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

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR FLOOD PROTECTION AND DRAINAGE IMPROVEMENT IN PHNOM PENH (PHASE IV) IN THE KINGDOM OF CAMBODIA

January 2017

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.

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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.

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.

January, 2017

Kunihiro YAMAUCHI
Director General
Global Environmental Department
Japan International Cooperation Agency

SUMMARY

1. Outline of Cambodia

With an area of 181,000km^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$ 1,140 in 2015 (ref.: US$775 in 2008). 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 October.

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

Urban drainage facilities in the Phnom Penh Capital City with functions of draining storm water and domestic wastewater have been gradually improved in line with the development of the city. However, all the drainage facilities, which have been constructed since the beginning of the 1900's, are not functioning well due to old age, as well as poor maintenance after the 1970's. Thus, the city suffers from habitual inundation and poor environmental conditions caused by stagnant wastewater in lowland areas. These are serious constraints to the residents' living environment as well as social and economic development, not only of Phnom Penh Capital City but the whole country in general.

The GOC had made a request for technical cooperation from the Government of Japan (hereinafter referred to as "the GOJ") to formulate a master plan for drainage improvement and flood control in Phnom Penh Capital City and suburbs. In response, the GOJ had dispatched a study team through the Japan International Cooperation Agency (hereinafter referred to as "JICA") to formulate a master plan and to conduct a feasibility study on priority projects selected from the master plan. That study was conducted from March 1998 to August 1999.

Based on these priority projects, "The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh" from 2001 to 2004, "The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)" (hereinafter referred to as "Phase II") from 2006 to 2010, and "The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)" from 2011 to 2015 were carried out under the Japan's Grant Aid Scheme.

Although drainage conditions in the target areas of three phases of the Japan's Grant Aid projects in the past have greatly improved by those grant aid projects, areas in the northern part of city core area such as the Wat Phnom Northern Area and the Tuol Kork Area (northern half of the Khan Tuol Kork) are still experiencing serious inundation damage in the rainy season. Therefore, "The Project for Flood Protection and Drainage Improvement in Phnom Penh (Phase IV)" (hereinafter referred to as "the Project") has been requested in July 2014 by the GOC for implementation under Japan's Grand Aid to improve the drainage condition in the remaining northern part of city core area. The requested items for the Project were evaluated in "the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area" in terms of economic efficiency.

And then, 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

Requested Components	Category	Tentative Contents of Requested Components
Improvement of Wat Phnom Northern area drainage system	Construction of Facility	- Drainage Pipe (Dia.1,000mm~1,800mm, Length=Max. 3.2km in total) - Pumping Station (Q=1.4m^3/s) - Underground Reservoir (V=5,000m^3) - Interceptor Pipe (Dia.1,000mm, Length=approx. 1.5km)
Mechanical screen cleaning facilities to screen pits at pumping stations constructed in Phase II	Construction of Facility	- Mechanical Screen at existing Four Pumping Stations (Chak Tomuk P.S. (P1), Preah Kumlung P.S. (P2), Phsar Kandal P.S. (P4), Phsar Chas P.S. (P5))
Improvement of Tuol Kork area drainage system	Construction of Facility	- Pumping Station (Q=1.4m^3/s) - Drainage Pipe (Dia.1,000mm~1,800mm, Length=Max. 7.3km in total) - Drainage Box Culvert (2m x 2m ~ 2.5m x 3.5m, Length=Max. 0.7km in total)
Procurement of drainage improvement equipment	Procurement of Equipment	- Vehicle-Mounted Drainage Pump (1~2 units)

Note: Components and contents requested for the Project had been confirmed in Minutes of Discussions, signed on April 28, 2016.

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

JICA dispatched the Preparatory Survey Team to Cambodia from March 28 to June 9, 2016. 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 October 8 to 16, 2016. Both sides had agreed on the contents and the finalization of the Preparatory Survey Report.

3.1 Basic Design Policy

To confirm and understand actual inundation state in the target area, interview surveys to Sangkat chief and residents around frequently inundated roads were carried out. And then, appropriate layout and scale of the drainage facilities were studied in consideration of results of interview survey.

(1) Improvement of Drainage System in Wat Phnom Northern Area

To mitigate inundation damages, construction of pumping station with underground reservoir, as well as construction of drainage pipes, are proposed. Objective of construction of these facilities is to reduce inundation area and duration caused by heavy rain, and thus to promptly recover sound living condition of the residents.

Pumping station will be constructed beside underground reservoir which retain stormwater temporarily and thus reduce a discharge capacity of pumping equipment.

Interceptor system will be introduced in this area to intercept wastewater discharged from existing drainage network to Tonle Sap River. Wastewater will be conveyed by interceptor and existing pipe, and then discharged into the wetland which is in northern area of Phnom Penh Capital City (hereinafter referred to as “PPCC”).

Basic policies and prerequisite conditions for designing of drainage facilities were set as followings.

- Inundation state shall be improved against rainfall with planning scale of 2-year

probability to be able to drain the storm water within 2 hours with 20 cm of allowable inundation depth.

- Capacities of drainage facilities shall be studied and designed based on hydraulic simulation to be able to achieve the improvement target.
- Pile foundation was adopted as the foundation of underground reservoir to avoid uneven settlement and deformation.

(2) Improvement of Drainage System in Tuol Kork Area

To mitigate inundation damages, construction of drainage pipes is proposed. Objective of construction of these facilities is to reduce inundation area and duration caused by heavy rain, and thus to promptly recover sound living condition of the residents.

Depending on the current inundation damages identified by the interview survey, target area of Tuol Kork Area is divided into three drainage areas, namely Northern drainage area, Central drainage area and Southern drainage area. Stormwater in these three drainage areas is discharged to the Poung Peay lake, No.1 Tuol Kork pumping station and No.2 Tuol Kork pumping station, respectively.

Basic policies and prerequisite conditions for designing of drainage facilities were set as followings.

- Inundation state shall be improved against rainfall with planning scale of 2-year probability to be able to drain the storm water within 2 hours with 20 cm of allowable inundation depth.
- Capacities of drainage facilities shall be studied and designed based on hydraulic simulation to be able to achieve the improvement target.

(3) Installation of Mechanical Screens in Pumping Stations Constructed in Phase II

Four pumping stations, namely Chak Tomuk (PS1), Preah Kumlung (PS2), Phsar Kandal (PS4) and Phsar Chas (PS5), were constructed by the Phase II. In these pumping stations, bar screens were installed at inlet of their pump in order to prevent impeller of the pump will clog up with solid wastes. Department of Public Works and Transport (hereinafter referred to as “DPWT”) of PPCC has done many efforts to remove wastes manually with rakes from bar screens to make smooth flow at bar screen, but the problem couldn’t be solved due to huge amount of wastes.

To solve this problem, auto-raking machines as mechanical screens shall be installed to existing four pumping stations.

Existing bar screens and screen pits are replaced with new facilities, and auto-raking machine shall be installed.

(4) Procurement of Equipment related to Drainage Management

Emergent drainage work is carried out by Drainage and Sewerage Division (hereinafter referred to as “DSD”) under the responsibility of DPWT. DSD has only one drainage pump vehicle, which is aged more than 30 years with small drainage capacity. DSD cannot carry out emergent drainage works timely and efficiently.

Vehicle-mounted drainage pump shall be procured to improve present conditions of emergent drainage works. Specification and quantity of the equipment shall be determined in consideration of needs, DSD's capacity for operation and maintenance of the equipment.

(5) Soft Component Plan

To achieve sustainable operation and maintenance work of vehicle-mounted drainage pump, mechanical screen, and other drainage facilities, it is necessary to implement technical assistance with soft component to enhance the management capability of DSD on operation and maintenance work.

Soft component (technical assistance) aims to enable the DSD carry out the systematic and scheduled maintenance work and to utilize drainage facilities and/or equipment constructed and/or procured by the Project. PPCC is required to install garbage boxes and to carry out activities for raising public awareness to stop garbage dumping in and around the markets during the soft component (technical assistance) of the Project.

3.2 Contents of the Project

Following structures and equipment shall be constructed and procured by the Project as the Japanese assistance.

Contents of Japan's Grant Aid for the Project

Covered by the Japan's Grant Aid			
Items	Description		Quantity
Construction Works			
Improvement of Wat Phnom Northern Area Drainage System	Drainage Main	Pipe	2.7 km
		Box Culvert	0.5 km
	Interceptor	Pipe	1.6 km
		Manhole Pump	1 unit
	Pumping Station	Pump	1.4 m^3/sec
		Underground Reservoir	6,500 m^3
		Mechanical Screen	1 unit
Improvement of Tuol Kork Area Drainage System	Drainage Main	Pipe	7.0 km
		Box Culvert	1.4 km
Mechanical Screen Cleaning Facilities to Screen Pits at Pumping Stations Constructed in Phase II	Auto Raking Machine	Chak Tomuk PS Preah Kumlung PS Phsar Kandal PS Phsar Chas PS	4 units
Procurement Works			
Procurement of Drainage Improvement Equipment	Vehicle-Mounted Drainage Pump		2 units
Soft Component			
The soft component (technical assistance) aims to enable the DSD carry out the systematic and scheduled maintenance work and to utilize drainage facilities/equipment constructed/procured by Japan's Grant Aid Projects. PPCC is required to install garbage boxes and to carry out activities for raising public awareness to stop garbage dumping in and around the markets during the soft component (technical assistance) of the Project.			

4. Implementation Period and Project Cost

Implementation period of the Project is estimated to be 8 months for detailed engineering design, and 36 months for construction work including procurement of equipment.

The project cost to be borne by the recipient country is estimated to be about US$418,200 (47.7 million Japanese Yen, US$1.0 = JPY133.65).

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 implementation has been verified from the following viewpoints.

- Large Scale of Beneficiaries:
  The Project area is located in city core area of Phnom Penh Capital City and number of beneficially is estimated approximately 200 thousand residences in total.
- Human Security:
  The Project would contribute to the preservation of people's health, conservation of living conditions and sustainment of work environment.
- Operation and Maintenance of Facilities:
  After completion of the technical assistance of the Project, DSD will be able to carry out adequate operation and maintenance work in a planned and consistent way.
- Consistency with Long Term Development Programme:
  The Project will contribute to the achievement of some of the Cambodian national long term development target and the City Development Strategy of Phnom Penh Capital City.
- Impact to Environment:
  There is no significant or permanent negative impact to natural and social environments caused by the Project. In contrast, positive impact such as improved living and social environments by mitigation of inundation condition is expected.
- Necessity and Superiority of Japanese Technology:
  Japanese technology is required to execute the Project under Japan's Grant Aid Scheme in terms of planning knowledge, construction technology, establishment of a consistent drainage system and utilization of local human resources.

5.2 Effectiveness of the Project

(1) Quantitative Effectiveness

By the completion of the Project, inundation damage in Wat Phnom Northern Area and Tuol Kork Area will be reduced against 2-year probability rainfall as shown in following table.

Name of Index		Baseline (Actual Value in 2015)	Target Value (in 2023) 【3 Years after the Project】
Inundation Area	Wat Phnom Northern Area (m^2)	111,600	49,500
	Tuol Kork Area (m^2)	460,800	169,200
Inundation Depth (Above Both Area) (cm)		Max. 50	Max. 20
Flood Duration (Above Both Area) (hour)		Max. 9	Max. 2

Note 1) The above target value is computed by the condition of the lower scale of 2-year return period rainfall. The intensity of 2-year return period rainfall is 44.8mm/hr. or 87.8mm/day.
Note 2) The above inundation area is computed by the flood duration which is longer than 10 minutes
Note 3) The monitoring point is as given below
Wat Phnom North Area : St.47×St.84, St.47×St.88
Tuol Kork Area : St.337×St.528, St.317×St.592, St.287×St.528

(2) Qualitative Effectiveness

- Economic Effectiveness
  The Project will contribute to the avoidance of occurrence of economic damage.
- Commercial Effectiveness

The Project will contribute to promotion of commercial pursuits and tourism due to mitigation of flood/inundation damage.

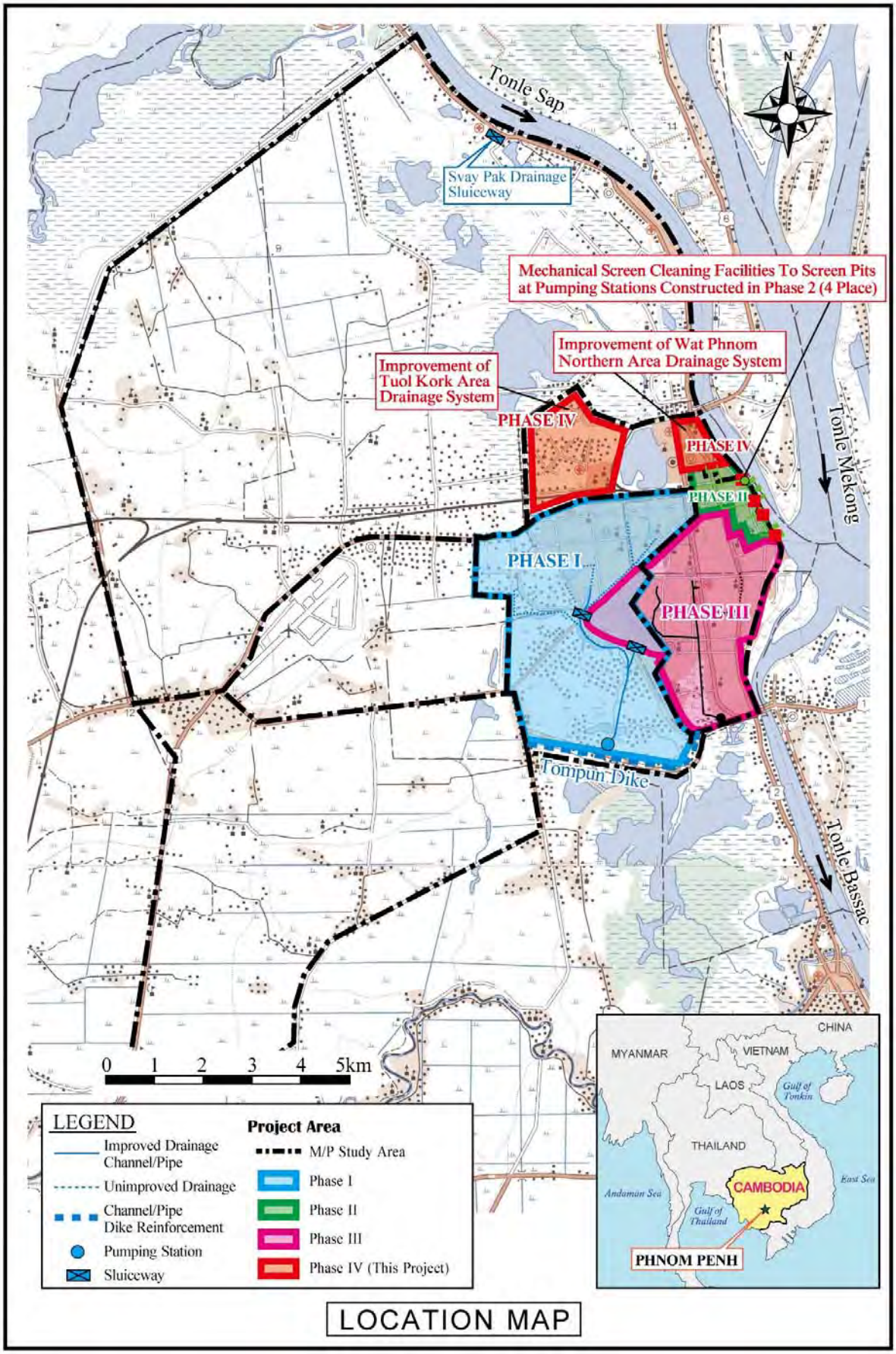
- Environmental Effectiveness
  Urban environment, like unpleasant odor, sediment/polluted sludge/litter at drainage facilities, will be reduced by the improvement of the drainage system.

- Hygienic Effectiveness
  As the indirect effect of the improvement of urban drainage facilities in the Project, the prevention of occurrence and spread of epidemics of waterborne disease due to inundation is expected.

- Improvement of Travel Condition
  Inundation periods will become shorter and inundation depths will become shallower, making it easier for ordinary vehicles to pass the roads.

