better living after the project.	Once every 6 months	1. DPWT 2. Local authorities	1. MoE 2. MEF 3. DoE 4. DLMUPC 5. DOWRAM
Public health and safety	− Building, the filter tanks − Place with the safety equipment, fire extinguisher, safety System, fire alarm, etc.) − Pipe system − Electricity system − Solid waste storage − Shelter − Access Road (Channel Maintenance Road)	− Monitoring of the atmosphere, temperature, and airing. − Monitoring of the management and operation of the safety equipment (Fire safety system, fire extinguisher, fire alarm, etc.) − Monitoring of solid-liquid waste management − Monitoring of the clean water supply and sanitation − Monitoring of the durable and safety	Once every 6 months	1. DPWT	1. MoE 2. MOT 3. DoE 4. DoLVT 5. DoH 6. Local authority

Resource	Monitoring Locations	Methodology and Parameters	Monitoring Cycles	Responsible/ implementing Institutions	Monitoring Institutions
		− Monitoring of the provision of safety equipment − Monitoring of the chlorination room − Monitoring of the medical facility for first aid			
Road	− The intersection of Rd. 271 and project's road − Access Road (Channel Maintenance Road)	− Monitoring of the damage and repair of the road − Monitoring of the safety on Access Road (Channel Maintenance Road) − Monitoring of the transportation, speed and traffic congestion − Monitoring of the installation of the traffic sign along the Access Road (Channel Maintenance Road).	Once every 6 months	1. DPWT 2. Contractor	1. MoE 2. DoE 3. DPWT 4. Local authority (traffic police)
Safety	− Households and buildings in project area − Material and fuel storage − Electric cable room or box − Place with the safety equipment, fire extinguisher, safety System, fire alarm, etc.)	− Monitoring of the electricity system, emergency exit in and outside the building − Monitoring of the oil and fuel storage − Monitoring of the management and operation of the safety equipment (Fire safety system, fire extinguisher, fire alarm, etc.)	Once every 6 months	1. DPWT 2. Relevant company	1. MoE 2. MoT 3. DoE 4. DoLVT 5. Local authority

Source: Survey Team

Implementation structures of EMP and EMoP during construction and O&M periods are as below.



Source: Survey Team

Fig. R 1.4.8 Implementation Structures of EMP and EMoP during Construction and O&M Periods

1.4.1.11 Public Consultations

(1) Introduction

Public consultation and discussion with the relevant and affected people in the project area are very important to get comments and requests to support the project implementation smoothly and efficiently.

The public consultation and discussion were taken place from October 5, 2018 to February 25, 2019 with the participation from relevant units, departments, institutions and authorities at all levels (village, commune, and district).

The public consultation and discussion were held to allow the people in the project area to understand the purpose of the project which will provide them many benefits in the future (contribute to royal government of Cambodia in reducing the poverty of the people in the project area).

(2) Consultation with Relevant Party

The survey team has conducted the public consultation and discussion with relevant departments, Khan, Sangkat and village in Phnom Penh with individual discussion and focus group discussion. The contents of public consultations were the result of EIA, the best ways to deal with the impacts on people's property, and how to minimize the impacts on the natural resources in the project area.

The number of interviewees were 33 (1 woman and 32 men).

Table R 1.4.35 Brief of the Public Consultation

Target	Date	Place	Method
Administrative of Phnom Penh Capital City (1 man)	December 7, 2018	Phnom Penh Capital City Hall	Individual discussion
Department of Industry and Handicraft (2 men)	October 18, 2018	Clean Water Office	Individual discussion
Department of Environment (2 men)	October 16, 2018	Department of Toxic Substance Control	Individual discussion
Department of Land Management Urban Planning and Construction (1 man)	October 22, 2018	Department of Land Management Urban Planning & Construction	Individual discussion
Department of Labor and Vocational Training (1 man)	October 22, 2018	Department of Labor and Vocational Training	Individual discussion
Department of Water Resources and Meteorology (1 man)	October 24, 2018	Department Water Resources and Meteorology	Individual discussion
Department of Rural Development (1 man)	October 26, 2018	Department of Rural Development	Individual discussion
Department of Tourism (1 man)	October 26, 2018	Department of Tourism	Individual discussion
Department of Planning (1 man)	October 30, 2018	Department of Planning	Individual discussion

Target	Date	Place	Method
Department of Health (1 man)	October 31, 2018	Department of Health	Individual discussion
Department of Women's affairs (1 woman)	November 06, 2018	Department of Women's affairs	Individual discussion
Department of Agriculture Forestry and Fisheries (4 men)	November 14, 2018	Department of Agriculture Forestry and Fisheries	Focus group discussion
Phnom Penh Water Supply Authority (1 man)	November 26, 2018	Phnom Penh Water Supply Authority	Individual discussion
Electricite Du Cambodge (2 men)	December 11, 2018	Electricite Du Cambodge	Individual discussion
Department of Mines and Energy (2 men)	December 11, 2018	Department of Mines and Energy	Individual discussion
Representatives of Khan Meanchey (1 man)	October 05, 2018	Khan Meanchey Hall	Individual discussion
Representative of Sangkat Chak Angre Leu (1 man)	October 12, 2018	Sangkat Hall	Individual discussion
Representative of Sangkat Chak Angre Krom (1 man)	October 12, 2018	Sangkat Hall	Individual discussion
Head of Prek Takong 1 village (1 man)	October 12, 2018	Head's House	Individual discussion
Representative of Prek Takong 1 village (135 families' heads including affected aquatic crops farmers 6 families) (7 men)	October 17, 2018	Head's House	Focus group discussion

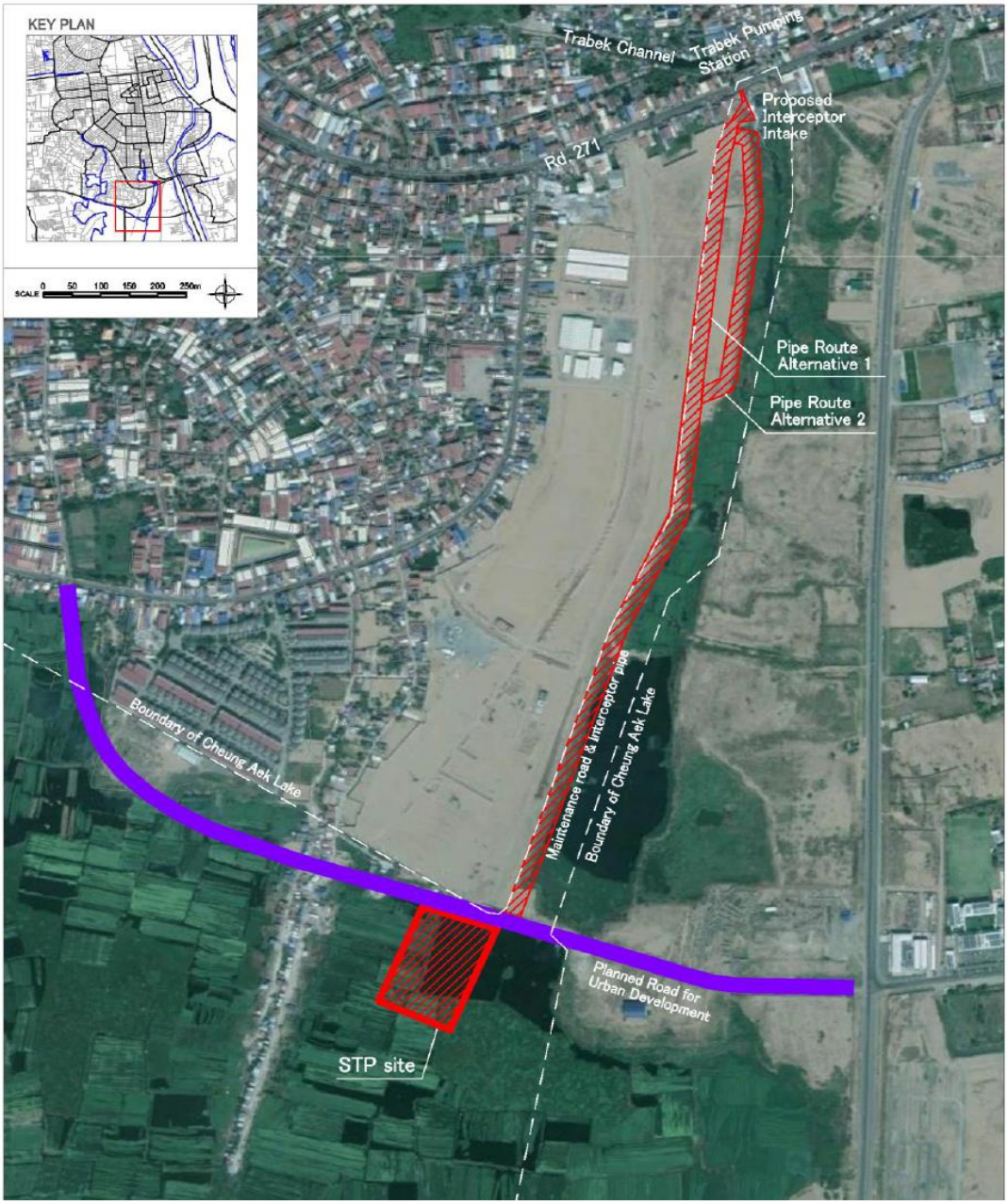
Source: Survey Team

The comments and suggestions in the consultations are shown in **[Appendices] 6.2**.

1.4.2 Land Acquisition and Involuntary Resettlement

1.4.2.1 Project Location and Impact Areas

Project Location is shown in **Fig. R 1.4.9**. The number of "Affected Households (hereinafter referred to as "AHs")" and "Affected People (hereinafter referred to as "APs")" are shown in **Table R 1.4.36** (all of them are illegally occupying or using the land).



Source: Survey Team

Fig. R 1.4.9 Project Location and Impact Areas

Table R 1.4.36 Number of AHs/APs and Affected Location

No.	Village	Category of AH and AP		Number AH and AP by project components		
				Access Road (Channel Maintenance Road)/Sewer	STP Site	Total
1	Praek Takong 1	Illegally occupying HH	AH	9	6	15
			AP	70	50	120
		User	AH	0	7	7
			AP	0	34	34
Total		Illegally occupying HH	AH	9	6	15
			AP	70	50	120
		User	AH	0	7	7
			AP	0	34	34

Source: Survey Team

1.4.2.2 Legal Framework of Land Acquisition and Involuntary Resettlement

(1) Legislation and Legal Procedure for Land Acquisition and Involuntary Resettlement

(a) Legislation

The legal framework for land acquisition and involuntary resettlement is mentioned in the table below.

Table R 1.4.37 Legislation related to Land Acquisition and Involuntary Resettlement

No.	Legislation	Description
1.	Royal Decree Constitution of the Kingdom of Cambodia (September 24, 1993)	All persons, individually or collectively, shall have the rights to own property. Only natural persons or legal entities of Khmer nationality shall have the rights to own land. Legal private ownership shall be protected by law. (Article 44: Protect property right)
2.	Royal Decree NS/RKM/0801/14, 2001, Land Law (August 30, 2001)	The law provides the distribution and management of land in Cambodia as well as protect property rights.
3.	Royal Decree NS/RKM/0210/003, Expropriation Law (February 26, 2010)	This Law defines the principles, mechanisms, compensation and procedures for expropriation relating to construction, rehabilitation and expansion of public physical infrastructure in Cambodia. Apply for only in Public Interest.
4.	Royal Decree NS/RKT/0806/339, 2006, on Provisional Guidelines and Principles Regarding the Reclassification of State Public Properties and of Public Entities (August 8, 2006)	The Royal Decree determines the principles and transitional provisions involving the transfer of public properties of the state and legal public entities.
5.	Anukret (Sub-decree) No. 22 ANK/BK, 2018 on the Standard Operating Procedures (SOP) for Land Acquisition and Involuntary Resettlement (LAR) for Externally Financed Projects	This SOP ensures that all safeguard matters relating to LAR are addressed in a consistent, transparent and fair manner with due regard to the national laws, regulations and the safeguard policies and procedures of Development Partners.
6.	Anukret (Sub-decree) No. 129/ANK.BK, 2006 on Rules and Procedures for Reclassification of State Public Properties and Public Entities (2006)	This Sub-decree was signed by the Prime Minister which states that any reclassification of state public land must comply with the Royal Decree (2006).
7.	Anukret (Sub-decree) No. 118 in 2005, on State Land Management (October 7)2005)	The Sub-decree provides the framework for state land management with 11 chapters and 33 articles in total
8.	Prakas (Declaration) No. 224 in 1996 Ministry of Economy and Finance, on Collection of Tax on Unused Land (1996)	No. 224 in 1996 Ministry of Economy and Finance, Prakas (Declaration) on Collection of Tax on Unused Land (1996)

No.	Legislation	Description
9.	Prakas (Declaration) No. 06 BRK 1999 on the Measure of Eliminating Anarchical land Encroachment. And following by "Sub-Decree on Right of Way of National Road Channels and Railroads of the Kingdom of Cambodia (2009)"	This provides the required measures to be taken by the government against anarchical land encroachment:
10.	Circular (Letter) No. 02 S.R 2007, related to illegal occupation of state land (February 22, 2007)	Supplementing the Land Law (2001), this circular provides the policy/ principle for dealing with illegal occupants in the state land.
11.	Circular (Letter) No. 03 SR 2010, Circular on Settlement of illegal construction on state land in cities and urban areas	The circular aims to provide solution to illegal constructions in state land.
12.	Circular (Letter) No. 06 SR 2015 on Procedure to Implement Resettlement of Development Projects	This will ensure the action required by the implementation agencies in: A. Project Feasibility Study Stage; and B. Resettlement Plan Implementation Stage and Post Resettlement Plan Implementation Stage

Source: Survey Team based on English Translation supplemented by JICA env. Profile 2013, Faolex, ADB (2014) Integrated Urban Environmental Management in the Tonle Sap Basin Project – Kampong Chhnang Urban Area Environment Improvements and UN Human Rights Council (2012) Report of the Special Rapporteur on the situation of human rights in Cambodia, Surya P. Subedi

(b) Procedure of Land Acquisition and Involuntary Resettlement

Sub-decree No.22 promulgated in 2018 describes detail standard operating procedures (SOP) for land acquisition and involuntary resettlement. Article 3 mentions that any provisions contrary to this Sub-Decree shall be deemed abrogated. Basic process is same as the one described by Ministry of Economy and Finance (MEF) in 2012, and some steps and necessary documents have been changed.

In SOP, the General Department of Resettlement (GDR) is the permanent secretariat of the Inter-Ministerial Resettlement Committee (IRC) and the lead agency for land acquisition and involuntary resettlement (LAR) for public investment projects. GDR is responsible for the preparation, implementation, monitoring and reporting of resettlement plans in accordance with the laws and implementing rules and regulations related to LAR.

Preparation of resettlement plan in SOP is two steps.

1. The resettlement plan prepared during the project feasibility stage, when the land required is not clearly demarcated, is referred to as the Basic Resettlement Plan (BRP).
2. A resettlement plan, which is prepared based on final alignment after detailed design is completed or where the actual land demarcation is known, is referred to as the Detail Resettlement Plan (DRP).

Responsible entity and tasks/activities in BRP and DRP are as follows.

<u>BRP (Project Preparation/Feasibility Study stage)</u>

Responsible entity: Executing Agency in consultation with GDR

Tasks/activities:

- Establish Cut-off-date for eligibility

- Consultation with affected communities
- Sample size of socio-economic survey (about 20%)
- Preparation of socio-economic profile based on sample size of SES
- Social impact assessment based on sample size
- Compensation entitlements (entitlement matrix)
- Determine if relocation to new site is required
- Initial cost estimate (where required)
- Approval of BRP by IRC and Development Partner
- Disclosure of BRP

DRP (Detailed Design/Land Demarcation stage)

Responsible entity: General Department of Resettlement

Tasks/activities:

- Detailed measurement survey (100% of household survey, census and inventory of lost assets)
- Consultation on compensation package
- Consultation on resettlement sites and possible locations (where displaced persons need to be relocated to new site)
- Replacement cost study
- Detailed compensation entitlement matrix
- Livelihood support program
- Computation of budget
- Establishment of grievance redress mechanism arrangements for the project
- Detailed implementation arrangement
- Monitoring mechanisms
- Approval of DRP by IRC and Development Partner
- Disclosure of DRP

After the DRP, resettlement plan is implemented. The Royal Government of Cambodia follows a centralized arrangement for the implementation of LAR under the overall guidance and oversight of the MEF and IRC. The GDR of MEF is mandated by the MEF to lead the implementation of LAR.

(2) Comparison between Cambodian Regulations and JICA Guidelines

The law and regulatory framework on resettlement and land issues are still at the development stage in Cambodia, and some implementation documents and institutions are not yet prepared completely, however, Royal Government of Cambodia (RGC) understands this situation and Development Partners' safeguard policies and considers supplemental measures and assistance in ARAP case by case.

Thus, in terms of practical operation, there is not much gap between the Cambodian country system and the JICA Guidelines' concept and requirements (see **[Appendices] 6.3**). A few points such as participation to public consultation which are not discussed clearly or concretely in the Cambodian country system are in accordance with the JICA Guidelines, ARAP, and other relevant documents in order to fill gaps.

1.4.2.3 Abbreviated Resettlement Action Plan (ARAP) Study

In accordance with Cambodian regulation, a Basic Resettlement Plan is necessary in this preparatory survey stage. A Detail Resettlement Plan, including 100% census, replacement cost study, and resettlement site, is required during detail design stage. However, as the Project must fulfil JICA Guidelines and the World Bank's Safeguard Policies, the Project decided to conduct Abbreviated Resettlement Action Plan Study

(1) Methodology Used in Preparing the Resettlement Plan

(a) Data Collecting Material

The basic tool used in the IOL and census of AHs was the survey questionnaire used in Khmer language. Detailed socio-economic information on AHs whose main structures (i.e., houses and shops excluding government buildings) will be partially or entirely affected, was obtained. The questionnaire covers concerns on socio-economic conditions of the AH, in addition to basic information on the household head, such as gender, age, educational attainment, and primary source of income. It also included the affected assets and income, as well as their perception on the Project

(b) Setting the Cut-off Date

The IOL and census of AHs were preceded by a series of stakeholder meeting in Khan Meanchey meeting hall. The purpose of the public meetings was to brief the local population about the Project background, activities of the survey team, the policy of JICA and the Cambodian government on involuntary resettlement for the Project, including the policy requirement on the cut-off date. The local people were informed by DPWT that the cut-off date is the first day of holding the IOL and census of the AHs, which was on **18th October 2018**.

(2) Basic Unit Costs (Estimation) Used in the Resettlement Plan

(a) Unit Cost of Land

The affected lands were divided into 2 main categories: Filled up Land and Flooded Land (agricultural). The way to obtain data on market rates is to gather data on recent land sales, however sale records could not be found at or around the Project area. Therefore, data of recent sales were collected by direct interviews with (i) land users at/around the Project area who are both AHs and non-AHs, and (ii) local authorities at or around the Project area.

Table R 1.4.38 Average Unit Price of Land in 2018

Khan	Sangkat	Village	Type of Land	Unit	Price
Mean Chey	Chak Amgre Leu	Phum 7	Filled Up Land	$/m^2	550.00
		Prek Ta Kong 1	Filled Up Land	$/m^2	550.00
			Agricultural (Flooded Land)	$/m^2	120.00

Source: Survey Team

(b) Unit Cost of Structures

The methodology employed for costing building/structures were composed of quantity surveys and detailed measurement of the component parts of each structure. Labour costs were also assessed at market prices for the structure as a whole based on the information provided by local building contractors in the survey areas. The unit prices of a typical structure for each category are provided in **Table R 1.4.39.**

Table R 1.4.39 Cost Estimation by Type of Structures in 2018

Type of use	Roof	Wall	Floor	Column	Story	Total Cost US$/m^2
Guarding building	Zinc	Brick	Mortar	Concrete	Single	110.00
Bath room	Zinc	Brick	Tile	Iron	Single	115.00
Shelter	Zinc	None	Wooden	Pole	Single	25.00
Awning	Zinc	None	Soil	Iron	Single	15.00
Awning	Zinc	None	Mortar	Iron	Single	23.00
Brick wall, 100 mm						15.00
Brick fence, 100 mm						27.00
Brick bund wall, 200 mm						32.00

Source: Survey Team

(c) Unit Costs of Trees

The primary data was collected through interviews to determine the income of owners/cultivators of crops and trees at the Project area. The market rates of trees have been calculated based on the yield and the period of maturity of trees as determined from interviews with residents near the STP area.

The formula used for fruit trees is as follows: (Number/Quantity of harvest per year) x (Market price) x (Number of years it will mature) + cost of seedling.

Trees qualify for full compensation cost if mature. Otherwise, their compensation value is their cost as a sapling tree or as a young tree.

Table R 1.4.40 Unit Cost Estimation by Type of Tree in May 2018

No.	Description	Unit	Quantity	Rate in 2018, USD
1	Mongo	Tree	1	51.0
2	Banana (mutual only)	Tree	1	2.5

Source: Survey Team

(3) Inventory of Affected Assets

(a) Land

The inventory of affected land in STP area of the project was in Cheung Aek Lake. There will be no compensation from the Project since the Project will be on public state land. Nevertheless, the survey team did determine the categories of the current occupiers or users, and if the affected lands are accompanied with immovable assets such as trees, buildings, and/or other structures. The landless households were also considered.

There were instances when the survey team could not complete their interviews with the AHs because the owners of the affected lands were either absent or did not attend during the survey. In such case, the survey team was only able to estimate the area of STP lands used for agricultural or commercial purposes.

According to the Sub-Degree on the Area Determination of the Cheung Aek Lack in Khan Meanchey and Dangkoa No. 124 RNKr. BK, dated on 3 September 2008 and Sub-Decree on the Area Correction of the Cheung Aek Lack in Khan Meanchey and Dangkoa No. 168 RNKr. SK, dated on 13 December 2018, the land appears to be owned by DPWT.

On the other hand, since more than 10 years after land reforms, people occupied the land. Over the course of subsequent years, a number of apportioned plots were transferred or sold to others. During field survey, there are 15 AHs claim their occupation on the affected land.

A total of **88,131.10 m²** of land (with 15 AHs) will be required for the construction of the Project. Of these, 79.35% (69,931.44 m², with 13 AHs) is flooded land (7 AHs at Access Road (Channel Maintenance Road)/Sewer site, 6 AHs at STP site) and used for agricultural purpose, 20.65% (18,199.66 m², with 2 AH) is filled land with no specific purpose (construct some structure/buildings and plant some trees). Among 15 AHs, 2 AHs which have filled land will be compensated not for providing alternative site because the loss of illegally occupied site is not by the Project but by the DPWT's public project, but for buildings and trees on the site.Within other 13 AHs, 7 AHs at Access Road (Channel Maintenance Road)/sewer site are out of target of compensation because the loss of illegally occupied site is not by the Project but by the DPWT's public project and they do not have any assets on the site. Other 6 AHs at STP site are also out of compensation because they do not any activities utilizing the illegally occupied site.

Table R 1.4.41 Number of Affected Households who will lose their Occupied Lands

Village	Flooded Land		Filled up Land	
	AH	m^2	AH	m^2
Phum 7	0	0.00	0	0.00
Praek Takong 1	13	69,931.44	2	18,199.66
Total	**13**	**69,931.44**	**2**	**18,199.66**

Source: Survey Team

(4) Structures/Building

There is only one AHs in the STP area of the Project, whose main structures (two buildings, one makeshift building and walls, etc.) will be affected by the Project. Another one AH will be affected only his secondary structure.

Table R 1.4.42 Number of AH and Floor Area (in m^2) of Structures

Type of use	Roof	Wall	Floor	Column	Story	Affected area, m^2
First Affected Household						
Guarding building	Zinc	Brick	Mortar	Concrete	Single	106.20
Bath room	Zinc	Brick	Tile	Iron	Single	7.80
Shelter	Zinc	None	Wooden	Pole	Single	73.40
Awning 1	Zinc	None	Soil	Iron	Single	36.00
Awning 2	Zinc	None	Mortar	Iron	Single	120.80
Brick wall, 100mm						18.60
Second Affected Household						
Brick Fence, 100mm						90.00
Brick Bund Wall, 200mm						120.00

Source: Survey Team

(a) Affected Crops and Trees

The start of civil works and the plant schedule of AHs who cultivate land within the STP area will be coordinated to allow smooth transition between harvesting of standing plants and the start of the Project construction in a particular section. Therefore, standing plants will not be affected if those can be harvested before construction work, but if they cannot be harvested before it, the unharvested plants will be compensated at replacement cost. However, fruit or timber trees in the STP area will be cleared for the Project construction. There is only one AH whose fruit trees will be affected by the Project.

Table R 1.4.43 Affected Trees

Type	Unit	Total
Mango	Tree	37
Banana	Cluster	10

Source: Survey Team

1.4.2.4 Income Restoration Strategy

(1) Income Restoration Strategy

Even though the Project will not acquire private land, there are 7 users who cultivate plants in the STP area. They will lose their income due to the Project impact. Therefore, the Project

will provide a livelihood restoration program for their income restoration.

Restoring the incomes of AHs, whose livelihood will be disturbed or removed, is a high priority for RGC and JICA. This is also of particular concern with respect to households whose livelihoods are lost as a result of the project. Possible measures to restore livelihood is not only relocation of cultivation area, and the contents of the measure should be different based on situations and need assessment of the target HH. Therefore, Income Restoration Program will be entitled to participate in three livelihood Restoration/Support Program.

- Land based livelihood restoration is provided for AHs with productive land for vegetable gardening, fruit tree and other similar land-based income generating sources. The project/IRC will intervene, if necessary.
- Trainings on farming is provided over 12 months as a skills training program.
- Cash assistant with lump sum cash grant equivalent to 3 months of income based on official poverty rate to re-start land based livelihood.

IRC will make contract with a Consulting Firm as a Service Provider to implement LRP directly with APs and IRC will monitor this activity.

(2) Entitlements

The project entitlements were developed and presented as shown in **Table R 1.4.44**: Entitlement Matrix. The entitlements adopted were guided by the applicable national laws and regulations and the JICA Guidelines. The entitlements and assistance may be revised based on the actual status of impact, as necessary, in the updated version of this ARAP.

Table R 1.4.44 Entitlement Matrix

Category	Type of Loss	Application	Category of AH	Entitlements	Clarification
1. Loss of Land					
1a	Loss of Land	N/A	N/A	• N/A	N/A
2. Loss of Use of Land					
2a	Loss of Crops and Fruit Trees	Agricultural trees/plants at Access Road (Channel Maintenance Road)/Sewer site	1 AHs who are engaged in farming	• For fruit trees, replacement cost of loss based on following formula: **[(Quantity Harvested per Year) X (Market Price) X (Number of years it will bear fruit)] + Cost of Seedling** Perennial trees that have a growth period of more than 5 years are classified.	Market Price is based on Farm-Gate Price. Full Price is amount calculated from the formula shown on the left with cost of seedling.
3. Loss of Buildings and Structures					

Category	Type of Loss	Application	Category of AH	Entitlements	Clarification
3a	Loss of Buildings and Structures	Commercial structures and other assets at Access Road (Channel	2 AHs who have buildings and structures	• Cash compensation equivalent to replacement value of loss of structures constructed by illegal occupier	The compensation rates will be based on market price determined by RCS.
3b	Loss of Buildings and Structures (Transport Allowance)	Transport allowance for household and personal goods	1 AHs who have buildings and structures and are using at present	• Fixed Lump Sum allowance per AH based on average cost of transportation to new relocation place. • Up to 5 Km (US$ 80) • More than 5 Km (US$ 150)	The allowance amount will be updated by RCS.
4. Loss of Income and Livelihood					
4a	Loss of Income during Transition Period-Subsistence Allowance	Loss of Income	7 AHs at STP site who lose income during the transition period	• Lump sum amount equivalent to **3 months** of income based on the official monthly poverty rate established by RGC. • **Monthly Poverty Rate X Number of Members in AH X 3**	Monthly Poverty Rate is established by the RGC. The last updated of the National Poverty Line for Phnom Penh-2013 is US$ 47.60 per month/capita. (Source: MOP)
4b	Permanent Loss of Livelihood Source due to Physical Relocation	Income Restoration	7 AHs at STP site who lose their partial source of livelihood permanently	• Entitled to participate in **livelihood Restoration/Support Programs:** • Land Based Livelihood Restoration for 7 AHs engaged in land base livelihood. (i) facilitate access to other land, based on source of income, like vegetable gardening, fruit tree, livestock and other similar land based on income generating sources and (ii) provision of training in farming over a 12 months training program.	Land Based for 7 AHs who lose land for generating livelihood source. For the affected 7 users, IRC will find the alternative land to be provided for them.

Source: Survey Team

1.4.2.5 Grievance Redress Mechanism

The MEF will facilitate the establishment of a Municipal Grievance Redress Committee (MGRC) which will be responsible for addressing grievances for the project. The MGRC will be established by the Municipal Governor in consultation with the IRC.

Any grievances of AHs in connection with the implementation of the ARAP will be handled through negotiation with the aim of achieving consensus. Complaints will go through three stages before they may be elevated to a court of law as a last resort. GDR/IRC will shoulder all administrative and legal fees that will be incurred in the resolution of grievances and complaints. The handling of the

complaint ends at the Third Step. There are no fees or charges levied on the displaced person for the lodgement and processing of the complaints under the First, Second and Third Step.

First Stage

The aggrieved displaced person can lodge a written complaint to the Head of the District (Khan) Office. The displaced person can bring a community elder or representative to mediate in the matter at the District/Khan level. The IRC-WG will apprise with the Head of the District (Khan) Office about the matter. If the complaint is resolved at this Level, the IRC-WG will inform DIMDM which will review and seek the approval of the DG, GDR for appropriate action.

If the complaint is rejected at this stage and the displaced person is not satisfied with the result, he/she can proceed to the next step and lodge a written complaint to the GDR for resolution.

Second Stage

The DIMDM, under the GDR, will record the complaint and check the merits of the claim within the framework of the agreed Entitlement Matrix. There is a possibility that a complaint refers to particular entitlement which was not envisaged at the time of the preparation of the Entitlement Matrix and the aggrieved displaced person has a just cause to seek remedy.

The DIMDM will therefore carry out a holistic review and prepare and submit a report on its findings with the relevant recommendations, if any, to the DG, GDR for a decision. It may also conduct a field visit to meet the aggrieved displaced person and the IRC-WG and carry out the assessment of the complaint. The final report must be completed within 30 working days from the date of receipt of the complaint. The final decision will be made by the DG, GDR within 5 working days after receipt of the DIMDM report. In the event that the subject matter requires a policy level intervention, it will be referred to the IRC for a decision in which 10 more working days will be added to the deadline for final decision.