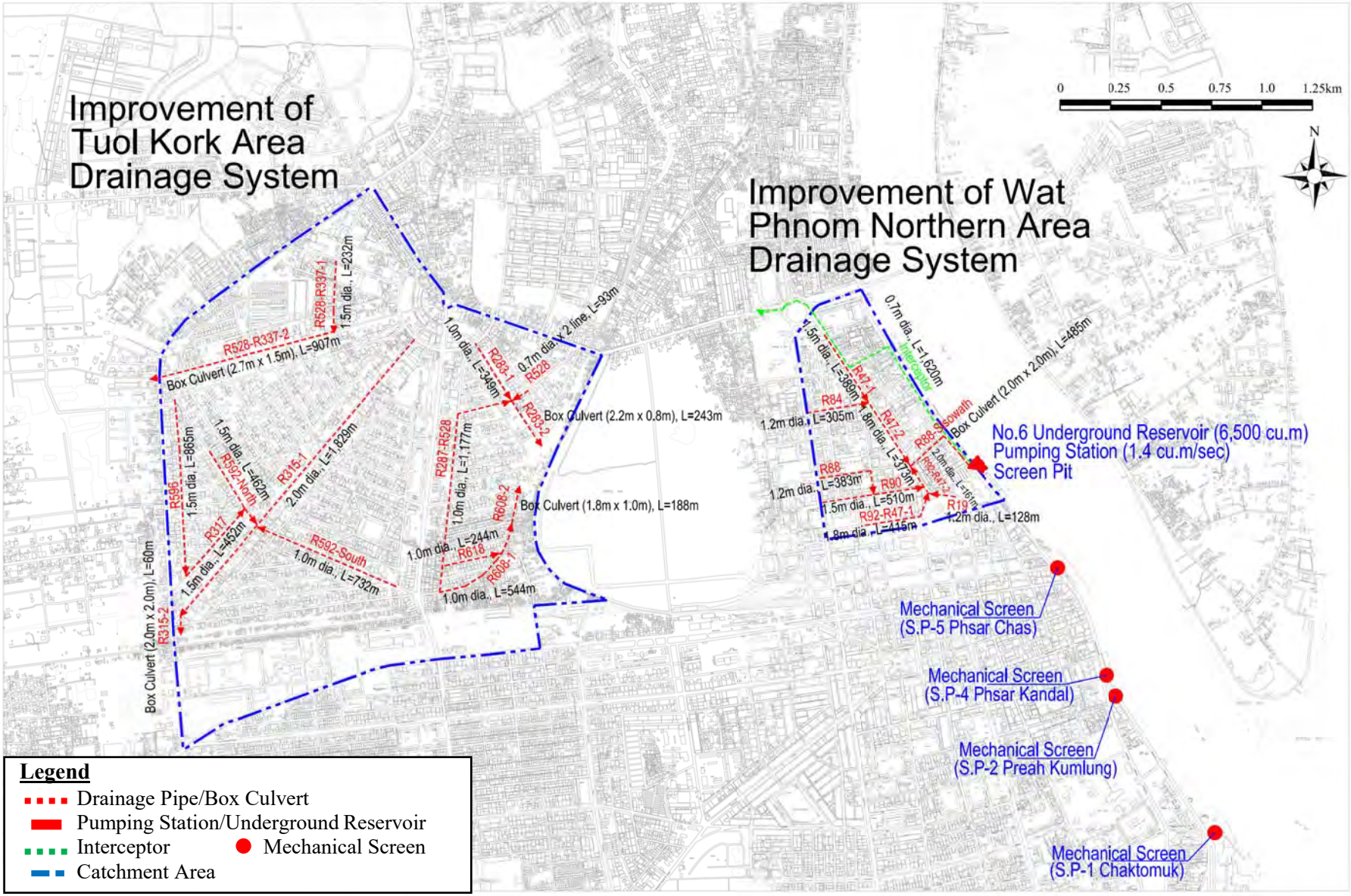
5.3 Conclusion

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



Location Map of the Project Area

Facility Layout in the Project Area



Perspectives

– Installation of Drainage Main

Before the Project: Present flooding condition during hard rain

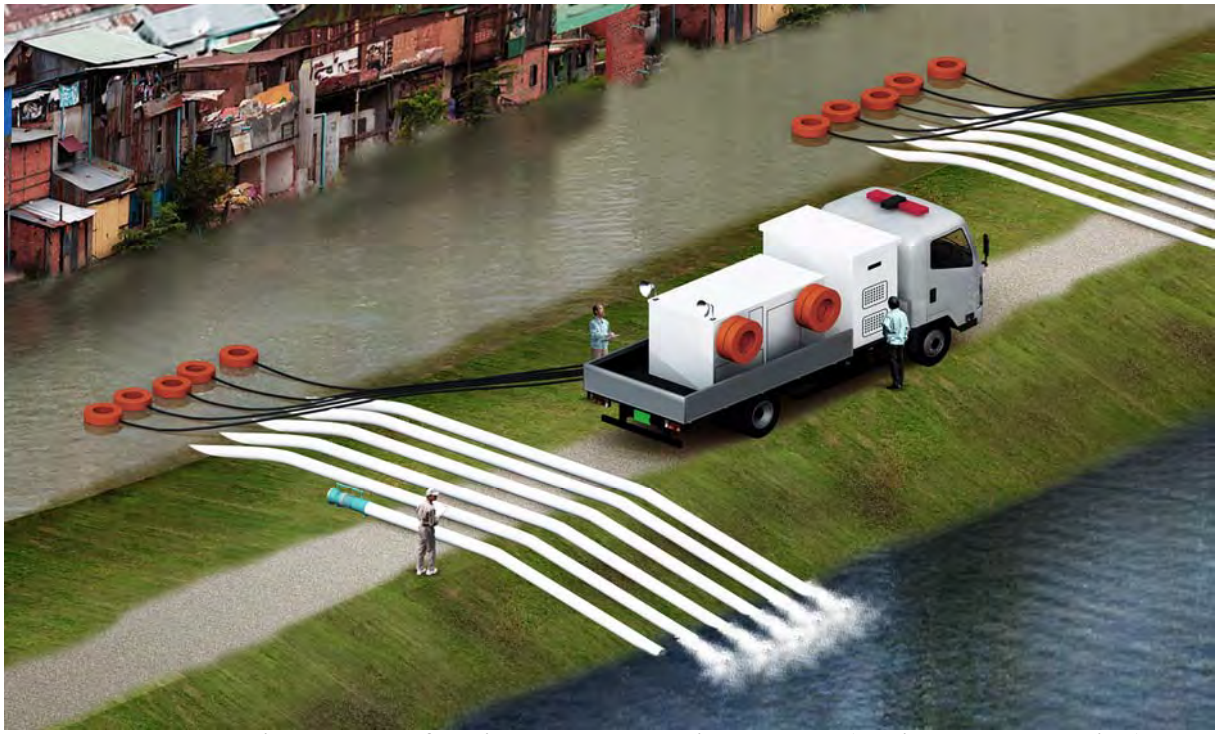
After the Project: Improved drainage condition during hard rain

Perspectives

– Construction of Underground Reservoir and Pumping Station

Perspectives

– Procurement of Vehicle-Mounted Drainage Pump (Drainage Pump Vehicle)



Emergency Drainage Work of Vehicle-Mounted Drainage Pump (Drainage Pump Vehicle) which will be Procured by the Project

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ABBREVIATIONS AND ACRONYMS

1. Organizations

AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
CDC	Cambodia Development Council
DGA	Department of General Affairs
DHI	Danish Hydraulic Institute
DICDM	Department of Internal Control and Data Management
DLMUPC	Department of Land Management, Urban Planning and Construction
DOE	Department of Environment
DOP	Department of Planning
DOWRAM	Department of Water Resources and Meteorology
DPWT	Department of Public Works and Transport
DR	Department of Resettlement
EDC	Electricité du Cambodge
DSD	Drainage and Sewerage Division
EA	Executing Agency
EMA	External Monitoring Agency
GDR	General Department of Resettlement
GOC	Government of Cambodia
GOJ	Government of Japan
GRC	Grievance Redress Committee
IRC	Inter-ministerial Resettlement Committee
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
KOICA	Korea International Cooperation Agency
MEF	Ministry of Economy and Finance
MGRC	Municipality Grievance Redress Committee
MOE	Ministry of Environment
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MRSC	Municipality Resettlement Sub-Committee
PDOE	Provincial Department of Environment
PEO	Provincial Environmental Office
PIU	Project Implementation Unit
PMU	Project Management Unit
PPCC	Phnom Penh Capital City
PPCH	Phnom Penh Capital Hall
PPWSA	Phnom Penh Water Supply Authority
UN	United Nations
WHO	World Health Organization

2. Technical Terms

AH	Affected Household
AIDS	Acquired Immune Deficiency Syndrome
AP	Affected People
ARAP	Abbreviated Resettlement Action Plan
ASTM	American Society for Testing and Materials
BOD	Biochemical Oxygen Demand
CBR	California Bearing Ratio

CFOCN	Cambodia Fiber Optic Communication Network
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CTS	Compact Transformer Substation
DEM	Digital Elevation Model
DMS	Detailed Measurement Survey
DO	Dissolved Oxygen
EC	Electrical Conductivity
EGS	Emergency Diesel-Engine Drive Generator Set
EIA	Environmental Impact Assessment
ESC	Environmental and Social Considerations
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
IEC	Information, Education, Communication
IEE	Initial Environmental Examination
IEIA	Initial Environmental Impact Assessment
IOL	Inventory of Losses
JIS	Japanese Industrial Standards
LARAP	Land Acquisition and Resettlement Action Plan
MPN	Most Probable Number
NO_2	Nitrogen Dioxide
NSDP	National Strategic Development Plan
NTU	Nephelometric Turbidity Unit
OJT	On-the-Job Training
PIB	Project Information Booklet
PO_4	Phosphate
PPUTMP	Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City
PS	Pumping Station
RCS	Replacement Cost Survey
ROW	Right-of-Way
SDG	Sustainable Development Goal
SHM	Stakeholder Meeting
SO_2	Sulfur Dioxide
SP	Screen Pit
SPT	Standard Penetration Test
TOR	Terms of Reference
TSP	Total Suspended Particles
TSS	Total Suspended Solid
UGR	Underground Reservoir
WG	Working Group

3. Units of Measurement

(Length)		(Weight)	
mm	: millimeter(s)	mg	: milligram(s)
cm	: centimeter(s)	g, gr	: gram(s)
m	: meter(s)	kg	: kilogram(s)
km	: kilometer(s)	ton	: tonne(s)
(Area)		(Time)	
mm^2	: square millimeter(s)	s, sec	: second(s)

cm^2	: square centimeter(s)	min	: minute(s)
m^2	: square meter(s)	h(hrs)	: hour(s)
km^2	: square kilometer(s)	d(dys)	: day(s)
ha	: hectare(s)	y, yr(yrs)	: year(s)

(Volume)		(Speed/Velocity)	
cm^3	: cubic centimeter(s)	cm/sec, cm/s	: centimeter per second
m^3	: cubic meter(s)	m/sec, m/s	: meter per second
ℓ	: liter(s)	km/hr, km/h	: kilometer per hour

(Flow/Discharge)		(Concentration)	
ℓ/sec, ℓ/s	: liter per second	mg/ℓ	: milligram per liter
m^3/sec, m^3/s	: cubic meter per second		
m^3/yr, m^3/y	: cubic meter per year		

(Electrical Units)		(Stress)	
W	: watt(s)	kg/cm^2	: kilogram per square centimeter
kW	: kilowatt(s)	ton/m^2	: ton per square meter
MW	: megawatt(s)		
kWh	: kilowatt-hour		
MWh	: megawatt-hour	(Monetary Terms)	
GWh	: gigawatt-hour	¥	: Japanese Yen
V	: volt(s)	US$	: United States Dollar
kV	: kilovolt(s)	Riel	: Cambodian Riels

4. others

(Cambodian Words)	
Boeng	: Lake
Prek	: River/Stream
Stoeng	: River (medium)
Tonle	: River (large)

CHAPTER 1 BACKGROUND OF THE PROJECT

1.1 Background of the Project

Phnom Penh Capital City, the capital of the Kingdom of Cambodia, is located in the western side of the confluence of Mekong River and Tonle Sap River. It is the political, economic and cultural centre of the country and had the population of about 1.6 million in 2013 (estimated in Final Report, Inter-Census Population Survey 2013, National Institute of Statistics, Ministry of Planning).

In the 1960's, the construction of outer ring dikes for the protection of Phnom Penh City from flooding of neighbouring rivers, lakes and swamps had started, and urban drainage facilities with functions of draining stormwater and domestic wastewater were improved in line with the development of the city, gradually. However, all of the drainage facilities constructed since the beginning of the 1900's stopped functioning well due to old age, as well as poor maintenance after the 1970's. As a result, the city suffers from habitual inundation and poor environmental conditions caused by stagnant wastewater in the lowland areas, which are serious constraints to the improvement of residents' living environment as well as social and economic development, not only of Phnom Penh City but the whole country in general.

To spur development, the Government of Cambodia (hereinafter referred to as "the GOC") made a request for technical cooperation from the Government of Japan (hereinafter referred to as "the GOJ") in order to formulate a master plan for flood protection and urban drainage improvement in Phnom Penh and suburbs. In response, the GOJ dispatched a study team through the Japan International Cooperation Agency (hereinafter referred to as "JICA") to carry out "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh" (hereinafter referred to as "MP1999"). This study was conducted from March 1998 to August 1999.

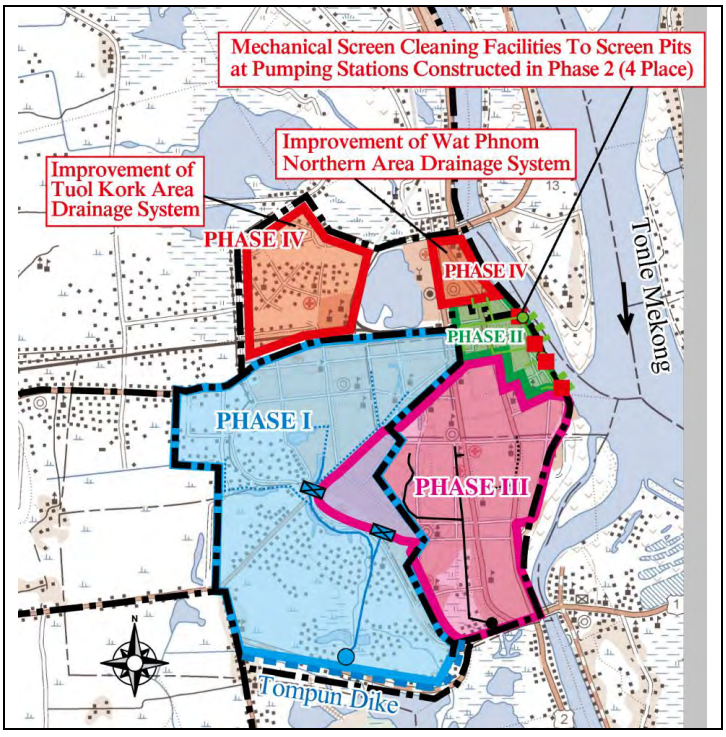


Fig. R 1.1.1 Area of Japan's Grant-Aid Project

Based on the master plan formulated in MP1999, three projects for flood protection and drainage improvement had been implemented under the Japan's Grant Aid scheme.

Outline of three Grant Aid Projects in the past are summarised in the following table.

Table R 1.1.1 Flood Protection and Drainage Improvement Project by Japan's Grant Aid

Project	Project Period	Target Area	Project Components
Phase I	2001~2004	Southwest area of the city (Tompun Watershed)	- Construction: Dike Reinforcement, Drainage Channel, Pumping Station, Sluiceway, Bridge, Road
Phase II	2006~2010	City centre and northeast area of the city (Central Market Area, Royal Palace & National Museum Area, Wat Phnom Basin)	- Construction: Revetment, Drainage Pipe, Underground Reservoir, Pumping Station
Phase III	2010~2015	Trabek Area (Southeast area of the city) (Catchment area of Trabek Pumping Station)	- Construction: Sediment Chamber, Drainage Pipe (21km) - Procurement: Cleaning Equipment of Drainage Pipe (8 units) - Operation Training

[Project Name] Phase I: The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh
Phase II: The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)
Phase III: The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)

Although drainage conditions in the most part of city centre have greatly improved by Phase I, Phase II and Phase III, areas in the northern part of city core such as the Tuol Kork Basin and Wat Phnom North are still experiencing serious flooding in the rainy season. Therefore, the GOC requested implementation of Japan's Grant Aid "the Project for Flood Protection and Drainage Improvement in Phnom Penh (Phase IV)" (hereinafter referred to as "the Project") to improve drainage condition in those areas. In response to the request, the GOJ decided to conduct a Preparatory Survey on the Project through JICA.

Furthermore, drainage problems have been generated in surrounding area of inner ring dike, due to rapid urbanization and changes in land use. Taking this condition into consideration, the GOC requested the GOJ a technical assistance for revision of the MP1999 as well as consideration of wastewater treatment. In response to the official request, the GOJ conducted "the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area" through JICA. During the course of revision, requested components of the Project had been evaluated and prioritized, and then urgently necessary components for the Project were selected.

1.2 Contents of the Request

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.

Table R 1.2.1 Description of Requested Components for the Project

Requested Components	Category	Tentative Contents of Requested Components
Improvement of Wat Phnom Northern area drainage system	Construction of Facility	- Drainage Pipe (Dia.1,000mm~1,800mm, Length=Max. 3.2km in total) - Pumping Station (Q=1.4m^3/s) - Underground Reservoir (V=5,000m^3) - Interceptor Pipe (Dia.1,000mm, Length=approx. 1.5km)
Mechanical screen cleaning facilities to screen pits at pumping stations constructed in Phase II	Construction of Facility	- Mechanical Screen at existing Four Pumping Stations (Chak Tomuk P.S. (P1), Preah Kumlung P.S. (P2), Phsar Kandal P.S. (P4), Phsar Chas P.S. (P5))
Improvement of Tuol Kork area drainage system	Construction of Facility	- Pumping Station (Q=1.4m^3/s) - Drainage Pipe (Dia.1,000mm~1,800mm, Length=Max. 7.3km in total) - Drainage Box Culvert (2m x 2m ~ 2.5m x 3.5m, Length=Max. 0.7km in total)
Procurement of drainage improvement equipment	Procurement of Equipment	- Vehicle-Mounted Drainage Pump (1~2 units)

Note: Components and contents requested for the Project had been confirmed in Minutes of Discussions, signed on April 28, 2016.

1.3 Natural Condition of the Project Area

1.3.1 Meteorological Phenomena

Meteorological data were collected from Pochentong Station which is managed by the Ministry of Water Resources and Meteorology (MOWRAM). Water level data of the Tonle Sap River from 2009 to 2013 were collected from Chaktomuk station and Phnom Penh Port station. The collected data are shown in **Fig. R 1.3.1** to **Fig. R 1.3.5** and **Table R 1.3.1**.

1.3.1.1 Rainfall

The daily rainfall data were collected from MOWRAM. The hourly rainfall data are not published and authorized due to lack of the credibility although MOWRAM have recorded the hourly rainfall data by automatic observation since 2012.

Average annual rainfall is approximately 1,490mm; however, the range of annual rainfall is wide, i.e., the maximum is 1,939mm (2008) and the minimum is 1,171mm (2006). The maximum annual rainfall for last nine years is recorded in 2008. Approximately 80% to 90% of annual rainfall is recorded in rainy season from May to November. Besides, the rainfall during rainy season is generally recorded more than 100mm per month. More than 200mm per month of rainfall have been recorded especially from August to October. The monthly rainfalls from December to April, which is dry season, are recorded less than 50mm per month.

1.3.1.2 Temperature and Humidity

Phnom Penh Capital City belongs to the monsoon climate zone. Annual average of maximum and minimum monthly temperature is respectively 33 and 22 degrees centigrade. Maximum monthly temperature was always more than 30 degrees centigrade, especially from March to May, the highest temperature persists. The highest temperature of maximum monthly temperature is 35.3 degrees centigrade, while the lowest temperature of minimum monthly temperature is 21.8 degrees centigrade. Annual average of humidity is 77 %, a typical climate of high-temperature and humidity is maintained all year round.

1.3.1.3 Water Level of Tonle Sap River

The highest water level of Tonle Sap River is generally recorded between August and October, beyond EL. +8.00. The lowest water level is recorded between March and May, below EL. +2.00. There is no particular tendency confirmed over the years, such as the continuous rise/decline of the highest/lowest water level. However, in recent years, the peak water level is slightly late, tending to become after October.

The highest and lowest water levels in the last 9 years were EL. +9.73 m in September 2001 and EL. +0.33 m at the Chaktomuk station in May 2005 at Chaktomuk station. The averages of annual highest and lowest water level at Chaktomuk station are EL. +8.70 m and EL. +0.68 m. The highest water level at Phnom Penh Port station in the last 10 years was EL. +9.84 m in 2011. The highest water level in the record was EL. +10.18 m at Chaktomuk station on 20 September 2000.