The GDR will issue a written response and convey the decision to the aggrieved displaced person. If the complaint has been found to have merit, the DIMDM will inform the relevant Department of Resettlement in the GDR to settle the claim within 15 working days after the decision is made. In case the complaint is rejected at the second step, the displaced person will have the option to submit the complaint to the PGRC for its consideration.

The DIMDM will create a central database to record all the relevant details about the complaints; summary of the findings; and the decision taken. A summary report on the status of all complaints will be prepared quarterly and submitted to the IRC and the DP for information.

Third Stage

This is a formal stage where the aggrieved displaced person can seek a final administrative decision by the PGRC. The displaced person will submit a written complaint to the PGRC through the Municipal Governor's Office. The displaced person or a representative will be given an opportunity

to present its case during the meeting and the MGRC may consider any compelling and special circumstances of the displaced person when reaching a decision. The GDR will send a representative, as a non-voting member, to provide explanation for the rejection of the complaint at the second step by the GDR. The decision of the PGRC must be reached on a consensus basis and will be final and binding except when the matter relates to any policy of RGC. Decisions on RGC policy matters on LAR are decided by the IRC. The PGRC will have 40 working days from the date of receipt of the complaint to reach a final decision.

The decision of the PGRC will be sent to the IRC through the GDR for endorsement before taking any remedial action.

However, as provided for in the Expropriation Law, the aggrieved displaced persons can file a suit at the Municipal Courts, as applicable, to seek a resolution. Such actions will be at the cost for the displaced person. At this stage, there is no involvement of the GDR, PRSC or IRC-WG unless there is a judicial order from the competent courts. If any party is unsatisfied with the ruling of the Municipal court, that party can bring the case to a higher court.

1.4.2.6 Organizational Framework

(1) The Executive Agency

PPCC is the Executing Agency (EA) for the Project It has overall responsibility for the successful implementation of the URAP. The EA will be assisted by a number of offices within and outside PPCC, starting with the Project Management Unit (PMU). If there are resettlement impacts caused by the project, EA/PPCC will request the IRC to undertake land acquisition and involuntary resettlement activities.

(2) The Project Management Unit (PMU)

The PMU will be established within DPWT to work closely with GDR/IRC. PMU IRC/GDR will join in establishing the Inter-ministerial Resettlement Committee Working Group (IRC-WG) in dealing with resettlement activities. The areas of activity for the PMU during the project implementation include:

(a) Construction supervision;
(b) Contract administration and management;
(c) Quality control procedure;
(d) Detailed design;
(e) Financial management; and
(f) Training and human resource development.

(3) The Project Implementation Unit (PIU)

PIU/DPWT of Phnom Penh, will work closely with the General Department of Resettlement

(GDR) in the preparation and implementation of the ARAP. Its tasks include the followings:

(i) Secure the approval of the ARAP by IRC;
(ii) Secure prior approval from IRC and JICA for any variations in the approved ARAP;
(iii) Secure the database of AHs and assets that will be gathered during the preparation and updating of the ARAP;
(iv) Prepare progress reports/internal monitoring on overall project implementation including the ARAP implementation and submit to PPCC, GDR/IRC and JICA.

(4) The Inter-ministerial Resettlement Committee (IRC)

The IRC mechanism was established, by the Prime Minister's Decision No.13 dated 18 March 1997, updated on 16 February 1999 by the Decision No.9: and decision dated December 2010, with the mandate to review and evaluate the resettlement impact and land acquisition for public physical infrastructure development projects in the Kingdom of Cambodia. The IRC by virtue of the Prime Minister's Decision, exercises the authorities of the Expropriation Committee under the Expropriation Law and is a collective entity, permanently chaired and led by the MEF, and with members from different line ministries. The IRC carries out its role and responsibilities through the IRC-WG which is established for each public investment project by MEF. The powers of the IRC are delegated to its permanent Chairman. The key responsibilities of IRC include:

- Provide effective oversight and ensure LAR complies with the laws and implementing rules and regulations.
- Ensure effective coordination between line Ministers, Municipal/Local Authorities and GDR-MEF in carrying out LAR.
- Provide overall guidance on implementing rules and regulation for LAR and propose updates; as necessary.
- Initiate the establishment of the Municipal Grievance Redress Committee (MGRC).
- Approve Basic Resettlement Plans (BRP), Resettlement Framework (RF), Detailed Resettlement Plans (DRP) and Updated Detailed Resettlement Plan (UDRP).

(5) The General Department of Resettlement (GDR)

The GDR is the Permanent Secretariat of the IRC and the lead agency for LAR for public investment projects. It is responsible for the preparation, implementation, monitoring and reporting of resettlement plans in accordance with the laws and implementing rules and regulations related to LAR and the mandatory requirements of the safeguard policies of the DPs. It is also responsible for the formulation of new regulation or updating of the SOP and is vested with the authority to interpret and clarify provisions of the SOP which shall be final. The key responsibilities include:

(i) Coordinate and collaborate with line ministries, Executing Agencies/Implementing Agencies (EAs/IAs) and other agencies involved in LAR activities.
(ii) Act as focal RGC counterpart for all LAR activities for cooperation with DPs.
(iii) Guide the EAs/IAs and/or the project preparation consultants (PPCs) in carrying out the sample socio economic surveys (SES) and in the preparation of the RF or the BRP during project feasibility study.
(iv) Review and endorse the draft BRP or RF prepared by the EAs/IAs during the project preparation phase for approval by IRC.
(v) Review and endorse all issues related to LAR, Memorandum of Understanding (MOU) and Minutes of Discussions (MOD) prepared by DPs during the project preparation, loan negotiation and project implementation stage.
(vi) Review and endorse covenants related to LAR in draft Project Administration Manual (PAM)/Project Implementation Manual (PIM) and draft financing agreements and participate in their negotiations, as necessary.
(vii) Conduct consultation with affected households and local authorities during the preparation of the DRP.
(viii) Prepare the DRP based on detailed measurement survey (DMS).
(ix) Update the DRP as and when necessary.
(x) Prepare and secure the necessary budget for the implementation of DRP.
(xi) Implement all LAR activities in compliance with the DRP or UDRP.
(xii) Calculate, prepare contracts and makes payments for compensation for each affected household based on the entitlement matrix in the DRP or UDRP.
(xiii) Ensure proper functioning of the Grievance Redress Mechanism (GRM).
(xiv) Supervise, monitor, and report on implementation progress of the DRP or UDRP.
(xv) Conduct awareness workshops for line ministries and local authorities on the implementing rules and regulations as specified in the SOP for LAR and related guidelines prepared by GDR from time to time.
(xvi) Serve as the focal knowledge center for LAR.

1.4.2.7 Implementation Schedule

During the detailed design stage, DMS and RCS will be conducted under management of IRC-WG. DMS will be implemented by IRC-WG in close cooperation with MRSC-WG and relevant local authorities. RSC will be implemented by independent agency recruited by IRC. Based on the results of DMS an RCS, IRC will calculate compensation amount and request budget disbursement to RGC.

During the DMS, consultation meetings will be held, and a project information booklet will be distributed to all AHs by IRC-WG assisted by PRSC-WG. The information program will precede the

marking of the STP area. Grievance procedures and structure will be established prior to DMS. The preparation for the DRP will follow immediately after the final identification survey and DMS.

Afterwards, the compensation amount is expected to be paid out simultaneously for different sections of the construction site. The compensation process, (including agreement and certified record of quantities and valuation of properties and physical payment of cash compensation and formal transfer of property in the form of land) will take place before any construction start in a designated stretch of the construction site. Compensation payments are made at least 30 days before construction starts. External monitoring will be conducted during all of the above stages of implementation of the DRP.

IRC will mobilize its working group to work closely with MRSC-WG before commencement of any resettlement activities, i.e., before DRP preparing. Land acquisition and relocation of AHs will not commence until the updated BRP (DRP) with specific compensation and support is reviewed and approved by both IRC and JICA.

DPWT will ensure that notice to commence will not be issued to the contractor on any part of a section of construction site unless it has (a) satisfactorily completed in accordance with the approved DRP, compensation payment and relocation; (b) ensured that income restoration program is in place; and (c) the area required for civil works, which is free of all encumbrances. **Table R 1.4.45** summarizes the various inter-related activities connected with the preparing and implementation of the DRP.

Table R 1.4.45 Indicative Schedule of Resettlement Activities

ACTIVITIES	SCHEDULE
GDR Approval of BRP	June 2019
BRP Updating (DRP) following Detailed Design	December 2019
Submission and JICA Approval of DRP	March 2020
Implementation of the Approved DRP	May 2020
Internal Monitoring (Submission of Quarterly Progress Reports)	May 2020
External Monitoring (Intermittent)	It will be confirmed by GDR
Post-evaluation	It will be confirmed by GDR
Start of Civil Works*	December 2020

Source: Survey Team

1.4.2.8 Cost and Budget

The cost for resettlement will be covered by the funds coming from the government counterpart. Funds for the implementation of the DRP are part of the Project Cost. The land acquisition and resettlement cost has been estimated based on results of the IOL and the Cost Estimation conducted during the Project Study in October and November 2018.

(1) Procedures for Flow of Funds

IRC will request the resettlement budget from MEF and the compensation amount will be transferred to relevant DEF of PPCC for releasing compensation and allowances to AHs. Payment of compensation and other entitlements will be in cash and will be distributed in public place (commune centre, school, pagoda etc.). The AHs will be notified through the

village chiefs with regards to the schedule of payment of compensation and other entitlements.

(2) Compensation Rates

The Cost Estimation was conducted by a local consultant during the project preparatory study as unit rate to estimate the total cost for resettlement and land acquisition of the ARAP. Once compensation payment to AHs have commenced, the RCS will be conducted to reflect the current market prices of the affected property. It will be conducted in parallel with the DMS during detail design stage.

(3) Estimated Costs for ARAP

The estimated costs for resettlement and land acquisition of the ARAP based on the Cost Estimation and the IOL found from the project preparatory study is shown in **Table R 1.4.46**. The cost amounts to 60,198.60USD.

Table R 1.4.46 Cost of Resettlement and Land Acquisition

No.	Items	Unit	Quantity	Rate ($/Unit)	AMOUNT (US$)
A	LAND				
1	Flooded land (Agricultural)	m^2	0	-	0
2	Filled up land (Residential)	m^2	0	-	0
B	STRUCTURES				24,281.40
3	Guarding building	m^2	106.20	110.00	11,682.00
4	Bath room	m^2	7.80	115.00	897.00
5	Shelter	m^2	73.40	25.00	1,835.00
6	Awning (AW1)	m^2	36.00	15.00	540.00
7	Awning (AW2)	m^2	120.80	23.00	2,778.40
8	Brick wall, 100mm	m^2	18.60	15.00	279.00
9	Brick fence, 100mm	m^2	90.00	27.00	2,430.00
10	Brick bund wall, 200mm	m^2	120.00	32.00	3,840.00
C	TREES AND FRUIT TREES				1,912.00
11	Mango tree	tree	37	51.00	1,887.00
12	Banana tree	tree	10	2.50	25.00
D	ALLOWANCES				5,005.20
13	Transport Allowance	AH	1	150.00	150.00
14	Income Loss[6]	person	34	142.80	4,855.20
SUBTOTAL					31,198.60
15	Administrative cost	ls	-	-	15,000.00
16	External Monitoring	ls	-	-	7,000.00
17	Livelihood Restoration Program	ls	-	-	7,000.00
GRAND TOTAL					60,198.60

Source: Survey Team

The Government will ensure timely provision of funds for resettlement costs and will meet any unforeseen obligations in excess of the resettlement budget in order to satisfy resettlement objectives.

[6] The National Poverty Line for Phnom Penh-2013 is 47.60 $/month/capita. The income loss allowance is calculated based on formula in entitlement matrix: [**(MPR) x (Number of members in AH) x 3]** which is equivalent to USD 4,855.20 (34person x 47.60$ x 3months).

Note: - 7 AHs (renter) equal to 34 household members. - MPR instates a Monthly Poverty Rate.

The resettlement estimated cost will be updated during the resettlement implementation based on the Detailed Measurement Survey (DMS) and the RCS.

1.4.2.9 Monitoring and Evaluation

(1) Internal Monitoring

IRC-WG and the PRSC-WG will be responsible for gathering data and information on the progress of the resettlement implementation (LAR) and will submit monthly report to the responsible Resettlement Department (in GDR). The monitoring will include progress reports, the status of the DRP implementation, information on location and numbers of people affected, compensation amounts paid by item, and assistance provided to AHs. The Resettlement Department will compile the field reports and prepare a consolidated report of the Project on a monthly basis. The report will be submitted to the DIMDM which is responsible for internal monitoring.

The following indicators will be monitored periodically by IRC-WG and PRSC-WG:

- Compensation and entitlements are computed at rates and procedures as provided in the approved DRP;
- AHs are paid as per agreed policy provided in the DRP by the Project authorities;
- Public information, public consultation and grievance redress procedures are followed as described in the approved DRP;
- Public facilities and infrastructure affected by the Project are restored; and
- The transition between resettlement and civil works is smooth.

(2) External Monitoring

The external monitor has a specific responsibility to study and report on measures for income restoration and in particular on the social and economic status of AHs particularly disrupted by the project, including all households whose houses or shops and stalls are to be relocated. The external monitor also has the responsibility of reviewing the potential for job opportunities and training for AHs, including the women and youth. In this process, they would be assisted by local authorities, with possible additional support from the Commune Resettlement Committees and Civil Society Organization.

GDR will recruit an External Monitoring Agency (EMA) to carry out monitoring and post-implementation evaluation. The TOR for the engagement of the EMA will be determined by the GDR and the external monitoring agency will be recruited prior to the commencement of the DRP implementation. The external monitoring reports will be submitted to DIMDM/GDR on quarterly basis. The post-implementation evaluation will be conducted within one year after all resettlement activities are being completed.

The EMA will have access to (i) the achievement of resettlement objectives, (ii) changes in living standards and livelihoods, (iii) the restoration of the economic and social conditions of the AHs, (iv) the effectiveness, impact and sustainability of assistance measures, (v) the need for further mitigation measures, if any; and, (vi) identify strategic lessons for future policy formulation and planning. The EMA will also be responsible for checking the procedures and resolutions of grievances and complaints. The EMA may recommend further measures to be taken to redress unresolved grievances.

1.4.2.10 Public Participation and Consultation

Stakeholders of the Project include Khan, Sangkat/village officials, local people along the STP area of the project, and representative of DPWT. Participation provides for the opportunity and the process by which stakeholders influence and become co-responsible for development initiatives and decisions that affect them. Through participation, the needs and priorities of the local population are solicited; the adverse social impacts of the Project, including the corresponding mitigating measures, are collectively identified; and the commitment and feeling of ownership over the Project is engendered among the AHs.

(1) Participatory Activities in Planning of ARAP

The public, especially the AHs, the local governments and land users will be consulted and their opinions are solicited. They will in fact participate in the preparation of the ARAP. **Table R 1.4.47** summarizes the roles and responsibilities of the EA, local governments, and AHs in the reparation.

Table R 1.4.47 Participatory Activities in ARAP Planning

Project Process Stage	Participatory Activities and Participants	Outputs	Responsible Institution
Preparation or Feasibility	Briefing to the Khan, Sangkat, village officials, local people in the STP area of the project, and DPWT about the Project technical assistance, the resettlement impact, and activities of the consultant (first stakeholder meeting).	The local population including AHs and their representatives, local government officials, and managers and technical staff of DPWT of PPCC participated in the meeting and were consulted on the objectives, planning and impact of the project and of resettlement.	DPWT
	Conduct of IOL, census of AHs, social impact assessment, and Cost Estimation.	An IOL, census of AHs and Cost Estimation was conducted and the results were included in the ARAP.	Local authorities and DPWT.
	Discussion/consultation with IRC-GDR and PMU-DPWT about the proposed project resettlement policy.	IRC were made fully aware of and consulted about social impact and resettlement policy.	DPWT
	Initial disclosure meeting with AHs to discuss the results of the IOL and gather suggestions on how to minimize and mitigate impacts, and discuss relocation options (second stakeholder meeting).	AHs and community leaders are informed of social impact and any damage or loss of property including land losses, and consulted on impact mitigation and resettlement including any relocation.	DPWT and, GDR
	Drafting of the ARAP and project	Draft of ARAP and PIB will be provided to and reviewed by DPWT, IRC-GDR and JICA for approval.	DPWT

Project Process Stage	Participatory Activities and Participants	Outputs	Responsible Institution
	information booklet (PIB)[7] and submission to PMU-DPWT, IRC-GDR and JICA for review and approval.		

Source: Survey Team

(2) Public Consultation During ARAP Preparation

During ARAP preparation stage, the following public consultations were held at different stages.

(i) First Stakeholder Meeting (Before the cut-off date)

(ii) Second Stakeholder Meeting (After the cut-off date)

(3) Schedule of Public Consultation meeting

The schedules of the stakeholder meetings are shown in **Table R 1.4.48**.

Table R 1.4.48 Stakeholder Meeting Held Regarding the Project

Nº	Date	Time	Sangkat	Khan	Meeting Place	Participant
(i) First Stakeholder Meeting (After the cut-off date)						
1	October 5, 2018	2:00 PM	Chak Angre Kroam	Mean Chey	Khan Mean Chey meeting hall	Total: 26 Female: 3
(ii) Second Stakeholder Meeting (After the cut-off date)						
1	May 10, 2019	8:30 AM	Chak Angre Kroam	Mean Chey	Khan Mean Chey meeting hall	Total: 21 Female: 2

Source: Survey Team

(4) Key Points Raised and Discussed

(a) The First Stakeholder Meeting (Before the cut-off date)

On 5th October 2018, the first stakeholder meeting was held at Khan Mean Chey Meeting Hall on the Project with relevant stakeholders, comprising DPWT of PPCC, JICA study team Local Authorities and local people. Participants are **Table R 1.4.49**. The meeting was chaired by PMU-DPWT and the meeting purpose of discussing are the following:

(i) Project technical assistance background and objectives;

(ii) The project outline and project site;

(iii) Informing on the Cut-Off Date for the project;

(iv) Main activities of the research team (i.e., conduct of socio-economic household survey, IOL, cost estimation, etc.);

(v) ARAP outline; and

(vi) Question and Response.

[7] An English version draft of PIB in *Appendix 1: Project Information Booklet (English Draft Version)* will be updated and translated in Khmer during the DMS. The updated PIB will be distributed before signing contract with AHs, information of rehabilitation options (including outline of IRP) will be added.

After an introduction by the Local Authority, a Representative of PMU/DPWT of PPCC described the project background and its current situation, the background of the Project and its impacts, both positive and negative. In each meeting, there was also an open floor for discussion among the participants. Question and Answer are as below.

Question: Mr. Mea Sopheap, Deputy Governor of Khan Mean Chey, requested to DPWT of PP PPCC to make pole clearly for the boundary of the project site. It is easy for local authority to protect any encroachment.

Answer: Mr. Chu Kimtry, Deputy Director of DPWT of PPCC, responded the poling will be made when DPWT get the sub-degree to certify PPCC ownership.

(b) The Second Stakeholder Meeting (After the cut-off date)

On 10th May 2019, the second stakeholder meeting was held at Khan Mean Chey Meeting Hall on the Project with relevant stakeholders, comprising from DPWT of PPCC, Local Authorities and local people. Participants are **Table R 1.4.50**. The meeting was chaired by PMU-DPWT and the meeting purpose of discussing the following:

(i) The project background, main project components and project location;

(ii) Reminded on the Cut-Off Date for the project;

(iii) Project policy on involuntary resettlement;

(iv) Project impact;

(v) Compensation policy;

(vi) Income restoration strategy;

(vii) Grievance redress mechanism; and

(viii) Question and Response.

After an introduction by the Local Authority, a Representative of PMU/DPWT of PPCC described the project background and its current situation, the background of the Project and its impacts, both positive and negative. In each meeting, there was also an open floor for discussion among the participants. There was no complaint to the Project. Question and Answer are below.

Question: Mr. Long Houn, Village Chief of Prek Ta Kong 1, explained that people often call to ask him about the size of the canal and how much area will be reserved for it?

Answer: Mr. Chu Kimtry said that the canal discussed during the meeting is an old canal from the Trabek pumping station, preserved according to a sub-decree. The canal is about 80 – 100 meters in width and there are 34 large yellow poles marking its border so people can identify the land preserved.

Question: Mr. Chea Sokhai, Chief of the Sangkat Chak Angre Krom, asked if the 19 ha preserved is part of the 520 ha of land that is preserved according the sub-decree.

Answer: Mr. Chu Kimtry replied that the 19 ha is part of the 520 ha of land preserved and given by the government to the PPCC by the sub-decree in 2008, and the PPCC has already gotten land title certificate and poled which was overseen by a joint committee including authorities from PPCC, Ministry of Land Management, Urban Planning and Construction, DPWT, and Khan Mean Chey.

Table R 1.4.49 Participants of the First Stakeholder Meeting

No.	Sex	Position / Department
1	M	Deputy Chief of Prek Tanou 2 village
2	M	Deputy Chief of Prek Tanou village
3	M	People in Phum 2 village
4	M	Chief of Prek Tanou 2 village
5	M	Chief of Prek Takong 1 village
6	M	Chief of Tuol Roka 1 village
7	M	Vice Chief of Cadastral Office Khan Mean Chey
8	M	Chief of Prek Takong 3 village
9	M	Vice Chief of Prek Tanou 1 village
10	M	Chief of Prek Tanou village
11	F	Chief Office of Khan Mean Chey
12	M	Chief of Tuol Roka village
13	M	Chief of Corporation Office of Khan Mean Chey
14	M	Sangkat Chief of Chak Angre Leu
15	M	Deputy Director of DPWT of PPCC
16	M	Sangkat Chief of Chak Angre Kroam
17	M	Deputy Governor of Khan Mean Chey
18	F	Chief Office of DPWT of PP
19	M	Resettlement Specialist/Bluefield
20	M	SAWAC Staff
21	M	SAWAC Staff
22	M	Field Supervisor IOL/Bluefield
23	M	Field Supervisor SESL/Bluefield
24	M	Deputy Team Leader/SAWAC
25	M	Team Leader ESIA/SAWAC
26	F	Administrative Director of Khan Mean Chey

Source: Survey Team

Table R 1.4.50 Participants of the Second Stakeholder Meeting

No.	Sex	Position / Department
1	M	Deputy Governor of Khan Mean Chey
2	M	Deputy Director of DPWT of PPCC
3	M	Resettlement Specialist/Bluefield
4	M	Office manager of PWT of Khan Mean Chey
5	M	Representative of Sangkat Chak Angre Leu
6	M	Vice chief of village Pram Pir
7	M	Village chief of Prek Takong
8	M	Village chief of Prek Tanou
9	M	Vice Chief of Cadastral Office Khan Mean Chey
10	M	Village chief of Tuol Roka
11	M	Village chief of Tuol Roka 1
12	F	Village chief of Tuol Roka 2
13	F	Vice chief of Tuol Roka 3 village
14	M	Sangkat chief of Chak Angre Kroam
15	M	Chief of Prek Tanou 2 village
16	M	Chief of Prek Takong 1 village
17	M	Chief of Prek Takong 3 village

No.	Sex	Position / Department
18	M	Chief of Prek Tanou 1 village
19	M	Chief of Corporation Office of Khan Mean Chey
20	M	Field Supervisor IOL/Bluefield
21	M	Field Supervisor SESL/Bluefield
22	M	Administrative Director of Khan Mean Chey

Source: Survey Team

1.5 Contribution to Climate Change Measures

Future rainfall intensity and frequency related to climate change and global warming have potential to cause negative impacts to sanitary condition in urban areas. Improvement of sewage treatment system in the Project is expected to contribute to reduction of risks of climate change, therefore, the Project reviewed expectation of mitigation capacity against climate change and adaptation function as climate change measure through the sewage treatment plant.

1.5.1 Mitigation

Regarding low carbon technologies as mitigation of climate change, the following eight types of low carbon technology are considered to be introduced to the STP site:

1) Introduction of high efficiency pumps,
2) Introduction of high efficiency blowers,
3) Optimization of pump operation in STP,
4) Introduction of inverter into sewerage system,
5) Introduction of high efficiency dewatering machine,
6) Optimization of sludge operation,
7) Utilization of biogas for power generation, and
8) Introduction of solar power system.

The Project introduce PTF for wastewater treatment. It doesn't use blower therefore electricity consumption is much lower than that of conventional wastewater treatment facility e.g. CASP. According to common specifications, electricity consumptions of PTF and CASP are estimated as;

PTF: 0.1 kwh/m^3 and CASP: 0.5 kwh/m^3.

Since the capacity of STF of the Project is 5,000 m^3/day, annual reduction of emission of CO_2 is calculated as follows.

(0.0005 MWh - 0.0001 MWh) x 5,000 m^3 x 365 days x 0.384 tCO_2/MWh (emission factor (Grid), Global Environment Center Foundation (2018)) = 280.32 tCO_2/year.

The effect of the emission reduction (280.32 tCO_2/year) is little, but if 282,000 m^3 of wastewater is treated with PTF, the emission reduction (15,697.92 tCO_2/year) is not small amount as one STP site.

1.5.2 Adaptation

The wastewater in the PPCC is treated with septic tanks in households and the treated liquid from the tanks are discharged to swamps/lakes through drainage channels. The liquid is still deteriorated but purified in the swamps/lakes by natural purification function. However, due to insufficient maintenance of septic tanks, the discharged liquid is seriously deteriorated, and unregulated land reclamation has led decrease of natural purification function in the swamp/lakes, in particular Cheung Aek Lake. Water quality of Cheung Aek Lake is getting worse, and it causes deteriorated sanitary condition.

Recently climate change causes flood by heavy rainfall, and PPCC is vulnerable to flood. The flood deteriorates living environment of residents beside rivers, open ditches, and swamps/lakes. Thus, improvement of sewerage system is an important climate change adoption strategy. Introduction of STP in Cheung Aek Lake is supposed to remedy sanitary condition and living environment near the Lake.

It may also decrease several problems caused by water deterioration during abnormal water temperature rise.

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Objective

The area of Cheung Aek Lake in which most of wastewater from PPCC flows into, is decreasing due to land reclamation and development. Water environment and sanitation condition around Cheung Aek Lake are becoming worse year by year. As a result, the city is beset with poor environmental conditions, deterioration of the residents' living condition and serious constraint to social and economic development, caused by the wastewater in the area.

To find a solution to these issues, the RGC and the PPCC has decided to implement this Project with the following objective.

Project Objective

- To minimize water pollution load to Cheung Aek Lake through construction of new sewage treatment facilities, thereby contributing to protecting and improving water environment of the Cheung Aek Lake as well as living and sanitation condition of the people in PPCC.

2.1.2 Basic Concept of the Project

To achieve the objective of the Project, this project is implemented in accordance with the short-term program in the phased implementation plan in the M/P, which is formulated in "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area".

As a result of "The Preparatory Survey on the Project for Sewerage System Development in the Phnom Penh Capital City", the following structures shall be constructed by the Project through the Japan's Grant Aid.

Detailed contents of the study done in the Preparatory Survey will be described hereinafter in this Chapter.

Table R 2.1.1 Contents of Japan's Grant Aid for the Project

Facilities		Major Specifications
Interception Facilities		Gate and Pump: 3.9 m^3/min×15kW×2 units
Sewer Pipe(Interceptor)		Length: 1.86 km, Ductile Pipe (φ300)
Access Road (Channel Maintenance Road)		Length: 1.69 km, Car Road Width: 7.0 m, Walkway: 1.5 m
Sewage Treatment Plant		
Wastewater Treatment Facilities	Reservoir Tank, Raw water Pump	Reservoir Tank：140 m^3, Raw Water Pump: 5.1 m^3/min×30kW×2 units Others：Screens, Mixer
	Floating Sponge Filter (FSF)	Area 24.0 m^2×Thickness: 0.6 m×2 tanks
	High-rate Trickling Filter (HTF)	Area 82.8 m^2×Thickness: 2.5 m×2 tanks
	Final Solid Liquid Separator (SLS)	Area 20.0 m^2×Thickness: 0.7 m×2 tanks
	Chlorination Tank	Chlorination Tank: 60 m^3

Facilities			Major Specifications
		Back Washing Water Storage Tank	Backwashing Water Storage Tank : Depth: 3.0 m×7.0 m×5.5 m Others: Mixer, Transfer Pump
		Primary Sedimentation Tank	Primary Sedimentation Tank : Depth:3.0 m×φ7.0 m Others : Sludge Scraper, Transfer Pump
	Sludge Treatment Facilities	Sludge Thickener	Gravity Thickener : Depth:4.0 m×φ5.5 m Others : Sludge Scraper, Transfer Pump
		Sludge Digestion Facilities	Primary Tank : Depth:11.0 m×φ7.5m Secondary Tank : Depth:10.0 m×φ7.5m Others : Gas Holder, Flare Stack, Sludge Transfer Pump
		Sludge Drying Beds	40 m^2×20 beds
Administration Building			Administration Room, Operation Room, Meeting Room, Electric Room, Laboratory, Workers Room
Transformer House			Electric Room
Structures for Exterior/Others			Landscaping Pond, Outfall, Gate and Fence, Yard piping and cabling, Pavement and Drainage

Source: Survey Team

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

The Project is implemented in accordance with the M/P formulated in "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area". In the M/P, Cheung Aek Treatment Area, in which wastewater from central area of PPCC is currently discharged to Cheung Aek Lake through existing combined drainage pipes/channels, is set-up, applying off-site sewage treatment. Furthermore, phased implementation plan for the treatment area, which consists of short-term (up to 2020), medium-term (from 2021 to 2030) and long-term (from 2031 to 2040). This project aims to construct STP and sewer pipe, based on the short-term program in the phased implementation plan.

In principle, project components are studied based on the request from the PPCC, and their quantity, capacity and specification are determined considering urgency and effectiveness to achieve the Project objective.

(1) STP

(a) Target Wastewater Qualities to be treated

In principle, BOD and TSS are targeted for designing sewage treatment facilities. Influent BOD and TSS are set based on those in the M/P. Effluent BOD and TSS are set in accordance with effluent standard for Commercial Building, Borey, Satellite City and Resort or Recreation Center in the Sub-decree on the Management of Drainage and Wastewater Treatment System, because effluent standards for designing STP is not yet established in Cambodia.

Design water quality of T-N and T-P are not set-up in this Project because 1) no effluent standards for designing STP is established in Cambodia and 2) PTF, which is introduced

in the Project is not applicable for removal of T-N and T-P independently[1]. However, since PTF have capacity to remove T-N and T-P to some extent, JICA Survey Team estimates the possible level of effluent concentration of T-N and T-P employing simulation results.