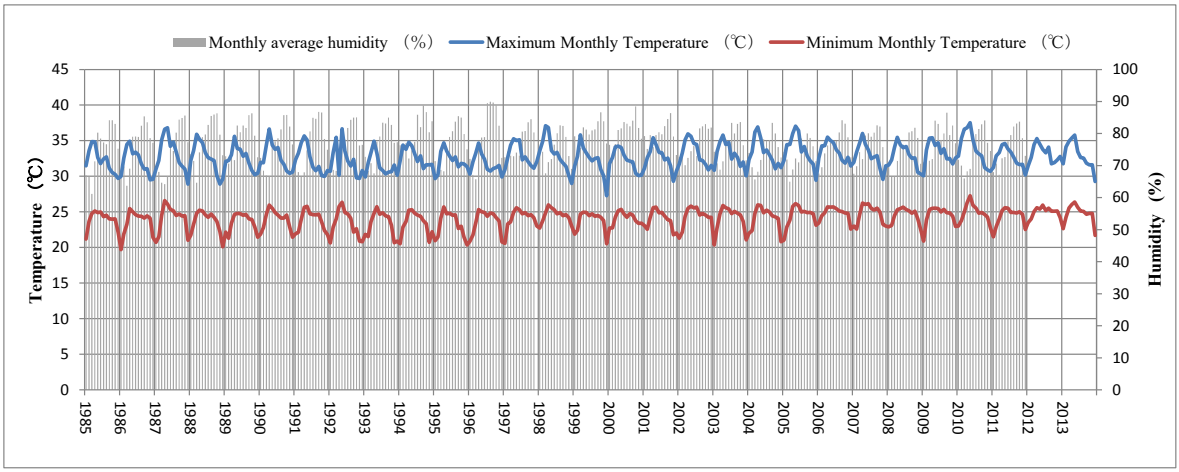


Fig. R 1.3.1 Maximum and Minimum Monthly Temperature and Monthly Average Humidity (From 1985 to 2013)

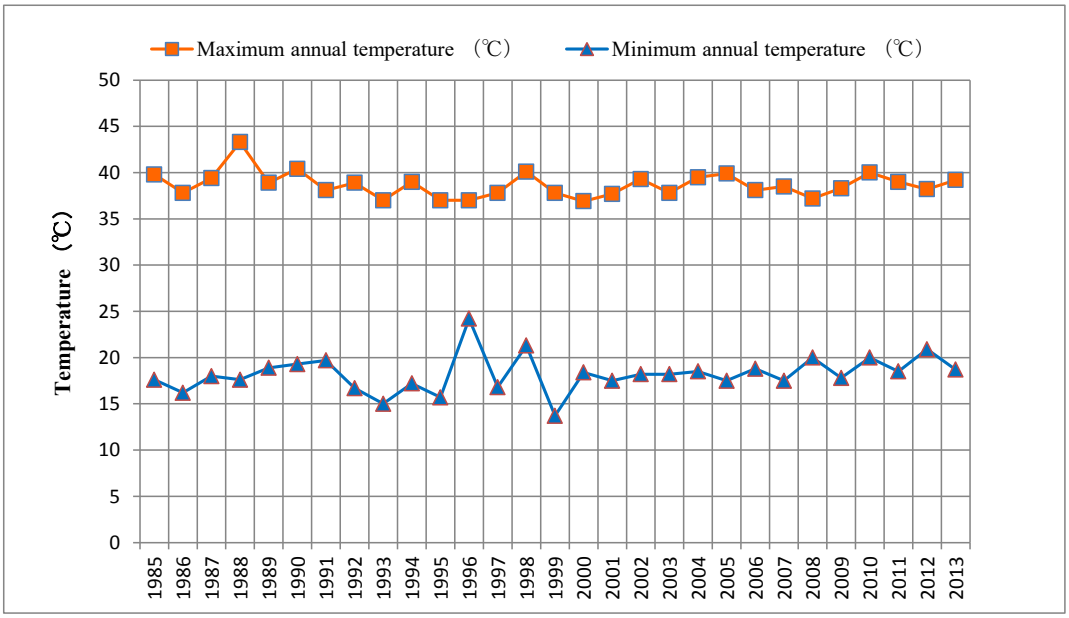


Fig. R 1.3.2 Maximum and Minimum Annual Temperature (From 1985 to 2013)

Table R 1.3.1 Monthly Rainfall (From 2004 to 2013)

Unit:mm/month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Season	Dry				Rainy							Dry	
2004	0.4	0.0	0.0	94.8	160.6	164.2	142.7	101.1	237.2	202.1	118.8	0.0	1221.9
2005	0.0	0.0	0.0	73.7	73.5	52.3	125.2	212.1	298.4	375.1	132.7	42.6	1385.6
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
Average	**19.0**	**8.1**	**35.0**	**101.8**	**127.7**	**149.1**	**166.8**	**186.7**	**272.4**	**244.0**	**130.2**	**46.3**	**1487.2**

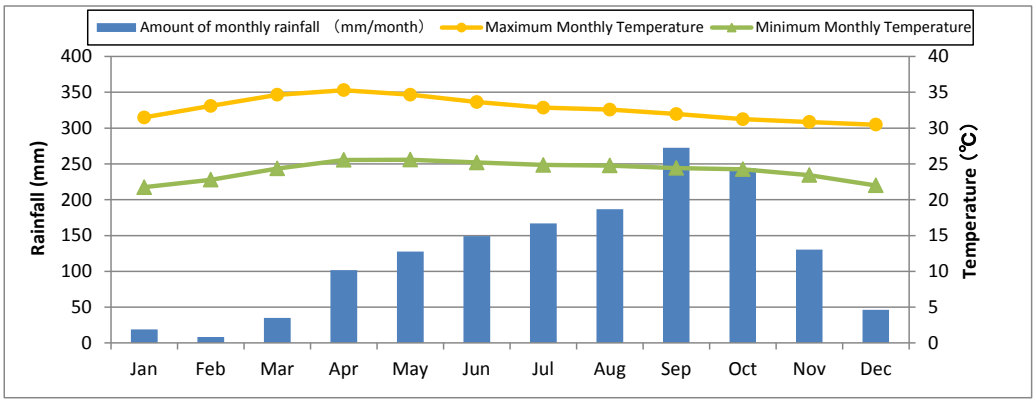


Fig. R 1.3.3 Average of Maximum and Minimum Monthly Temperature and Average of Monthly Rainfall (From 2004 to 2013)

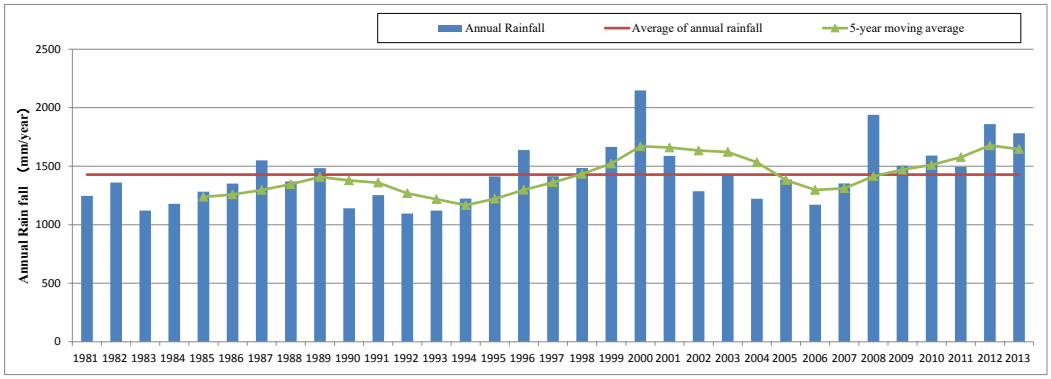


Fig. R 1.3.4 Annual Rainfall (From 1981 to 2013)

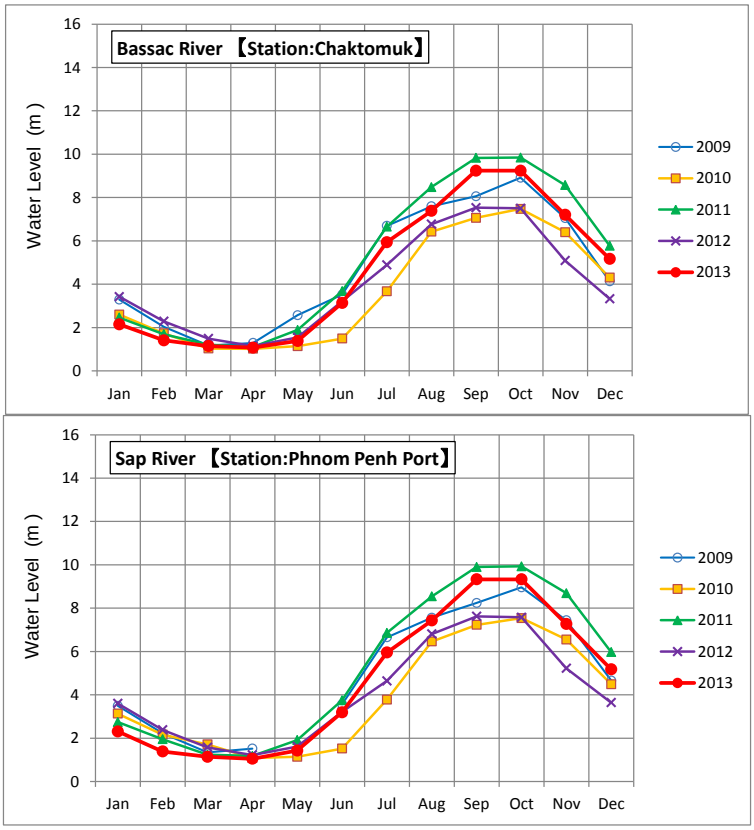


Fig. R 1.3.5 Water Level at Chaktomuk station and Phnom Penh Port Station (From 2009 to 2013)

1.3.2 Topography

The land of Cambodia is roughly divided into mountainous areas in the border area, the central plains formed by Mekong River and Tonle Sap River, and hilly areas distributed between those two areas. Most of economics, industries and societies are vitalized in central plains.

The Phnom Penh Capital City (PPCC) is located in alluvial lowland formed by Mekong River and Tonle Sap River, at the right bank of the confluence of Mekong River and Tonle Sap River, and at the fork of Mekong River and Bassac River. The central urban areas are located on the natural levee or in the surround by ring levee. The suburban residential area is located in swampy plains. There is Tamok Lake in north of outside of ring levee, Cheung Aek Lake in south, the rivers in east and low-lying land in west. The lakes and wetlands are scattered inside of ring levee such as Poung Peay Lake in north, Tumpun and Trabek Lakes in south.

1.3.2.1 Topographic Survey

Topographic surveys have been conducted to collect the basic data for the design and planning of drainage facilities and the supervision of construction work. The surveyed data (topography, location of existing drainage facilities, elevation) was used for simulation and modeling of drainage pipe network analysis. The conducted topographic surveys were as follows:

- Longitudinal profile and cross section survey of the roads along the planning drainage pipe lines and box culverts.
- Plan survey around the planning underground reservoir and pumping station.
- Elevation survey of existing manholes in Tuol Kork area and Wat Phnom northern area.

The summary of the survey is given in **Table R 1.3.2**, and the locations are as shown in **Fig. R 1.3.6** and **Fig. R 1.3.7**. The site conditions during the survey are as shown in **Photo R 1.3.1**.

Table R 1.3.2 Summary of Topographic Survey

Work Items	Survey Items	Quantities
Road	Longitudinal Profile	About 22.0 km
	Cross Section (L=20m)	About 440 sections
Underground reservoir Pumping station	Plan Survey	About 40,000 m^2
Manhole	Manhole elevation	About 250 points

Photo R 1.3.1 Site Condition during the Topographic Survey

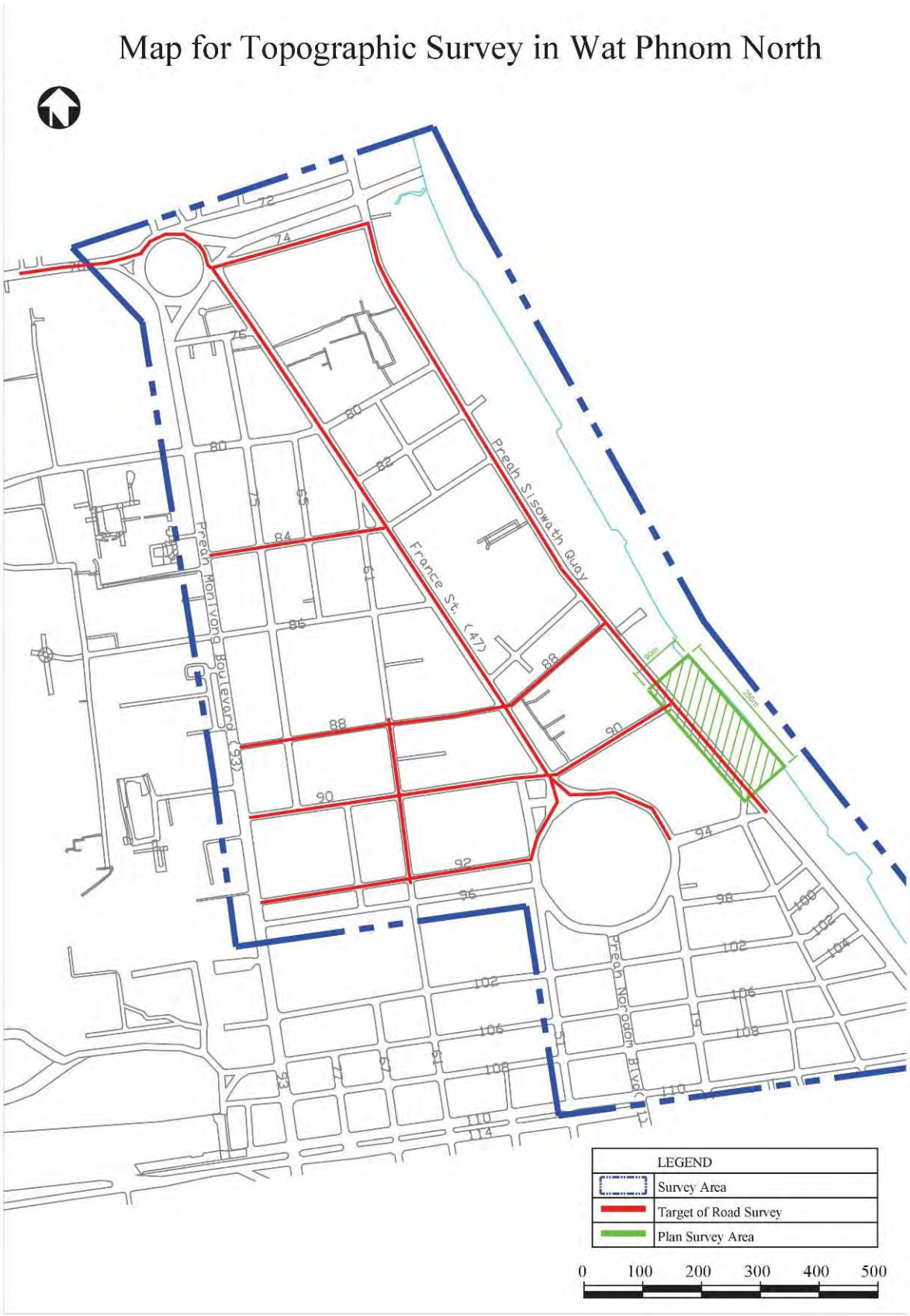


Fig. R 1.3.6 Locations Conducted Topographic Survey (Wat Phnom Northern Area)

Fig. R 1.3.7 Locations Conducted Topographic Survey (Tuol Kork Area)

1.3.2.2 Manhole Survey

The manhole survey was conducted at about 250 points in Wat Phnom northern area and Tuol Kork area. In addition, the data of manhole survey in Wat Phnom northern area, which was conducted in Phase II, was also utilized for design and planning. The manhole survey aimed to achieve the following:

- To ascertain the existing conditions of drainage networks for the hydraulic analysis by using Mike-Urban simulation
- To ascertain the conditions of solid waste, sludge and sediment in existing manhole. In addition, to ascertain drainage flow, and existences of connection pipes in existing manhole
- To collect the basic information for updating the data-base of existing drainage facilities, which is useful for operation and maintenance and rehabilitation planning

Target manholes were selected considering the following:

- The manhole which is located in necessary places for the modeling of hydraulic analysis
- The manhole which is located in the current flooding/inundation area
- The manhole which is located near alignment requested by PPCC
- The manhole which is located near alignment assumed at the beginning of Preparatory Survey

T the locations are as shown in **Fig. R 1.3.8** and **Fig. R 1.3.9**. The site conditions during the survey are as shown in **Photo R 1.3.2**.

Photo R 1.3.2 Site Condition during the Manhole Survey

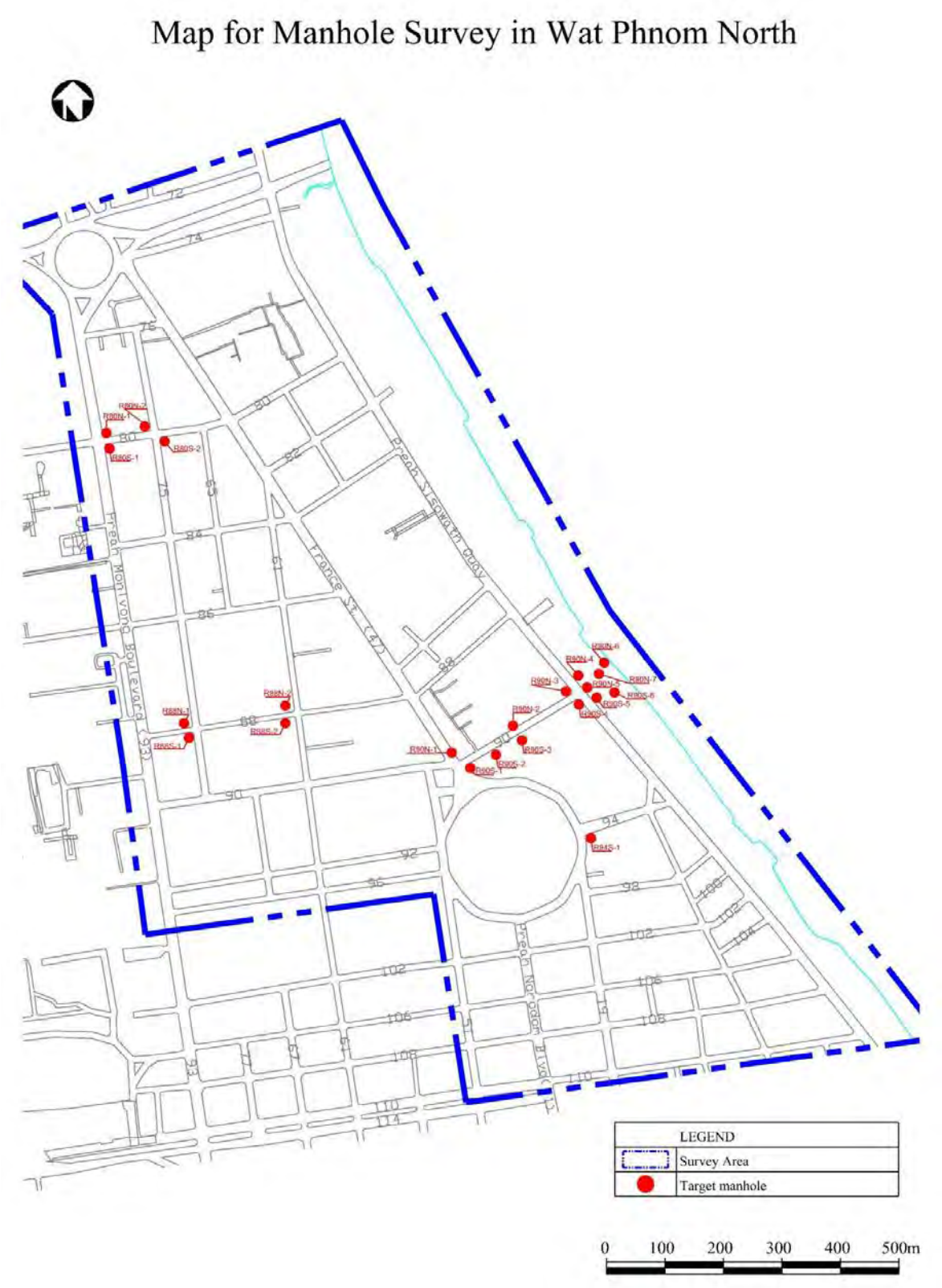


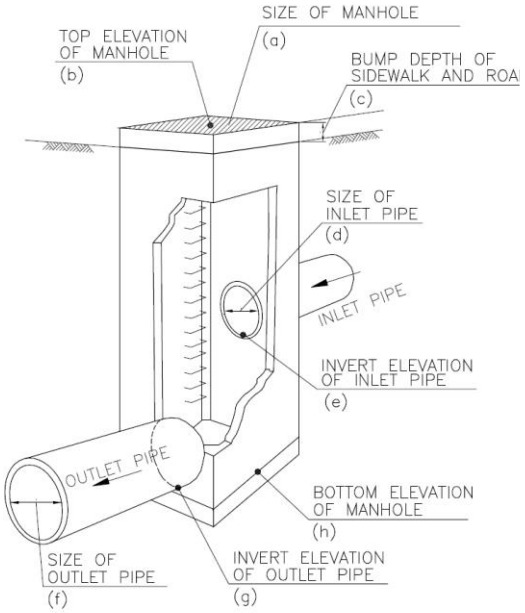
Fig. R 1.3.8 Locations Conducted Manhole Survey (Wat Phnom Northern Area)

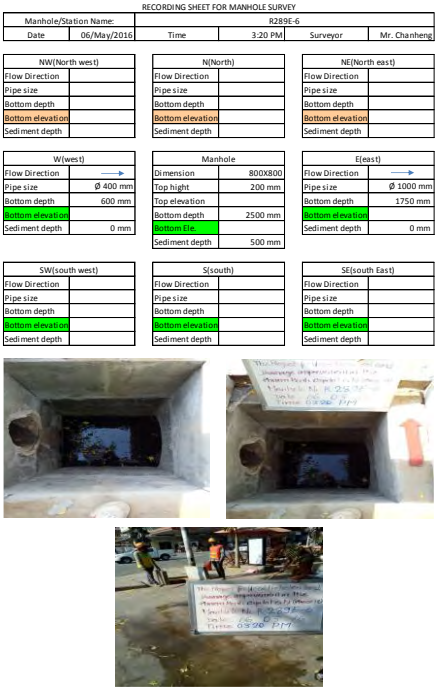
Fig. R 1.3.9 Locations Conducted Manhole Survey (Tuol Kork Area)

Surveyed items were shown in **Table R 1.3.3**. The data gathered from the surveyed manholes were recorded on a data sheet, as illustrated in **Fig. R 1.3.10** and **Fig. R 1.3.11**.