(b) Wastewater Treatment Method

PPCC requested PTF to be applied in this Project, on the other hand, two method, namely, PTF and CASP, are recommended in the M/P (Both of the methods have the same score in the quantitative evaluation). Therefore, JICA survey team re-evaluates the PTF and CASP considering BOD removal efficiency, construction cost, operation cost, easiness of operation and maintenance and so on.

(c) Sludge Treatment Method

PTF generates excess sludge in common with other wastewater treatment systems. Should sludge treatment system be not equipped in the facilities, stable operation of wastewater treatment is impossible. Proper sludge treatment system is extremely important for wastewater treatment. Sludge treatment process is determined by conducting alternative study, including such processes as gravity sludge thickener, sludge drying bed, and dewatering by mechanical dehydrator to minimize quantity of sludge. In the alternative study, not only technical matter but also capital expenditures (CAPEX) and operating expenditures (OPEX) are considered. In addition, since global warming is recently focused, reduction of greenhouse gases is also analysed.

(d) Landscaping Pond

Landscaping pond is installed to demonstrate the effect and benefit of the Project. The landscaping pond shall be designed considering future use as environmental education and enlightenment for the citizens. Therefore, the pond shall be easy to visit, useful and comfortable. In addition, O&M cost for the pond should be minimized.

(e) Smooth Expansion

The capacity of STP of this Project is 5,000m^3/day, and it will be expanded up to 282,000m^3/day in accordance with long-term plan of the M/P. Therefore, the facilities in this Project (capacity of 5,000 m^3/day) are designed as much as possible not to be useless and will smoothly be expanded for the future capacity of the long-term plan.

(2) Interception Facilities and Sewer Pipe

The design of interception facilities shall be determined considering workability, construction cost, wastewater volume, land use and so on. To finalize intercepting method, alternative study of (i) Fixed-type Interception, and (ii) Float-type Interception methods, are

[1] National Institute for Land and Infrastructure Management, MLIT Japan, B-DASH project No.12 Guideline for introducing a Technology for Advanced Pre-Treatment Trickling Filter System, ISSN1346-7238, No.951 (February 2017).

conducted. As for sewer pipe, alternative study of (a) Gravity flow and (b) Pressure flow, is conducted comparing construction cost, operation cost and workability.

The acquisition of private land and house relocation often cause social conflicts. To avoid such conflicts, the right of way for the installation of sewer pipes shall be set within the public land (in which Access Road (Channel Maintenance Road) is constructed in this project) near existing drainage canal, which is located from Trabek Pumping Station to the STP site.

(3) Reclamation

Construction site of STP designated by the Royal government of Cambodia is located in the north-east part of Cheung Aek Lake. The STP site shall be reclaimed before construction of the STP to be higher than flood water level of Cheung Aek Lake. The bottom of the proposed area must be covered by sludge and organic sediments. Therefore, removal of these sludge and organic sediments shall be included in the Project. Moreover, analysis on the soil condition of lake bottom is conducted in order to evaluate the soil stabilization and consolidation, as well as select ground improvement method.

The planned ground level in new STP is set as +10.50 m referring to development plan around the STP site.

(4) Socio-Economic Condition

The proposed area of STP is located in north-east area of Cheung Aek Lake. There is no possibility of resettlement and house relocation. Only removal of some tool shed and compensation for cultivation area of aquatic plant such as water morning glory, are required.

Although the proposed STP site is far from residential and commercial area, the facilities in the STP shall be designed paying attention to the surrounding environment including landscape. The implementation plan of construction works shall therefore be formulated to minimize noise, vibration as well as negative impact to economic activities and landscape.

(5) Construction/Procurement

(a) Design Standard

Since the design standards for STP construction in Cambodia have not yet been established, well-known standards of the developed nations such as Japan, European Union, Australia and the United States are adopted. Since previous Japan's Grant Aid projects have adopted Japanese design standards, this Preparatory Survey also adopts the Japanese design standards.

Design standards for bridges and national roads have been established by the Ministry of Public Works and Transport (MPWT) in 2003. Therefore, the following Cambodian design standards are adopted for the maintenance road:

- Road Design Standard Part 1.Geometry (CAM.PW.03.101.99), 2003
- Pavement Design Standard Part 2. Geometry (CAM.PW.03.101.99), 2003

(b) Procurement Situation

Main construction materials such as cement, reinforcing bars, aggregates and so on, and basic construction equipment are available in Cambodia; therefore, locally available materials and construction equipment shall be used as much as possible for the construction work to minimize the construction cost. The Preparatory Survey also consider the future improvement plan to avoid the duplication of investment.

On the other hand, ductile pipes, valves, pumps, control panels and mechanical and electrical equipment for the STP will be procured in Japan or another country and disembarkation point will be the port in Sihanouk Ville.

(c) Related Law/Regulation

Phnom Penh Capital Administration (hereinafter referred to as PPCA) shall obtain the land for STP in Cheung Aek Lake as the national land. The land title shall be transferred from national land (Public State Land) to Phnom Penh Capital Land (Private State Land) to start the construction of STP. Then, PPCA shall apply for construction authorization to cabinet together with the abovementioned application for transferring land title, or it shall apply the authorization to Ministry of Land Management, Urban Planning and Construction (MLMUPC)

The Project owner should implement and complete the Environment Impact Assessment (hereinafter referred to as "EIA") before commencement of the Project based on the environmental standard of Cambodia. The EIA shall be approved by the Ministry of Environment.

(6) Applicability of Cambodian Company

(a) Civil Works

There are local contractors in Cambodia who have some experience in construction work related to Japan's Grant Aid projects and adequate skill on general construction works such as roads, drainage channels and simple concrete structures. Therefore, local contractors can be employed as subcontractors for the general construction components to reduce the construction cost.

Some local engineers capable of supervising general construction work are also available in PPCC. These local engineers also could be employed as site managers of the contractor or site inspectors of the consultant for the general construction components to reduce the construction cost.

(b) Mechanical and Electrical Works in STP

In PPCC, the engineers who have specialized experiences for electrical and mechanical works related to STP are not available. Therefore, the engineers should be dispatched from Japan to conduct these special electrical and mechanical works.

(7) Soft Component

There is no staff with experience of STP operation in DPWT. For the sustainable and effective operation and maintenance of new facilities, the enhancement and improvement of O&M capacity of the staff in DPWT is required. The following components are planned as soft component.

- Capacity development in Operation and Maintenance of STP: Technical transfer and capacity development on O&M of STP, especially, wastewater treatment facilities, sludge treatment facilities, sludge management and water quality
- Assistance for formulating Financial Plan for Management of STP: Capacity development on preparation of financial plan, budget and expenditure management

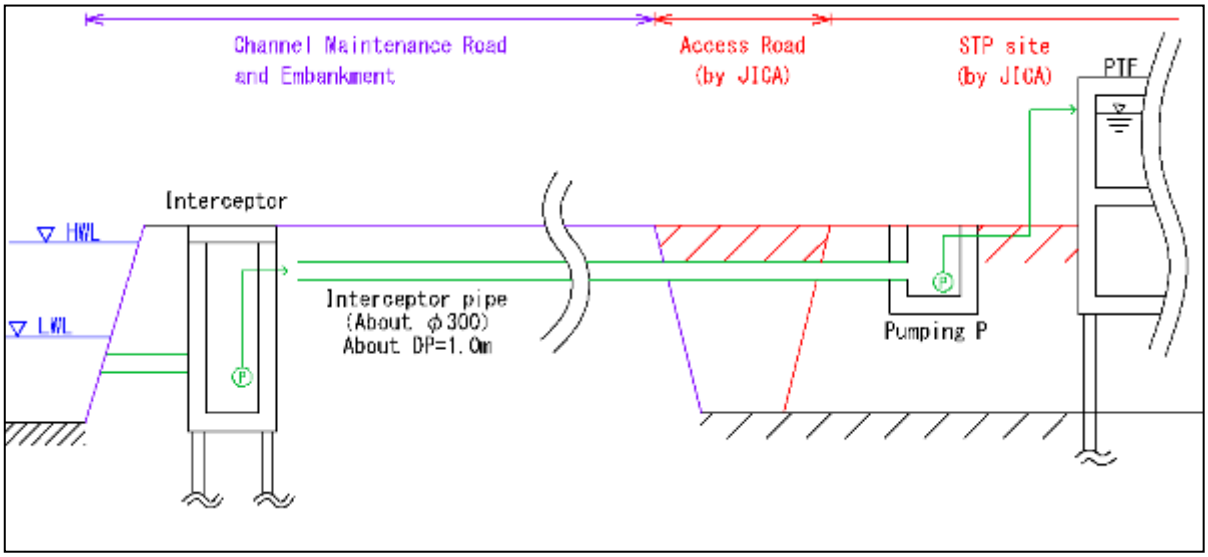
2.2.2 Basic Plan

2.2.2.1 Interception Facilities and Sewer to STP

(1) Basic Policy of Interception Facilities

The preliminary location and profile of interception facilities and sewer is preliminary studied as below:

- Location of sewage interception: Adjacent to the discharge channel of Trabek Pumping Station (PS)
- Preliminary profile of sewer: It is shown in **Fig. R 2.2.1**.



Source: Survey Team

Fig. R 2.2.1 Profile Outline for Interception Facilities and Sewer Pipe

(2) Location and Methodology of Sewage Interception

(a) Location of Sewage Interception

Present situation around Trabek Pumping Station is shown in **Photo R 2.2.1** and **Table R 2.2.1**.

In case that the location of sewage interception is determined to be intake point or in Trabek PS, space of interception facilities and access to the site is very limited. In addition, the sewer to STP should be installed crossing Rd. 271, which has heavy traffic as well as several underground utilities.

Installation method of the sewer will be pipe-jacking method or open-cut method. However, there is no enough space of driving vertical shaft for pipe-jacking method around Trabek PS, and the pipe-jacking machine should be procured from abroad. Therefore, only open-cut method will be feasible to install the sewer crossing Rd. 271. But, in this case, hindrance to traffic is huge and sewer installation work becomes more difficult.

On the other hand, at the discharge channel of Trabek PS, there is enough space for interception facilities and no significant objection to install sewer to STP. Thus, discharge channel of Trabek PS is more feasible to establish interception facilities.

a) Intake of Trabek PS -1

b) Intake of Trabek PS -2

c) Building of Trabek PS -1

d) Building of Trabek PS -2

e) Discharge point of Trabek PS -1

f) Discharge point of Trabek PS -2

Source: Survey Team (as of August 28, 2018)

Photo R 2.2.1 Present Situation around Trabek PS

Table R 2.2.1 Present Situation around Trabek PS

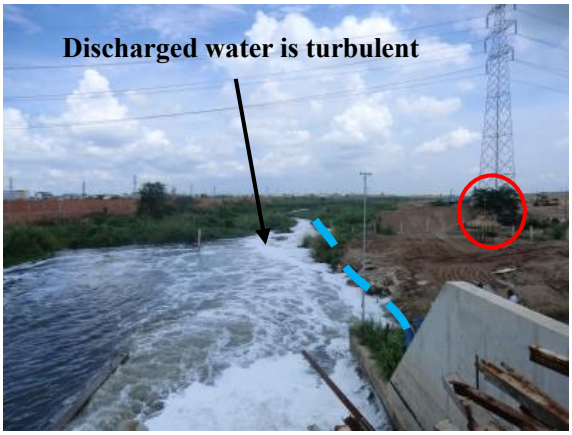
Location	Present Situation as of August 28, 2018
Intake Point	- There is not enough space and working space. - Access to the site is poor. - Sewer should be installed crossing Rd. 271 which has heavy traffic and several underground utilities.
Discharge Point	

Location	Present Situation as of August 28, 2018
Discharge Channel	- There are enough space and working space. - Access to the site is easy.

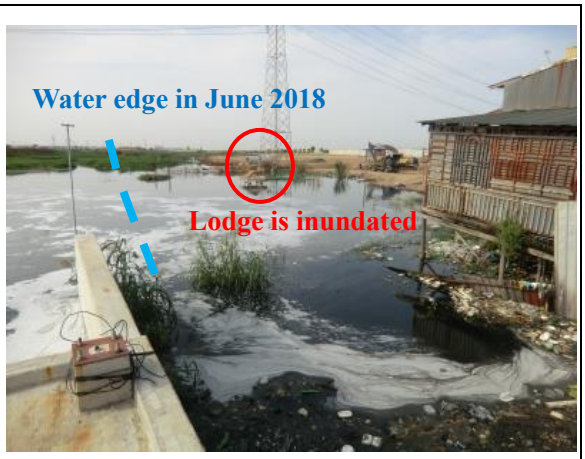
Source: Survey Team

In order to determine exact location of sewage interception, situation of water level and water flow is confirmed at the discharge channel during the second field survey in August. **Photo R 2.2.2** shows situation of the discharge channel as of August 22, 2018. As a comparison, situation as of June 1, 2018 is also shown in **Photo R 2.2.2**.

Width of the channel in June is almost same as the width of 11 discharge pipes of Trabek PS. However, the channel width is expanded in August due to increasing of discharged water volume and water level. Small lodge beside the channel is inundated. Therefore, it is confirmed location near discharge point from Trabek PS is significantly affected by seasonal fluctuation of water level. In addition, the discharged water including sand or suspended solid is turbulent at the discharge point as shown in **Photo R 2.2.2-a)**.



a) Discharge Channel as of June 1, 2018



b) Discharge Channel as of August 22, 2018

Source: Survey Team

Photo R 2.2.2 Situation of Discharge Channel

In addition, there is a plan to construct maintenance road along right bank of the discharge channel. The boundary of the maintenance road is shown by red line in **Fig. R 2.2.2**. The planned road is connected to Rd. 271, next to the discharge pipe from Trabek PS. This space will be available for sewage interception facilities.

Source: Survey Team based on the image of Google Earth

Fig. R 2.2.2 Planned Maintenance Road of Discharge Channel

Considering seasonal variations of discharge at the discharge point, and plan for maintenance road of the discharge channel, the location of sewage interception is proposed, as shown in **Fig. R 2.2.3**. The interception point is located along maintenance road and about 50 m downstream of discharge point of Trabek PS, at which discharge water flow from Trabek PS is stable.

Source: Survey Team based on the image of Google Earth

Fig. R 2.2.3 Proposed Location of Sewage Interception

(b) Methodology of Sewage Interception

Considering seasonal variations of discharged water from Trabek PS, the main conditions for sewage interception are as below;

- Water level of the discharge channel has considerable seasonal variations.
- The discharged water in the channel contains large amount of sand or other suspended solids (SS).

Regarding method of sewage interception, the above situations will be considered. In general, the interception level shall be set below Low Water Level (LWL). However, this level will be close to bottom of the discharge channel, and SS or sand will enter into interception facilities. Therefore, study on method of sewage interception is implemented. Applicable methods of sewage interception are enumerated below:

Alternative 1: Fixed-type sewage interception
Alternative 2: Float-type sewage interception

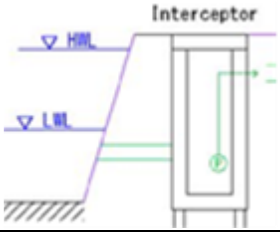
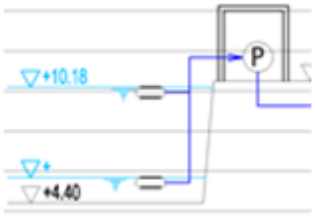
Alternative 1 is a sewage interception method based on the basic policy in **Subsection 2.2.2.1**. The interception level is below LWL and interception chamber is required. In this case, the water level is low during dry season so that the interception chamber will be deep. However, this system is similar to that of ultimate stage sewerage system.

Alternative 2 is a sewage interception method, consisting of floating intake facilities and land pump. The interception level is water surface. In this case, land pump and pumping building is required but SS volume flowing into STP will be less than that of Alternative 1. On the other hand, influent water quality of STP will not be stable due to fluctuation of intake condition (intake point is always floating).

Table R 2.2.2 shows comparison of sewage interception methods. As a conclusion, Alternative 1 is applied, considering the effectiveness as the first project and future utilization of facilities.

As for required facilities for sewage interception, Alternative 2 is simpler than Alternative 1. In addition, construction work will be easy because underground facilities will not be required. However, Alternative 1 has advantages as the first-step sewerage project in Phnom Penh. Alternative 1 consists of interception chamber such as manhole and sewer. Therefore, operation of sewerage system will be similar to ultimate sewerage system, and it is expected to enhance management capacity of personnel in charge of sewer operation and maintenance.

Table R 2.2.2 Comparison of Sewage Interception Method

Interception Method	Alt. 1: Fixed-type Interception	Alt. 2: Float-type Interception
Schematic Diagram of Sewage Interception		
Interception Level	- Below LWL - Near bottom of the discharge	- Surface of the discharge channel

Interception Method	Alt. 1: Fixed-type Interception	Alt. 2: Float-type Interception
	channel	
Required Facilities for Interception	- Interception conduit - Interception chamber - Pump	- Float-type interception facility - Pump - Pumping building
Effectiveness as a Pilot Sewerage Project, especially for Sewer Lines.	- Good for enhancement of management capacity for personnel in charge of sewer operation and maintenance.	- Not expected because this system just catches and transfers sewage to STP.
Future Utilization for Sewerage Works	- Utilization as manhole for on-site training on operation and maintenance. - Continuous utilization as interception facility during beginning of future expansion of sewerage system. - Utilization as water sampling spot for monitoring of water quality.	- Continuous utilization as interception facility during beginning of future expansion of sewerage system.
Main Concerns on the Alternatives	- Inflow of SS into interception chamber. - Cleaning work of the interception chamber - Structure of interception chamber will be big and deep.	- Quite different with future sewerage system - Purpose of the facility is only for sewage interception and conveyance to STP - Broken of float-type interception facility is concerned by rapid flow of discharged water. - Influent quality to STP will not be stable due to float-type interception.
Evaluation (as Sewerage System)	Good (Applied)	Poor

Source: Survey Team

2.2.2.2 Study on Layout of Interception Facilities

In this section, layout of the interception facilities is studied in terms of reduction of sand volume at interception point and sand removal from the interception chamber.

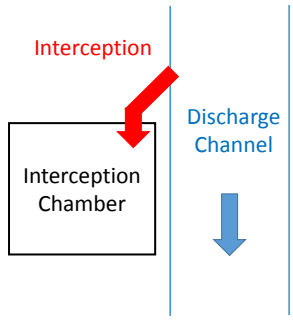
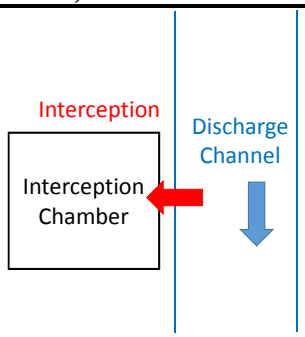
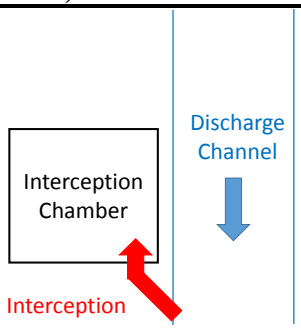
(1) Measures of Protection from Sand at Intercepting Point

In this measure, inflow of sand to the chamber will be reduced in combination of interception direction and arrangement of interception conduit to the chamber as below.

(a) Direction of Sewage Interception

Regarding sewage interception, three directions to introduce water from the discharge channel are selected as shown in **Table R 2.2.3**. Among the three directions, interception from the side of water stream is better than others to reduce inflow of sand, considering flow direction of particles in the discharge channel.

Table R 2.2.3 Direction of Sewage Interception

i) Upstream Side	ii) Vertical Direction	iii) Downstream Side
		
NOTE: - Sand will easily enter into the interception chamber due to the stream.	NOTE: - Sand will enter into the interception chamber, but the volume will be less than i)	NOTE: - Based on the result of field survey, sand is accumulating due to slower flow. There is a possibility that the sand flow into Chamber.
Poor	Excellent (Applied)	Good

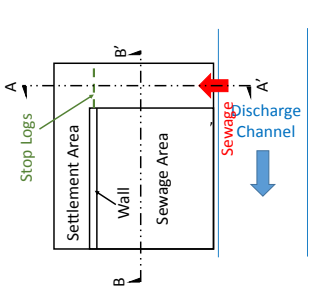
Source: Survey Team

(2) Measures of Sand Removal at Interception Chamber

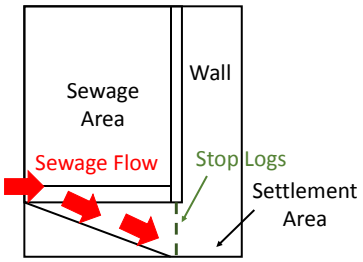
If the structure of interception chamber is simple, like normal manhole, the sand is easily settled at the bottom and cleaning work become difficult. Therefore, the following arrangement will be made for sand removal.

- Separation of sewage area and settlement area.
- Making different level between the sewage area and the settlement area
- Installation of stop logs to separate the sewage area and the settlement area for water removal and cleaning of the chamber.

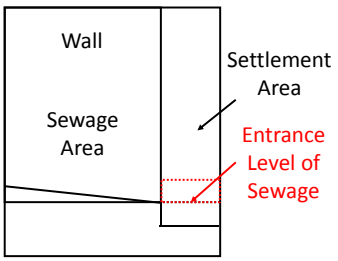
The schematic plan and section of the interception chamber is shown in **Fig. R 2.2.4**. In this case, dimension of interception chamber will be big and deep, and stop log is also required. However, sand will be settled at lower part in the chamber and cleaning work can be implemented by removing water. If it is necessary to remove water at pumping area, another stop log will be installed at entrance of sewage, which is connection point between interception conduit and the interception chamber.



i) Plan



ii) A-A' Section



iii) B-B' Section

Source: Survey Team

Fig. R 2.2.4 Schematic Diagram of Interception Facilities

(3) Arrangement of Supporting Facility

In addition to interception conduit and chamber, supporting facilities will be arranged especially for maintenance work such as cleaning of the chamber. The necessary facilities will be as below;

- Stop logs to stop water inflow at interception chamber during maintenance
- Entrance manhole and steps to go up and down inside the interception chamber
- Grating cover at interception point for protection of large garbage or debris.

2.2.2.3 Study on Sewer to STP

Sewer to STP will be installed from the interception facilities to receiving well at STP.

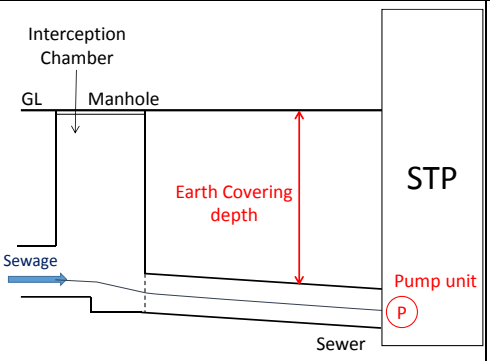
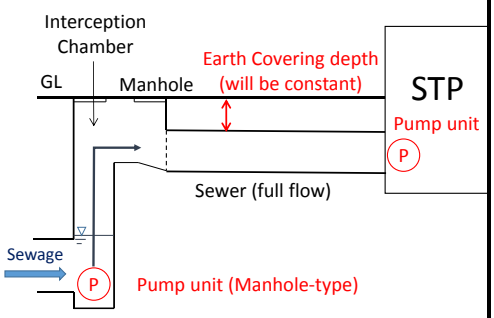
(1) Conveyance Method of Sewage to STP

Conveyance method of sewage is gravity flow or pressured flow by pump equipment. Considering interception level, water level and distance to STP from the interception facilities, application of pressured flow is more feasible than gravity flow in this Project.

- Interception level: below LWL, which is lower part
- Water level: it should be determined based on LWL condition
- Distance to STP (length of sewer): approximately 2 km

Table R 2.2.4 shows comparison of sewage conveyance method.

Table R 2.2.4 Comparison of Sewage Conveyance Method

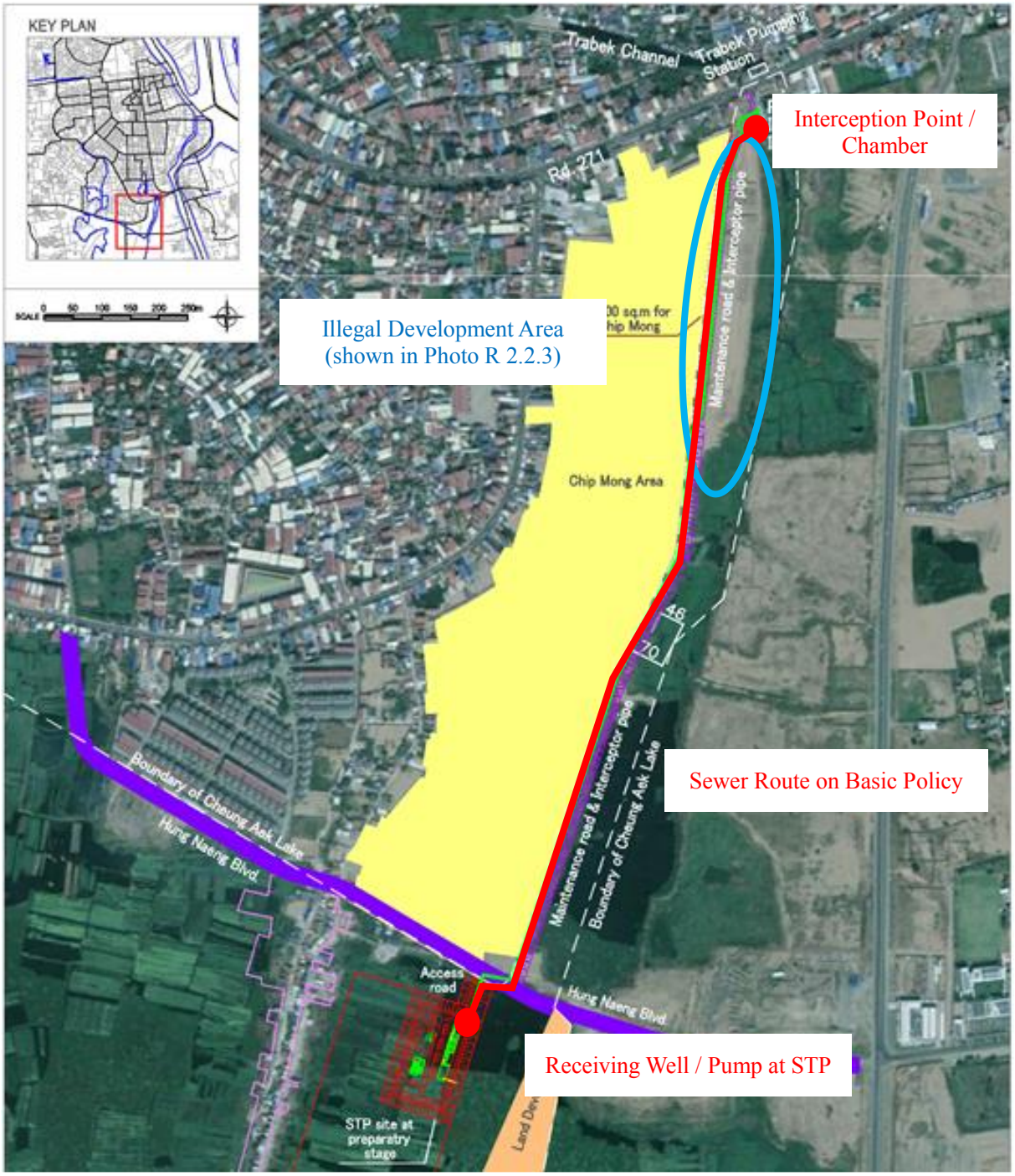
Flow Type	Gravity Flow		Pressure Flow	
System				
Features	- Water level at start point is very low. - Sewer length to STP is long as approximately 2 km. - The earth covering depth becomes deep due to gradient of sewer. - SS is easily settled in sewer in case insufficient gradient and flow velocity. - Many intermediate manholes are required. - Installation work of sewer becomes more difficult due to large volume of water protection from channel and deep excavation. - Receiving level of sewage at STP becomes also deep.		- Water level at start point is very low. - Sewer length to STP is long as approximately 2 km. - Manhole-type pump is available. - The earth covering depth becomes shallow because sewer gradient is not concerned. - Installation work of sewer becomes easier considering water protection from channel and excavation depth. - Receiving level of sewage at STP becomes also shallow.	
Cost Comparison (Unit: construction cost, million USD, O&M cost, million USD/year)				
Construction Cost (Direct Cost)	Pipe installation	3.24	Pipe installation	0.57
	Pumping equipment	0.10	Pumping equipment	0.13
	Total	3.34	Total	0.70
O&M Cost[1)]		0.04		0.05
Comment	Construction cost of gravity type is more than four times as much as that of pressure flow. On the other hand, difference is O&M cost is about 0.01 million only.			
Evaluation	Poor		Good (Applied)	

Note 1): O&M cost is for electricity of operation of pumping equipment.
Source: Survey Team

(2) Sewer Route to STP

(a) Basic Policy

The basic policy on sewer route to STP is as shown in **Fig. R 2.2.5**.



Source: Survey Team

Fig. R 2.2.5 Sewer Route on Basic Policy

(b) Present Situation of Sewer Route

Present situation on sewer route as of August 28, 2018 is shown in **Photo R 2.2.3**.