Table R 1.3.3 Manhole Survey Items

(1)	Size of manhole	(2)	Top elevation of manhole
(3)	Size of inlet pipe	(4)	Invert elevation of inlet pipe
(5)	Size of outlet pipe	(6)	Invert elevation of outlet pipe
(7)	Bottom elevation of manhole	(8)	Condition of manhole, pipe and sedimentation





RECORDING SHEET FOR MANHOLE SURVEY

Manhole/Station Name:		R289E-6			
Date	06/May/2016	Time	3:20 PM	Surveyor	Mr. Chanheng

NW(North west)	
Flow Direction	
Pipe size	
Bottom depth	
Bottom elevation	
Sediment depth	

N(North)	
Flow Direction	
Pipe size	
Bottom depth	
Bottom elevation	
Sediment depth	

NE(North east)	
Flow Direction	
Pipe size	
Bottom depth	
Bottom elevation	
Sediment depth	

W(west)	
Flow Direction	→
Pipe size	Ø 400 mm
Bottom depth	600 mm
Bottom elevation	
Sediment depth	0 mm

Manhole	
Dimension	800X800
Top hight	200 mm
Top elevation	
Bottom depth	2500 mm
Bottom Ele.	
Sediment depth	500 mm

E(east)	
Flow Direction	→
Pipe size	Ø 1000 mm
Bottom depth	1750 mm
Bottom elevation	
Sediment depth	0 mm

SW(south west)	
Flow Direction	
Pipe size	
Bottom depth	
Bottom elevation	
Sediment depth	

S(south)	
Flow Direction	
Pipe size	
Bottom depth	
Bottom elevation	
Sediment depth	

SE(south East)	
Flow Direction	
Pipe size	
Bottom depth	
Bottom elevation	
Sediment depth	

Source: JICA Survey Team

Fig. R 1.3.10 Surveyed Items of Manhole **Fig. R 1.3.11 Manhole Survey Sheet**

In addition, the photographs not only inside of manhole but also peripheral conditions were taken for design and planning at the time of manhole survey. The result of manhole survey was classified by catchment area and tidied survey sheet together with site photos.

1.3.2.3 Geological Survey

In order to ascertain the geological conditions necessary for designing and planning of pumping station and underground reservoir, machine boring and laboratory tests have been conducted at the planned sites of pumping station and underground reservoir in Wat Phnom northern area and Tuol Kork area. The locations of machine boring are shown in **Fig. R 1.3.12**. The result of geological survey was used for consideration of foundation form for pumping station and underground reservoir, and calculation of load bearing capacity for pile foundation.

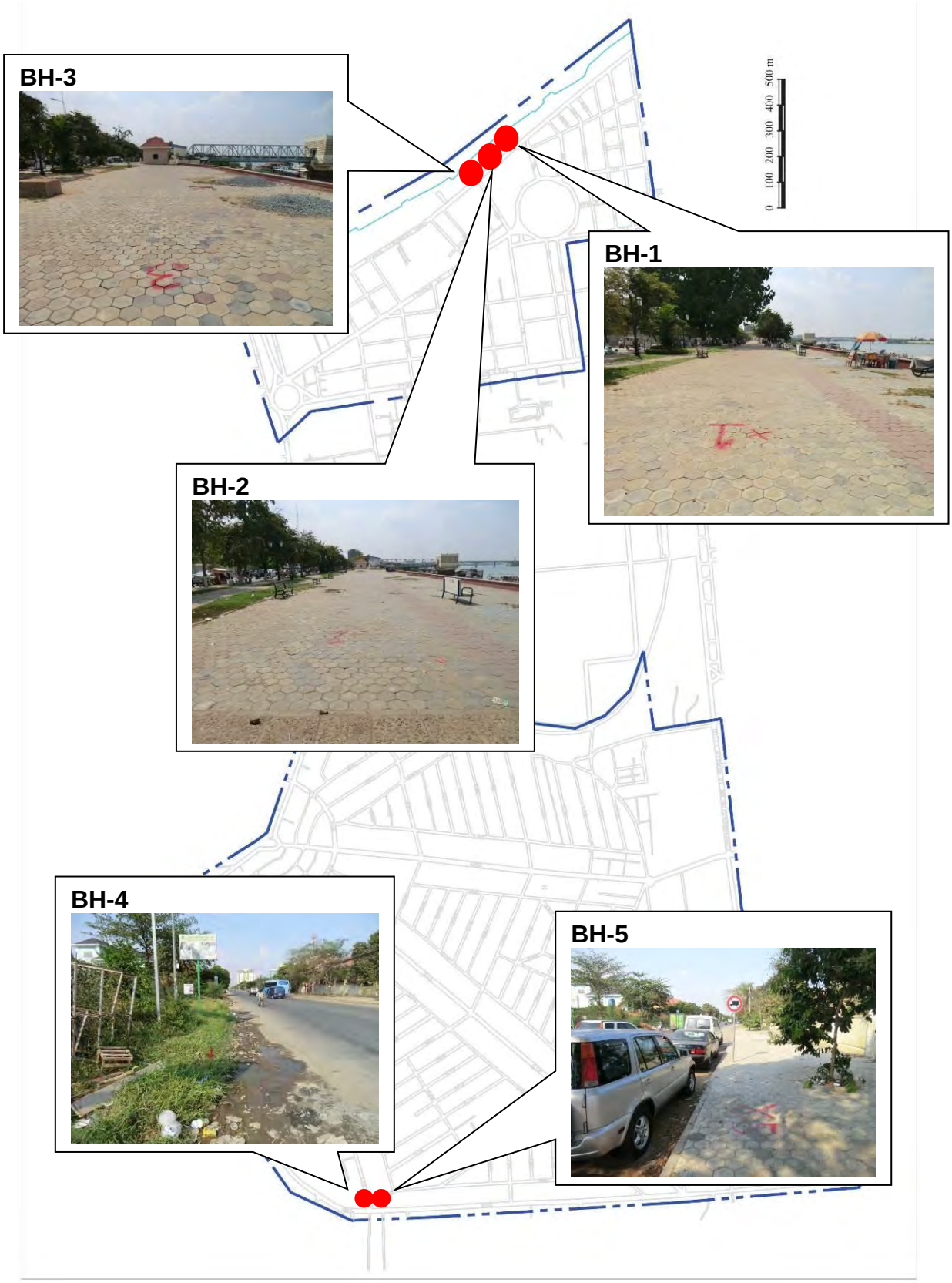


Fig. R 1.3.12 Locations of Machine Boring

(1) Machine Boring

Summary of machine boring is shown in **Table R 1.3.4**, site conditions during the boring ate shown in **Photo R 1.3.3**. During the drilling, four types of in-situ tests were conducted, and collected disturbed and undisturbed samples for laboratory tests.

Table R 1.3.4 Summary of Machine Boring

Item	Summary
Locations of boring	3 locations for underground reservoir (Wat Phnom northern area) 2 locations for pumping station (Tuol Kork area)
Specification of boring	Drilling depth; 35 m (position where more than 3m thickness with "N value" over 50) Boring Diameter; 66mm
In-situ test	(1) Standard Penetration Test (SPT) (2) Groundwater level survey (3) Sampling of every layer (4) Geological columns
Laboratory Test	(for Disturbed sample) ・Unit weight analysis ・Solid density ・Grain Size ・LL/PL Test ・Moisture Content (for Undisturbed sample) ・Consolidation test ・Direct shear test ・Unconfined compression test

Photo R 1.3.3 Site Condition during the Boring Survey

(2) Test Results

The distribution of N-value in the boreholes is shown in **Fig. R 1.3.13**.

(a) Wat Phnom Northern Area (BH-1, BH-2, BH-3)

The boreholes have sandy silty lean cray and sandy cray layer with the depth up to EL. -5.0m with a low N-value (0 – 20) below the topsoil. Then all boreholes encounter the hard layer with N-value of more than 50 (bearing layer) with the depth more than EL. -15.0m.

(b) Tuol Kork Area (BH-4, BH-5)

N-value shows about 20 with the depth more than EL. +5.0m, and is encountered more than 50 (bearing layer) with the depth more than EL. -5.0m in both boreholes.

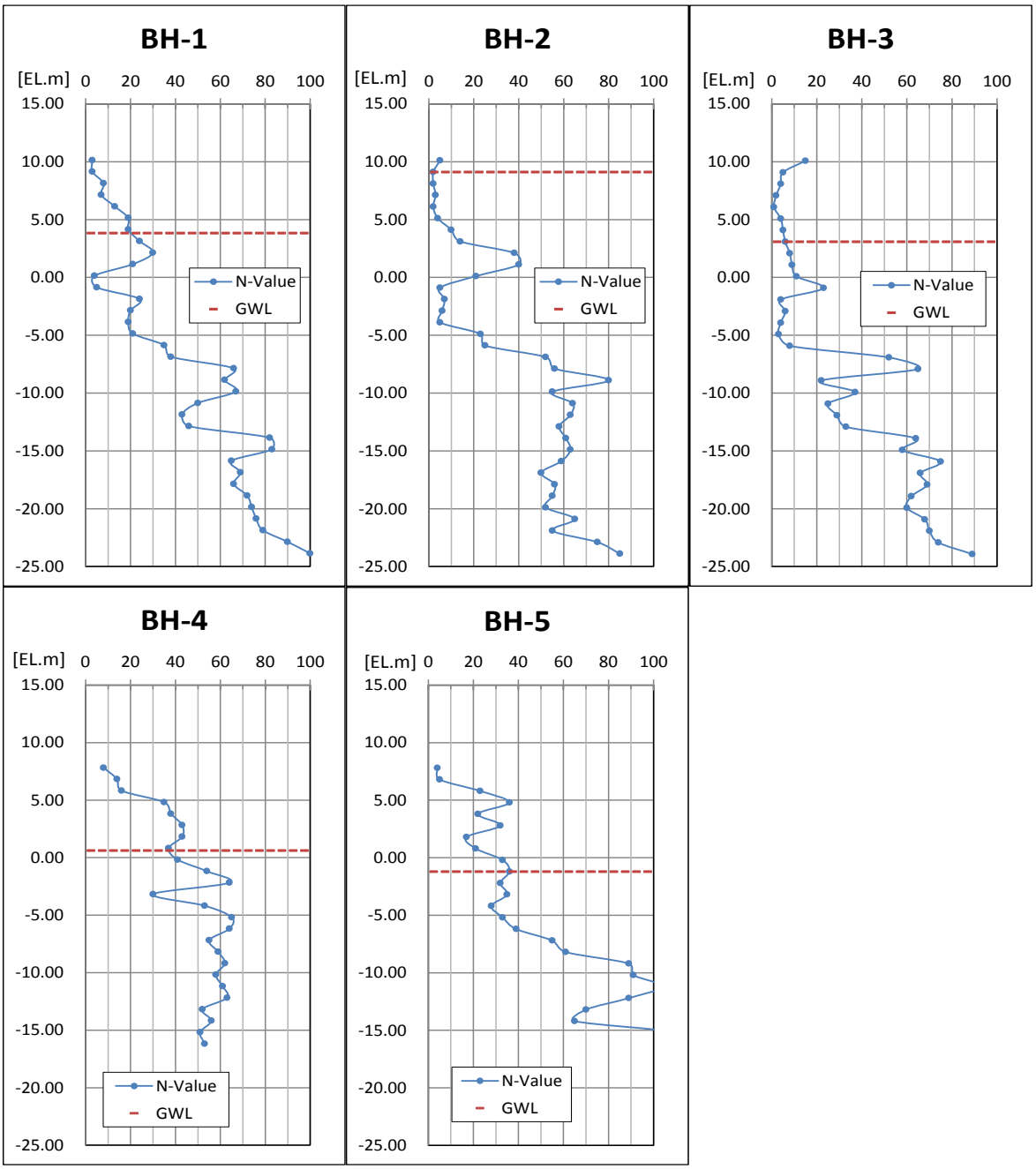


Fig. R 1.3.13 Distribution of N-value of Boreholes

1.3.2.4 Underground Facilities Survey and Test Excavation

(1) Data Collection of Underground Facilities

The survey was conducted with the aim of ascertaining the existing underground facilities might be obstacles to install new drainage pipes or box culverts in target areas. As shown in **Table R 1.3.5**, there are six types of underground facilities such as drainage pipe, water supply pipe, electric cable, telephone cable, television and optical cable, are laying in Phnom Penh City. The JICA Survey Team called management authorities of each underground facilities, and explained the outline of the Project, then collected necessary information and data of existing underground facilities.

Table R 1.3.5 Management Authorities of Underground Facilities

Underground Facility	Public / Private	Management Authority
Drainage pipe	Public	Department of Public Works and Transport (DPWT)
	Public	District Offices
Water supply pipe	Public	Phnom Penh Water Supply Authority (PPWSA)
Electric cable	Public	Electricité du Cambodge (EDC)
Telephone cable	Public	Telecom Cambodia
	Private	Camintel
Television	Private	PPFO TV
Optical cable	Private	Cambodia Fiber Optic Communication Network (CFOCN)

Among the collected data, only the drawing of transmission pipeline (Diameter 1,200mm) of PPWSA is mentioned detailed and exact locations of facilities while other drawings are mentioned only rough locations. It was difficult to grasp detailed location and depth of existing underground facilities from the collected data.

(2) Test Excavation

All newly drainage pipes and box culverts, which will be constructed in the Project, are to be installed under the public roads which also include traversal on main traffic frequent roads. When designing a pipeline without grasping the exact locations of existing underground facilities, it might be happened the unexpected discrepancy in designed locations at the time of construction stage. Therefore, it may need a change of alignment and depth of pipelines which will affect the extra construction cost and duration. For the purpose of avoiding the difference between design stage and construction stage, the test excavation was conducted in five locations where there are expected important underground facilities within the designed pipeline. Test excavation was conducted from May 16 to 20 2016, the locations are shown in **Fig. R 1.3.14**.

It was clarified underground condition at major and important locations through this test excavation. However, the total length of test excavation is too short, less than 1% of planned drainage pipeline length. Therefore, is necessary for contractor to carry out test digging in all designed locations of pipeline before implementing the installation work, and to ascertain the accurate location and depth of each facility.

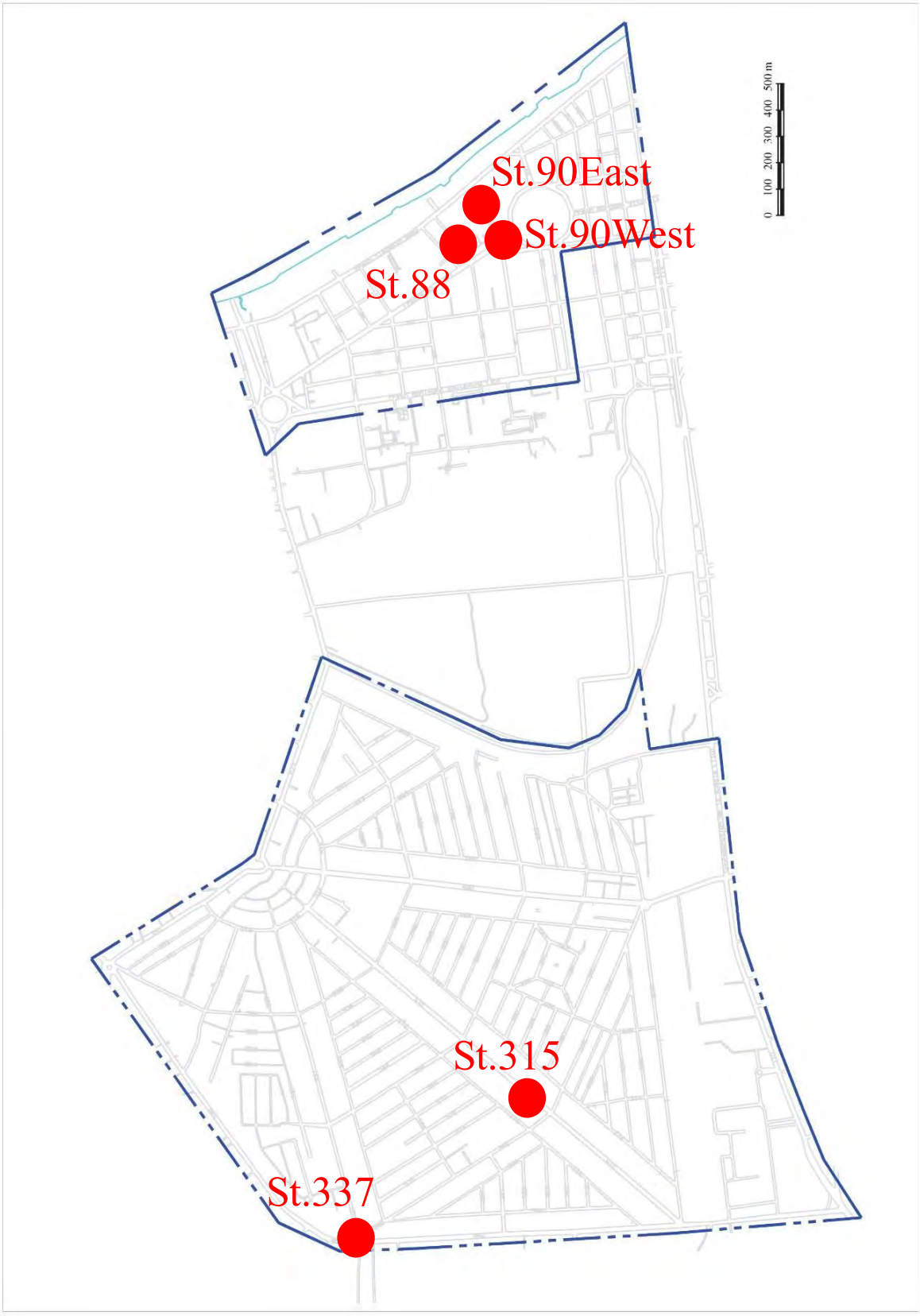


Fig. R 1.3.14 Location of Test Excavation Site

(a) Drainage Pipe

Data on the existing drainage system has been collected from DPWT. However, the data on the DPWT drawing do not show the minor drainage line laid by the district offices. The existing major drainage line has been laid underneath the walkway along the main road, basically. However, these drainage pipelines often run across the branch roads. As the basic policy of design, the existing drainage pipe will be left in the ground, and new pipe will be installed.