This area is inside public discharge channel of Trabek PS. The sewer will be installed under the road.

a) Developing Situation -1 b) Developing Situation -2

c) Developing Situation -3 d) Developing Situation -4

Source: Survey Team

Photo R 2.2.3 Developing Situation inside Public Discharge Channel of Trabek PS

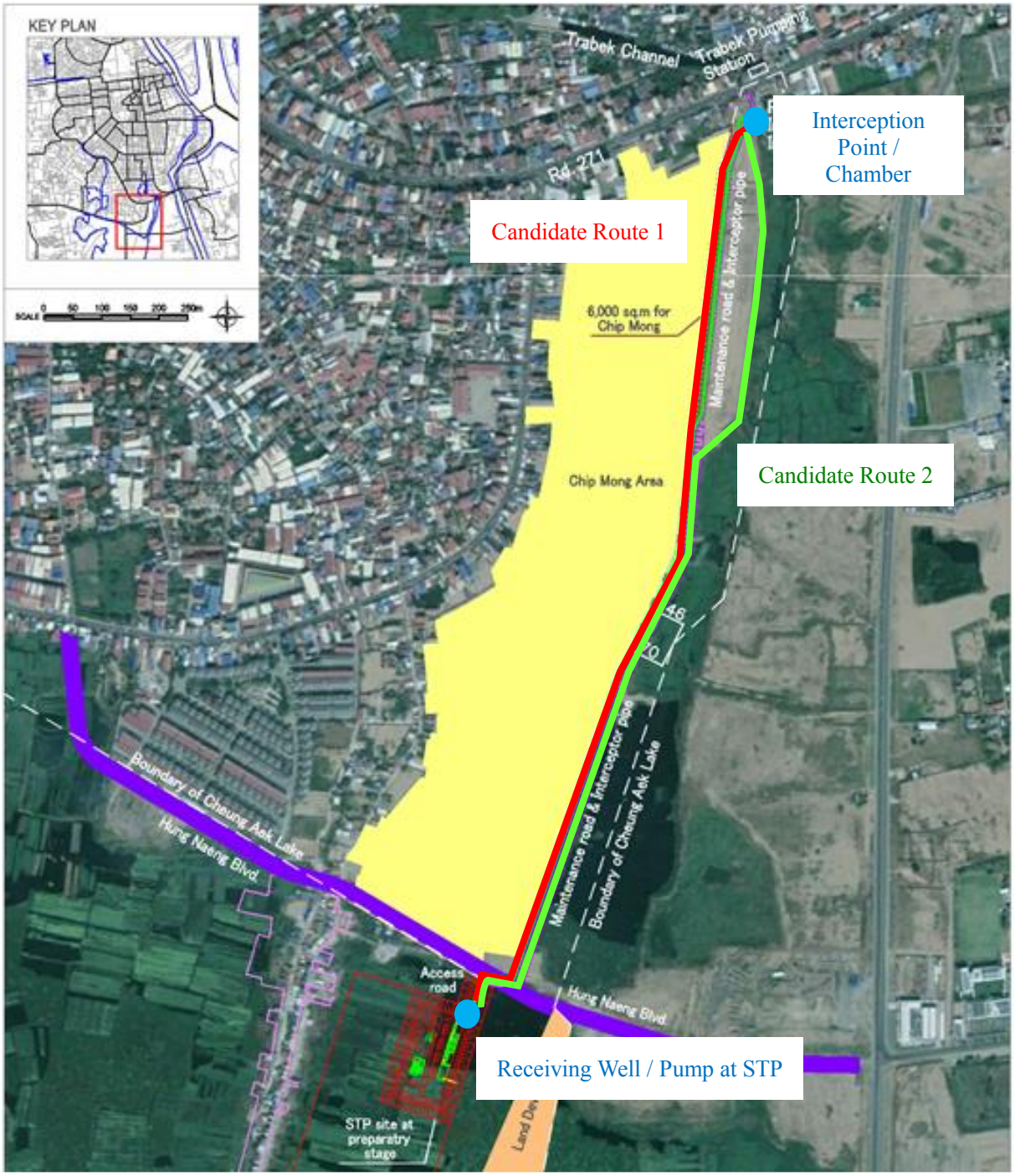
(c) Candidate Sewer Route

Based on the present situation around the discharge channel, Survey Team prepared two candidate sewer routes as below and the location of the routes are as shown in **Fig. R 2.2.6**.

Candidate 1: Along the boundary wall of Chip Mong Group and discharge channel

Candidate 2: Along the boundary of illegal development area and discharge channel

Regarding the sewer length, there is no big difference between the two candidates. Moreover, PPCA requested to have more accent in Candidate 1 in order to smoothly maintain the drainage channel. Therefore, Candidate 1 is selected for sewer route in this Project.



Source: Survey Team

Fig. R 2.2.6 Candidate Sewer Route Routes

(3) Condition on Sewer Design

The following conditions on flow calculation are determined based on Planning and Design Guideline for sewerage facilities in Japan issued by Japan Sewage Works Association in 2009.

(a) Flow Rate

The capacity of STP is 5,000 m^3/day, which is the daily maximum sewage volume. It is

equivalent to 0.058 m^3/s.

Normally, flow rate of sewer is determined by the hourly maximum sewage volume. However, the amount of sewage pumped in this Project is controlled and equalized and not be affected by the fluctuation of water flow around interception facilities. Therefore, the flow rate of sewer to STP is applied at 0.058 m^3/s not to install oversized sewer and pump.

(b) Equation of Hydraulic Calculation

Hazen-Williams' equation is applied for hydraulic calculation, as follows;

$$Q = A \times V$$
$$V = 0.84935 \times C \times R^{0.63} \times I^{0.54}$$

Where;

V: Average flow velocity (m/s)
C: Coefficient for flow velocity (= 110)
R: Hydraulic radius (= D/4, D: Pipe diameter)
I: Hydraulic gradient (h/L, L: Sewer length)
h: Friction head to sewer length (m)

Coefficient for flow velocity: C, there are several bending points on the sewer route. Therefore, the coefficient value of 110, which includes bending and other losses, is applied.

Hydraulic radius: R, sewage flow is full flow in case of pressured system. Therefore, the hydraulic radius is quarter of pipe diameter.

(c) Flow Velocity

Flow velocity is determined to be 0.8 m/s or more, considering prevention of settlement of SS in sewer. In addition, the flow velocity should be below 3.0 m/s to avoid any damage of sewerage facilities.

(d) Pipe Diameter

Minimum pipe diameter is determined to be 250 mm because sewage intercepted is introduced from combined system. Based on flow rate and velocity, pipe diameter is determined to be 300 mm as shown in **Table R 2.2.5**. In this case, required hydraulic gradient is determined to be 0.32% from the Hazen-Williams's equation.

Table R 2.2.5 Pipe Diameter and Flow Velocity (Full Flow)

Diameter (mm)	Q (m^3/s)	A (m^2) (= π x $(D/1000)^2$ / 4)	V (m/s) (= Q/A)	Flow Velocity
250	0.058	0.0491	1.182	Fast
300	0.058	0.0707	0.821	Appropriate
350	0.058	0.0962	0.603	Slow

Source: Survey Team

(e) Pipe Material

Pressured sewer system is applied to the sewer to STP. Therefore, the pipe material will be selected among the following materials.

- Ductile cast iron pipe (DCIP)
- Hard vinyl chloride pipe (VP)
- High density polyethylene pipe (HDPE)

Table R 2.2.6 shows comparison of pipe material. Considering characteristics of the materials, requirement and condition on the installation, DCIP is applied to the material of sewer to STP for the Project from view point of less restrictions in this stage.

Table R 2.2.6 Comparison of Pipe Material

Material	DCIP	VP	HDPE
1) Strength / Resistance			
Internal Pressure	- Enough strength to high pressure condition	- Not suitable under high pressure condition	- Not suitable under high pressure condition
External Pressure	- High resistance to bending and load - Flexible and enough strength to impact	- Resistance to deformation is less - Weakness to impact - It is breakage.	- Resistance to deformation is less - It is vulnerable.
Corrosion	- Epoxy resin coating is necessary for internal surface	- Resistance to corrosion is good, it is weak to chemicals and possible to be melt.	- Good resistance
2) Applicability			
Restrictions for Appropriate Operation	- Internal and external coating against corrosion is required, but no other restriction is considered.	- Applicable diameter for pressured pipe is limited to small diameter under low pressure condition less than 0.5 MPa. - Enough measures on corrosion, damage by impact and floatation are required.	- Applicable diameter for pressured pipe is limited to small diameter under low pressure condition of less than 0.3 MPa. - Enough measures on corrosion, damage by impact and floatation are required. - Fusion jointing is required to connect pipes by expert of the work.
Main Installation Condition	- Under maintenance road of the discharge channel of Trabek PS (Large vehicle will run). - Installed between development area of Chip Mong Group and the discharge channel of Trabek PS - Condition of natural soil is soft, and groundwater level is high, but soil condition is improved after landfill and construction of the maintenance road. - Installation depth is shallow (about 1 m), and length is long (approximately 2 km). - Sewage to be conveyed is contaminated and mixed wastewater from Trabek drainage area		
Unit Cost	Almost same as VP	Almost same as DCIP	Higher than VP and DCIP
Reliability for the Project	- Very high	- Low	- High, but jointing work of pipes is concerned.
Evaluation	Excellent (Applied)	Poor	Good

Source: Survey Team based on Characteristics of material for pressure sewer pipe issued by the Society for Pressure Sewer Pipe

2.2.2.4 Land Development for STP

(1) Summary

Construction site of STP designated by the Royal Government of Cambodia is located in the north-east part of Cheung Aek Lake. The STP site is covered by water and utilized as farm field of aquatic vegetable, such as water morning glory or water cress, at present. The STP site shall be reclaimed before construction of the STP facilities to be higher than flood water level of Cheung Aek Lake.

Source: Survey Team

Fig. R 2.2.7 Present Condition of the STP Site

Photo (A): STP Site (View from West)

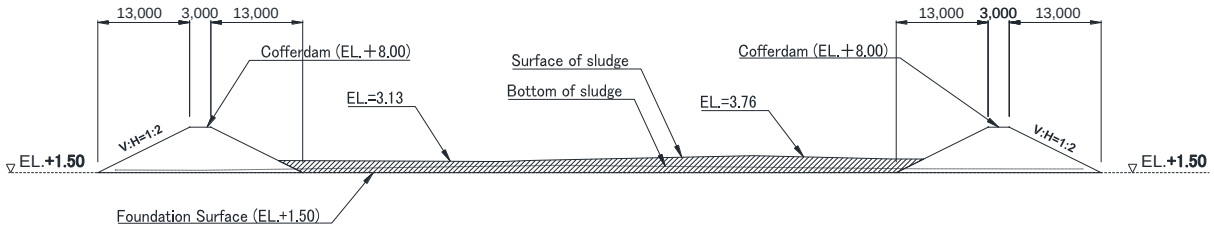
Photo (B): STP Site (View from East)

Source: Survey Team

Photo R 2.2.4 Present Condition of the STP Site

Survey Team conducts topographic survey, water level monitoring and geological survey to investigate present condition of the STP site. The objectives of these surveys are: (i) to study volume of reclamation, (ii) to study necessity of foundation improvement work, (iii) to confirm surrounding environment and obstacles during construction period, and (iv) to provide the required data for consolidation analysis and structural design.

According to the results of the topographic survey, geological survey and water level monitoring, existing ground level is from EL.+3.1 m to EL.+3.4 m. The lowest ground level of bottom of sludges is EL.+1.6m. Water level varies from EL.+5.5 m to EL.+8.0 m. Typical cross section of reclamation work is provisionally proposed as shown in the figure below.



Source: Survey Team

Fig. R 2.2.8 Typical Cross Section of Reclamation for STP (Final Shape)

For the reclamation, cofferdam at surrounding of STP site is constructed for the first step. Then, dewatering of the STP area, and removal of sludge and organic sediments are implemented. Finally, backfill by good soil and construction of embankment is implemented. The elevation of cofferdam and embankment is EL. +8.0 m and EL. +10.50 m.

(2) Ground Improvement Method

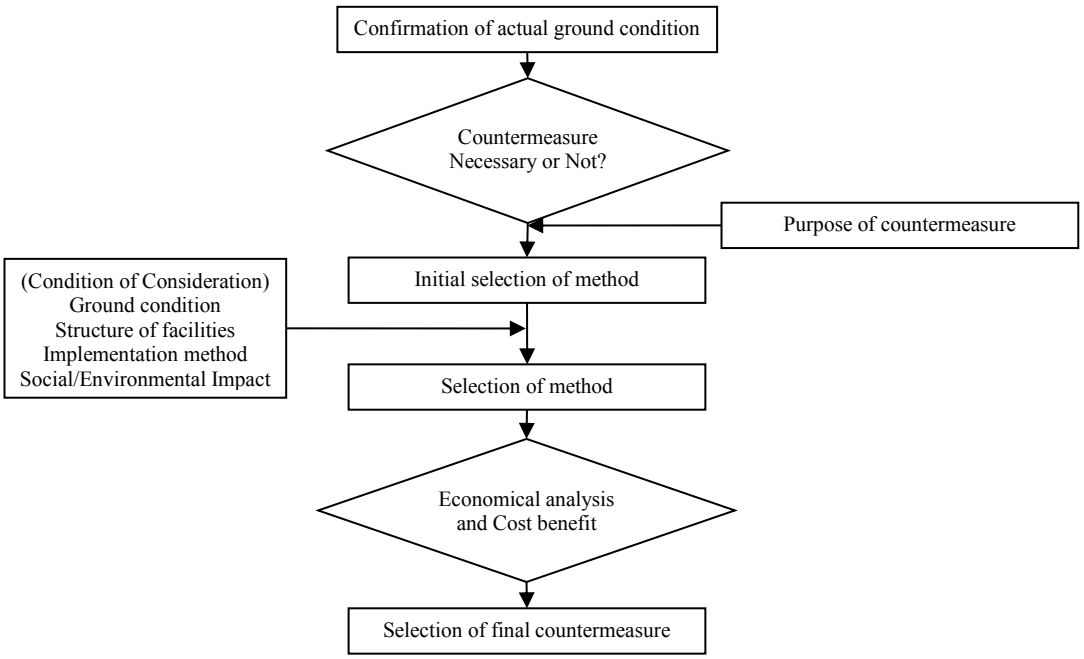
Because the STP site is covered by water and utilized as farm field of aquatic vegetable, foundation of the STP site must be covered by soft soil/sludge and consists of sand and clay layers. Soil stabilization should be considered before preparing structural design. There are numerous techniques for soil stabilization. These methods mainly depend on the nature of strata and the purpose of improvement. Major ground improvement methods are shown in **Table R 2.2.7**.

Table R 2.2.7 Purposes and Methods for Ground Improvement

Countermeasure For	Effectiveness		Method
Ground Subsidence	Acceleration of consolidation settlement	To accelerate consolidation settlement, and reduce remaining settlement volume	- Surcharge method - Vertical drain method
	Restraint of total settlement	To reduce total settlement of ground	- Sand compaction pile method - Soil-solidification method
Stabilization	Reduction of shearing deformation	To restrain swelling up and moving sideways by embankment	- Surface treatment method
	Restraint of strength degradation	To restrain degradation of strength of the ground, and to improve sustainability of the soil	- Slow loading method
	Acceleration of strengthening	To stabilize the ground by acceleration of strengthening the ground	- Vibration compaction method
	Increase sliding resistance	To increase sliding resistance by changing embank formation or replacing part of ground	- Replacement method - Loading berm method - Reinforced banking method

Note: Seismic Countermeasure is not considered, Effectiveness of each method is only typical one.
Source: Survey Team

The procedure for the selection of ground improvement is as follow.



Source: Survey Team

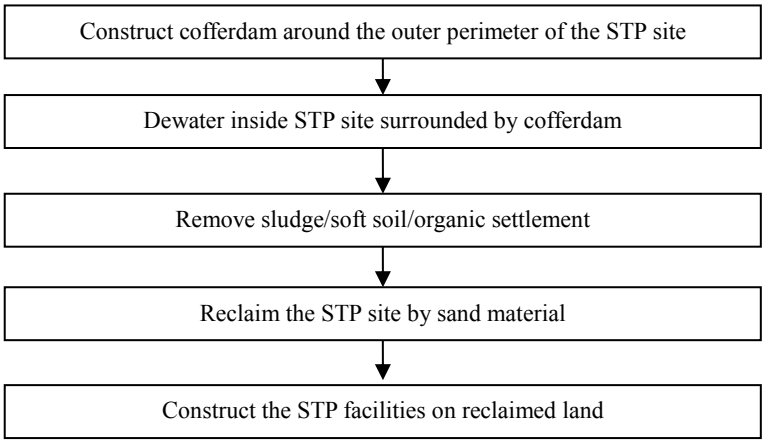
Fig. R 2.2.9 Procedure for Selection of Ground Improvement

Considering the height of embankment (7 m; from bottom of lake to planned ground level), replacement method will be preferable and existing sludge and organic settlements will be replaced by good soil. It will secure the stabilization of the embankment. Therefore, countermeasure for consolidation settlement will not be adopted due to duration and higher

construction cost.

(3) Implementation Plan

The following figure summarized implementation plan for reclamation.



Source: Survey Team

Fig. R 2.2.10 Implementation Plan for Reclamation

Despite of the removal of sludge and organic sediments of lake bottom, subsidence due to soil consolidation at deeper layer is unavoidable. Estimated subsidence after reclamation are about 8 cm in a year, 16 cm in 3 years and 30 cm in 10 years. Therefore, surplus of 30 cm will be applied for reclamation of STP site. In addition, structural and mechanical measures such as flexible pipe joint and grout hole at bottom slab of pile supported structures is considered in the design.

(4) Social Impact of Land Development

The STP site has clearance of 50 to 100 m from surrounding residence area. Land development for the STP site will not affect surrounding area. However, the land is utilized for agricultural use, so some agricultural field will be lost.

Trabek Pumping Station is located north of the STP site. Remaining land after land development of the STP site has enough space for water discharged from Trabek Pumping Station. There is no other water flow around the STP site. Land development for the STP site will neither block nor interfere with the water flow in Cheung Aek Lake.

In addition, the flow rate of wastewater from Trabek pump station is about 0.5 m/s even at the highest flow rate, so that reclamation of STP site will not suffer effects such as erosion.

2.2.2.5 Planning of STP

(1) Design Flow and Targeted Wastewater Qualities to be treated

Design flow and targeted wastewater qualities for designing sewage treatment facilities are summarised in **Table R 2.2.8**. In principle, BOD and TSS are utilised for designing sewage

treatment facilities. Influent BOD and TSS are set based on those in the M/P. Effluent BOD and TSS are set in accordance with effluent standard for Commercial Building, Borey, Satellite City and Resort or Recreation Center in the Sub-decree on the Management of Drainage and Wastewater Treatment System, because effluent standards for designing STP are not yet established in Cambodia. The effluent BOD and TSS, proposed in the project is deemed to be reasonable, considering neighbouring countries' upper limits of design effluent water quality for STP, as shown in **Table R 2.2.9**.

Design parameter of T-N and T-P are not set in this Project because 1) no effluent standards for designing STP is established in Cambodia and 2) PTF is not applicable for removal of T-N and T-P independently. However, since PTF have capacity to remove T-N and T-P to some extent, Survey Team estimates the possible level of effluent concentration of T-N and T-P employing simulation result (see **[Appendices] 6.7**)

Table R 2.2.8 Amount and Quality of Wastewater for Designing STP

Item		Contents	Remarks
Design Flow		5,000 m^3/day	
Targeted Wastewater Qualities			
	BOD_{in}	195 mg/L	Based on the M/P
	BOD_{out}	< 30 mg/L	1)
	TSS_{in}	205 mg/L	Based on the M/P
	TSS_{out}	< 80 mg/L	1)
	T-N and T-P	Not set-up	Not set because 1) No effluent standards for designing STP is established in Cambodia and 2) PTF is not applicable for removal of T-N and T-P independently.

Note 1) Effluent standards for BOD and TSS are set in accordance with effluent standard for Commercial Building, Borey, Satellite City and Resort or Recreation Center in the Sub-decree on the Management of Drainage and Wastewater Treatment System, because no effluent standards for designing STP is established in Cambodia
Source: Survey Team

Table R 2.2.9 Upper Limits of Design Effluent Water Quality for STP

	Cambodia		Thailand		Vietnam	Myanmar
	Protected Public Water Area	Public Water Area and Sewer	National Level	Bangkok	National Level	Yangon City[3)]
BOD (mg/L)	< 30	< 80	< 20[1)]	< 20	10～30	< 20
TSS (mg/L)	< 60	< 120	< 30[2)]	< 30	10～30	< 30

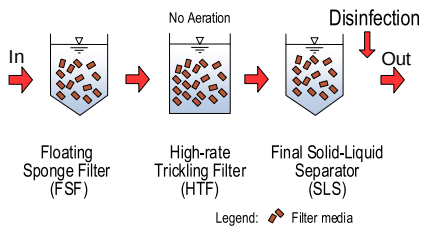
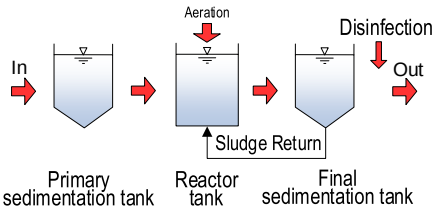
Note 1) Filtered sample shall be monitored for Lagoon
Note 2) 50 mg/L shall be applied to Lagoon
Note 3) National Standard is not available in Myanmar
Source: Sub-Decree on Water Pollution Control, Annex 2, Effluent standard for pollution sources discharging wastewater to public water areas or sewer.
Vietnam: Discharge StandardTCVN7222:2002
Preparatory Survey for Bangkok Wastewater Treatment Project in Thailand, Final Report, 2011, JICA
Preparatory Survey Report on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City in the Republic of the Union of Myanmar, 2014, JICA

(2) Wastewater Treatment Method

In the M/P, two methods, namely, PTF (Pre-treated Trickling Filtration) and CASP (Conventional Activated Sludge Process), are recommended. On the other hand, PPCC requested PTF to be applied in this Project. Therefore, PTF and CASP, which are recommended in the M/P, are re-evaluated in **Table R 2.2.10**.

As shown in the table, PTF is recommended for the STP in this project, mainly due to cheaper construction and O&M cost, as well as easiness of operation.

Table R 2.2.10 Comparison of PTF and CASP

Item	PTF	CASP
Flow Sheet		
Outline	This is Japanese new technology upgrading trickling filter by introducing new filter media.	Most popular sewage treatment method using mechanical equipment. Higher treatment performance in pollution load reduction is achieved but energy consumption is bigger than PTF.
BOD Removal Rate	< 30 mg/L	< 15 mg/L
Land Requirement	< 3.0 ha (for 5,000 m^3/day)	< 3.5 ha (for 5,000 m^3/day)
Construction Cost [1)]	0.9	1.0
O&M aspect	No aeration is required and thus energy consumption is smaller than that of CASP. O&M is easier than that of CASP. Filter bed can be easily washable and thus prevent offensive odor generation and flies from filter bed	This method require aeration in the reactor and thus energy consumption is much bigger than that of PTF. Moreover, highly skilled technique is required for operation.
Others	Contribution to reduce greenhouse gases is larger than CASP due to smaller energy (electricity) consumption.	Contribution to reduce greenhouse gases is smaller than PTF due to bigger energy (electricity) consumption.
Number of the method applied	Number of the method applied is currently increasing especially in sewerage development project in Vietnam.	Application is large in number
Evaluation	Land requirement as well as construction cost is smaller than that of CASP. O&M cost is cheaper and easier than that of CASP since aeration is not required. Moreover, the number of the method is increasing especially in Vietnam. Considering the above, PTF has more advantages than CASP	Treatment performance is higher than that of PTF but energy consumption (electricity) is larger and higher skilled technique is required, compared to PTF.
Overall Evaluation	Best Option	Second Option

Note: 1) Ratio of STP construction cost in comparison with CASP is based on cost estimation in "the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area".
Source: Survey Team

(3) Sludge Treatment Method

(a) Study Policy

PTF system generates excess sludge in common with other wastewater treatment systems. Should sludge treatment system be not equipped in the facility, stable operation of wastewater treatment is impossible. Proper sludge treatment system is extremely important for wastewater treatment. Not only technical matter but also consideration of capital expenditures (CAPEX) and operating expenditures (OPEX) are necessary when making decision of the treatment process. Especially how to reduce OPEX is the most important for securing sustainability. On the other hand, with recent focus on global

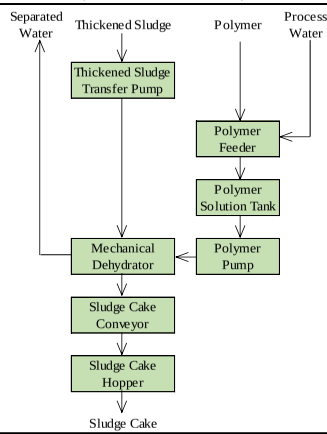
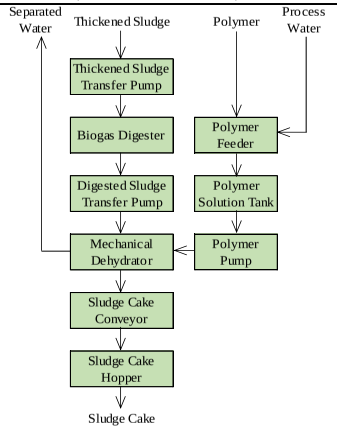
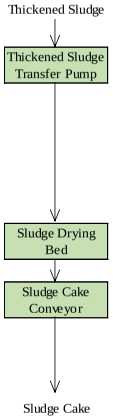
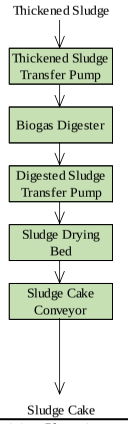
warming, generation of greenhouse gases by the project should be minimized. From these points of view, the following 4 cases of treatment system were compared and evaluated.

Case 1: Sludge Dewatering by Mechanical Dehydrator
Case 2: Sludge Digestion (Anaerobic Digestion) + Dewatering by Mechanical Dehydrator
Case 3: Sludge Drying by Drying Bed
Case 4: Sludge Digestion (Anaerobic Digestion) + Drying by Drying Bed

(b) Evaluation Result

Table R 2.2.11 shows the evaluation result of sludge treatment system. Should mechanical dehydrator be installed, namely for *Case 1* and *2*, chemical (polymer) is necessary to use. For this reason, OPEX of these cases becomes higher than *Case 3* and *4*. Comparing between *Case 3* and *Case 4* which are equipped with sludge drying bed, both CAPEX and OPEX of *Case 3* are not widely different but lower than *Case 4*. Amount of sludge disposed among these cases however is significantly different. Sludge disposal site is not clearly designated at present, sludge amount disposed should be minimum. *Case 4* has much advantage in this point of view. In addition, *Case 4* can minimize greenhouse gases generated. Overall, Case 4 is the most recommendable system of sludge treatment. Detail of evaluation result is shown in [**Appendices] 6.8**.

Table R 2.2.11 Evaluation Result of Sludge Treatment System

Case	Case 1	Case 2	Case 3	Case 4
Treatment System	Sludge Dewatering by Mechanical Dehydrator	Sludge Digestion + Dewatering by Mechanical Dehydrator	Sludge Drying by Drying Bed	Sludge Digestion + Drying by Drying Bed
Amount of Solid Generation (Dry Basis)	910 kg-DB/day	482 kg-DB/day	910 kg-DB/day	482 kg-DB/day
Amount of Final Disposal (Sludge Cake, Wet Basis)	6,067 kg-WB/day (85% of Moisture Content)	1,928 kg-WB/day (75% of Moisture Content)	2,023 kg-WB/day (55% of Moisture Content)	964 kg-WB/day (50% of Moisture Content)
Treatment Process Flow				
Number of Staff for O&M	Technician Class: 2 persons Labor Class 1 person Truck Driver 2 persons	Technician Class: 2.5 persons Labor Class 1 person Truck Driver 1 person	Technician Class 0.5 person Labor Class: 6persons Truck Driver 1 person	Technician Class: 1 person Labor Class: 3persons Truck Driver:0.5person
Area Requirement for Sludge Treatment Facility	160m^2	360m^2	1,000m^2	700m^2
Power Consumption	68kWh/day	148kWh/day	11kWh/day	108kWh/day
Chemical Consumption	Polymer 18.2 kg/day (Dosing Rate 2.0 %)	Polymer 9.7 kg/day (Dosing Rate 2.0 %)	Not Required	Not Required
CAPEX	USD 524,700.00	USD 703,300.00	USD 475,700.00	USD 489,600.00
OPEX	USD 65,031.00/year	USD 56,811.00/year	USD 23,744.00/year	USD 27,079.00/year
GHGs Emission	680,901kg-CO2/year	296,584kg-CO2/year	653,971kg-CO2/year	284,053kg-CO2/year
Advantages and Disadvantages	^^ The smallest area required v High Skilled Technician required v Higher Capex vv Highest OPEX vv Largest amount of final disposal vv Since the capacity is small, it will not continiously be used after expansion vv Largest GHGs emission	^ The smaller area required ^ Smaller GHGs emission | Not small amountof final disposal v Higher Opex vv Highest CAPEX vv High Skilled Technician required vv Since the capacity is small, it will not continiously be used after expansion	^^ Easiest operation and maintenance ^^ Lowest CAPEX and OPEX ^^ The Facility applicable for back up for dewatering unit after expansion ^ Smaller amount of final disposal v Larger GHGs emission vv Largest area required vv Much man power required	^^ Smallest amount of final disposal ^^ The Facility is applicable for back up of dewatering unit after expansion ^^ Smallest GHGs emission ^ Lower CAPEX and OPEX ^ Easier operation and maintenance | Larger area required | Man power required **Recommended**

^^ Excellent
^ Very Good
\| Good
v Fair
vv Poor

Source: Survey Team

(4) Possibility of Power Generation using Biogas

At anaerobic digestion process, biogas which mainly consists of CH_4 and CO_2 is generated through biodegradation of organic matter. CH_4 is applicable as fuel for boiler, power generator and vehicle fuel etc. CH_4 production potential in this project is $114m^3_N$/day ($190m^3_N$/day as biogas), it will only generate 3.4kWh of electricity in case power generation efficiency is 30%. Since such small generator is not available in the market, the biogas generated should properly be oxidized and discharged into air.

Thus, biogas utilization facility is not installed. A gas holder, flare stack and related equipment are installed in order to properly discharge biogas after burning.

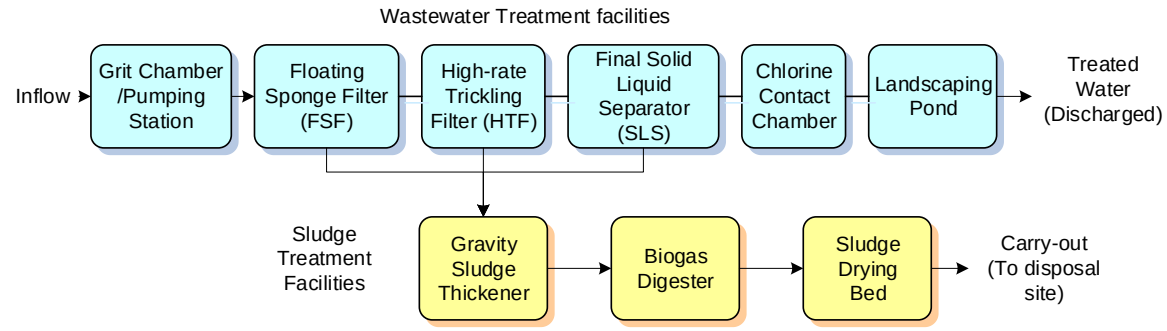
(5) Processing Flow

Treatment flow is shown in **Fig. R 2.2.11**. Applied wastewater treatment method is PTF. Treatment facilities consist of: pumping station, wastewater treatment facilities, namely, Floating Sponge Filter (FSF), High-rate Trickling Filter (HTF) and Final Solid Liquid Separator (SLS), as well as chlorine contact chamber and landscaping pond (Image of landscaping pond is shown in **Photo R 2.2.5**).