Therefore, if the newly designed drainage pipes will intersect with these existing drainage pipes, the alignment and elevation of the new pipeline have to be examined carefully prior to the completion of detail design work.

(b) Water Supply Pipe

Data on the water supply network has been obtained from the Phnom Penh Water Supply Authority (PPWSA). The drinking water treated in the treatment plant at PPWSA is distributed to the entire city area through the complicated pipe network. There is an intake facility in Tonle Sap River around the Wat Phnom northern area. Transmission pipes are laid from intake to treatment plant. Especially, transmission pipes which were installed in 1964, have two alignments which are laid in St.90 and St.88. There are no drawings and data of these transmission pipes because of their age. Therefore, test excavation was conducted in these roads, St.90 and St.88. Distribution pipe which is diameter of 900mm is laid in St.315 around Tuol Kork area. Test excavation was also conducted in St.315.

In case that the new drainage pipeline will run across a road, the driving of steel sheet piles for the temporary retaining wall and the excavation works have to be carefully executed to avoid accidents. The precise alignment and elevation of the piles also have to be checked.

(c) Electric Cable

Data on electric cables has been obtained from the Electricite du Cambodge (EDC). Electric cables consist of a high-voltage power cable distributing power to each sub-station and a low-voltage power cable distributing power to each household. In case of high-voltage power cable, the cables are laid with the depth of 0.9m in paved road, and with the depth of 0.7m in sidewalk. On the other hand, low-voltage power cables are laid with the depth 0.5m – 0.8m in sidewalk, and are laid with overhead lines in some places.

These electric cables are not serious obstructions to the drainage pipe installation work in the Project. If new drainage pipes will interfere with the electric cables, the cables should be relocated. The driving of steel sheet piles for the temporary retaining wall and the excavation works have to be carefully executed to avoid accidents. The precise alignment and elevation of the cables also have to be checked.

(d) Telephone Cable

Data on the telephone cables has been obtained from Telecom Cambodia. The telephone cables are laid along the sidewalk basically within 1.0m depth from the ground level. Therefore, these telephone cables will not be a serious obstruction to the new drainage construction work in the Project. However, major telephone cables are installed in St.315

of Tuol Kork area. The test digging in advance is needed in order to confirm the exact locations and depth of the telephone cables.

(e) Television

The television cables for Cable TV are owned by PPFO TV (a private company). The television cables are laid under sidewalk within 1.0m depth from the ground level. Therefore, the television cables will not seriously obstruct the new drainage pipe construction work in the Project.

(f) Optical Cable

Data on the optical cable laid in Phnom Penh Capital City has been obtained from the Cambodia Fiber Optic Communication Network Co., Ltd. (CFOCN). According to CFOCN, the optical cables bundled into 8 pieces of two layers (4 pieces per layer) inside PVC pipes are laid basically under the sidewalk at a maximum depth of 1.0m.

However, in cases where the PPCC did not approve the excavation and laying of optical cables across a busy road, the drilling method of laying optical cables across the road between the manholes at opposite sides of the sidewalk was adopted. The depth for laying optical cables in the center of road is estimated to be 4m to 5m.

In case that the new drainage pipes encounter an optical cable across a road, the cable will be lifted up and relocated in order to excavate the trench for the installation of the new drainage pipes. However, prolonged and costly relocation work of the optical cables or design change of the drainage pipes have to be executed if optical cables installed by drilling method at the busy intersections obstruct the drainage pipe alignment.

Consequently, when the new drainage pipes will intersect with these optical cables, the alignment and elevation of the cable have to be examined carefully prior to the commencement of the construction work. In addition, test digging works before the installation of pipes at all sites have to be executed, although collected information regarding underground facilities can be adopted for all drainage pipe designs because length of test excavation pit and resulting information from the test excavation is very limited. If the new drain pipe and optical cables interfere with each other, discussion with CFOCN is needed to take appropriate measures.

1.3.2.5 Inundation Condition Survey (Social and Environmental Survey)

(1) Purpose of the Survey

The objective of the survey was to clarify the present environmental and social conditions and inundation conditions in and around the Project target areas, and to grasp the improvement condition from inundation damages in past Japan Grant Projects. The result was contributed to consideration of placement and size of facilities in the target area, construction plan, examination of matters concerning environmental and social condition and evaluation of the past projects.

(2) Methods

(a) General

The JICA Survey Team had sublet the survey to an appropriate survey team. The contents of the survey in each survey area are shown in the table below.

Table R 1.3.6 Items for the Project Requested by the Government of Cambodia

Project Area	Survey Area	Survey to be Done
Phase IV (the Project)	Wat Phnom Northern area, Tuol Kork area	- Interview to Sangkat Chiefs - Interview to Households (170)
Phase II, III	Central Market area, Royal Palace & National Museum area, Trabek basin & adjacent area	- Interview to Households (130)

(b) Interview with Sangkat Chiefs (Interview-1)

Items of questions of interview survey to the Sangkat chiefs in the area were 1) Location of inundated road, inundated length and its inundation level; 2) Location and length of existing drainage pipes; and 3) Desired location to improve the drainage condition in the Sangkat. Six Sangkats were subjected to be interviewed. Interview survey was also conducted to DPWT in the same manner.

(c) Interview with Households (Interview-2)

300 households were interviewed. Among 300 households, interviews of 170 households were conducted in the Project target area and 130 households were in the project area of Phase II and Phase III. In the Project area, 170 households were randomly extracted in heavy flooding area based on the results of interview survey with Sangkat chiefs and DPWT. In Phase II and Phase III project area, 130 households were extracted near drainage facilities constructed in Phase II and Phase III. Area of interview survey with household is shown in **Fig. R 1.3.15**.

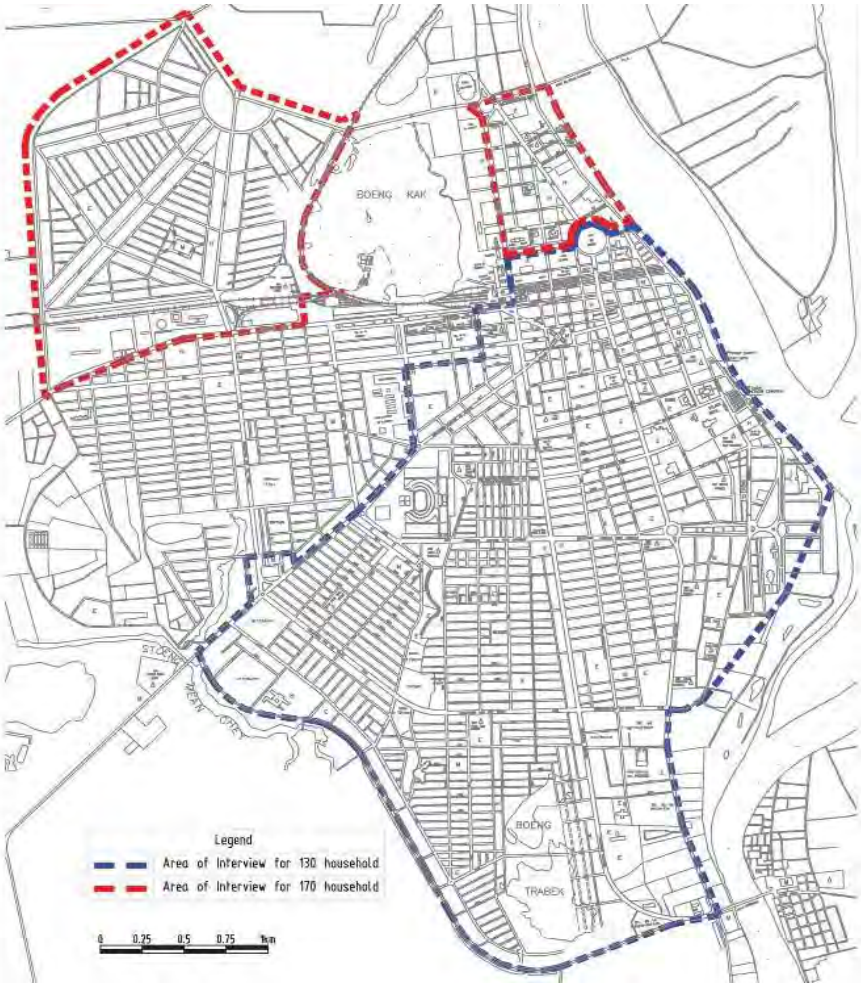


Fig. R 1.3.15 Survey Area for Interview with Household (Interview-2)

The interview items were as follows:

(i) General Question

These questions included the type of interviewee, address, employment of the house master, number of persons staying in the house and dwelling years at the place, type of dwelling, rental cost of dwelling if rented, monthly household expenditure, and previous land use of their house space.

(ii) Questions on Inundation Situation

These questions included the experiences of flooding in front of house, frequency of flooding, depth and duration of flood.

(iii) Questions on Sanitary Condition

These questions included the problems encountered after flooding, disposal method of night soil, and disease experienced after flooding.

(iv) Questions on Social Considerations

These questions included the opinions on drainage improvement project in front of house, expectation for the Project, and reasons for objection of the Project, if opposed.

(v) Question on Effects of Projects Phase II and Phase III

These questions included the effects of Project Phase II and Phase III, how the effects are; frequency of food, depth and duration of flood.

Photo R 1.3.4 Interview with Household

(3) Results

(a) Interview with Sangkat Chiefs and DPWT

The major interview results are as follows and all of the results are shown in **Fig. R 1.3.16**.

- St.317 and part of St.592 in Tuol Kork area have inundation damages
- St.283, St.285, St.287 and part of St.528 in Tuol Kork area have inundation damages.
- St.47, St.88, St.90 and around Wat Phnom in Wat Phnom northern area have inundation damages.

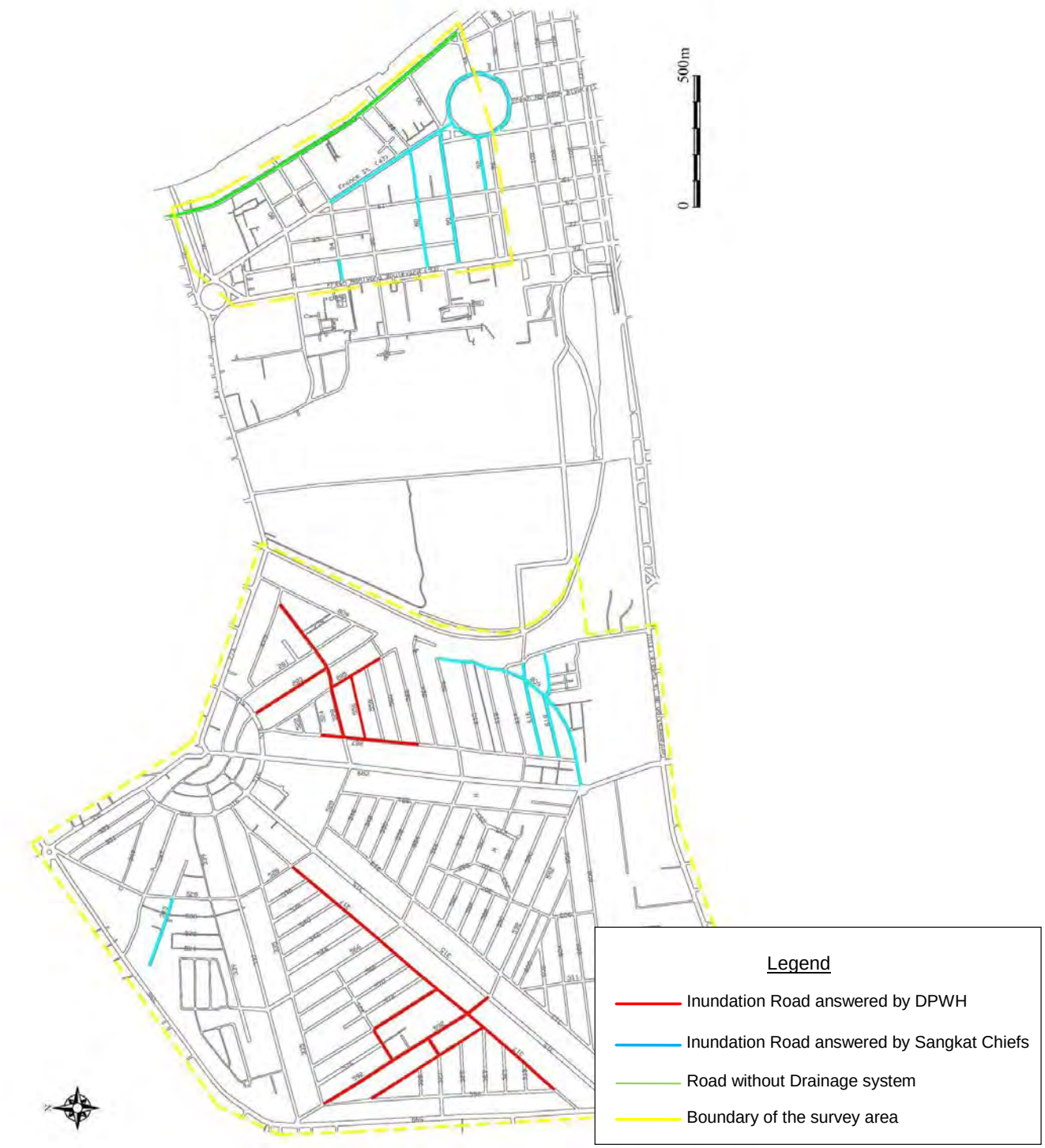


Fig. R 1.3.16 Results of Interview with Sangkat Chiefs and DPWT (Interview-1)

(b) Interview with Households (170 Households, target area of the Project)

(i) General Questions

Survey results for general questions are shown in **Table R 1.3.7** to **Table R 1.3.12**. The number of housewives is the largest among the interviewees. Masters' occupations are mostly in tertiary industries. As shown in **Table R 1.3.9** and **Table R 1.3.10**, the households of interviewees consist of a large number of families and have lived in their houses for a long period. Some 3 in 4 houses are owned. As shown in **Table R 1.3.12**, about 40 percent of interviewees are living with less than 500 USD per month of expenditure.

Table R 1.3.7 Number and Type of Interviewees

Type	Housewife	Master	Children	Other House Members	Housekeeper	Others	Total
Number of Respondents	94	15	24	14	16	7	170
Weight (%)	55.3	8.8	14.1	8.2	9.4	4.2	100

Table R 1.3.8 Number of Masters and Employment Type

Type	Primary Industry	Secondary Industry	Tertiary Industry	Pensioner (Retired)	Unemployed	Others	Total
Number of Respondents	1	7	115	11	12	24	170
Weight (%)	0.6	4.1	67.6	6.5	7.1	14.1	100

Table R 1.3.9 Number of Persons Staying in the House

No. of Persons	1	2	3	4	5	6	7	More than 8	Total
Number of Respondents	0	4	15	27	28	22	17	52	165
Weight (%)	0.0	2.4	8.8	15.9	16.5	12.9	10.0	30.6	97.1

Table R 1.3.10 Number of Persons Staying in the House

Period (Year)	Less than 5	5 to 9	10 to 19	20 or more	No Answer	Total
Number of Respondents	36	37	26	68	3	170
Weight (%)	21.2	21.8	15.3	40.0	1.7	100

Table R 1.3.11 Number of Type of Dwelling

Type	Own House	Rental	No Answer	Total
Number of Respondents	132	33	5	170
Weight (%)	77.6	19.4	3.0	100

Table R 1.3.12 Expenditure of Household (USD per month)

Type	100 or less	101-200	201-500	501-1000	1001-2000	2001 or more	Total
Number of Respondents	3	6	53	70	33	5	170
Weight (%)	1.8	3.5	31.2	41.2	19.4	2.9	100

(ii) Questions on Inundation Situation

Some 136 respondents corresponding to 80 percent of the total number of interviewees replied that they had experienced flooding in front of their houses. About 93 percent of interviewees who had experienced flooding in front of their houses mentioned that flooding frequently occurs multiple times in a year, as shown in **Table R 1.3.14**.

The experienced flood depth ranges from ankle to waist deep. Around 80 percent of the interviewees who had experienced flooding mentioned that the depth was up to the shin (approximately 20cm) or higher. The experienced flood duration ranged from less than 30 minutes to 1 day. Around 63 percent of the interviewees who experienced flooding mentioned that the duration was longer than 2 or 3 hours.

Table R 1.3.13 Experience of Flooding in Front of House

Answer	Yes	No	Do not know	Total
Number of Respondents	136	25	9	170
Weight (%)	80.0	14.7	5.3	100

Table R 1.3.14 Frequency of Flooding

Type	Once in 2–3 years	Once a year	2–3 times a year	More than 4 times a year	Others	Do not know	Total
Number of Respondents	1	4	50	81	0	9	170
Weight (%)	0.7	2.8	34.5	55.9	0.0	6.1	100

Table R 1.3.15 Depths of Flood

Type	Up to ankle	Up to shin	Up to knee	Up to thigh	Up to waist	Higher than waist	Do not know	Total
Number of Respondents	23	65	40	7	1	0	9	145
Weight (%)	15.9	44.8	27.6	4.8	0.7	0.0	6.2	100

Table R 1.3.16 Durations of Flood

Duration	Less than 30 min.	30 min. to 1 hour	2-3 hours	Around 4-6 hours	Almost half day	1 day	More than 1 day	Do not know	Total
Number of Respondents	8	46	53	4	1	17	7	9	145
Weight (%)	5.5	31.7	36.6	2.8	0.7	11.7	4.8	6.2	100

No.	Conditions
(1)	All of the interviewees replied that flood inundation frequency is more than 4 times a year.
(2)	Half or more interviewees replied that inundation depth is higher than the shin.
(3)	Half or more interviewees replied that inundation duration is longer than 2 or 3 hours.

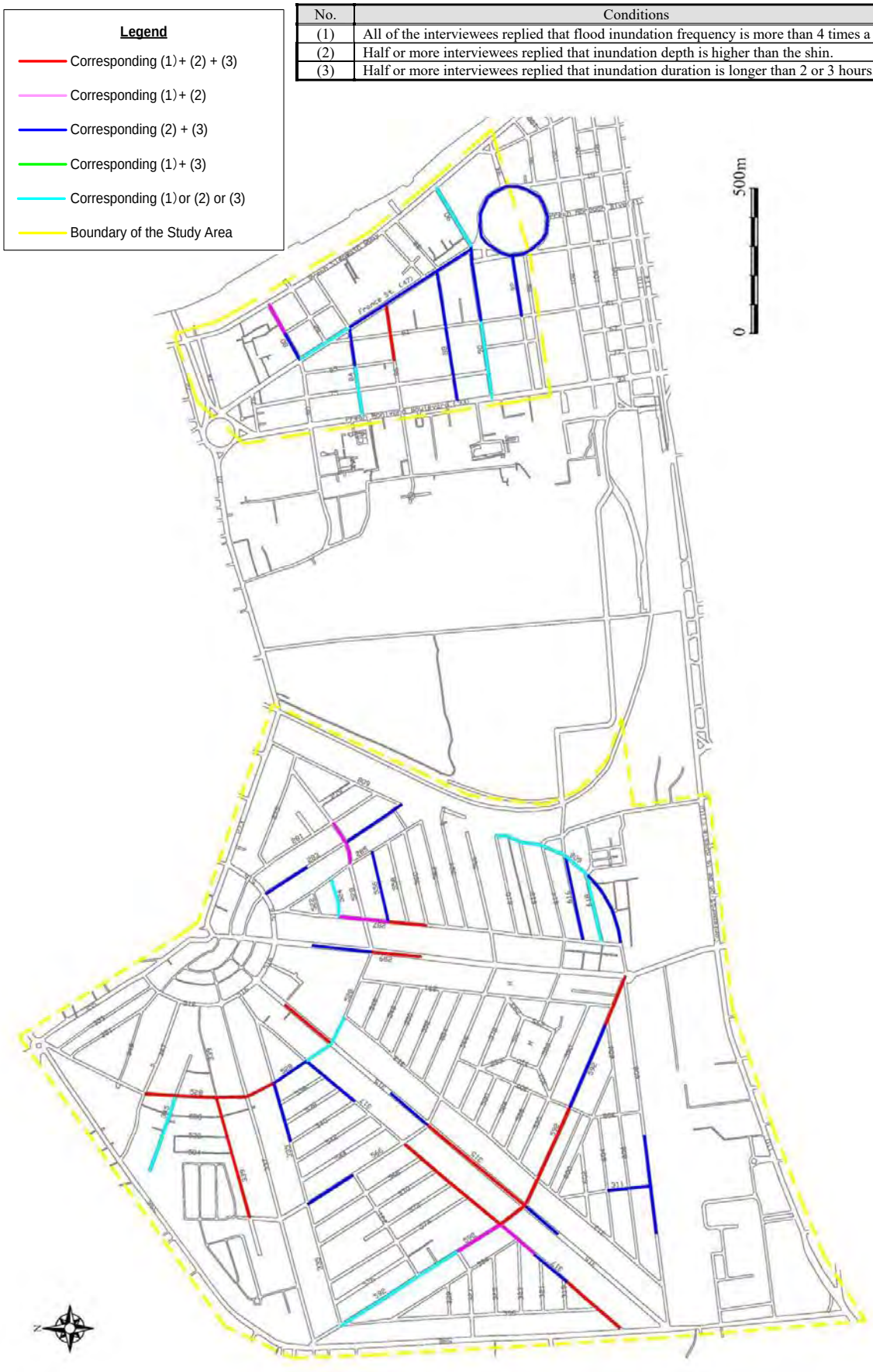


Fig. R 1.3.17 Results of Interview with Households (Interview-2, the Project Area)

(iii) Questions on Sanitary Condition

Some 77 percent of the interviewees replied that they had some problems after a flood. Most of the problems concern the smell in their houses and the disturbance of their businesses and daily living environment. The problems regarding family health include skin diseases, influenza, diarrhea, typhoid fever and dysentery. Regarding the disposal method of night soil, 87 percent of it flow into the drainage pipes.

Table R 1.3.17 Problems after Flood

Answer	Yes	No	No answer	Total
No. of Respondents	130	40	0	170
Weight (%)	76.5	23.5	0.0	100

Table R 1.3.18 Occurrence of Diseases in Family after Flood

Type	Skin Disease	Flu	Food Poisoning	Diarrhea	Typhoid	Dysentery	Total
No. of Respondents	55	78	2	31	10	19	195

Table R 1.3.19 Disposal Method of Night Soil

Answer	No treatment (defecate in backyard)	Septic Tank	Flow into drainage pipe	Others	Do not know	Total
No. of Respondents	0	8	147	3	12	170
Weight (%)	0.0	4.7	86.5	1.8	7.0	100

(iv) Questions on Social Considerations

About 75 percent of the interviewees replied that they agree with the drainage improvement even if the project requires construction works in front of their houses.

Table R 1.3.20 Opinions on Drainage Improvement Project in front of Houses

Answer	Agree	Disagree	Do not know	Total
No. of Respondents	128	42	0	170
Weight (%)	75.3	24.7	0.0	100

Table R 1.3.21 Opinions on Construction Work for Project in front of Houses

Answer	Agree	Disagree	Do not know	Total
No. of Respondents	127	1	0	128
Weight (%)	99.2	0.8	0	100

(c) Interview with Households (130 Households, Phase II, Phase III target area)

(i) General Questions

Survey results for general questions are shown in **Table R 1.3.22** to **Table R 1.3.27**. The number of housewives is the largest among the interviewees. Masters' occupations are mostly in tertiary industries. As shown in **Table R 1.3.24** and **Table R 1.3.25**, the households of interviewees consist of 4 - 6 persons and have lived in their houses for a long period. About 65 percent houses are owned. As shown in **Table R 1.3.27**, about 30 percent of interviewees are living with less than 500 USD per month of expenditure.

Table R 1.3.22 Number and Type of Interviewees

Type	Housewife	Master	Children	Other House Members	Housekeeper	Others	Total
Number of Respondents	92	4	8	12	0	14	130
Weight (%)	70.8	3.1	6.1	9.2	0.0	10.8	100

Table R 1.3.23 Number of Masters and Employment Type

Type	Primary Industry	Secondary Industry	Tertiary Industry	Pensioner (Retired)	Unemployed	Others	Total
Number of Respondents	0	21	99	4	3	3	130
Weight (%)	0.0	16.2	76.2	3.1	2.3	2.3	100

Table R 1.3.24 Number of Persons Staying in the House

No. of Persons	1	2	3	4	5	6	7	More than 8	Total
Number of Respondents	2	11	10	26	27	23	6	25	130
Weight (%)	1.5	8.5	7.7	20.0	20.8	17.7	4.6	19.2	100

Table R 1.3.25 Number of Persons Staying in the House

Period (Year)	Less than 5	5 to 9	10 to 19	20 or more	No Answer	Total
Number of Respondents	32	20	32	46	0	130
Weight (%)	24.6	15.4	24.6	35.4	0.0	100

Table R 1.3.26 Number of Type of Dwelling

Type	Own House	Rental	No Answer	Total
Number of Respondents	85	42	3	130
Weight (%)	65.4	32.3	2.3	100

Table R 1.3.27 Expenditure of Household (USD per month)

Type	100 or less	101-200	201-500	501-1000	1001-2000	2001or more	計
Number of Respondents	0	5	34	41	37	9	126
Weight (%)	0.0	3.8	26.2	31.5	28.5	6.9	96.9

(ii) Questions on Inundation Situation

Some 108 respondents corresponding to 83 percent of the total number of interviewees replied that they had experienced flooding in front of their houses. About 97 percent of interviewees who had experienced flooding in front of their houses mentioned that flooding frequently occurs multiple times in a year, as shown in **Table R 1.3.29**.

The experienced flood depth ranges from ankle to waist deep. Around 80 percent of the interviewees who had experienced flooding mentioned that the depth was up to the shin (approximately 20cm) or higher. The experienced flood duration ranged from less than 30 minutes to 4-6 hours. Around 65 percent of the interviewees who experienced flooding mentioned that the duration was only less than 1 hour.

Table R 1.3.28 Experience of Flooding in Front of House

Answer	Yes	No	Do not know	Total
Number of Respondents	108	21	1	130
Weight (%)	83.1	16.1	0.8	100

Table R 1.3.29 Frequency of Flooding

Type	Once in 2–3 years	Once a year	2–3 times a year	More than 4 times a year	Others	Do not know	Total
Number of Respondents	1	0	23	82	2	0	108
Weight (%)	0.9	0.0	21.3	75.9	1.9	0.0	100

Table R 1.3.30 Depths of Flood

Type	Up to ankle	Up to shin	Up to knee	Up to thigh	Up to waist	Higher than waist	Do not know	Total
Number of Respondents	22	43	32	8	2	0	1	108
Weight (%)	20.4	39.8	29.6	7.4	1.9	0.0	0.9	100

Table R 1.3.31 Durations of Flood

Duration	Less than 30 min.	30 min. to 1 hour	2-3 hours	Around 4-6 hours	Almost half day	1 day	More than 1 day	Do not know	Total
Number of Respondents	19	51	28	9	0	0	0	1	108
Weight (%)	17.6	47.3	25.9	8.3	0.0	0.0	0.0	0.9	100

No.	Conditions
(1)	All of the interviewees replied that flood inundation frequency is more than 4 times a year.
(2)	Half or more interviewees replied that inundation depth is higher than the shin.
(3)	Half or more interviewees replied that inundation duration is longer than 2 or 3 hours.

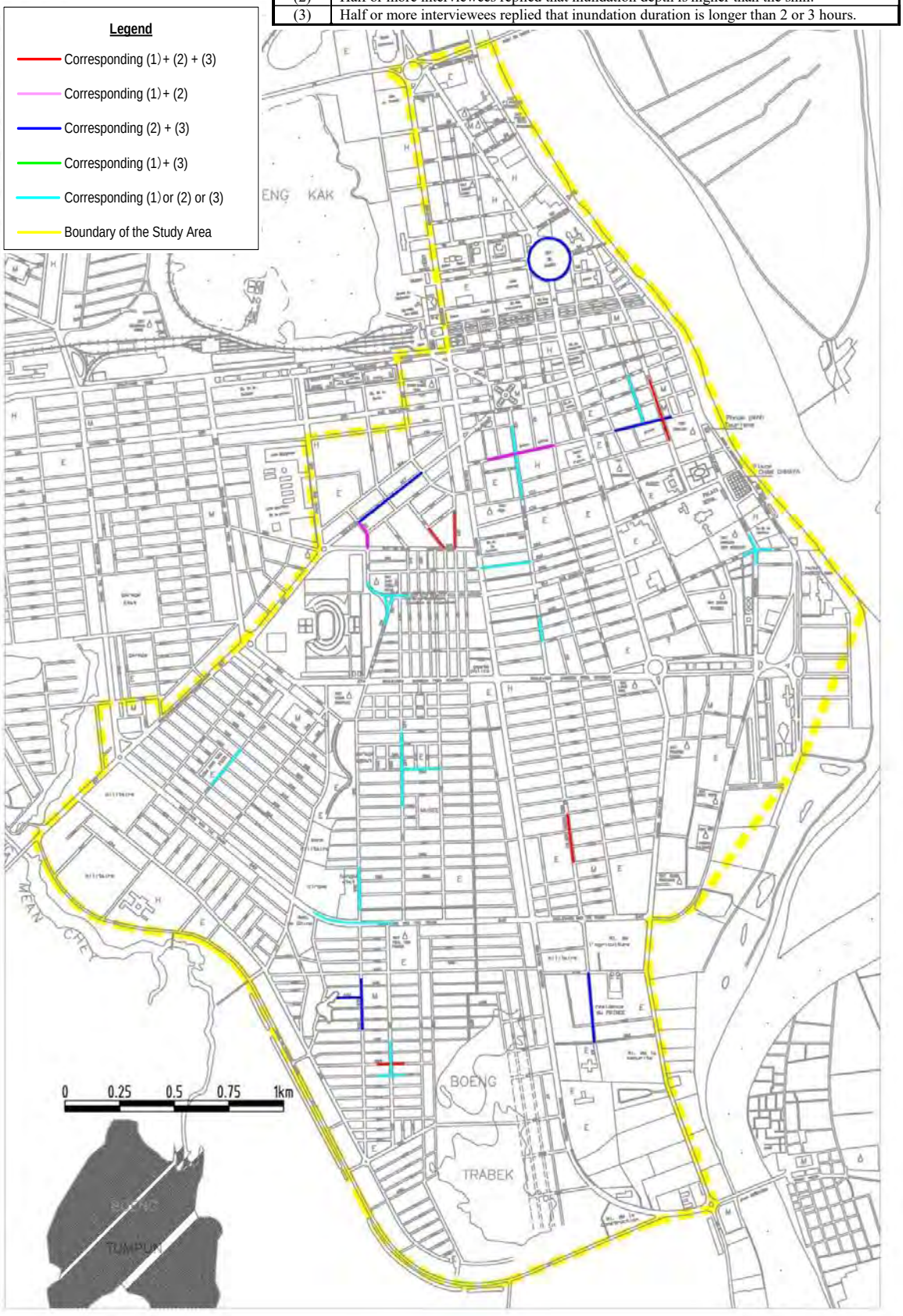


Fig. R 1.3.18 Results of Interview with Households (Interview-2, Phase II, Phase III Area)

(iii) Questions on Sanitary Condition

Some 72 percent of the interviewees replied that they had some problems after a flood. Most of the problems concern the smell in their houses and the disturbance of their businesses and daily living environment. The problems regarding family health include skin diseases, influenza, diarrhea, typhoid fever and dysentery. Regarding the disposal method of night soil, 59 percent of it flow into the drainage pipes.

Table R 1.3.32 Problems after Flood

Answer	Yes	No	No answer	Total
No. of Respondents	94	36	0	130
Weight (%)	72.3	27.7	0.0	100

Table R 1.3.33 Occurrence of Diseases in Family after Flood

Type	Skin Disease	Flu	Food Poisoning	Diarrhea	Typhoid	Dysentery	Total
No. of Respondents	29	26	4	6	1	2	68

Table R 1.3.34 Disposal Method of Night Soil

Answer	No treatment (defecate in backyard)	Septic Tank	Flow into drainage pipe	Others	Do not know	Total
No. of Respondents	0	49	76	2	3	130
Weight (%)	0.0	37.7	58.5	1.5	2.3	100

(iv) Questions on Effects of Past Projects

About 82 percent of the interviewees replied that they have seen the effect of Phase II and Phase III. Most of interviewees who have seen the effects of the past Projects have recognized reduction of frequency, duration and depth of flood.

Table R 1.3.35 Effects of Past Projects

Answer	Yes	No	Do not know	Total
No. of Respondents	106	13	11	130
Weight (%)	81.5	10.0	8.5	100

Table R 1.3.36 Detailed Effects

Type	Reduction of frequency	Reduction of depth	Reduction of duration	Reduction of disease	Convenient of commute	Reduction of traffic jam	Others	Total
Number of Respondents	102	104	106	59	75	88	3	537
Weight (%)	19.0	19.4	19.7	11.0	14.0	16.4	0.6	100

1.4 Environmental and Social Considerations Study

1.4.1 Environmental Impact Assessment

1.4.1.1 Outline of the Project having an environmental impact

(a) Title of the Project

The Project for Flood Protection and Drainage Improvement in Phnom Penh (Phase IV)

(b) Location of the Project

The Project areas having approximately 6.63 km^2 in total are Tuol Kork Area (4.75 km^2), Wat Phnom Northern Area (1.88 km^2), and the existing four (4) pumping stations as shown in the figure below.

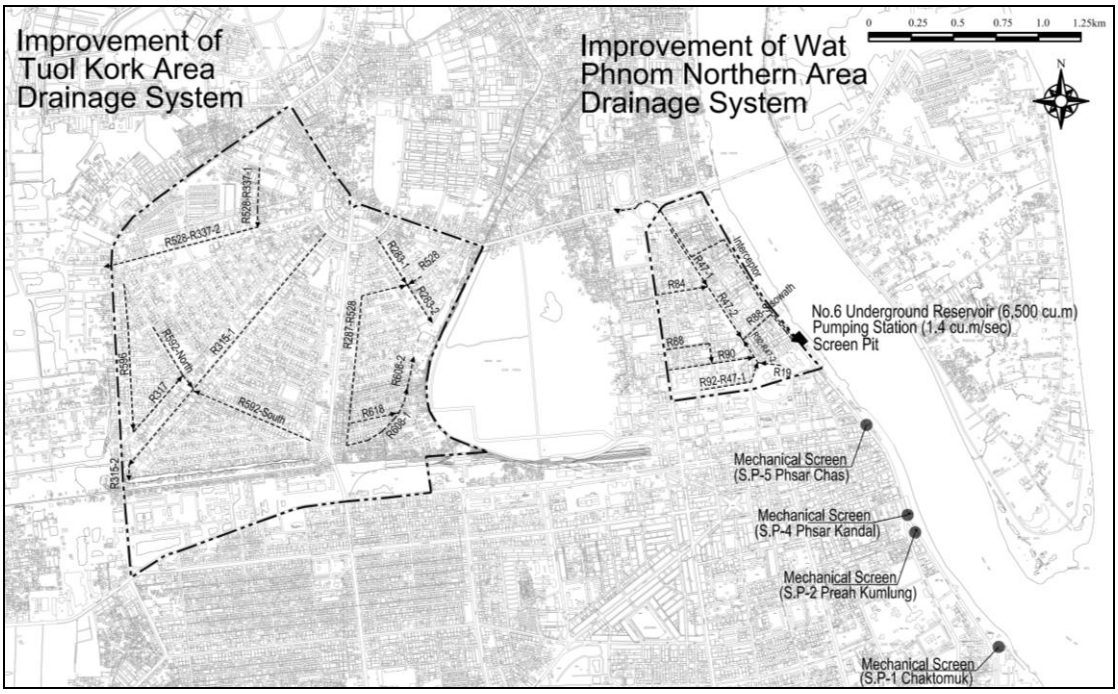


Fig. R 1.4.1 Location of the Project

(c) Outline of the Project Components

The objective of the Project is to minimize inundation by local rainfall and reduce inundation damage in the sites of the Project, Tuol Kork Area, Wat Phnom Northern Area and four existing pumping stations. Items of construction works and procurement works which will be covered by Japan's Grant Aid in the Project are as shown in the following table.