Landscaping pond is installed to demonstrate the effect of treatment. As discussed in the previous sub-section, sludge treatment facilities consist of gravity sludge thickener, biogas digester and sludge drying beds. Dewatered sludge in sludge drying beds is transported to sludge disposal site (Dangkor Solid Waste Disposal site or new Solid Waste Dumping Site, subsequent site of Dangkor).

The dewatered sludge is transported by using existing dump truck owned by DPWT.

Photo R 2.2.5 Image of Landscaping Pond



Source: Survey Team

Fig. R 2.2.11 Draft Flow Sheet of STP

2.2.2.6 Design of STP

(1) General Layout of STP Site

General layout of STP site is determined based on the following considerations.

- Necessary area and shape line of both preparatory stage and ultimate stage are based on **Fig. R 2.2.12**.
- Hun Neang Blvd. which is planned to connect from Hun Sen Blvd to Rd. 371 via Chip Mong Group area will be used for the access road for STP.
- The STP site shall be planned to not touch the existing Prek Takong 1 village.
- Minimum width of 50 m for watercourse of Trabek channel is secured by DPWT.

Source: Survey Team

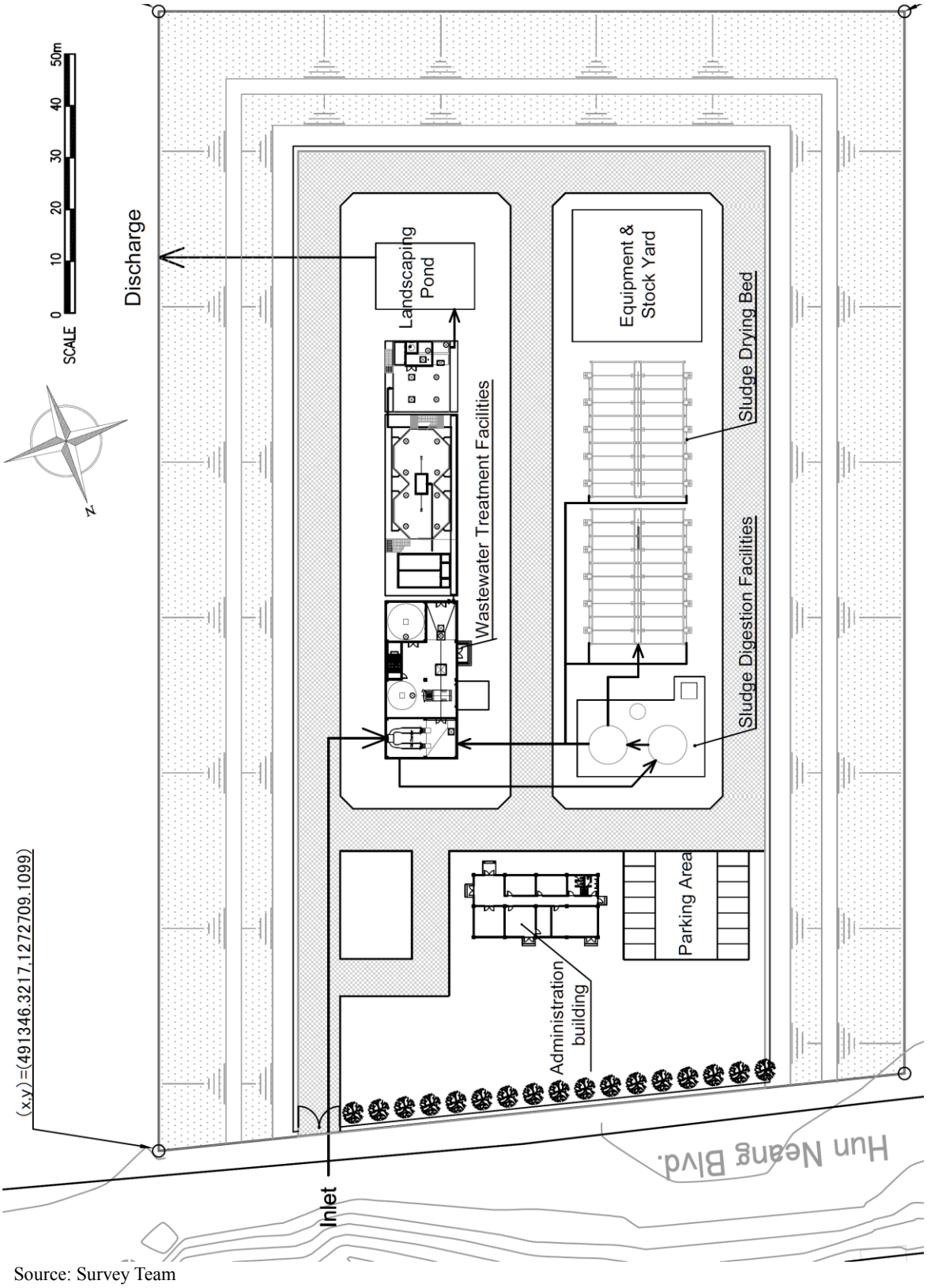
Fig. R 2.2.12 Location of STP

(2) Layout of STP Facilities

STP consists of wastewater treatment facilities, sludge treatment facilities, administration building, and other outdoor structures including pipes, pavement, fence and landscaping

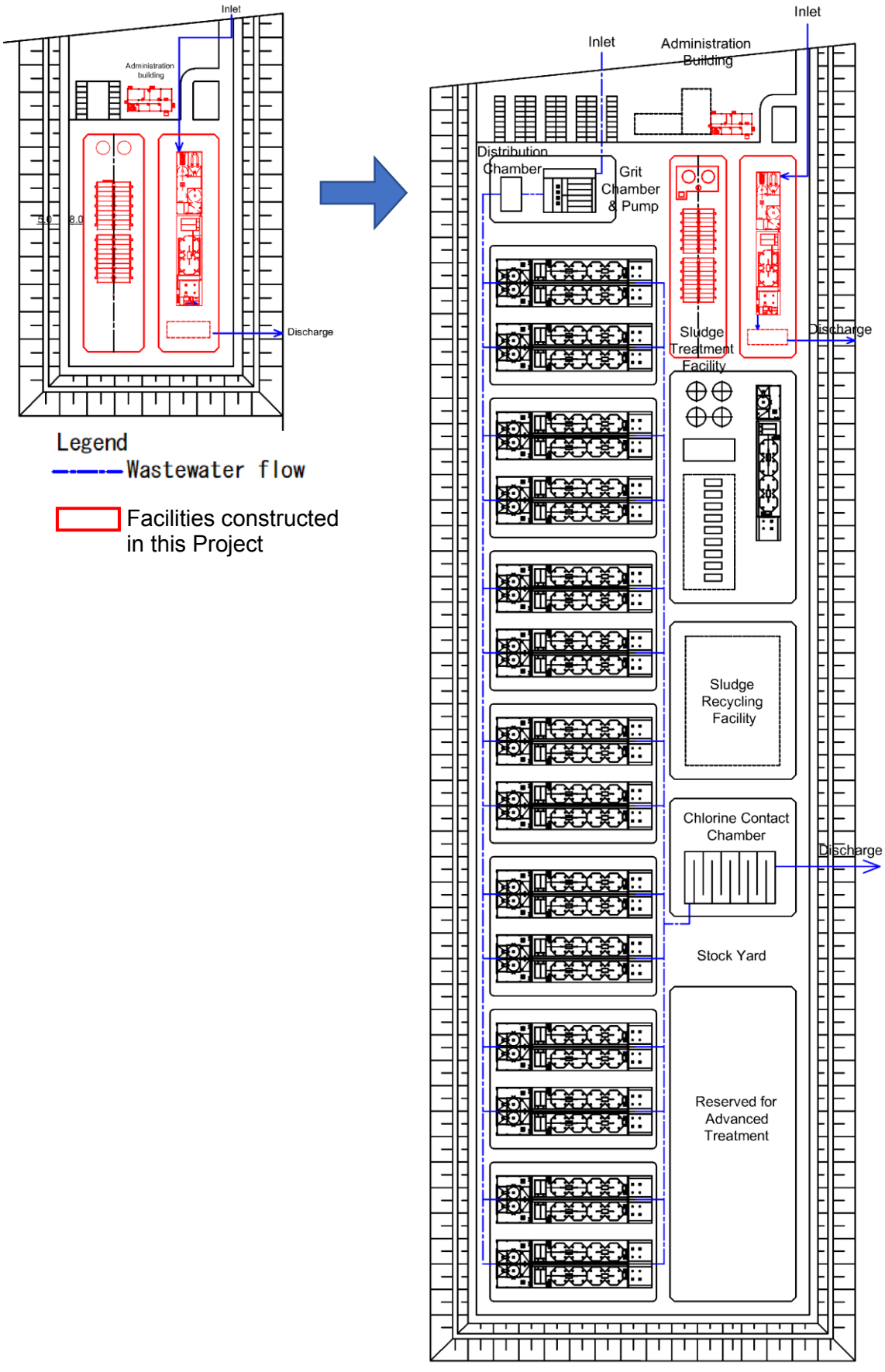
pond. Layout of STP is determined based on the following considerations.

- Facilities for the Preparatory Project (capacity of 5,000 m^3/day) are designed as much as possible not to be useless for the ultimate stage (capacity of 282,000 m^3/day).
- Based on the above consideration, administration building is planned to be a part of the one in the ultimate stage. Sludge drying beds are planned to be located at the southwest corner of the site, being adjacent to sludge treatment facilities in the future expansion plan.
- Grit chamber/pumping station will be separated from the ones in the ultimate stage since sewer pipe at preparatory stage will be pressure type and shallow while sewer pipe at ultimate stage will be gravity type and far deeper.
- Entrance of the STP site is located at the northeast corner of the site facing to Hun Neang Blvd. Wastewater treatment facilities are designed to introduce wastewater from Hun Neang Blvd. and discharge treated water to the watercourse from Trabek channel.



Source: Survey Team

Fig. R 2.2.13 Layout Plan of STP in this Project



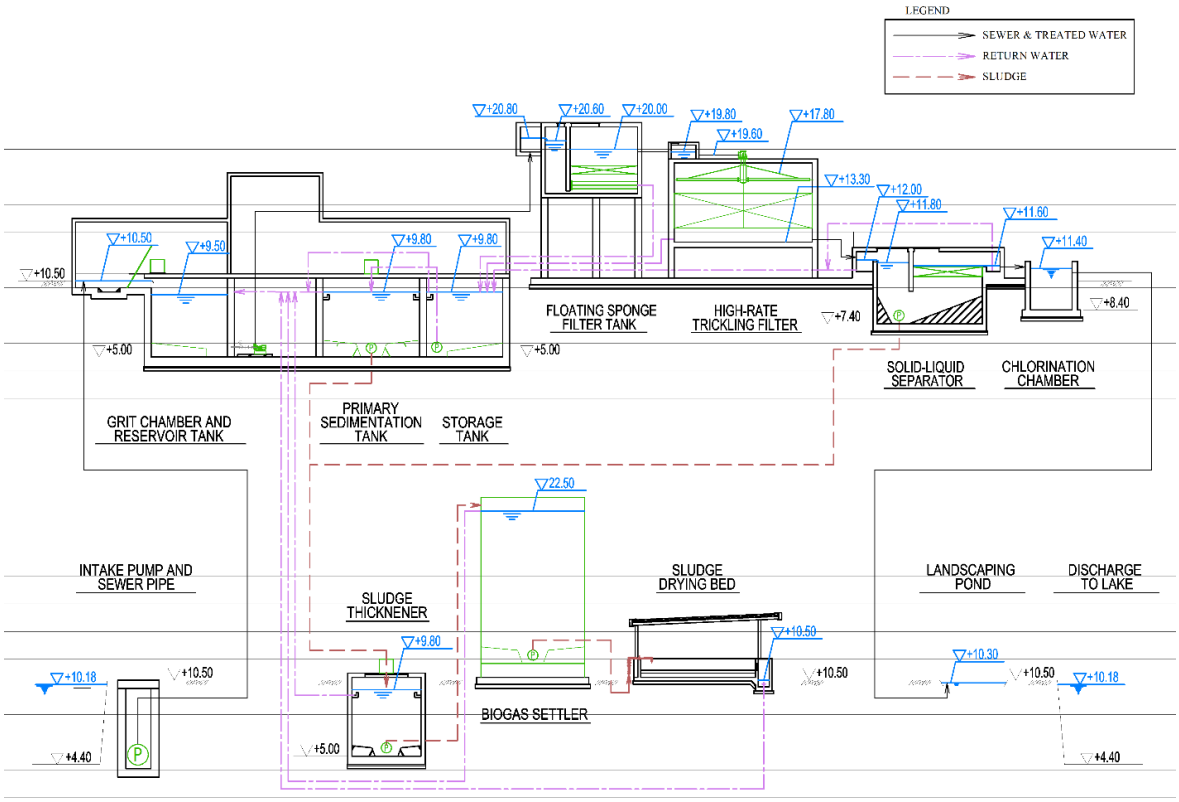
Source: Survey Team

Fig. R 2.2.14 Expansion of STP Site from this Project to Ultimate Stage

(3) Hydraulic Profile of STP Facilities

Hydraulic profile of STP facilities is shown in **Fig. R 2.2.15**. Hydraulic profile is determined based on the following considerations.

- Design ground level is set, considering the highest water level of Bassac River (EL.+10.18 recorded at Chaktomuk Station), as well as ground level of the surrounding area of STP, namely, ING City's design ground level (EL.+10.50 m)
- Design water level of interception facilities and invert level of the intake conduit are set EL.+5.30 m and EL.+4.80 m, respectively, considering water level survey results conducted in this preparatory survey. Discharge level of the STP is set considering the highest water level of Bassac River (EL.+10.18 recorded at Chaktomuk Station).
- Hydraulic profile of the wastewater treatment facilities should be designed to flow wastewater by gravity from Floating Sponge Filter (FSF) tank to the Lake.
- Storage tank accepts backwashing water from tanks of FSF, HTF and SLS, while reservoir tank accepts returning water from sludge thickener, biogas settler and sludge drying bed. Thus, those gravity flows are considered.

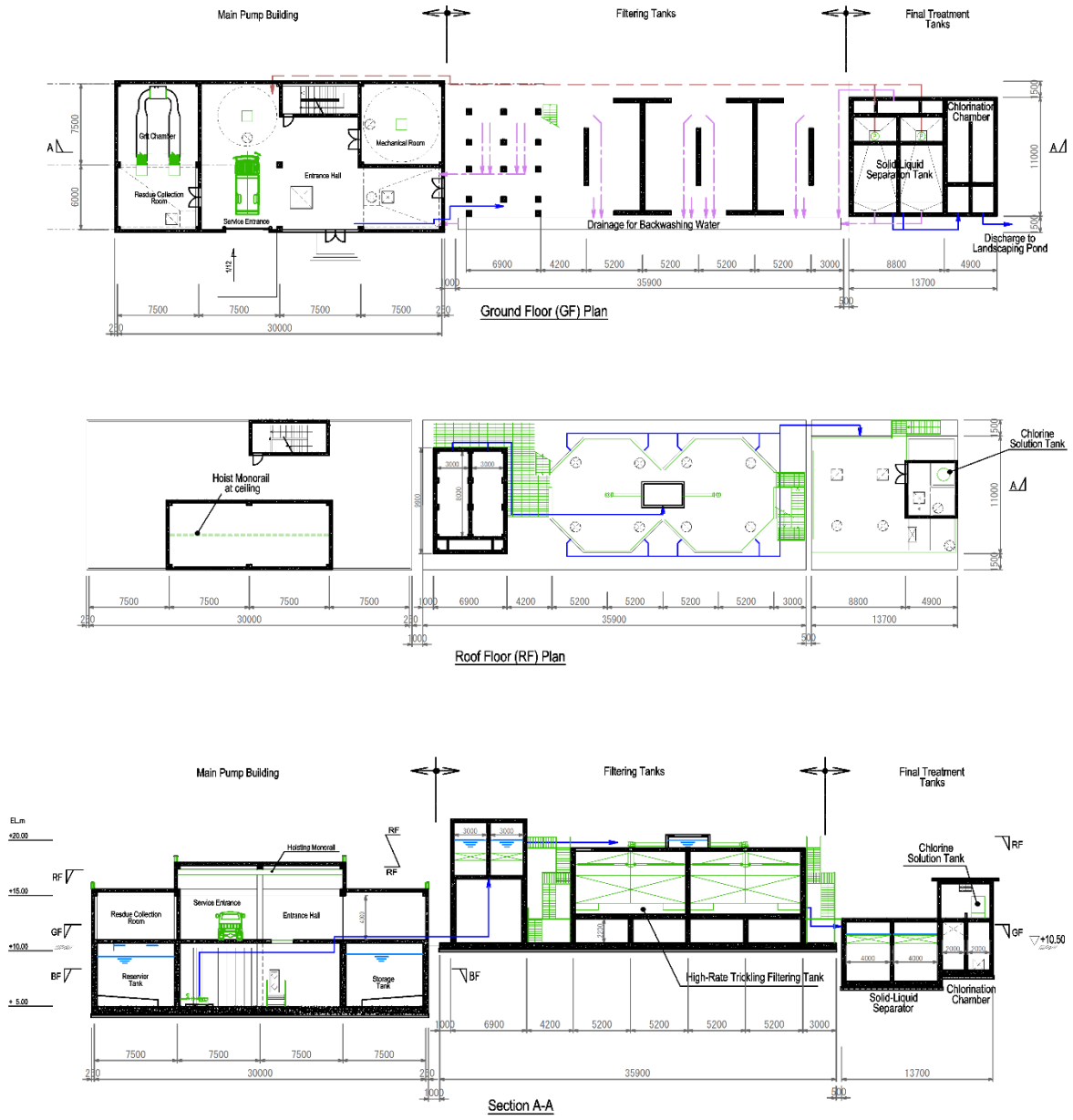


Source: Survey Team

Fig. R 2.2.15 Hydraulic Profile of STP

(4) General Layout of Wastewater Treatment Facilities

General layout of wastewater treatment facilities is shown in **Fig. R 2.2.16**.



Source: Survey Team

Fig. R 2.2.16 General Layout of Wastewater Treatment Facilities

Wastewater facilities are designed based on the following considerations.

(a) Main Pump Building

Reservoir tank, storage tank and primary sedimentation tank have pumps at the basement level. For maintenance, those pumps are preferable to be placed all in one room which can be accessed by hoisting crane from ground level. Sludge thickener also needs pumps at the basement level. The main pump building is designed to contain those pumps as well as grit chamber and mechanical room.

(b) Filtering Tanks

Floating Sponge Filter (FSF) tanks and High-rate Trickling Filter (HTF) tanks bear heavy

loads and need to be placed together above the ground. Therefore, it is preferable to separate those tanks from the main pump building and place them outside the building. Double-deck steel walkways are designed surrounding the tanks for maintenance and operation of valves and meters.

(c) Final Treatment Tanks

HTF tanks are followed by Solid-Liquid Separator (SLS) tanks and chlorination chamber. Since the water levels of those tanks and chamber are close, it is efficient to build them as one structure, with a small house for chlorine solution tank.

(5) Administrative Building

Necessary rooms for administrative building are shown in the following table.

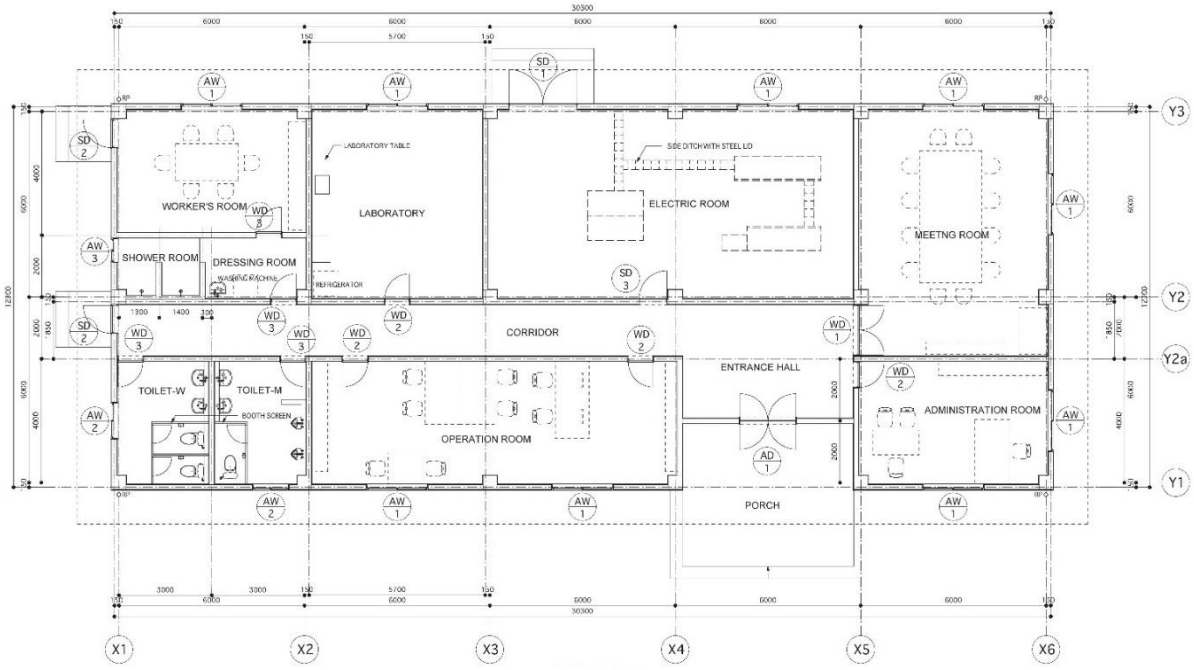
Table R 2.2.12 Necessary Rooms for Administrative Building

Room	Floor Space	Description
Administration Room	25～30m^2	Administration room is designed for use by the STP administrator, with work desk, table set and cabinet.
Meeting Room	40～60m^2	Meeting room is designed to hold meetings or seminars with up to 15 people. Table set, screen and AV systems will be installed.
Operation Room	40～60m^2	Operation room is designed to accommodate 3 engineers and 1 staff, with personal desks, 2 LCD monitor, meeting corner and cabinets
Laboratory	30～40m^2	Laboratory is designed to conduct water quality test which does not require heating and freezing equipment. Lab tables, sink, fridge and storage for wastewater samples will be installed
Electric Room	60～80m^2	Electric room is designed to accommodate electrical equipment such as control panels and distribution panels.
Workers Room	30～40m^2	Workers room is designed to accommodate up to 6 workers, who are in charge of sludge loading works, with shower booth, locker area and table set
Others	-	Entrance hall, Sanitary booth etc.

Source: Survey Team

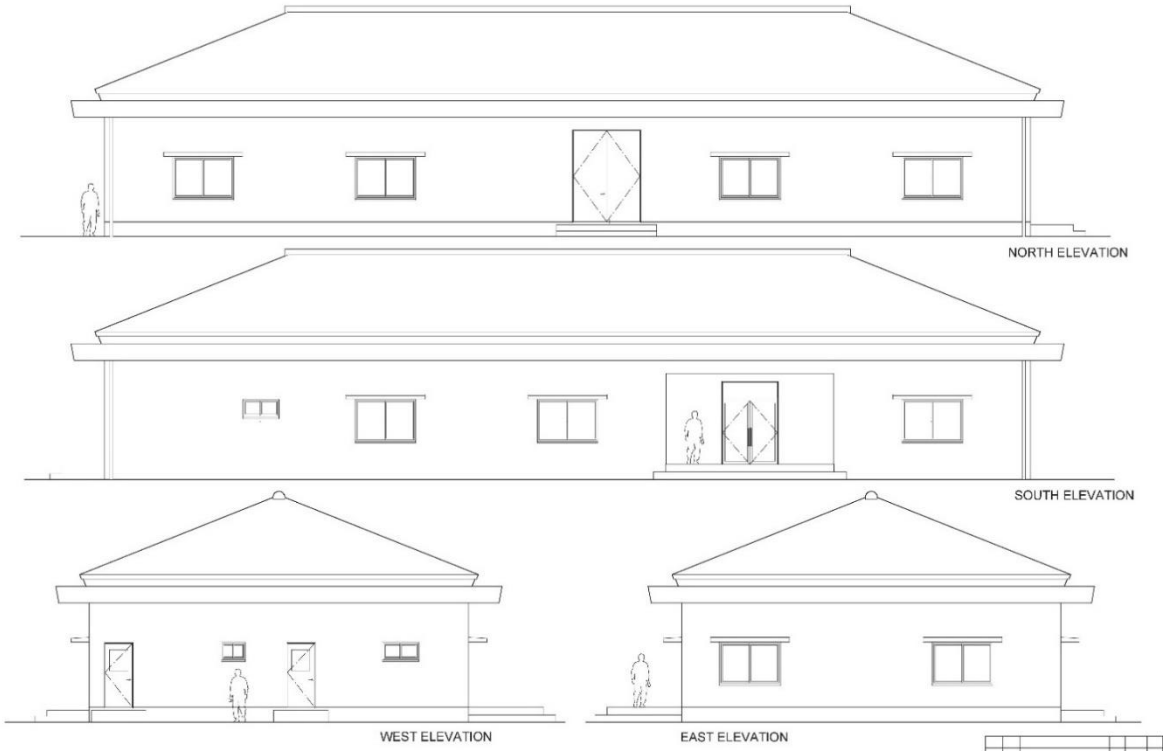
The layout of rooms is designed considering the following points;

- Main entrance is located in southern side of the building considering viewability of each facility, and place the carriage entrance.
- Conference room and administration room are located in the eastern side near entrance.
- Operation room is located near electric room and laboratory for easy access.
- Electric room has double doors for carrying in and out of the equipment.
- Workers entrance is installed for not meeting traffic line of the guests.
- Facilities of water supply and drains are close.



Source: Survey Team

Fig. R 2.2.17 Layout Plan of Administration Building



Source: Survey Team

Fig. R 2.2.18 Side View of Administration Building

2.2.2.7 Power Supply

(1) Power Supply to STP

Electricity supply around the Trabek pumping station comes from GS-2 Grid Substation which is located around 550 meters east away from the pumping station. Receiving voltage at GS-2 is 115kV and supplying voltage is 22kV. The location of GS-2 Grid Substation is shown in **Fig. R 2.2.19**. Users who are willing to enjoy the lowest tariff, are requested to directly connect the grid substation with own cabling.

There is a distribution substation named D005AD005 beside the pumping station, which receives power at 22kV via underground cable of 240 mm^2 and supplies two classes of voltage at 380V and 220V. The capacity of the substation in total is 3,500kVA consists of 2,500kVA at 380V for supplying to Trabek pumping station and 1,000kVA at 220V for supplying to households in the surrounding area.

There is also a pole transformer named P1217, located in a narrow road in Prek Takong 1 village which is approximately 400 meters west away from the planned site of construction. Should the capacity be more than 630kVA, the transformer shall be installed in a house. The capacity of pole transformer therefore is not more than 630kVA. **Photo R 2.2.6** shows distribution substation D005AD005 and pole transformer P1217. The pole substation receives 22kV but cable size is only 70 mm^2. It is not suitable for future expansion of the STP because the power demand after expansion is expected at more than a few Mega Watt.

Source: Survey Team using Google Earth's Image

Fig. R 2.2.19 Location of GS2 Grid Substation

Distribution Substation D005AD005

Pole Transformer P1217

Source: Survey Team

Photo R 2.2.6 Distribution Substation and Pole Transformer

There is 150 mm^2 cable has been erected on Rd. 371 to supply electricity to west side as well. Once the planned road named Hun Neang Blvd. which is connected between the Rd. 371 and Hun Sen Blvd. is completed, new network is possible to install on the road. **Photo R 2.2.7** shows 22kV transmission line on the Rd. 371.

Source: Survey Team

Photo R 2.2.7 22kV Transmission Line on Rd. 371

Table R 2.2.13 shows some options of route of power supply. As for direct connection to GS-2 Grid Substation, EDC requests that the capacity exceeds more than 5MW. Since the expected power demand is smaller, it is unable to choose the way of connection even the tariff is the lowest. Case 3 is the shortest route but choosing this Case is risky at this moment, because Hun Neang Blvd. has not been constructed yet. The best way is therefore Case 2. During detail design stage of the project, the route will be re-studied when Hun Neang Blvd. is realized.

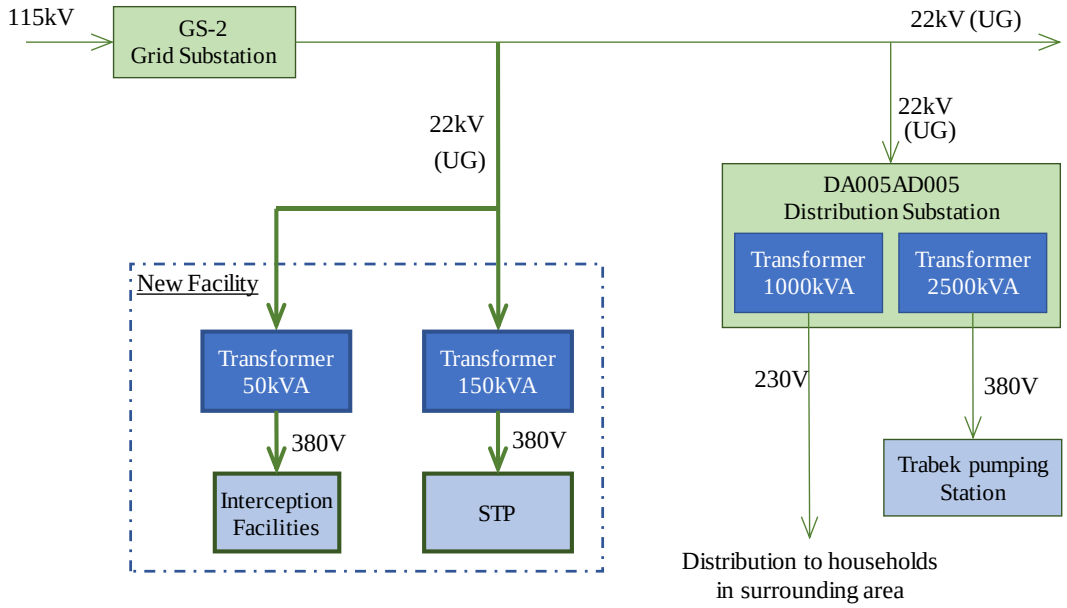
Table R 2.2.13 Necessary Rooms for Administrative Building

Case	Case 1	Case 2	Case 3
Connecting Point for STP (Except intake facility)	at GS-2 Grid Sub Station	Upstream of D005AD005	Intersection between Rd. 371 and Hun Neang Blvd
Receiving Voltage	22kV	22kV	22kV
Size of existing cable to be connected	Directly Grid Sub Station	240mm^2 (UG)	150mm^2 (AG/or UG)
Distance to STP	Approx.2,700m	Approx.2,000m	Approx.1,500m
Cable Route	via Hun Sen Blvd.	via Access Road (Channel Maintenance Road) from Trabek Pumping Station.	via Hun Neang Blvd.
Tariff	USD0.1475kWh	USD0.1706/kWh	USD0.1706/kWh
Advantages	- The Lowest Tariff	- The most realistic and concrete route because the road is already existing	- The lowest CAPEX
Disadvantages	- The longest cable - If the capacity does not exceed 5MW, EDC will not accept the direct connection to GS-2.	- Connection with the existing cable underground - Countermeasure for road congestion	- The plan of road construction is not yet realized.

UG: Underground, AG: Aboveground
Source: Survey Team

(2) Recommended Power Receiving System

Fig. R 2.2.20 shows recommended power receiving system. The STP needs to have a transformer with capacity of approximately 150kVA and supply power to STP at 380V. An independent transformer for the interception facilities is also equipped. Both transformers are connected to 22kV at upstream of D005AD005. Cable should be installed underground of the channel maintenance road to maintain the landscape because new housing area in front of the road is being developed.



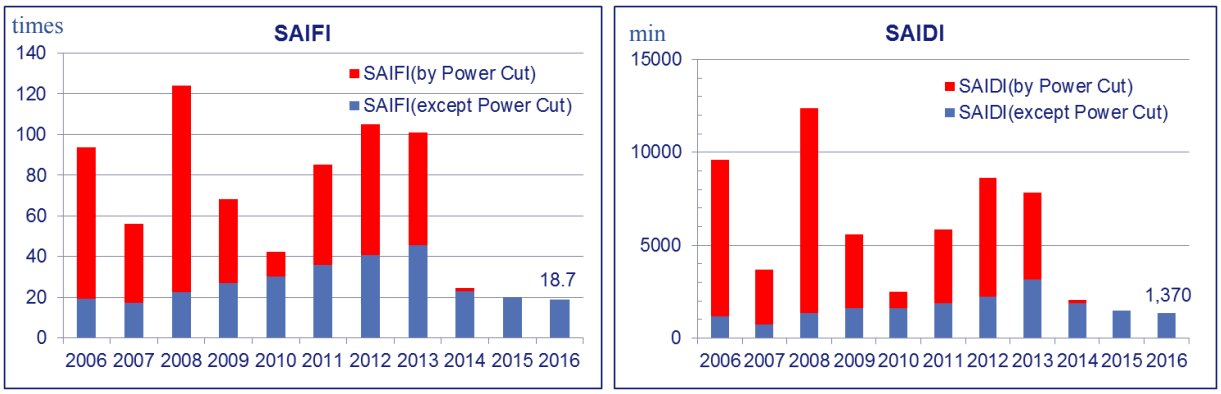
UG: Underground
Source: Survey Team

Fig. R 2.2.20 Schematic Diagram of Power Receiving System

(3) Emergency Power Generation System

In Cambodia, power failure due to overloading was almost solved in 2014, System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) are significantly improved. **Fig. R 2.2.21** shows SAIFI and SAIDI from 2006 to 2016. SAIFI and SAIDI in 2016 are 18.7 times/year and 1,370minutes/year respectively. According to EDC, SAIFI in Phnom Penh is much smaller than the figure, frequency of power failure is approximately once in 2 to 3 months, duration of a power failure is mostly within 1 hour. The power failure is caused not by overloading but installation or restoration of their facility. Fluctuation of voltage is within acceptable range which is around ±5%.

Since power failure is not frequent in Phnom Penh, power failure will not affect the STP. From these points of view, any emergency power generation system is not installed to save the construction cost and to be free from maintenance work.



Source: Hirose, JICA Expert (2018)

Fig. R 2.2.21 SAIFI and SAIDI in Cambodia

(4) Water Supply Drain System

Water supply system will be installed in STP for administration building and washing at other facilities. As the result of interview with PPWSA, there is a plan for installation of distribution pipe with 300 mm diameter along Hun Neang Blvd. Water supply for STP will be connected to this planned distribution pipe. Wastewater from drain system in STP will flow back to chamber of water treatment facilities.

2.2.3 Outline Design Drawings

(1) List of Outline Design Drawings

Title	Drawing No.
General Map	
General Map	GM-001
General Note	GM-002
SEWAGE TREATMENT PLANT	
General	
General Layout of Sewage Treatment Plant	STP-GN-001
Hydraulic Profile	STP-GN-002
General Layout of Wastewater Treatment Facilities	STP-GN-003
Main Pump Building	
Main Pump Building Plan (1/3)	STP-MB-001
Main Pump Building Plan (2/3)	STP-MB-002
Main Pump Building Plan (3/3)	STP-MB-003
Main Pump Building Section (1/4)	STP-MB-004
Main Pump Building Section (2/4)	STP-MB-005
Main Pump Building Section (3/4)	STP-MB-006
Main Pump Building Section (4/4)	STP-MB-007
Main Pump Building Elevation	STP-MB-008
Main Pump Building Finish Schedule	STP-MB-009
Main Pump Building Door & Window List	STP-MB-010
Filtering Tank	
Filtering Tank Plan (1/4)	STP-HT-001
Filtering Tank Plan (2/4)	STP-HT-002
Filtering Tank Plan (3/4)	STP-HT-003
Filtering Tank Plan (4/4)	STP-HT-004
Filtering Tank Section (1/4)	STP-HT-005
Filtering Tank Section (2/4)	STP-HT-006
Filtering Tank Section (3/4)	STP-HT-007
Filtering Tank Section (4/4)	STP-HT-008
Solid-Liquid Separation Tank(SLS)	
Solid-Liquid Separation Tank Plan	STP-SL-001
Solid-Liquid Separation Tank Section	STP-SL-002
Chlorination Tank	
Chlorination Tank Plan & Section	STP-CT-001
Chlorination Tank Elevation	STP-CT-002
Chlorination Tank House Finish Schedule and Door & Window List	STP-CT-003
Sludge Digestion Facilities	
Sludge Digestion Facilities Plan & Section (1/2)	STP-SD-001
Sludge Digestion Facilities Plan & Section (2/2)	STP-SD-002
Sludge Drying Bed	
Sludge Drying Bed Plan	STP-DB-001
Sludge Drying Bed Plan & Section	STP-DB-002
Administration Building	
Administration Building Floor Plan	STP-AB-001
Administration Building Elevation	STP-AB-002
Administration Building Detail Section	STP-AB-003
Administration Building Finish Schedule	STP-AB-004
Administration Building Structural Drawing	STP-AB-005
Administration Building Door & Window Schedule 1	STP-AB-006
Administration Building Door & Window Schedule 2	STP-AB-007
Landscaping	
Layout of Yard Piping	STP-LS-001
Profile and Detail of Yard Piping	STP-LS-002
Layout of Pavement, Drainage, Gate & Wall	STP-LS-003
Detail of Pavement & Drainage	STP-LS-004
Detail of Outfall (1/2)	STP-LS-005
Detail of Outfall (2/2)	STP-LS-006
Detail of Gate & Wall	STP-LS-007
Landscaping Pond	STP-LS-008

Title	Drawing No.
Layout of Yard Cabling & Lighting	STP-LS-009
Detail of Handhole, Trench Excavation and Yard Lighting	STP-LS-010
Land Fill	
Layout Plan of Cofferdam	STP-LF-001
Section of Cofferdam (1/2)	STP-LF-002
Section of Cofferdam (2/2)	STP-LF-003
Layout Plan of Dredging	STP-LF-004
Section of Dredging (1/2)	STP-LF-005
Section of Dredging (2/2)	STP-LF-006
Layout Plan of Landfill	STP-LF-007
Section of Landfill (1/2)	STP-LF-008
Section of Landfill (2/2)	STP-LF-009
INTERCEPTION FACILITY & SEWER PIPE	
General Layout of Interception Facility & Sewer Pipe (all)	ISP-001
General Layout of Interception Facility & Sewer Pipe (1/3)	ISP-002
General Layout of Interception Facility & Sewer Pipe (2/3)	ISP-003
General Layout of Interception Facility & Sewer Pipe (3/3)	ISP-004
Channel Maintenance Road Detail	ISP-005
Channel Maintenance Road Section (1/2)	ISP-006
Channel Maintenance Road Section (2/2)	ISP-007
Site Plan of Interception Facility	ISP-008
Section of Interception Facility (1/2)	ISP-009
Section of Interception Facility (2/2)	ISP-010
Layout Plan & Sections of Interception Facility	ISP-011
MECHANICAL AND ELECTRICAL WORK	
Mechanical Work	
General Flow Diagram	MW-001
Mechanical Equipment Layout for Main Pump Building (1/2)	MW-002
Mechanical Equipment Layout for Main Pump Building (2/2)	MW-003
Mechanical Equipment Section Layout for Main Pump Building (1/4)	MW-004
Mechanical Equipment Section Layout for Main Pump Building (2/4)	MW-005
Mechanical Equipment Section Layout for Main Pump Building (3/4)	MW-006
Mechanical Equipment Section Layout for Main Pump Building (4/4)	MW-007
Mechanical Equipment Layout for Filtering Tank (1/4)	MW-008
Mechanical Equipment Layout for Filtering Tank (2/4)	MW-009
Mechanical Equipment Layout for Filtering Tank (3/4)	MW-010
Mechanical Equipment Layout for Filtering Tank (4/4)	MW-011
Mechanical Equipment Section Layout for Filtering Tank (1/4)	MW-012
Mechanical Equipment Section Layout for Filtering Tank (2/4)	MW-013
Mechanical Equipment Section Layout for Filtering Tank (3/4)	MW-014
Mechanical Equipment Section Layout for Filtering Tank (4/4)	MW-015
Mechanical Equipment Layout for Solid-liquid Separation Tank	MW-016
Mechanical Equipment Section Layout for Solid-liquid Separation Tank	MW-017
Mechanical Equipment Plan & Section for Chlorination Tank	MW-018
Mechanical Equipment Layout for Sludge Digestion Facilities (1/2)	MW-019
Mechanical Equipment Layout for Sludge Digestion Facilities (2/2)	MW-020
Electrical Work	
Single Line Diagram for Sewage Treatment Plant (1/2)	EW-001
Single Line Diagram for Sewage Treatment Plant (2/2)	EW-002
Single Line Diagram for Interception Facility	EW-003
System Configuration	EW-004
Cabling Layout for Power Supply (1/5)	EW-005
Cabling Layout for Power Supply (2/5)	EW-006
Cabling Layout for Power Supply (3/5)	EW-007
Cabling Layout for Power Supply (4/5)	EW-008
Transformer House	
Transformer House Plan and Section & Elevation	TH-001
Transformer House Finish Schedule and Door &Window List	TH-002

(2) Outline Design Drawings

Outline design drawings are attached at the end of the report.

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

(1) Basic Policy of Project Implementation

- The Project is to be implemented under the Japan's Grant Aid Scheme. Japan's Grant-Aid is provided through the following procedures:
  - Preparatory Survey conducted by JICA.
  - Appraisal by the Government of Japan (hereinafter referred to as "the GOJ") and JICA, and Approval by the Japanese Cabinet.
  - Exchange of Notes (hereinafter referred to as "the E/N") between the GOJ and the GOC.
  - Grant Agreement (hereinafter referred to as "the G/A") between JICA and the GOC.
  - Implementation of the Project on the basis of the G/A.
- The client of the Project is Phnom Penh Capital City (PPCC). Agreements for Contract Documents and Certificate of Completion shall be issued by the Governor of PPCC or the person designated by the Governor of PPCC.
- The implementation agency of the Project is the Department of Public Works and Transport (DPWT) of Phnom Penh Capital City. With regard to the operation and maintenance of facilities, the Drainage Pumping Station and Sewage Treatment Plant Office (DSO) of DPWT will be in charge after the construction and procurement.
- The GOC will enter into contract with the Consultant for consulting services with regard to designing, tendering, cost estimating and supervising the procurement and construction works for the Project. The Consultant shall be a Japanese consulting firm, which shall be selected by JICA and recommended to the GOC for the Project in order to maintain technical consistency.
- The GOC will enter into contract with the Contractor who shall be selected through competitive tendering, and the contract shall be verified by JICA to fulfil accountability to Japanese taxpayers. The Contractor shall be a Japanese firm who is capable of procuring the products and of construction in proper manner under Japan's Grant Aid.
- To establish a smooth and safe construction method and schedule, the following conditions shall be considered: (i) Natural Environment: meteorology, topography and geology, (ii) Social Environment: traffic control, underground facilities and other negative impacts against residents.

(2) Construction and Procurement Policy

In principle, construction materials and labor are procured in Cambodia.

The Project includes the reclamation work, STP construction work, interception facilities, pipe installation work and road construction work. No special technique is required for such civil works. However, the construction works in the Project are done in parallel at STP site and another site. In addition, the construction work of STP is the first time in Cambodia and the work is large scale work. It is necessary to pay attention to safety, environment, and quality control during construction period. Therefore, it will be necessary to dispatch Japanese experts/engineers to the Project to ensure that the works are properly performed in accordance with plan and design.

The Japanese experts/engineers are also dispatched to install and adjust of mechanical and electrical works for STP, and to engage in technical transfer for operation at start-up.

In Phnom Penh, there are over 15 local construction firms, some of which have experience in Japan's Grant Aid Project as subcontractors of Japanese general contractors. Therefore, the local construction firms are eligible for the subcontractor for the Project and supervisor, mechanical operator, labor for form works, concrete placing and so on, shall be procured in Cambodia.

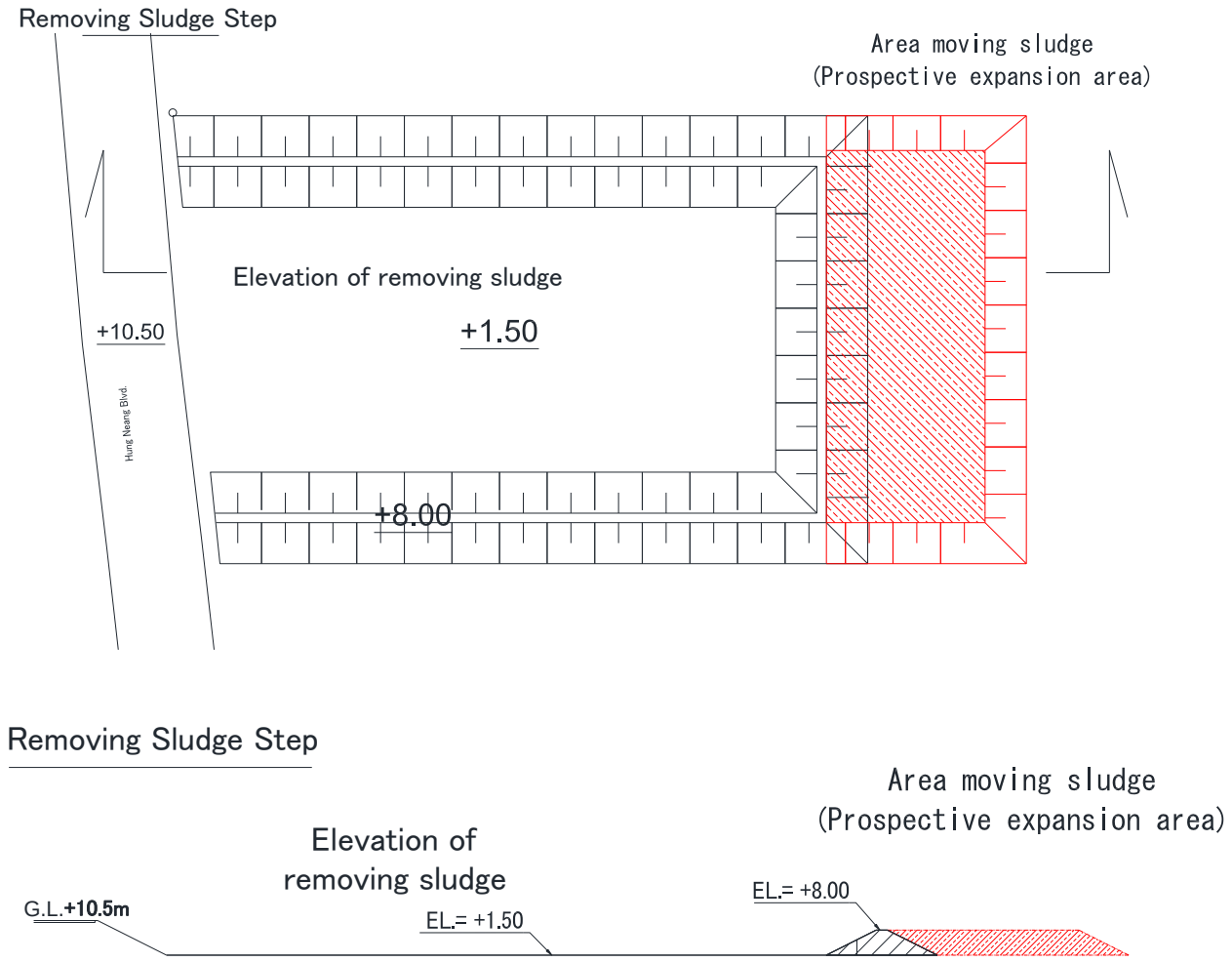
2.2.4.2 Implementation Conditions

Implementation conditions are described below.

(1) Reclamation Work

As described in **Subsection 2.2.2.4**, the step of reclamation work in STP is 1) Construct cofferdam around the outer perimeter of STP site, 2) Dewater in STP site, 3) Remove sludge/soft soil, 4) Reclaim STP site by sand, and 5) Construction of facilities. Conditions for the construction works are enumerated below:

- With the consideration of fluctuation of water level, the top elevation of cofferdam is EL.+8.0m, with top width of 3 m and slope gradient of 1:2. Only two team (direction) can work simultaneously for construction of cofferdam. The work should be implemented in the dry season.
- The elevation of removing sludge/soft soil is EL.+1.5m. Removed sludge will be dried and moved to prospective expansion area.
- Reclamation material must be high-quality river sand collected in Mekong River.

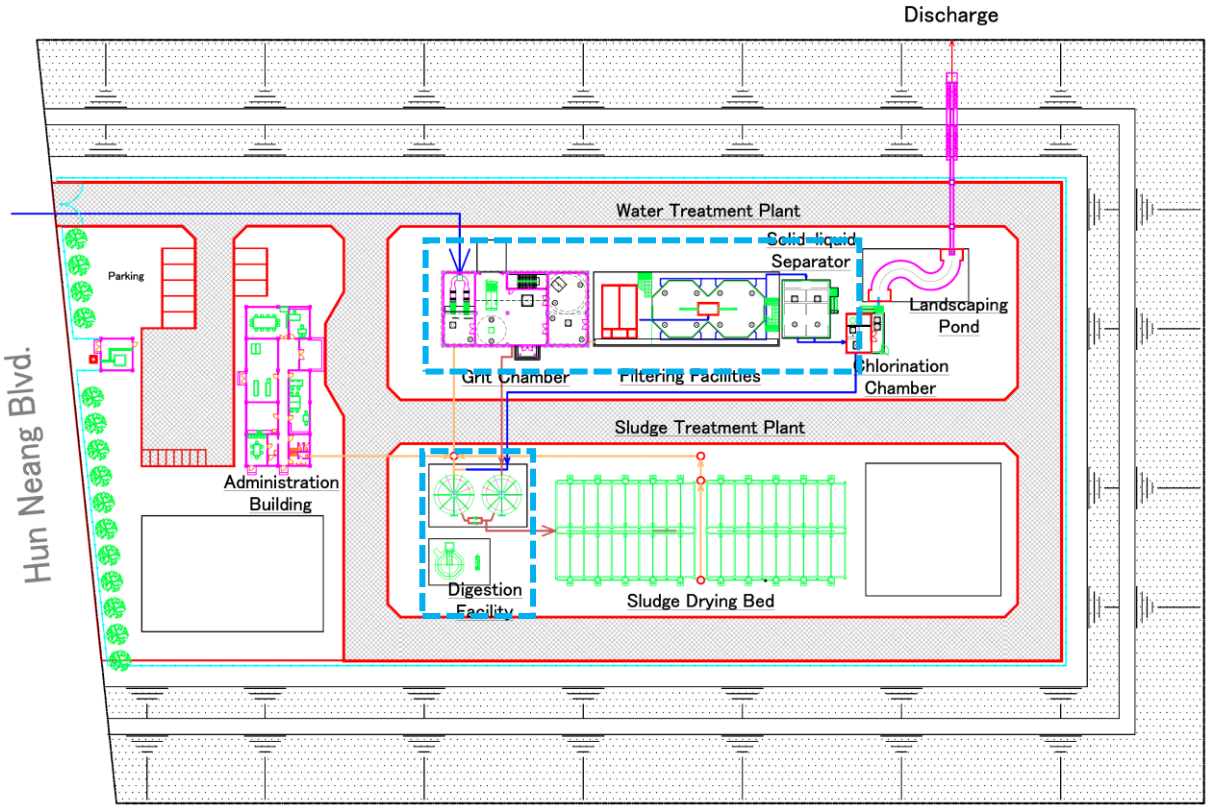


Source: Survey Team

Fig. R 2.2.22 Plan and Cross Section in Removing Sludge

(2) Foundation Work and Earth Work

Lay out plan of STP is shown in **Fig. R 2.2.23**. Grit chamber, Filtering facilities, Solid-liquid separator and digestion facilities need pile foundation.



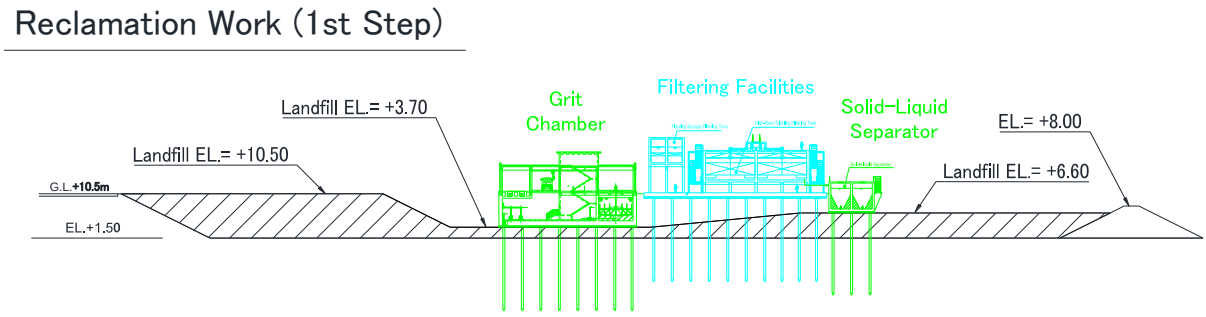
Source: Survey Team

Fig. R 2.2.23 Layout Plan of STP

The elevations of top of pile foundation of Grit chamber and Filtering facilities have 5.9 m height difference. Considering the effectiveness of construction equipment, it is better to implement the constructions at the same period. However, those two facilities are located very close, only 4.0 m distance, if pile works are implemented at the same period, preparation of retaining wall with height of 5.9 m will be required. This work will be very difficult.

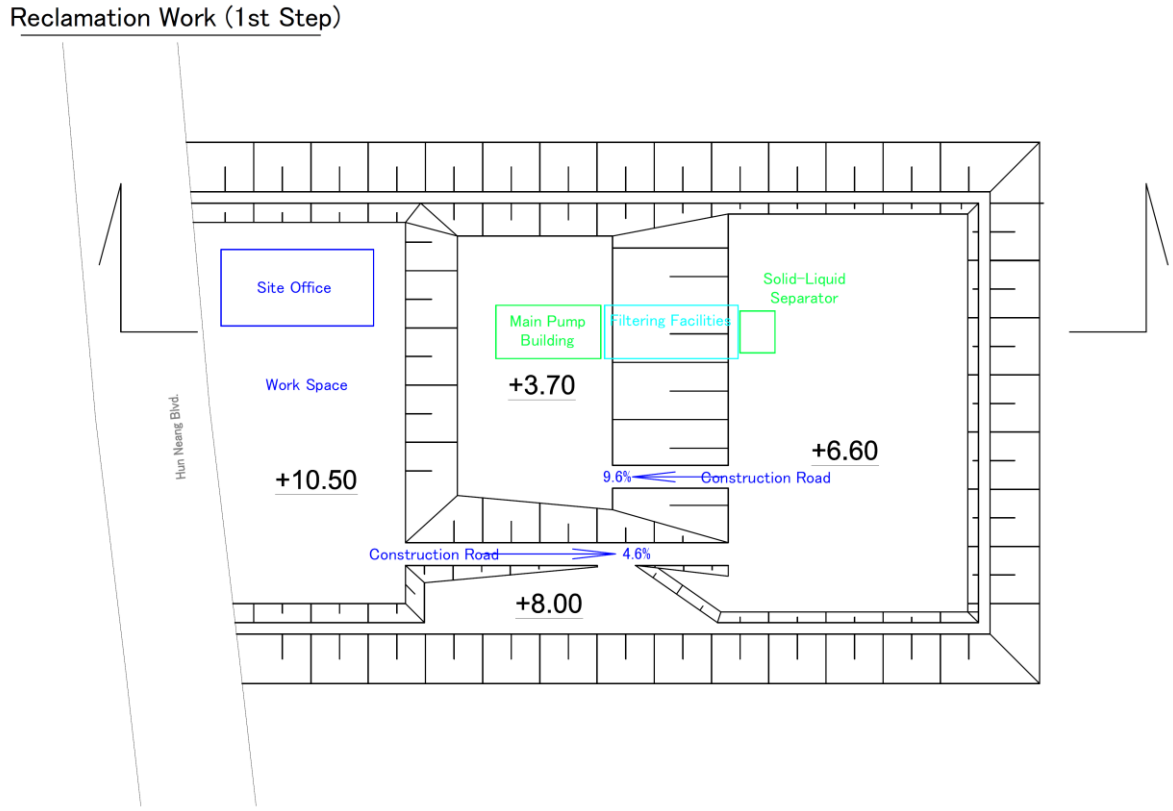
Therefore, the reclamation work will be divided into two steps, 1st step and final step. In the 1st step, reclamation work will be up to the level of foundation of grit chamber and filtering facilities, while reclamation work in final step is done in the remaining area. The reclamation work of final step will start after completion of civil work (Underground) of grit chamber and filtering facilities. Cross section drawing of 1st step is shown in **Fig. R 2.2.24**, and plan view is shown in **Fig. R 2.2.25**.

Concrete pile is precast one with 400 mm diameter. Pile driving is done by using hydraulic hammer to prevent noise and oily smokes.



Source: Survey Team

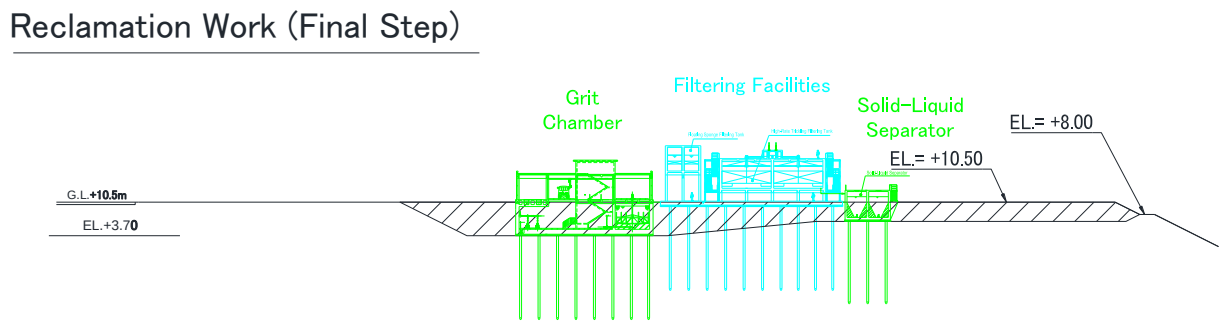
Fig. R 2.2.24 Cross Section of Reclamation Work (1st Step)



Source: Survey Team

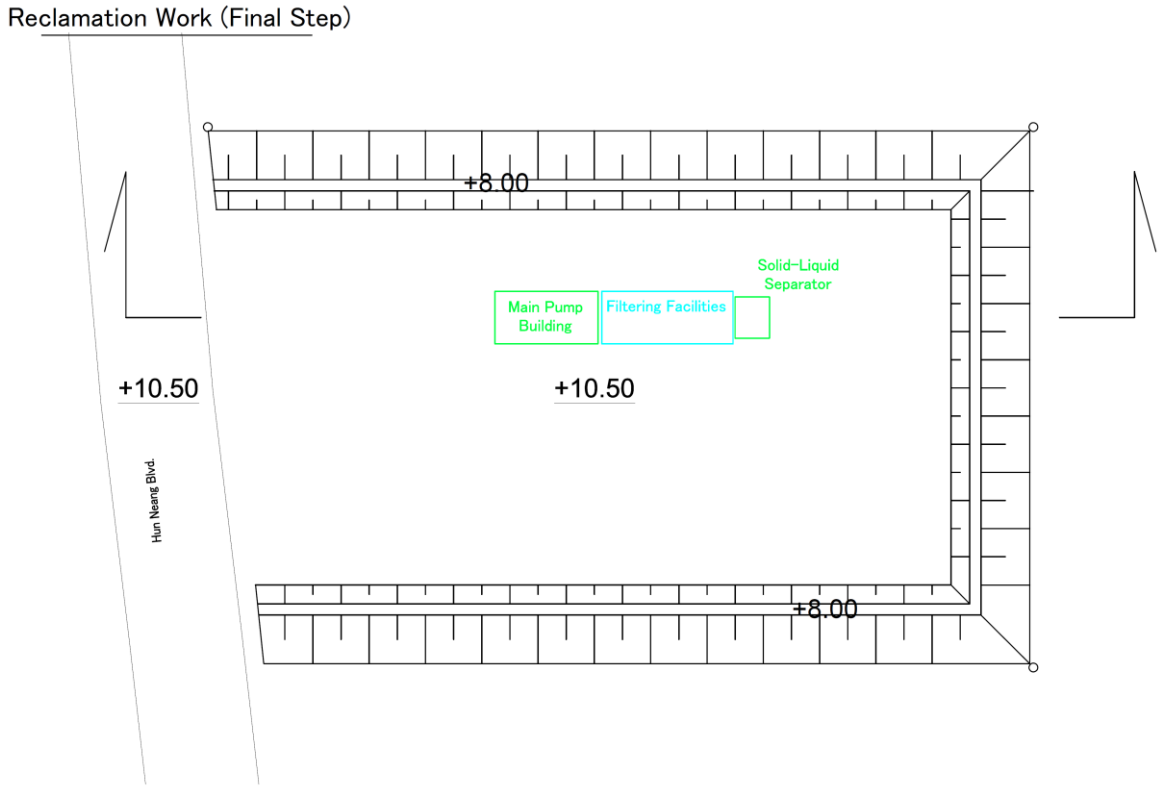
Fig. R 2.2.25 Plan View of Reclamation Work (1st Step)

Cross section and plan view of reclamation work (Final Step) are shown in **Fig. R 2.2.26** and **Fig. R 2.2.27**. Concrete pile is precast one with 400 mm diameter. Pile driving is done by using hydraulic hammer to prevent noise and oily smokes.