Table R 1.4.1 Outline of the Project Components

Covered by Japan's Grant Aid			
Items	Description		Quantity
Construction Works			
Improvement of Wat Phnom Northern Area Drainage System	Drainage Main	Pipe	2.7 km
		Box Culvert	0.5 km
	Interceptor	Pipe	1.6 km
		Manhole Pump	1 unit
	Pumping Station	Pump	1.4 m^3/sec
		Underground Reservoir	6,500 m^3
		Mechanical Screen	1 unit
Improvement of Tuol Kork Area Drainage System	Drainage Main	Pipe	7.0 km
		Box Culvert	1.4 km
Mechanical Screen Cleaning Facilities to Screen Pits at Pumping Stations Constructed in Phase II	Auto Raking Machine	Chak Tomuk (PS1) Preah Kumlung (PS2) Phsar Kandal (PS4) Phsar Chas (PS5)	4 units
Procurement Works			
Procurement of Drainage Improvement Equipment	Vehicle-Mounted Drainage Pump		2 units

1.4.1.2 Status of IEIA/IEE on the Project

(a) Former IEE(IEIA) prepared for the Project of Phase II and Phase III

The Initial Environmental Examination (IEE) of Phase II was prepared by the Department of Public Works and Transport (DPWT) of PPCC in February 2006, and was submitted to the Department of Environment (DOE) of PPCC. The survey area of the IEE included the Project Area of Phase III. The DOE evaluated IEE and considered no need to carriy out EIA (Environmental Imapct Assessment) because of no significant negative impacts by the project of Phase III. The DOE approved the IEE on June 8th, 2006.

(b) IEE/IEIA adopted to the Project

The Ministry of Environment (MOE) demands severer correspondence from 2015 with an approval of Initial Environmental Impact Assessment (IEIA) or EIA procedures in Cambodia. There was the meeting held on 05 May 2016 at the Director's office of EIA Department in the MOE regarding an adaptation of IEIA or EIA for the Project, with the attendance of the Director of the EIA Department of MOE, Deputy Director of DPWT-PPCC, DOE-PPCC, and JICA Survey Team.

Through the discussion, it was confirmed that the MOE decided to adopt IEIA for the Project, based on the following reasons.

- The Project is Japan's Grand Aid (in category "B"),
- General Guideline for conducting IEIA/EIA report (Declaration N.376 BRK.BST. MOE issued in September 2009)

It was also instructed by the MOE that based on Sub-decree (Declaration) No.215, MOE, issued in May 2009, an implementing agency of the project shall employ the registered local consultant companies (13 companies as of January 2016) to conduct a subletting work for IEIA/EIA survey for the Project. The JICA Survey Team agreed to follow this Sub-decree for subletting for the Project.

1.4.1.3 Baseline Survey of Existing Environmental and Social Considerations

(a) Outline of the Project Area

Current information on topography, geology, soil erosion, meteorology, ecology, status of inundation damage, land use, population, air quality, noise & vibration, water quality in the river around PPCC, and environmental concerns on living are quoted mainly from "Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014 JICA" and "The Study on Drainage and Sewerage Improvement Project in Phnom Penth Metropolitan Area, JICA May 2016".

(i) Topography

The Phnom Penh Capital City (PPCC) is located in alluvial lowland formed by Mekong River and Tonle Sap River, at the right bank of the confluence of Mekong River and Tonle Sap River, and at the fork of Mekong River and Bassac River. The city center is located inside of the natural levee and the suburban residential area is in a swampy plain, which is prone to inundation. The area is topographically relatively flat and its elevation is lower than the maximum water level of the Mekong River that potentially reaches more than 10 m during the rainy season. Therefore, the urban and

suburban areas of Phnom Penh are highly prone to flooding, despite being surrounded by dikes.

(ii) Geology

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

In the central area of Phnom Penh, monadnock of basic rock is found under Wat Phnom area, and basic rock is found in relatively shallow depth under Chroy Changvar Bridge (about 7 m in depth) and Phnom Penh Port (about 17 m in depth). No basic rock is found up to the depth of 36 m in the southern area where the Japanese Embassy is located and thick organic clay is found in some places.

(iii) Soil Erosion and Sedimentation

Geologic structure of the Mekong Delta region, where the Preparatory Survey 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 River and its tributaries and then Holocene deltaic alluvium was formed. The Holocene Alluvium, consisting largely of unconsolidated silt and clay with some lenses of sand, virtually blankets the entire delta. The Holocene Alluvium in and around the Preparatory Survey 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 Phnom Penh capital is characterised by the sandy mud covered on base terrane inclined from west to east, as well as soft clay layer at some places.

(iv) Meteorology

1) Climate and Temperature

According to the observed data from 1985 to 2013 at Pochentong Station, the averages of monthly maximum and minimum temperature are 35.3 and 21.8 degrees Celsius in PPCC.

Temperature in March to May is higher than other seasons, and the difference between maximum and minimum is about 20 degrees Celsius.

Annual average of humidity is 77%, ranging from 70% to 80% and secular change is not observed.

Maximum and minimum monthly temperature is shown in the following figure.

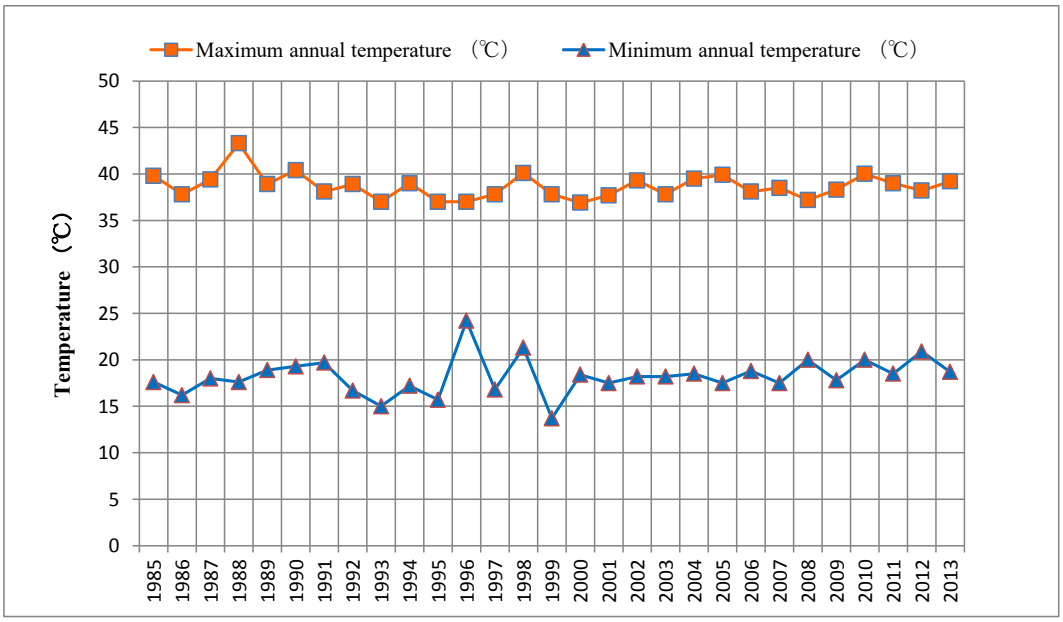


Fig. R 1.4.2 Annual Maximum and Minimum Temperature (1985-2013)

2) Wind Direction and Speeds

Wind speed tends to be stronger in the dry season than that in the rainy season. The maximum wind speed between 2001 and 2010 was 20 m/s, which was recorded in June 2006. Generally, the wind flows in the northerly direction from October to January, southeasterly from February to April, and westerly to southwesterly from May to September.

3) Evaporation

The daily average evaporation between 2000 and 2010 is 4.6 mm. The daily maximum evaporation in the rainy and dry seasons is 9.5 mm and 43.8 mm, respectively. The seasonal variation of evaporation is large as that in dry season is five times as much as that in rainy season.

4) Rainfall

PPCC belongs to the tropical monsoon climate. The annual average rainfall in 2000 to 2010 is 1,500 mm/year with minimum of 1,171 mm/year (2006) and maximum of 2,147 mm/year (2010). In the dry season, especially from January to March, recorded rainfall is almost zero. On the other hand, 80% of rainfall is recorded in the rainy season (May to November).

5) Water Level in Tonle Sap River

The water level of Tonle Sap River is high during August to October generally recorded at about EL. +8.00 m and the lowest water level is recorded at about EL. +2.00 m from March to May. There is no big difference in yearly maximum and minimum. Annual highest water level is generally recorded in October.

The highest water level recorded at Chaktomuk station in past 9 years is EL. +9.73 m (recorded in September 2001) and lowest level is EL. +0.33 m (recorded in May 2005). Average annual maximum and minimum at the station are EL. +8.70 m and EL. +0.68 m, respectively.

The highest water level of past 10 years at the station is EL. +9.84 m (recorded in 2011). Historical highest level was recorded at EL. +10.18 m on 20th September, 2000.

(v) Ecology

1) Aquatic Biodiversity

There is no important fauna in the Project area, like migratory birds or important fish species nor important flora in the ponds which is partly covered by water hyacinth.

2) Terrestrial Biodiversity

Terrestrial biodiversity in the Project area is limited to scattered trees, both exotic and endemic, alongside of the roads and pet fed by city dwellers. "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 the similar potential for biodiversity. Among the species, 75 vertebrate animals and 23 plant species were listed as endangered species in the Red List in the International Union for Conservation of Nature (IUCN) at 2011. The statuses are shown below.

Table R 1.4.2 Status of Endangered Species in Cambodia

Red List Species		Red List Status		Red List Species		Red List Status	
Taxon	Total	Taxon	Total	Taxon	Total	Taxon	Total
Mammal	26	VU	18	Amphibians	2	VU	2
		EN	6			EN	0
		CR	2			CR	0
Bird	26	VU	9	Fish	9	VU	0
		EN	10			EN	6
		CR	7			CR	3
Reptile	12	VU	7	Plant	23	VU	0
		EN	3			EN	13
		CR	2			CR	10

Notes: VU-Vulnerable, EN-Endangered, CR-Critically Endangered
Source: National Biodiversity Steering Committee in Kingdom of Cambodia (2014) 5th National Report to the Convention of Biological Diversity based on the IUCN 2011 and Bird Life International Cambodian Program 2013
"The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area, JICA May 2016"

(vi) Protected Areas

There is no protected area in Phnom Penh Capital City. In Cambodia, naturally important environmental features are protected under No. 07 NS/RKM/2008, Protected Areas Law (Royal Decree No. NS/RKM/2008/007).

(vii) Status of Inundation Damage

The inundation condition survey in the Project area was carried out by the JICA Survey Team in April 2016 and the result was summarized as shown in the table below.

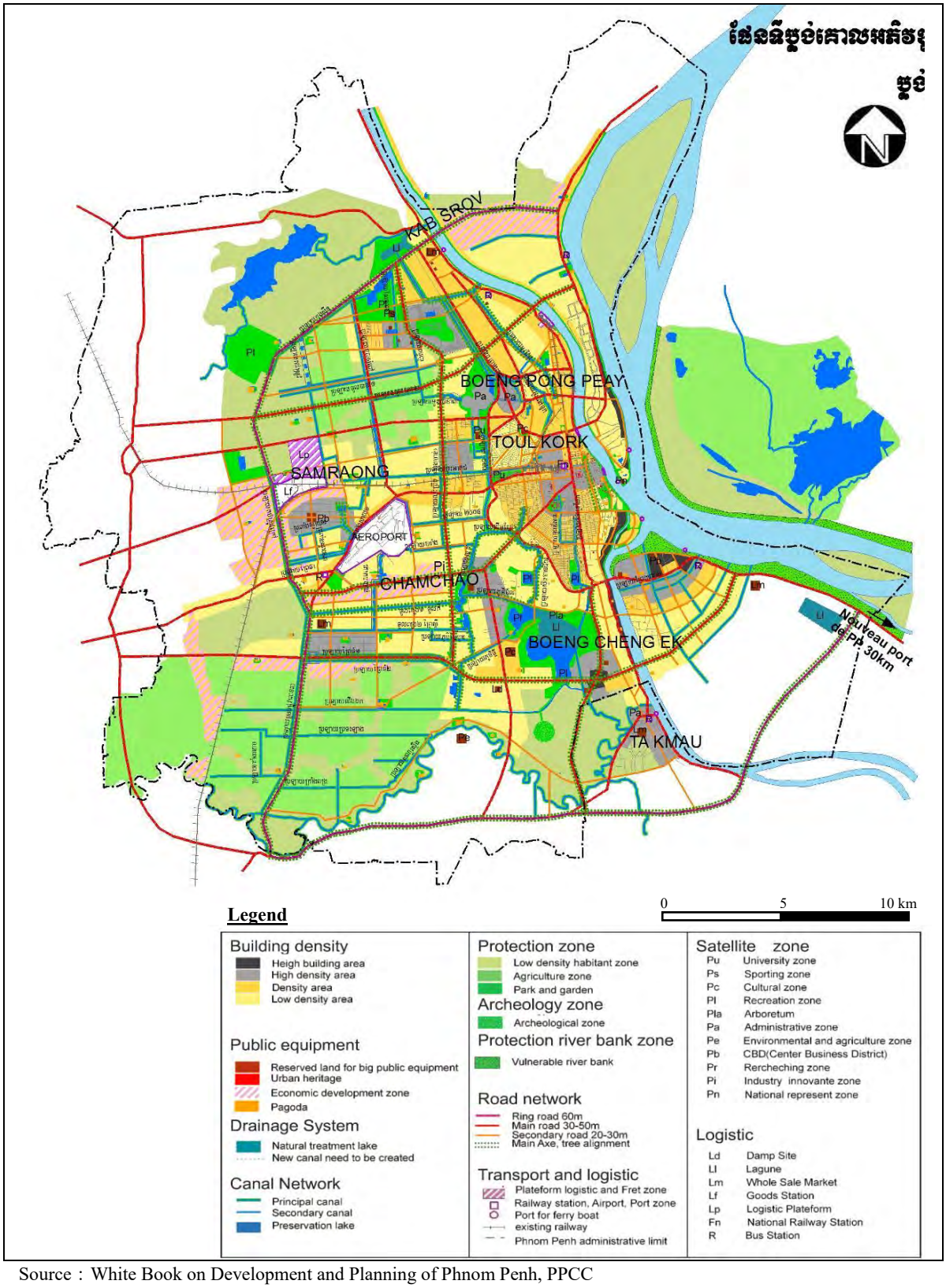
Table R 1.4.3 Results of Inundation Survey in the Project Area

Project Area	Survey Method	Results
Wat Phnom Northern Area	• Interview with Sangkat Chiefs/ DPWT-PPCC • Interview with Households	• Inundated areas along Roads of St.47, St.88, St.90, and the Northern area around Wat Phnom. • Inundated with a frequency of less than four (4) times a year, or inundation duration of two (2) - three (3) hours, and inundation depth of higher than the shin.
Tuol Kork Area	• Interview with Sangkat Chiefs/ DPWT-PPCC • Interview with Households	In Tuol Kork Area, • Inundated partly along Roads of St.317 and St.592. • Inundated partly along Roads of St.283, St.285, and St.287. • Inundated with a frequency of more than four (4) times a year, or inundation duration of two (2) - three (3) hours, and inundation depth of higher than the shin.

(viii) Land Use

Administration area for the Phnom Penh Capital City (PPCC) was changed in 2008 and the area was expanded from approximately 377 km^2 to approximately 678.5 km^2 at 2008. Approximate areas for the land use in the previous capital (old Phnom Penh capital area of approximate 377 km^2) are shown below.

Land use in the Project area is a mixture of residential, small to medium scale commercial development areas along the roads. Most part of the project area is highly dense-populated.



Source：White Book on Development and Planning of Phnom Penh, PPCC

Fig. R 1.4.3 Land Use in Phnom Penh Capital City (2035)

(ix) Population

Population up to 2035 has been projected based on the results of census in 1998 and 2008, and population projection up to 2030 in the "Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City" (2014 JICA), as shown below.

Table R 1.4.4 Population Projection by JICA Project

Name of Khan		1998	2008	2012	2016	2020	2035
01	Chamkarmon	187,082	182,004	184,200	196,500	200,900	240,400
02	**Daun Penh**	**131,913**	**126,550**	**119,500**	**123,300**	126,700	138,200
03	7 Makara	96,192	91,895	93,300	95,100	96,600	102,700
04	**Tuol Kork**	**154,968**	**171,200**	**186,100**	**187,900**	185,100	181,100
01-04 Sub-total		**570,155**	**571,649**	**583,100**	**602,800**	**609,300**	**662,400**
05	Dangkor	48,921	73,287	96,100	128,500	148,900	183,700
06	Po Senchey	73,414	159,455	234,900	269,300	321,600	349,500
07	Meanchey	97,190	194,636	282,700	349,100	403,300	490,800
08	Chbar Ampov	108,796	133,165	160,500	194,300	210,100	251,500
09	Reussey Keo	76,473	115,740	152,600	178,800	204,300	251,300
10	Chroy Changvar	53,231	68,708	84,000	102,900	126,700	155,500
11	Sen Sok	70,676	137,772	198,600	237,000	296,700	392,500
12	Prek Pnov	34,574	47,313	59,700	84,700	84,500	129,900
05-12 Sub-total		**563,275**	**930,076**	**1,269,100**	**1,544,600**	**1,796,100**	**2,204,700**
Total Population		**1,133,430**	**1,501,725**	**1,852,200**	**2,147,400**	**2,405,400**	**2,867,100**

* The population is corrected based on new administrative area in PPCC (678.5 km^2)
Source: JICA, "Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City, 2014"

The Project area is approximately 6.63 km^2 in total, consisting of 4.75 km^2 of Tuol Kork Area and 1.88 km^2 of Wat Phnom Northern Area. Estimated populations in 2016 are 75,858 persons in total, consisting of 17,588 persons in Tuol Kork Area and 58,270 persons in Wat Phnom Northern Area. In terms of population density, the Project area has 12,267 person/km^2 which is equivalent to the population density of 12,403 person/km^2 in Koto-ku Tokyo Metropolitan, Japan.

(x) Air Quality

The air quality monitoring result as available secondary information is still limited in Cambodia and some available data are shown below. The result of the monitoring of Ambient Air pollution (2014, Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, **Table R 1.4.5**) shows that CO, NO_2 and SO_2 values are within the standard. However, the dust parameters of particulate matters (PM2.5, PM 10) are found very high. The trend also found in the record in 2001 having high Total Suspended Particles (TSP) (**Table R 1.4.6**).

Table R 1.4.5 Air Quality along the Road NH4 in Phnom Penh

Type	Unit	Point 1 (7 Makara)	Point 2 (Sen sok)	Point 3 (near Hanoi road Junction)	Point 4 (Airport)	Point 5 (near Junction with NH3)	Cambodian Standard	WHO standard
CO	mg/m^3	2.86	1.79	2.86	3.58	3.58	20	
NO_2	mg/m^3	0.057	0.029	0.045	0.056	0.058	0.1	
SO_2	mg/m^3	0.033	0.027	0.027	0.025	0.033	0.3	
PM2.5	$\mu g/m^3$	128	107	284	186	248	n.a.	25
PM10	$\mu g/m^3$	93	68	150	71	169	n.a.	50

Note: The results are average of 24 hours continuous survey
Source: Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014

Table R 1.4.6 Ambient Air pollution in Phnom Penh

Parameters	2000		2001		2002		2014	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
CO (mg/m^3)	3.06	7.12	1.98	2.42	3.50	5.71	3.02	3.87
NO_2 ($\mu g/m^3$)	32.08	47.17	2.45	3.77	30.19	56.60	24	71
SO_2 ($\mu g/m^3$)	-	-	2.60	7.80	7.80	13.00	10	27
TSP (mg/m^3)	-	-	0.63	0.84	0.41	1.00	0.128	0.169

CO=Carbon Monoxide: mg/m^3=milligrams per cubic meter; $\mu g/m^3$=micrograms per cubic meter; NO_2=Nitrogen Dioxide; TSP=Total Suspended Particles. Mean Value in the 2014 were received as tentative values.
Source: MOE (2014), ADB (Asian Development Bank) 2006 Country Synthesis Report on Urban Air Quality Management, "Research collaboration with Yokohama University from 2000-2002.
Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014
Quoted in MOE and Ministry of Health (2006). Country Report: Cambodia, Hang Dara, Chin Chamroeun, Sourn Pun Lork, and Chim Sophan, Paper presented at the Clean Air for Asia Training Course for Developing Countries, Thailand, 24 May-02. from ADB.