Source: Survey Team

Fig. R 2.2.26 Cross Section of Reclamation Work (Final Step)

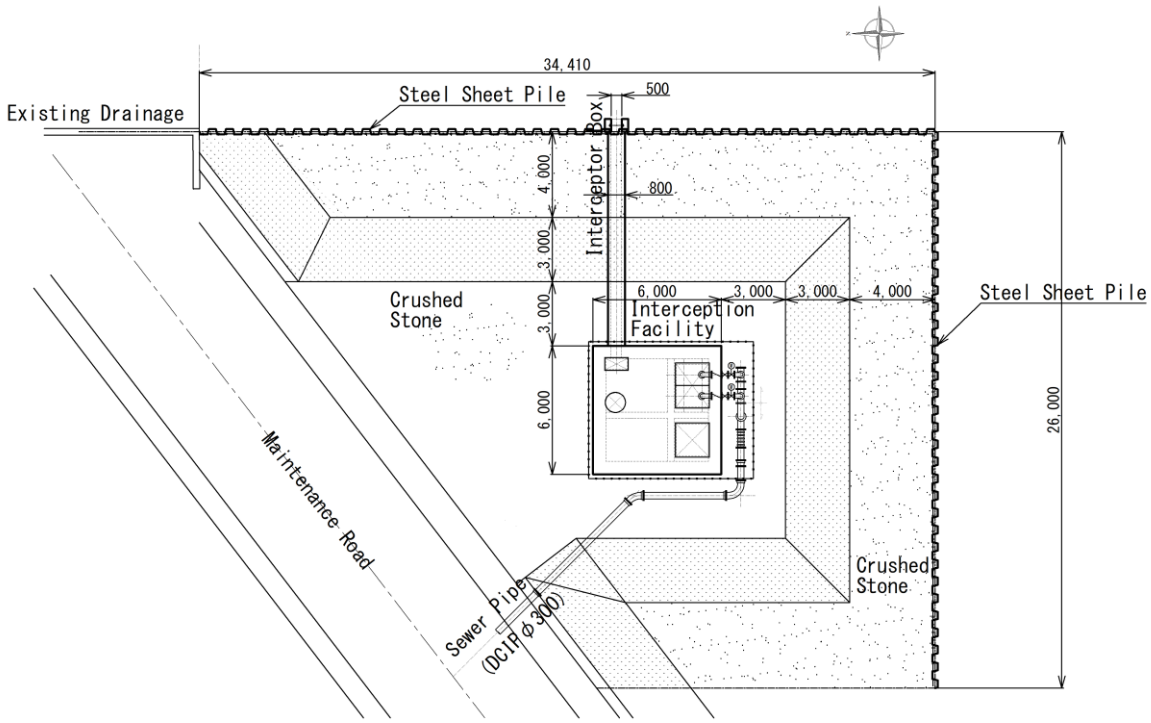


Source: Survey Team

Fig. R 2.2.27 Plan View of Reclamation Work (Final Step)

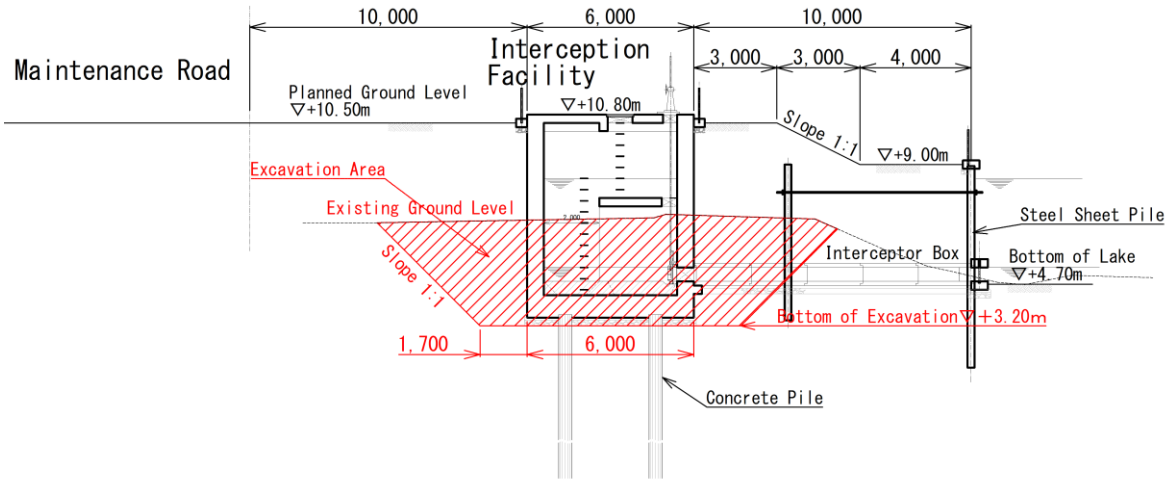
(3) Foundation Work and Earth Work in Interception Facilities

Foundation of interception facilities is precast concrete pile with 400 mm dimeter. The location of interception facilities is near discharge point of Trabek pumping station. Water level varies depending on season. Therefore, on the east side and the south side facing the waterway, steel sheet piles are placed all over to construct revetment. In addition, these steel sheet piles are utilized as retaining walls during construction of interception facilities. The plan view and sectional view of the interception facilities construction site are shown below.



Source: Survey Team

Fig. R 2.2.28 Plan View of Interception Facility



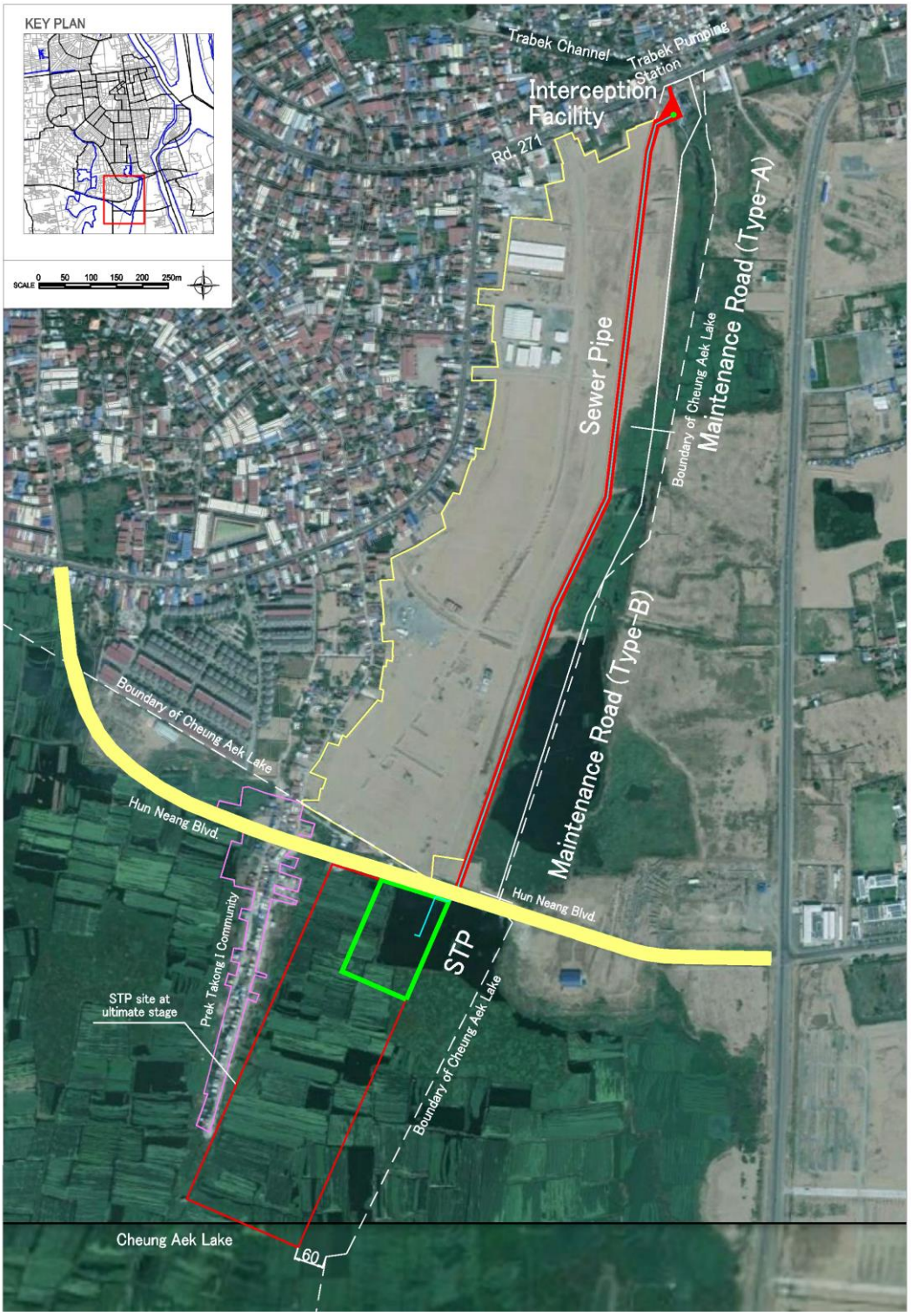
Source: Survey Team

Fig. R 2.2.29 Sectional View of Interception Facility

(4) Sewer Pipe and Maintenance Road

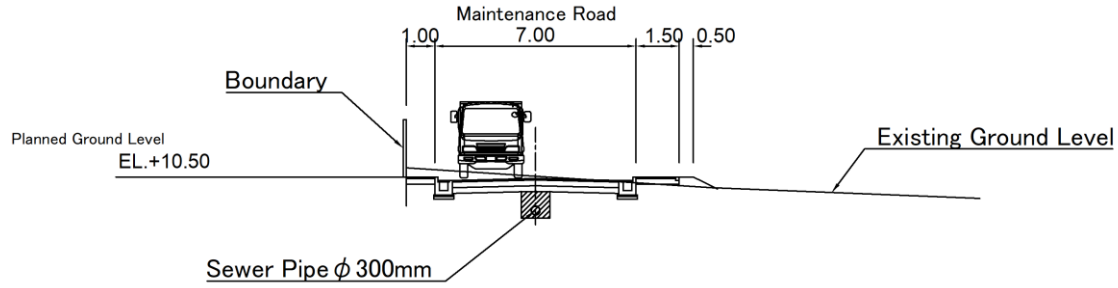
Pipe material is Ductile Cast Iron Pipe (DCIP) with diameter of 300 mm. The earth covering depth is 1.0 m. The sewer pipe connects interception facilities and grit chamber of STP, with length of about 1,860 m (See **Fig. R 2.2.30**). Maintenance road will be constructed between Rd. 271 and Hung Neang Blvd. The sewer pipe will be installed in the center of maintenance road. The site of proposed area has two types of ground level at present. The ground level of

Type-A is already backfilled between EL.+9.0 m and EL.+11.0 m. The ground level of Type-B is natural condition of Cheung Aek Lake, the level is between EL.+6.0 m and EL.+8.0 m. Type-A needs earth cutting, Type-B needs embankment. Typical cross sections are shown in **Fig. R 2.2.31** (Type-A), and **Fig. R 2.2.32** (Type-B).



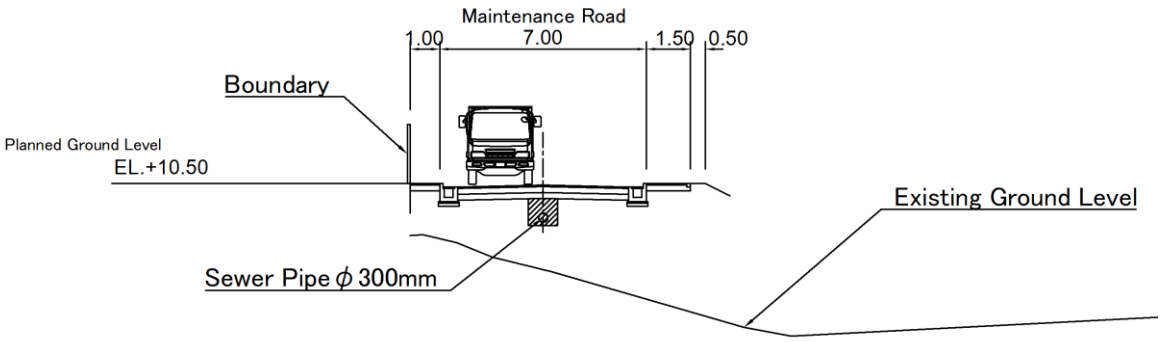
Source: Survey Team

Fig. R 2.2.30 Location Map of Maintenance Road and Sewer Pipe



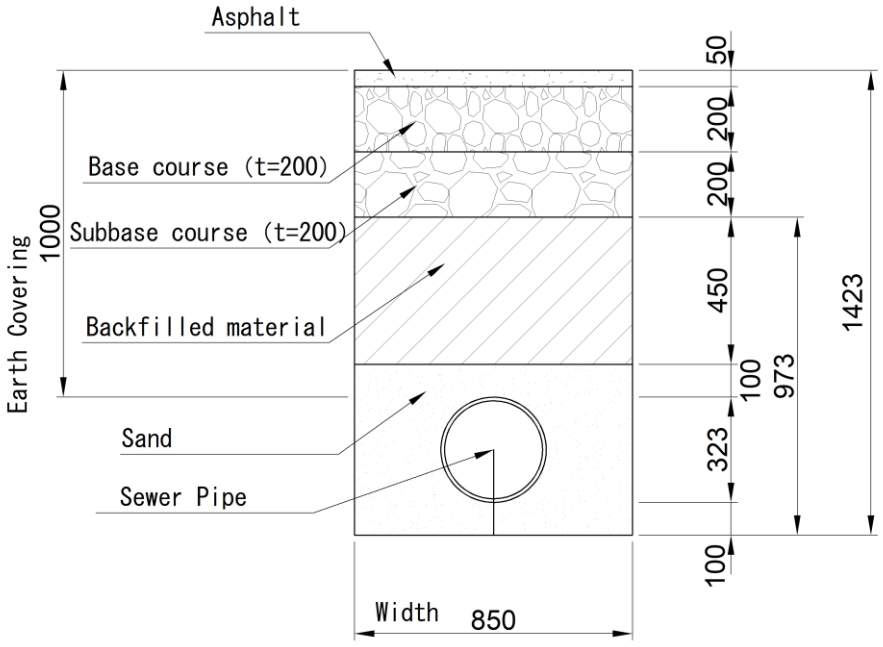
Source: Survey Team

Fig. R 2.2.31 Typical Cross Section of Maintenance Road (Type-A)



Source: Survey Team

Fig. R 2.2.32 Typical Cross Section of Maintenance Road (Type-B)



Source: Survey Team

Fig. R 2.2.33 Cross Section of Sewer Pipe Installation

2.2.4.3 Scope of Works

The scope of work for the Japanese and Cambodian sides needs to be clarified before the implementation of the Project. Each side shall assume responsibility for the work set forth in accordance with the policy of Japan's Grant Aid. The undertakings or responsibilities of both sides are as shown in the table below.

Table R 2.2.14 Major Undertakings for Construction and Procurement by Each Government

Item	Contents	Responsibility	
		Japanese Side	Cambodian Side
Procurement of Materials and Equipment	Procurement, shipping and transportation of construction materials	O	-
	Customs clearance of the procured cleaning equipment	-	O
	Land transportation of construction materials	O	-
Preparation Work	Land acquisition and resettlement for construction site	-	O
	Land acquisition for site office, stockyard, workshop and disposal site	-	O
	Acquisition of the necessary permits (construction permit, EIA)	-	O
	Other preparation works	O	-
Relocation/ Removal	Relocation/removal of underground facilities, such as water supply pipes, communication lines, electric cables and so on	O	-
Construction Work	- Construction of STP, Interception facilities, Maintenance road - Installation of sewer pipes	O	-

Note: "O" Responsible; "-" Not Responsible
Source: Survey Team

2.2.4.4 Consultant Supervision

The Consultant shall provide services to the GOC with regard to detailed design, cost estimation, tendering and supervision of the procurement and construction works for the Project in accordance with a contract with the GOC.

(1) Detailed Design

The Consultant will conduct the detailed design study for the project, including the following:

- Kick-off meeting with executing agency and site investigation
- Detailed design study on civil and architectural structures and preparation of detail design drawings
- Detailed design study on mechanical and electrical works and preparation of detail design drawings
- Implementation planning
- Cost estimation

(2) Tendering Management

The Consultant will assist the GOC in conducting the procurement tendering in fair and proper manner, as follows:

- Preparation of tender documents

- Notice for Prequalification
- Evaluation of Prequalification Documents
- Tender Notice
- Execution of tendering and Evaluation of tendering
- Facilitation of contract engagement between the Client and the Contractor

(3) Construction Supervision

The Consultant will provide appropriate supervision and guidance to the Contractor, on behalf of the GOC, as follows:

- Confirmation and approval of survey results of the Contractor
- Confirmation and approval of construction plan of the Contractor
- Quality and quantity control
- Construction schedule control
- Work progress control
- Safety control
- Discussion and negotiation with organizations concerned
- Inspection and hand-over of completed facilities in the course of project implementation

The whole construction period is estimated to be 32 months. Work at several locations and sites will be carried out in parallel.

To supervise the construction work properly, a Japanese qualified representative (1 person) and local inspectors (3 persons) shall be assigned regularly throughout the construction period, and experts shall be dispatched to the project site from time to time according to the schedule of spot engineering services to handle and solve technical issues.

(4) Engineers for the Supervision Services

The following qualified Japanese consulting engineers shall be dispatched for construction supervision services.

(a) Project Manager

The Project Manage shall engage in overall management in technical and operational aspects. The Project Manager shall engage in such activities as commencement, partial hand-over and completion of the construction works, arrangement of the works, consultation and negotiation with the Client and the Contractor, confirmation of issues and inspection. The Project Manager shall also hold meeting with the Client and the Contractor, give assistance and suggestions for quality control, as well as check progress

of the construction works.

(b) Resident Engineer (Overall Supervisor)

The Resident Engineer shall be resident from commencement to completion of the construction works in order to engage in quality and schedule controls and give instructions to the Contractor. The Resident Engineer shall attend meetings with the Client and/or the Contractor, as well as agencies concerned.

(c) Civil Engineer (Reclamation)

The Civil Engineer (Reclamation) shall be dispatched to Cambodia as follows.

#1 At the beginning of the construction works, the engineer shall be dispatched to attend meetings with agencies concerned to supervise construction works, controlling quality and schedule for construction works of reclamation work.

#2 After the completion of reclamation works (1st stage), the engineer shall be dispatched for supervising the piling works of STP.

(d) Architect

The architect shall be dispatched at the beginning of architectural work of STP for attending meetings with agencies concerned to supervise architectural works, controlling quality and schedule for construction works. The architect shall verify and review construction methodology, materials and working drawings.

(e) Mechanical Engineer

The Mechanical Engineer shall review working drawings before the contractor will order/manufacture the materials and equipment and inspect mechanical equipment in the factory and shipment of them in Japan, and shall supervise operate and adjust the equipment after installation from time to time.

(f) Electrical Engineer

The Electrical Engineer shall review working drawings before the contractor will order/manufacture the materials and equipment and inspect electrical materials and equipment in the factory and shipment of them in Japan, and shall supervise operate and adjust the equipment after installation from time to time.

(g) Defect Inspection Engineer

The Defect Inspection Engineer shall be despatched to engage in defect inspection implemented a year after completion.

2.2.4.5 Quality Control Plan

(1) Quality Control Plan of Construction Materials and Works

The quality control of main construction materials and construction works shall be performed under the conditions set below. The tests shall be decided based on the "Civil Work Quality Control Standard" of the Ministry of Land, Infrastructure and Transport, Japan.

Table R 2.2.15 Quality Control Tests

Work Item	Test Item	Standard (*)	Test Frequency
Concrete	Compressive strength test	JIS A 1108	Twice a day: in the morning and in the afternoon.
	Slump test	JIS A 1101	Once every agitator for site mixed and ready mixed
	Salt content test	JIS A 5308	Once a week
	Air content	JIS A 1116	Twice a day: in the morning and in the afternoon.
	Cement material	JIS R 5210	Before construction work and material change
Aggregate	Sieve analysis	JIS A 1102	Once a day
Embankment /Backfill	Compaction test	JIS A 1210	Before construction work and material change
	Grain size analysis	JIS A 1204	
	Field density test	JIS A 1214	3 places x once in every 3,000 m^3.
Subbase Course	Modified CBR Test	AASHTO T193	Before construction work and material change
	Sieve analysis	JIS A 1102	
	Field density test	AASHTO T99	3 places x once in every 1,000 m^2.
Base Course	Revised CBR Test	AASHTO T193	Before construction work and material change
	Sieve analysis	JIS A 1102	
	Field density test	AASHTO T180	3 places x once in every 1,000 m^2.
Asphalt Pavement	Sieve analysis	JIS A 1102	Before construction work and material change
	Density and water absorption test	JIS A 1109, 1110	
	Filler moisture test	JIS A 5008	
	Marshall stability test	ASTM D 1559	
	Asphalt extraction test	AASHTO T194	Once a day
	Field density test	JIS K 2207	1 place x once in every 1,000 m^2.
Pump	Total head	Technical Spec.	Factory inspection
	Rotational speed	JIS B 8301, 8325	Factory inspection
	In/Out head pressure	JIS B 8301, 8325	Factory inspection
	shaft	JIS B 8301, 8325	Factory inspection
Valve	Pressure resistant, leakages, size, workability, painting	JIS B 2031, 2003	Factory inspection
High voltage substation facility	Insulation resistance test	JIS C 4620	Factory inspection, After installation
	Commercial frequency withstanding voltage test	JEM 1425	Factory inspection
	Earth resistance measurement		After installation
Radiocommunication facility	Transmission frequency, output	Technical Spec.	Factory inspection, After installation
	Transmission occupied frequency bandwidth		Factory inspection
	Spectrum distribution		Factory inspection

Note: (*) Other equivalent international standards could be applied.
Source: Survey Team

Construction materials and construction work shall be controlled under the following conditions:

(a) Concrete

Concrete shall have the specified strength, durability and water-tightness, and dispersion of quality of concrete shall be small. The standard strength of concrete shall be based on 28-day Compressive Strength. The method of compressive strength test shall satisfy

JIS A1108 and 1132. A sample of mixed concrete shall be picked up twice a day, and the strength tests of 7 days and 28 days shall be carried out for every sample. At the time of concrete-placing, slump test shall be carried out in site and the slump value shall be confirmed against the specified value. Since the concrete placing work is performed in the tropics, temperature control of concrete shall be performed adequately and temperature of pouring concrete at the time of placing shall be lower than the provided temperature (35^{o}C).

(b) Placing and Curing of Concrete

Concrete shall be placed using the method that can possibly avoid the separation of materials, and adequately compacted with a vibrator at placing and immediately after placing. After the placing of concrete, the surface of concrete shall be kept wet for at least five (5) days.

(c) Cement

Portland cement shall be used for the construction and its quality shall conform to JIS R5210.

(d) Aggregate

Aggregates shall be clean, strong and durable, and shall have adequate grain sizes. Aggregates shall be confirmed not to include contaminations such as dust, sludge, organic substance, salinity and so on. Especially, fine aggregates shall not include thin or slender pieces of stone. Unit weight of oven dried aggregate shall be not less than 2.5 g/cm^3.

(e) Reinforcing Bar

Reinforcing bar shall have the specified strength. Deformed bar may be used as reinforcing bar in case of not specified. The material test of reinforcing bar shall be carried out according to instructions of the Consultant of the Engineer before use.

(f) Storage of Reinforced Concrete Material

In case of storing the materials of reinforced concrete, the storage method shall follow the Japanese Concrete Standard Specification.

(2) Quality Control Plan of Procurement of Equipment

The quality of equipment shall be controlled under the following conditions; (i) specifications and quality control method of the equipment shall be confirmed between the Consultant and the manufacturer before manufacturing, (ii) number, quality, function and performance of the equipment and its spare parts shall be confirmed by factory inspection, (iii) pre-shipment inspection shall be done by independent organization at embarkation port.

2.2.4.6 Procurement Plan

(1) Procurement in Cambodia

(a) Cement and Concrete

Cement products of Thailand freely circulate in the local market. The cement has a good reputation on both quality and quantity to satisfy the demands in Phnom Penh.

There are more than ten (10) ready-mixed concrete suppliers in Phnom Penh, all of which were established with foreign investment. Under these circumstances, the ready-mixed concrete will be commonly used in the construction site in Phnom Penh. Among the concrete suppliers mentioned above, the CPAC which has been established with Thai capital and is considered to be the most reliable company. Concrete precast pile (PC Spun Pile), which has been used in the past Japan's Grant Aid project, is also used in this project. This concrete pile can be procured from the suppliers in Cambodia.

(b) Steel Materials

With regard to reinforcing bars and other steel materials, products of Thai and Vietnam origin are widely used in the country. Recently, Vietnamese iron bars are popular in PPCC.

(c) Construction Equipment

The construction equipment, which is available in the recipient country, are Backhoe, Dump truck, Rough Terrain Crane. Recently, Silent Pile Driver is also available in Cambodia.

(2) Import Item

In case the construction materials and equipment are not available locally, their quality is not reliable or their supply amount is insufficient in Cambodia, those construction materials and equipment shall be imported from Japan or other countries such as Thailand and Vietnam

Items imported from Japan are (i) Ductile Cast Iron Pipes, (ii) Valves, (iii) Flowmeters, (iv) FRP manhole cover, and (v) Mechanical and Electrical Equipment for STP

Transportation route is from Japanese port to Sihanoukville port via Singapore by marine transport. Transportation route from Sihanoukville port to Phnom Penh City shall be national road No. 4 by trailer.

Table R 2.2.16 Major Material and Equipment

Item	Responsibility		
	Cambodia	Japan	Third Country
Cement	○		
Asphalt material	○		
Gravel, sand, Laterite	○		
Steel sheet pile	○		
L H steel	○		
Reinforcing bar	○		
Mechanical/Electrical equipment for STP		○	○
Ductile Cast Iron Pipe		○	○
Polyethylene pipe	○		
Steel pipe	○		
Sluice valve		○	○
Air valve		○	○
Flow meter		○	○
Water gauge		○	○
Manhole cover	○	○	
Pump and control panel		○	○
Other equipment		○	○
Waterproof sheet	○		
Painting material	○		
Concrete block	○		
Concrete pile	○		
Form, timber support	○		
Fuel	○		
Fitting frames (metallic, wooden)	○		
Lightning protection equipment	○		

Source: Survey Team

2.2.4.7 Operational Guidance Plan

Executing agency will be PPCC, and agency for operation and maintenance will be DPWT. Drainage Pumping Station and Sewage Treatment Plant Office (DSO) in DPWH will be the one to have responsibility of O&M of the constructed STP. However, currently there is no STP in Phnom Penh Capital City, DSO is working for only drainage facilities.

Since the installation of the mechanical and electrical equipment for STP is the first experience in Cambodia, Training for staff on the operation and maintenance method of the equipment by experts from manufacturers, will be required. The other technical capacity will be transferred through soft component.

2.2.4.8 Soft Component Plan

PPCC has so far no experience of sewage management utilizing STP and no staff with experience in operation and maintenance of STP; therefore, it is essential to train the staff of PPCC to guarantee sustainable operation of the STP constructed in this project.

DSO will be in charge of operation and maintenance of the STP. In DSO, only two regular staff are assigned for operation and maintenance of the STP, belonging to “Pumping Station, STP and Pond Canal Maintenance Section”. In addition, they are at present engaged in maintenance of pumping

station and canal, since STP is not in operation in PPCC. Considering the situation described above, it is necessary from scratch to train the staff engaged in operation and maintenance of STP.

In this project, soft component for operation and maintenance of STP are proposed, aiming to technology transfer and capacity development for operation and maintenance of sewage treatment facilities, including water treatment, sludge treatment, sludge disposal, water quality control and so on.

STP regularly requires various costs such as electric power, chemicals, sludge disposal and repairing/replacing equipment. Without the budget to cover the costs, it is impossible to keep operating STP.

Meanwhile, PPCC has been constructing many drainage facilities (canals/drainage pipes/pumping stations) by domestic funds or Japan's Grant Aid. In addition, the STP will be constructed by this project. Large costs are required for the operation and maintenance of these facilities. So, it is important for DSO to grasp accurate cost of operation and maintenance of the STP, and obtain knowledge of the budget and expenditure management for the STP.

Therefore, soft component, focusing on transferring knowledge/skills for proper budget and expenditure management, is also proposed, targeting i) staff of Finance and Planning Office managing the budget of DPWT and ii) staff of Administration and Personnel Section in DSO. On the other hand, transferring knowledge/skills for public enterprise accounts is not included.

Thus, the Soft Components in this Project are organized as follows (see **[Appendices] 5** for details).

- Capacity Development in Operation and Maintenance of STP
- Assistance for Formulating Financial Plan for STP Management

2.2.5 Implementation Schedule

The Project will be implemented under Japan's Grant Aid based on the Grant Agreement (G/A) between GOC and JICA after the Exchange of Notes (E/N) has been concluded between GOC and GOJ. The Project will begin with the detail design study immediately after the signing of contract for consultancy services. The consultancy services will require 13 months including engineering design services, preparation of tender documents and tender administration. The total construction period will be 37 months including construction work and soft component. Thus, total implementation period of the Project, including soft component amounts to 50 months. The implementation schedule from the detail design study to completion of the construction works is shown in the following figures.

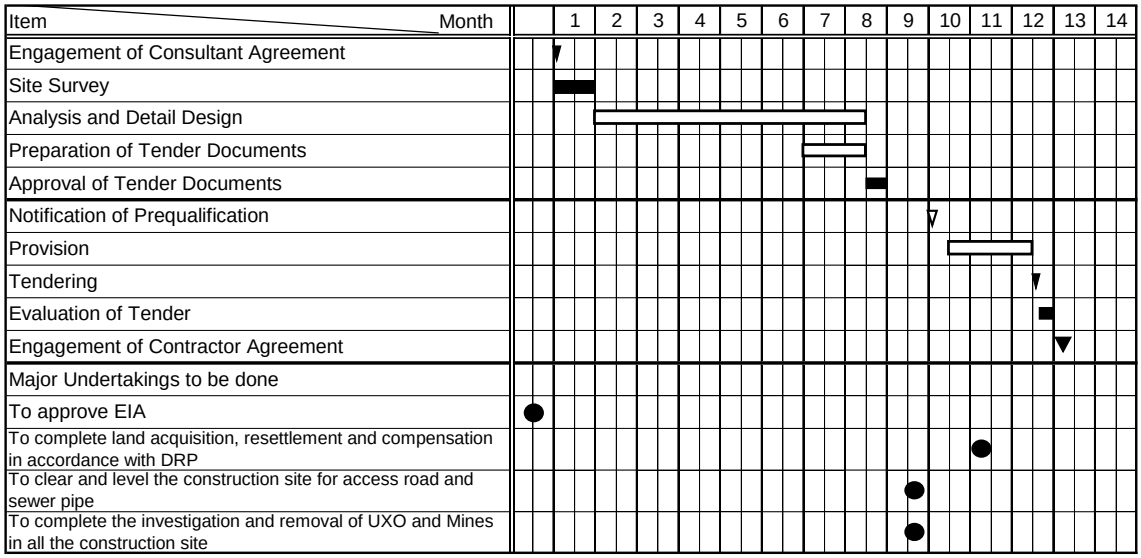


Fig. R 2.2.34 Implementation Schedule (Detailed Design and Tendering Stage)

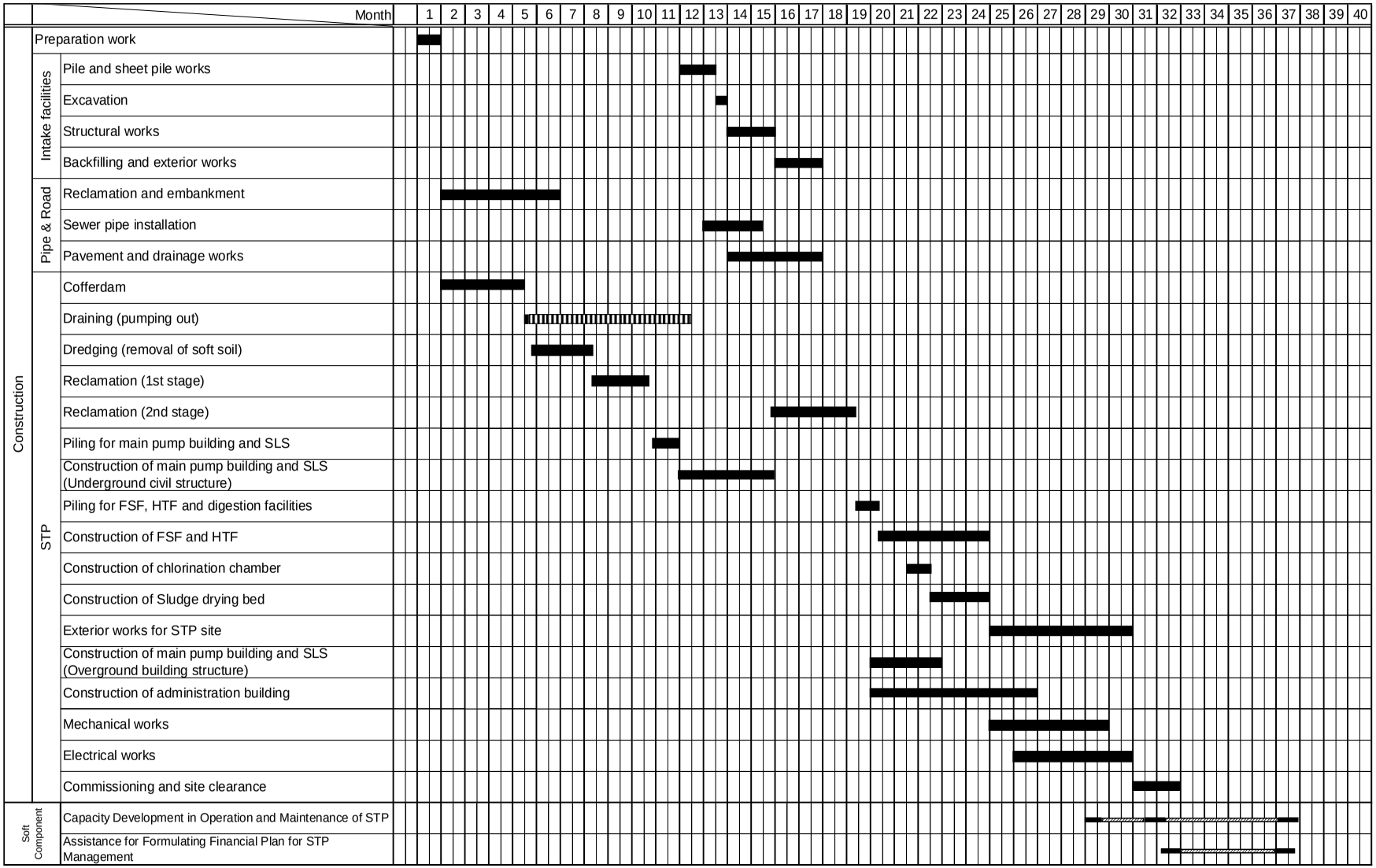


Fig. R 2.2.35 Implementation Schedule (Construction and Soft Component Stage)

2.3 Obligations of Recipient Country

(1) General Undertakings of Cambodia

The Cambodian side shall undertake the following for the smooth implementation of the Project.

(i) To secure and acquire the lands required for implementation of the Project such as construction site, stockyard, temporary working yard, disposal area and land for site office before the commencement of construction work. To get approval of land use from the agency concerned, if any.

(ii) To provide facilities of distributing power line to the site and site office, and city water distribution main to the site and site office.

(iii) To ensure prompt unloading, tax exemption and Customs clearance of the products at the port/terminal of disembarkation in Cambodia.

(iv) To exempt Japanese nationals from Customs duties, internal taxes and other fiscal levies that may be imposed in Cambodia with respect to the procurement of products and services under the Project.

(v) To arrange the acquisition of visa and other formalities that may be necessary for the entry of Japanese nationals into Cambodia and stay therein for the performance of the work.

(vi) To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project.

(vii) To maintain and use the facilities and equipment properly and effectively with a suitable number of staff assigned for the operation and maintenance and to bear all expenses other than those covered under the Grant Aid.

(viii) To bear the advising commission on the Authorization to Pay (A/P) and payment commission to the Japanese bank for banking services based upon the Banking Arrangement (B/A).

(2) Specific Undertakings of Cambodia

The specific undertakings required of the Cambodian side for the smooth implementation of the Project are as described below.

(i) Environment Impact Assessment (EIA)

Approval of EIA shall be received before the implementation. The Cambodia side is required to implement land acquisition and resettlement in accordance with ARAP.

(ii) Changing the Status of Land

The Cambodian side is required to obtain permission from Prime Minister's office to

change the status of land from National Public Land to Private State Land requested by PPCA and prepare sub-decree on transferring land title from National Public Land to Private State Land by PPCA in coordination with relevant ministries and institutions. The Cambodian side shall also obtain construction permission for the Project before the implementation (The procedures for transferring land title and obtaining construction permission are completed in December 2018).

(iii) Land Area Preparation

The land required for implementation of the Project such as stockyard, temporary working yard, disposal area and land for site office shall be prepared.

(iv) Removal of UXO

UXO detection survey and removal shall be implemented before the construction work.

(v) Application for Electricity

STP and interception facilities installed in the Project will basically be operated with commercial electric power. The Cambodian side is required to make an application to EDC for the utilization of electricity and the installation of the wattmeter at STP and interception facilities before the mechanical work. All commissions regarding the application and the installation cost of the wattmeter shall be borne by the Cambodian side.

(vi) Application for Water Supply

The Cambodian side is required to make an application to the Phnom Penh Water Supply Authority (PPWSA) for the utilization of water supply services and the installation of the water meter at STP. All commissions regarding the application and the installation cost of the water meter shall be borne by the Cambodian side.

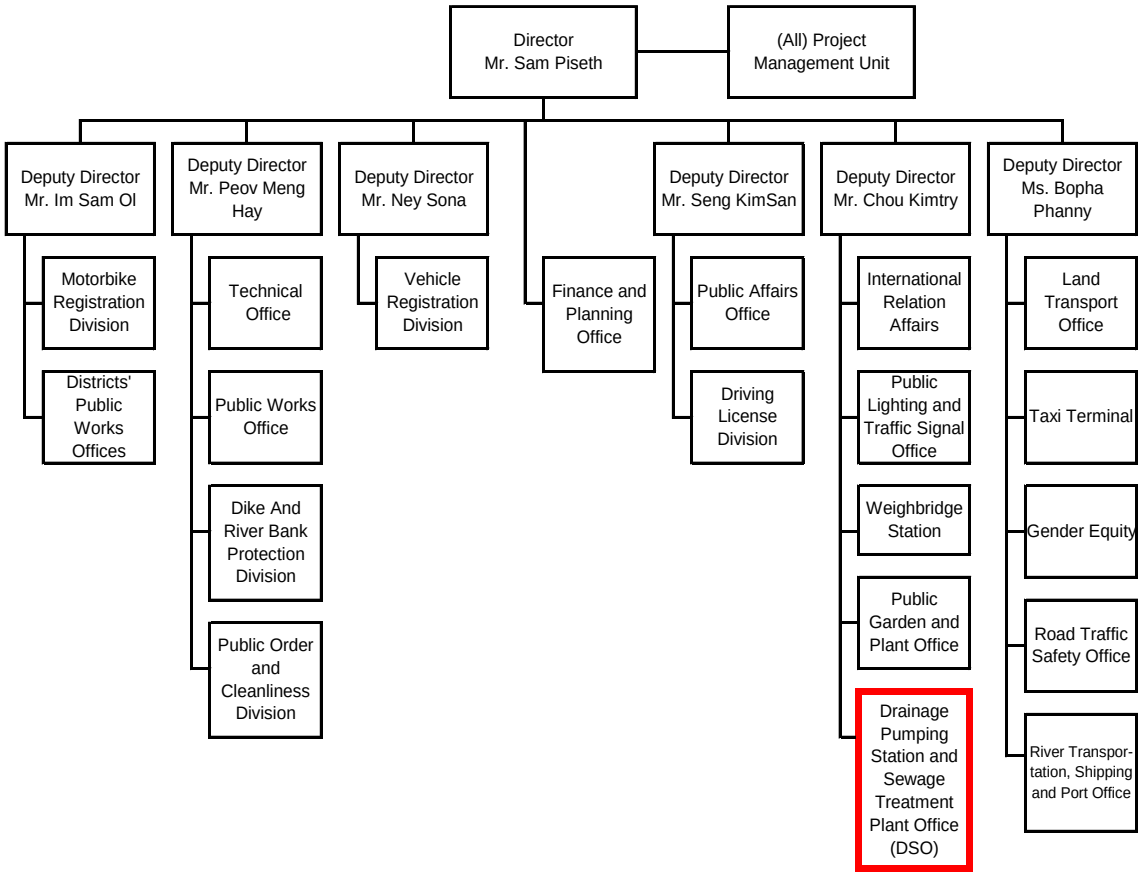
(vii) Implementation of EMoP

The Cambodian side is required to conduct Environmental Monitoring Plan and submit the quarterly report to JICA Cambodia.

2.4 Project Operation Plan

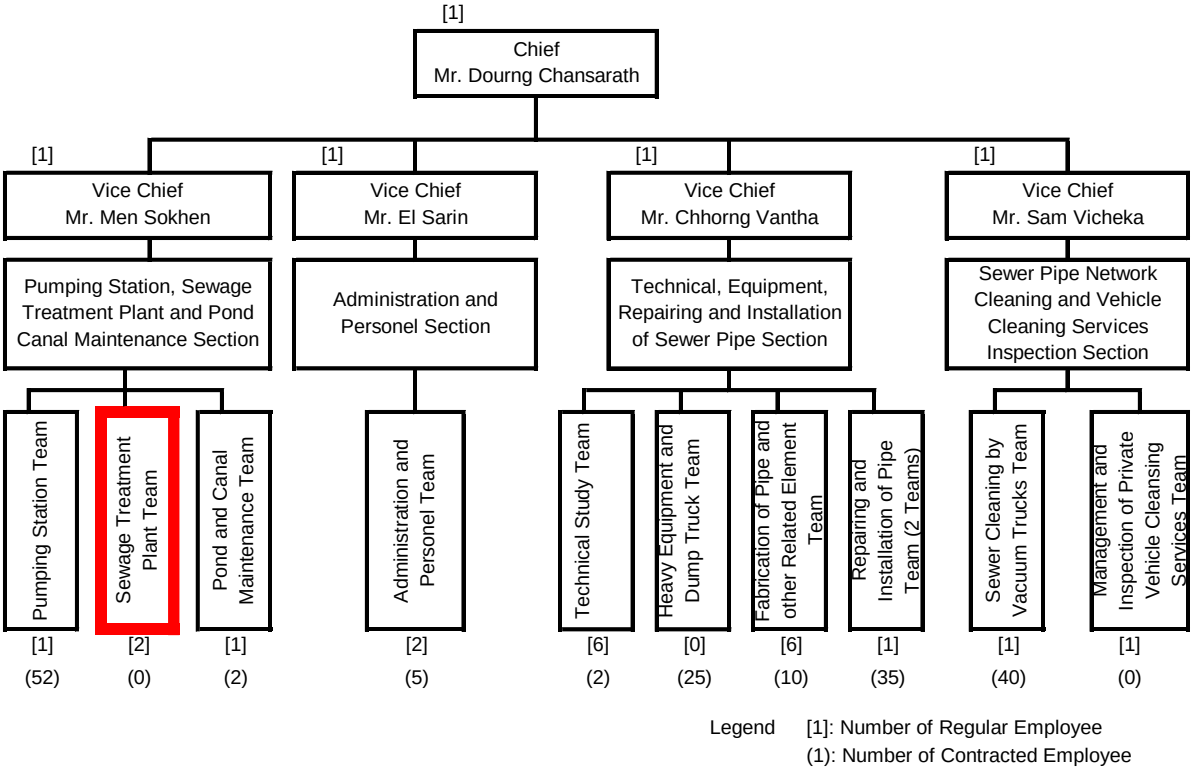
(1) Organization for Operation and Maintenance of STP

DSO (see **Fig. R 2.4.2**) of the Department Public Works and transport (DPWT, see **Fig. R 2.4.1**) shall be in charge of operation and maintenance works of the facilities constructed in the Project such as STP, interception facilities, sewer pipe and maintenance road.



Source: DPWT

Fig. R 2.4.1 Organizational Chart of DPWT



Source: DPWT

Fig. R 2.4.2 Organizational Chart of DSO

Breakdown of number of employees of DPWT is shown in the following table.

Table R 2.4.1 Breakdown of DPWT Staff

Department	Regular Staff	Contracted Staff	Total
1. Management Unit	8	-	8
2. Administration and Personnel Office	8	5	13
3. Finance and Planning Office	12	2	14
4. Technical Management Office	19	4	23
5. Public Works Office	28	37	65
6. Road Transport Office	18	6	24
7. River Transportation, Shipping and Port Office	-	-	-
8. Road Traffic Safety Office	-	-	-
9. Public Facilities Cleaning Division	6	19	25
10. River Bank and Revetment Division	3	-	3
11. Drainage Pumping Station and Sewage Treatment Plant Office	26	171	197
12. Public Lighting Office	6	16	22
13. Public Garden Office	16	279	295
14. Vehicle Registration Division	51	14	65
15. Motorbike Registration Division	22	14	36
16. Driving License and Traffic Safety Division	44	3	47
17. Districts' Public Works Offices	30	-	30
Total	297	570	867

Source: DPWT

DSO has currently Sewage Treatment Plant team with two regular staff. However, those two staffs are working at pumping stations and/or drainage channels because there is no STP in Phnom Penh. PPCC and/or DPWT should have enough number of staff by the commencement of soft component in this project.

(2) Operation and Maintenance Method

(a) Tasks and Demarcation on O&M after construction of STP

To operate and maintain STP, demarcation of tasks related to the STP operation and maintenance, as well as water quality management shall be clarified. Therefore, demarcation of tasks after construction of STP is proposed as shown in the following table.

Table R 2.4.2 Proposed Demarcation of Tasks after Construction of STP

Organization			Tasks
PPCA			● Regulatory Agency ● Secure Budget
MIH and MOE			● Monitoring and Guidance of Business Enterprises and Factories
DPWT	Finance and Planning Office		● Budget Planning and Management ● Asset Management (Pumping Station/Drainage Channel and Pipe/STP)
	Public Affairs Office		● Public Relations ● Environmental Education
	DSO	Administration and Personnel Section	● General Affairs, Drafting Budget and Budget Control ● Public Relations ● Environmental Education
	DSO	Pumping Station, Sewerage Treatment Plant and Pond Canal Maintenance Section.	● Water Quality Management ● Formulation of O&M Plan (Pumping Station/Drainage Channel/STP) ● Implementation of O&M (Pumping Station/Drainage Channel/STP) ● Asset Management (Pumping Station/Drainage Channel/STP)
	DSO	Technical, Equipment, Repairing, and Installation of Sewer Pipe Section	● Formulation of O&M Plan (Drainage Pipe) ● Implementation of O&M (Drainage Pipe) ● Asset Management (Drainage Pipe) ● Guidance of House Connection
		Sewer Pipe Network Cleaning and Vehicle Cleaning Services Inspection Section	
	DSO	Each Construction Supervision Team	● Safety and Health Management

Source: Survey Team

(b) Proposed staff for STP O&M

Proposed O&M staff of STP is as shown in the following table. The staff consists of Custodian, Mechanical and Electrical Engineer, Water Quality Management Engineer, and Clerical Officer, as well as Workers (Wastewater and Sludge Treatment). Number of the staff is eleven in total.

Table R 2.4.3 Proposed member of STP O&M

Job	No.	Description
Custodian	1	Facilities manager
Mechanical/Electrical Engineer	2	O&M of sewerage treatment facilities
Water Quality Management Engineer	1	Water Quality Sampling, Test and Analysis
Clerical Officer	1	General Affairs, Public Relations (deal with visitor etc.)
Worker (Wastewater Treatment)	2	Removal of Scum
Worker (Sludge Treatment)	4	Disposal of Sludge and Cleaning of Facilities
Total	**11**	

Note: 1) Staff dose not stay during night time, because remote monitoring by mobile phone will be installed.
2) BOD, and TSS will be analyzed at outsource laboratory, easy parameters such as temperature, DO, pH etc. will be analyzed at STP laboratory
Source: survey team

(3) Belonging of STP staff

Staff of STP proposed in the previous subsection, belongs to Sewage Treatment Plant Team of DSO. Independent organization under new vice chief is not established in this project, because the capacity of the STP in this Project is 5,000 m^3/day, which is not full-scale (282,000 m^3/day) of Cheung Aek STP.

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

(1) Cost Borne by Japan's Grant Aid

The cost borne by the Japan's Grant Aid is not shown in this report due to confidentially.

(2) Cost Borne by Recipient Country

The cost to be borne by the Government of Cambodia is estimated to be about US$746,000 (83.4 million Japanese Yen). The breakdown is presented in the following table.

	Item	Cost (US$)	Cost (million Japanese Yen)
1	Land Acquisition and Compensation	60,200	6.7
2	UXO Survey	588,500	65.8
3	Advising Commission for Banking Arrangement (B/A) and Authorization to Pay (A/P), and Payment Commission	52,800	5.9
4	Periodical Environmental Monitoring Cost during the Construction Stage (12 times in total)	39,100	4.4
5	Application Fee for Electricity	4,900	0.5
6	Application Fee for Water Supply	500	0.1
TOTAL		746,000	83.4

Exchange Rate: US$1.00 = 111.84 Japanese Yen (as of March 2019)

(3) Cost Estimation Conditions

1. Estimation Timing : September 2018

2. Foreign Exchange Rate : US$1.00 = JPY 111.84 US$: US Dollar
JPY: Japanese Yen

Foreign Exchange Rate applied is the average of Telegraphic Transfer Rate (TTS rate) for three months from June 2018 to August 2018.

3. Construction Period : The implementation schedule of the detailed design, construction and procurement is shown in **Subsection 2.2.5**.

4. Remarks : This cost is estimated by taking Japan's Grant Aid scheme into account.

2.5.2 Operation and Maintenance Cost

(1) Operation and Maintenance Cost

Total annual operation and maintenance cost such as personnel expense, electric utility expense, chemical expense, cost of sludge disposal, repair expense with/without replacement expense are calculated at **200,573USD** and **433,271USD** as shown in the table below.

Table R 2.5.1 Total Annual Operation and Maintenance Cost of the Project (with and without Replacement Expenses

Unit:USD

Item for Operation and Maintenance Cost	Without Replacement Expenses	With Replacement Expenses
Personnel Expenses	39,624	39,624
Electric Utility Expenses	90,384	90,384
Chemical Expenses	13,884	13,884
Sludge Disposal Expenses	5,957	5,957
Water Monitoring Expenses	1,440	1,440
Repair Expenses (Mechanical & Electrical Equipment)	46,540	46,540
Replacement Expenses (Mechanical & Electrical Equipment)	0	232,698
Repair Expenses (Maintenance road)	2,745	2,745
Total Operation and Maintenance Cost	200,573	433,271

Source: Survey Team

(2) Economic Evaluation of O&M Cost

The O&M cost of the project shall be borne by the users of the service. According to JICA's "IRR Calculation Manual" the Affordability To Pay (ATP) for sewerage service is 2% of disposable income of a household (P. 29). Average disposable income for a household in Phnom Penh is shown in the following table.

Table R 2.5.2 Monthly Average Disposable Income for Household in 2017

Area	Riel	USD
Cambodia	1,947,000	486.75
Phnom Penh	**2,833,000**	**708.25**
Other Urban	2,482,000	620,50
Other Rural	1,749,000	437.25

Note) USD1 = 4,000Riel
Source: National Institute of Statistics and Ministry of Planning Cambodia, "Socio-Economic Survey 2017"

As the average number of persons in a household is 5.08 according to the 2008 Census, the number of households covered by the project is 3,740 (= 19,000 / 5.08). Thus, the total ATP in a year is calculated as follows:

(708.25 x 2%) x 3,740 x 12 = 635,725USD.

The O&M cost of the project is fully covered by the total ATP, so it can be said that this project is feasible.

On the other hand, the O&M cost is compared with the he sewerage and drainage related expenditures of PPCC for last five years as shown in the table below. As a result, this O&M costs (with/without replacement expenses) is only 6.2% (in case without replacement expenses) or 13.3% (in case with replacement expenses) of the sewerage and drainage related expenditures of PPCC in 2014, which is the lowest amount in last five years, 13,031 million Riels or 3.26 million USD. Compared to the latest amount in 2017 (56,738 million Riels or 14.18 million USD), this O&M cost is equivalent to only 1.4% (in case without replacement expenses) or 3.1% (in case with replacement expenses).

Table R 2.5.3 Sewerage and Drainage related Expenditures of PPCC

Unit: Million Riels

Expenditure	2013	2014	2015	2016	2017
Pumping Station Electricity Expenses	5,264.00	4,447.00	3,850.83	5,967.30	6,062.10
Pumping Station Fuel Expenses	619.00	419.00	304.80	304.80	160.00
Pipe & Channel Cleaning Expenses	3,866.00	4,272.00	176.70	667.90	477.59
Pipe Repair & New Construction Expenses	2,774.00	3,181.00	94,943.22	91,161.99	42,825.43
Pumping Station Building Maintenance & Construction Expenses	362.00	256.00	15,362.00	51,162.58	7,143.59
Pumping Facility Maintenance & Installation Expenses	450.00	456.00	230.00	160.00	70.00
Total in Million Riels	13,335.00	13,031.00	114,867.55	149,424.57	56,738.71
Total in Million USD	3.33	3.26	28.02	37.36	14.18

Note) USD1 = 4,000 Riel in 2013, 2014, 2016 and 2017; USD1 = 4,100 Riel in 2015
Source: PPCC

CHAPTER 3 PROJECT EVALUATION

3.1 Preconditions

(1) Land Acquisition and Construction Permission

Project components, namely, interception facilities, sewer pipe and STP, will be constructed in the PPCC's land (public waterbody).

The procedures to transfer status of public state land to STP construction site, as well as obtaining construction permission was completed in December 2018. The ARAP survey, which was conducted in this preparatory survey, revealed that (i) involuntary resettlement is not required in the project area, and (ii) 22 AHs, including land owner and aquatic plant cultivators were identified in the construction site, although they own the land and cultivate the aquatic plant illegally.

PPCC has to compensate them, remove their structures of them and clear the land to smoothly implement the project before the commencement of construction works.

Other precondition is that DPWT shall complete the arrangements of the temporary land acquisition for site office, material storage space, stock yard, dumping site and so on prior to the commencement of construction works.

(2) Acquisition of Approval of EIA

In conformity to the Environmental Law in Cambodia, the following procedure is required for implementation of the Project.

- Full EIA survey is required for all size of wastewater treatment plant in accordance with the sub-decree No. 72.
- The EIA survey must be conducted by the consultant who is registered by MOE in Cambodia.
- The EIA survey must be approved by MOE because the project cost is higher than USD 2,000,000.

As mentioned above, the environmental precondition for the Project is that the result of the EIA survey is approved by the MOE.

(3) Completion of Survey and Removal of UXO

PPCC has to complete survey of UXO, which may exist in the project area and remove them, if any, before the commencement of construction works.

3.2 Necessary Inputs by Recipient Country

Necessary inputs by the Government of Cambodia to exert and sustain the effect of the Project are as below.

(1) Securing of Staff to Operate and Maintain STP

DSO in DPWT is in charge of operation and maintenance of the STP constructed in the project. The number of staff for the O&M of the STP is 11 in total, as shown in **Section 2.4.**. PPCC has to secure the staff before commencement of the soft component "Capacity Development in Operation and Maintenance of STP".

(2) Securing Sustainable O&M of STP and Budget

STP regularly requires various costs such as electric power, chemicals, sludge disposal and repairing/replacing equipment. Without the budget to cover the costs, it is impossible to keep operating STP. Therefore, it is important for DPWT to grasp accurate cost of operation and maintenance of the STP. Also, DPWT shall regularly encourage PPCC to allocate enough budget for the O&M of the STP in accordance with working plan.

3.3 Important Assumptions

Important assumptions to accomplish the project objective and to make project sustainable are as follows.

- Development strategy of national level and municipal level will not be changed.
- Budget of O&M for STP will not be rapidly reduced by the PPCC.
- Public order in PPCC and Cambodia will not deteriorate.

3.4 Project Evaluation

3.4.1 Relevance

Relevance of the Project is verified from the following viewpoints.

(1) Target Scale of Benefit

The number of direct beneficiary by the Project is approximately 19,000 people. Starting with this project, the improvement of water environment in PPCC is accelerated. In addition, improvement of hygienic condition is expected due to reduction of incidence rate of waterborne disease, like diarrhea, typhoid and dysentery. Further, increase in price of people's property and/or asset value around the Project site, will be expected.

(2) Urgency of Improvement of Living Condition of the People

The area of Cheung Aek Lake, the project area of the preparatory survey, is decreasing especially from 2003 to 2015. The natural purification function is also affected due to rapid urbanization and population increase. Thus, deterioration of natural purification function of the lake is accelerated. Moreover, offensive odor from wastewater flowing into the lake seriously affects living condition of the people around the lake. Therefore, mitigation measures to improve the condition are urgently required.

(3) Consistency with Long-Term Development Programme

GOC places importance on construction and sustainable operation of facilities related to sewage management and drainage improvement in the major cities including PPCC in such national strategies as "National Strategic Development Plan (NSDP), 2014-2018" In addition, PPCC sets goals of "Prevention of water pollution" and "Promotion of sewage treatment" in "City Development Strategy (CDS), 2005" and sets priority on the development of sewerage facilities in the PPCC's city development plan of "White Book on Development and Planning of Phnom Penh, 2015". The White Book proposes the construction of wastewater treatment plant in Cheung Aek Lake. Thus, the relevance of the Project is high since the Project is consistent with the long-term development programme of the Cambodia and PPCC.

(4) Impact to Environment

Significant or permanent negative impact to natural and social environments are not expected by implementing the Project. In contrast, positive impact such as improvement of living and social environments by the construction of STP is expected.

(5) Consistency with Japan's Aid Policy and Objective

The Project is to be implemented based on the M/P formulated in "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area, JICA, December 2016". In addition, this Project applies Japanese unique wastewater treatment method of PTF, which is the first technology verified in the "International Technology Verification Program", conducted by Japan Sewage Works Agency. Thus, this Project is consistent with one of the Japanese aid policies of "Quality Infrastructure Investment".

3.4.2 Effectiveness

(1) Quantitative and Direct Effectiveness

19,000 project beneficiaries and reduction of BOD load discharged to the public waterbodies are expected by implementing the Project, as shown in the following table.

Table R 3.4.1 Index of Quantitative Effectiveness by the Project

Indicators	Present (2018)	Future (2027) (3 years after completion of the project)
Sewered Population (person)	0	19,000
Amount of Wastewater Treated (m^3/day)	0	5,000
BOD Concentration (effluent water quality) (mg/L)	195	30

Source: Survey Team

(2) Qualitative and Indirect Effectiveness

By implementing this Project, the following qualitative effectiveness for improving living and hygienic condition of the people are expected.

- Wastewater treatment facilities constructed in the Project contributes to improve the water quality of Cheung Aek Lake, mitigate offensive odor and thus improve living condition of the people around the Lake.
- Wastewater treatment facilities constructed in the Project decrease the waterborne disease. Thus, hygienic condition of the people around the Lake is improved.

The above effectiveness contributes to accomplish the goals of "Prevention of water pollution" and "Promotion of sewage treatment" in City Development Strategy of PPCC.

3.4.3 Conclusion

The Project has high relevance and effectiveness. Hence, early implementation of "the Project for Sewerage System Development in the Phnom Penh Capital City" is highly recommended.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