As the normal requirement of the IEIA survey, the baseline survey of air quality in the Project area is required by the MOE, Cambodia. Along this line, an actual measurement of air quality, noise/vibration, and water quality was carried out in July 2016 in the Wat Phnom Northern Area and Tuol Kork Area of the Project. The results of the air quality measurement are tabulated in **Table R 1.4.7**. As shown in the table, the all results are lower than the standard. It is said that at present the ambient air quality at the Project area seems good.

Table R 1.4.7 Results of Air Quality Measurement at the Project Area (2016)

Parameters	Unit	Cambodian Standards(i), 24h	Measurement Results	
			at Kunthak Bopha Hospital, Wat Phnom Northern. date July 20-21, 2016	at Gasoline (Tela) station Tuol Kork, date July 21-22, 2016
Carbon Monoxide (CO)	mg/m^3	20(ii)	12.88	8.44
Nitrogen Dioxide (NO_2)	mg/m^3	0.1	0.028	0.025
Sulfur Dioxide (SO_2)	mg/m^3	0.3	0.022	0.018
Total Suspended Particles (TSP)	mg/m^3	0.33	0.285	0.243
PM10	mg/m^3	-	0.149	0.126

Notes: There was heavy rain at 12:30 pm during measurement.
(i) Sub-decree No.42, on Air Pollution Control and Noise Disturbance, Annex 1: Ambient Air, Quality Standard
(ii) 8hs. average
Source: JICA Survey Team, MOE's laboratory staff in July 2016.

(xi) Noise and Vibration

Air quality, noise and vibration are regulated by the Sub-decree No.42 declared in 2000. Annex 6 of this Sub-decree indicates maximum standard of noise level allowable in the public and residential area (dB(A)) as shown below.

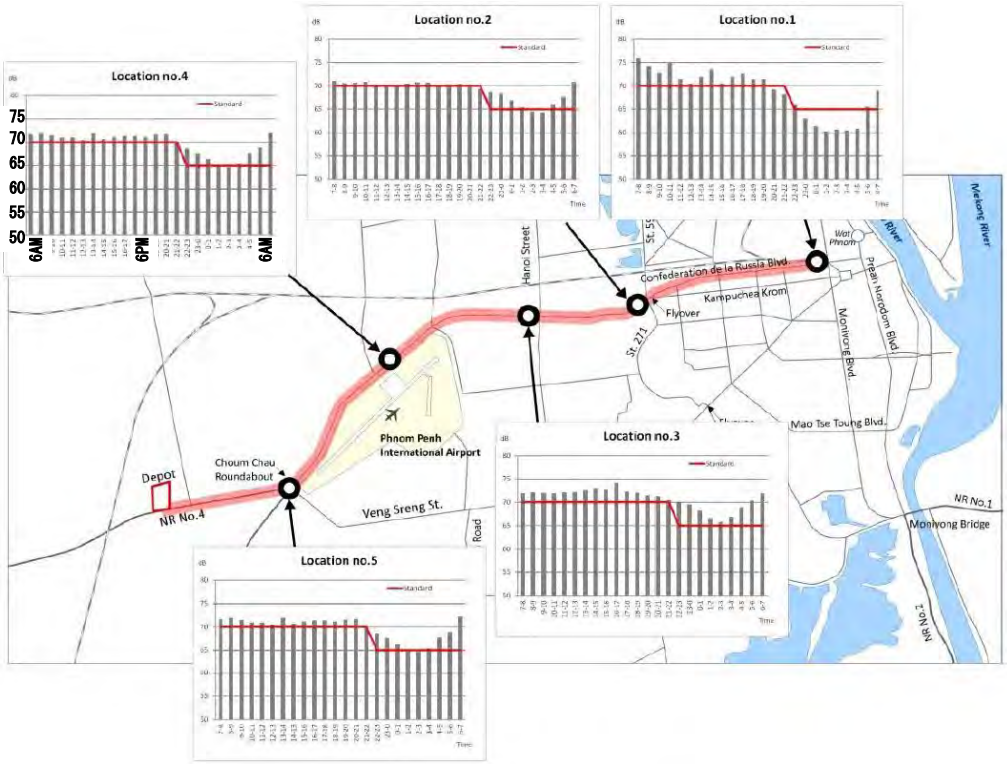
Table R 1.4.8 Maximum Standard of Noise Level Allowable in the Public and Residential Areas (dB)

No.	Areas	Period of Times		
		6 a.m. - 6 p.m.	6 p.m. - 10 p.m.	10 p.m. - 6 a.m.
1.	Quiet Area (Hospital/Library/School/Kindergarten)	45	40	35
2.	Residential Area (Hotel/Administrative office/Villa/ flat)	60	50	45
3.	Commercial and service areas and Area of multiple business	70	65	50
4.	Small industrial factories mingling in residential area	75	70	50

Source: Sub-decree No.42 ANK/BK The Control of Air Pollution and Noise Disturbance, the Royal Government of Cambodia、2000

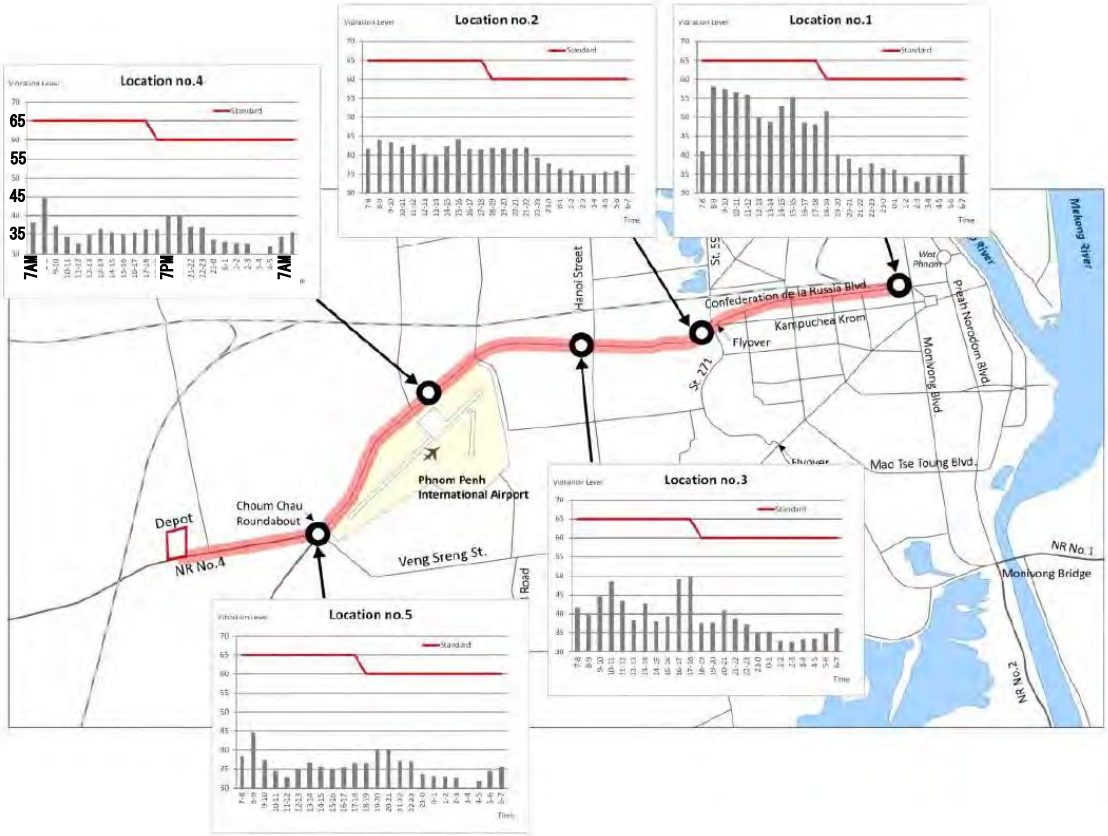
The Department of Air Quality, Noise and Vibration Management of the MOE are supposed to carry out the monitoring of measurement of noise and vibration with their own equipment and establish a database of monitoring records, based on this Sub-decree. However, according to the Department of Air Quality, Noise and Vibration Management, they have not carried out the measurement yet and there is no record of data due to lack of manpower. On the other hand, JICA Survey Team of PPUTMP (Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014) monitored noise and vibration measurement data along NR No.4 Route (Russian Avenue between Canter of PPCC and the Airport). Tuol Kork area, one of the survey area of the Project, is located along the NR No.4.

According to the results, the noise slightly exceeds Cambodian standard (70 dB) applied to commercial and multiple business area from 6 AM to 6 PM and the noise substantially exceeds the standard (50 dB) from 6 PM to 6 AM, as shown in **Fig. R 1.4.4.** As for vibration, the results are compared with Japanese standard (65dB from 6 AM to 6 PM and 60dB from 6 PM to 6 AM), because Cambodian standard is not available. As a result, no records exceed the Japanese standard, as shown in **Fig. R 1.4.5.**



Source: Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014

Fig. R 1.4.4 Survey Location and Result in PPUTMP (Noise)



Source: Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City, 2014

Fig. R 1.4.5 Survey Location and Result in PPUTMP (Vibration)

On the other hand, the air quality measurements of noise and vibration were conducted on the same location and date of the air quality measurement carried out through the Project by the MOE's laboratory staff of the general department of environmental protection. The following table described the results of noise and vibration measurement at both stations, Wat Phnom Northern Area and Tuol Kork Area of the Project area. According to the tables, noise measurements obtained during the day time and evening time are almost lower than the Cambodian standards, while the night time is slightly higher value than the standards, which is caused by the road network in place. As for the vibration measurements, all were below the standard.

Table R 1.4.9 Results of Noise Measurement at the Project Area (2016)

Time	Cambodian Standard (*), dB(A)	Result, dB(A)
Station 1: at Kunthak Bopha, Wat Phnom Northern, date July 20-21, 2016		
Day (6:00 - 19:00)	70	63-66
Evening (19:00 - 23:00)	65	58-65
Night (23:00 - 6:00)	50	**55-64**
Station 2: at Tela Station, Tuol Kork date July 21-22, 2016		
Day (6:00 - 19:00)	70	68-**75**
Evening (19:00 - 23:00)	65	59-6**7**
Night (23:00 - 6:00)	50	**53-68**

Notes: (*) Sub-Decree on Air Pollution Control and Noise Disturbance, Annex 6: Maximum permitted noise in public and residential area, point 3 Commercial and service areas and mix.
Source: JICA Survey Team, MOE's laboratory, the IEIA report on the Project, 2016.

Noise standards (Cambodian standard, Japan standard, WHO guideline) are compared as shown in the following table.

Table R 1.4.10 Comparison of Noise Standards (Cambodia, Japan and WHO)

Area	Standard	Value	
		Daytime (6 a.m. – 10 p.m.)	Nighttime (10 p.m. – 6 a.m.)
AA	Cambodia 1)	40 – 45 dB	35 dB
	Japan（MOE）	50 – 60* dB	40-55* dB
	WHO Guideline 2)	50 – 55 dB	30 – 45 dB
A・B	Cambodia 1)	50 – 65 dB	45 dB
	Japan（MOE）	55 – 65* dB	45-55* dB
	WHO Guideline 2)	50 – 55 dB	45 dB
C	Cambodia 1)	65 – 75 dB	50 dB
	Japan（MOE）	60 – 70* dB	50-65* dB
	WHO Guideline 2)	55 – 70 dB	55 dB

Notes:
*Areas facing traffic roads having a traffic lane or more than two traffic lanes.
1) Sub-decree No.42 ANK/BK the Control of Air Pollution & Noise Disturbance
2) WHO environmental noise values, 24 hours duration, healthy influence protection guideline.
AA: Medical treatment facilities, social welfare facilities, etc.
A・B: Residential area, administration, government & municipal areas, hotels.
C: Small scale factory and residential areas.

(xii) Water Quality in the Rivers around PPCC

Water quality in and around PPCC is monitored by the MOE. According to the data of the MOE from January 2010 to December 2013, water quality is monitored at 9 points as shown in the table below. The Project area directly connects with the Tonle Sap River. 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 and I) are monitored to meet "Effluent Standard for Public Water Area and Sewer"

Table R 1.4.11 Minimum, Maximum and Average at Monitoring Point

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	6.35	16.0	0.1	1.6	-	0.01	0.01	ND
	Max	8.50	592.0	4.9	7.8	-	1.15	0.50	0.090
	Average	7.41	108.5	2.0	4.0	-	0.26	0.08	0.023
B. Tonle Sap River (Phnom Penh Port)	Min	6.49	22.0	0.2	1.4	-	0.08	0.02	ND
	Max	8.24	474.0	6.5	9.3	-	8.11	0.50	0.320
	Average	7.32	106.5	2.3	4.5	-	1.23	0.11	0.027
C. Prek Thnot River (Thakhmao Bridge)	Min	6.09	5.8	0.2	1.3	-	0.13	0.03	ND
	Max	8.21	520.0	57.9	145.0	-	3.97	4.08	0.220
	Average	7.30	157.3	13.8	23.8	-	1.33	0.98	0.038
D. Bassac River (Thakhmao)	Min	4.85	26.0	0.1	0.8	-	0.07	0.01	ND
	Max	8.50	526.0	5.8	9.4	-	0.74	0.34	0.110
	Average	7.31	108.3	2.0	4.2	-	0.31	0.12	0.023
E. Mekong River (Kien Svay)	Min	5.52	29.0	0.0	0.6	-	0.04	0.00	ND
	Max	8.47	526.0	6.5	9.7	-	1.73	0.32	0.120
	Average	7.33	114.7	1.9	3.6	-	0.31	0.08	0.019
Cambodian Standard for A. to E.		6.5-8.5	<100	<10	-	-	-	-	<0.005
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	8.18	442.0	58.4	-	126.7	11.93	1.74	0.010
	Average	7.36	119.5	17.4	-	31.8	4.91	0.53	0.006
H. Trabek	Min	6.35	46.0	70.9	-	47.9	1.48	0.81	ND
	Max	8.35	378.0	258.1	-	215.0	18.40	6.73	0.200
	Average	7.39	153.1	152.1	-	117.7	7.39	3.03	0.021
I. Tumpun	Min	6.78	70.0	68.9	-	63.5	0.32	0.23	ND
	Max	8.02	402.0	261.3	-	226.2	18.55	6.60	0.020
	Average	7.39	155.2	161.9	-	111.6	6.05	2.93	0.009
Cambodia Standard for F to I.		5.0-9.0	<120	<80	-	<100	-	-	<0.05

Notes: ND: Not Detected. COD_{Mn}: <8 mg/L based on ANNEX 4
Since there are no standards of COD (Chemical Oxygen Demand), T-N and T-P in Cambodia, the standard in parenthesis in the above table shows Japanese standard of Ministry of the Environment Japan for reference purpose only.

Source: MOE, "The Study on Drainage and Sewerage Improvement Project in Phnom Penth Metropolitan Area, JICA May 2016"

As the measuring baseline of water quality before the project implementation and based on the request by the MOE, the water quality measurement was carried out during the Preparatory Survey stage on the Project. The base line survey was conducted at the selected three (3) sampling points selected by the JICA Survey Team as shown in table below.

Table R 1.4.12 Water Quality Examination at the Project Area (2016)

No.	Parameters	Unit	Standards 1) and Results of River Water Test					Standards 2) and Test Results of Sewage			
			Standards			Test Results		Standards			Test Results
			*1	*2	*3	R1=S1*	R2=S2*	*1	*2	*3	WW1=S3 *
1	pH		6-9	6.5 - 8.5	-	6.7	6.9	5-9	5.8-8.6	-	6.9
2	Temperature	^{0}C	<45	-	-	36	29.3	<45	-	-	30.2
3	Electrical Conductivity (EC)	µS/cm	-	-	-	-	184	-	-	-	400
4	Turbidity	NTU	-	-	-	-	8.75	-	-	-	22.60
5	Dissolved Oxygen (DO)	mg/l	2.0-7.5	2.5	-	1.68	5.89	>1	-	-	3.27
6	Total Suspended Solid (TSS)	mg/l	25-100	25 -100	-	**180**	68	<120	200	-<120	77
7	Biochemical Oxygen Demand(BOD_5)	mg/l	1.0-10	3.0 - 8.0	-	**122.40**	3.46	<80	160	-	38.90
8	Chemical Oxygen Demand (COD)	mg/l	1-8	< 8	-	0.94	-	<100	-	-	ND (not detected)
9	Oil and Grease	mg/l	-	-	-		4.85	<15	-	-	7.84
10	Nitrate	mg/l	-	<0.6	-	6.66	0.42	<20	-	50	4.69
11	Phosphate (PO_4)	mg/l	-	<0.05	-	3.26	ND	<6	-	-	0.35
12	Total Coliform	MPN/ 100ml	<500 0	-	-	**$9.3x10^3$**	$2.1x10^3$	-	-	-	$2.4 x10^4$

Notes: 1) Water quality standard in public areas for bio-diversity conservation for river, lake and reservoir.
2) Effluent standard for pollution sources discharging wastewater to public water area or sewer.
Standards: *1: Cambodia standards, *2: Japan standards, *3 WHO guideline

Three (3) water sampling locations; *Sample code	Location	GPS (Global Positioning System) point	Remarks
R1=S1	in front of water pumping station Wat Phnom	X=491743; Y=1280024	Tonle Sap River
R2=S2	Pres Komlong Station	X=492484 ; Y=1278920	Tonle Sap River
WW1=S3	Existing sewage pipeline in front of Tela gas Station	X=487712; Y=1280337	Sewage water in manhole along the main road

Note: Sampling and testing done on 15 July 2016.
Source: JICA Survey Team, MOE's laboratory, the IEIA report on the Project, 2016.

(xiii) Environmental Concerns on Living

1) Deterioration of Drainage System

Drainage facilities in the Project Area constructed from the beginning of the 1900's are not functioning well due to old age, as well as poor maintenance after the 1970's. As a result, the city suffers from habitual inundation and poor environmental conditions caused by stagnant wastewater in lowland areas, which are serious constraints to the residents' living environment, as well as social and economic development, in not only of the PPCC but the whole country in general. Such

deteriorated drainage condition is alerted in a tourist guide book as dangers information

2) Traffic Congestion

Under economic significant growth and population growth, the number of traffic has been rapidly increased in Cambodia. It frequently causes the traffic congestion in the Project Area. The traffic volume in the PPCC area is 60,000 - 90,000 vehicles/day and 75% of the vehicular traffic is motorcycles (2014, Project for Comprehensive Urban Transport Plan in Phnom Penh Capital City). Associated with the drainage pipe installation in the city area, public traffic movement may be affected.

1.4.1.4 Laws and Regulations related to Environmental Consideration

(1) Laws for Environmental and Social Considerations

In Cambodia, the Law on Environmental Protection and Natural Resource Management, 1996 (Kram/NS-PKM-1296/36, 1996, 24 Dec.) provides general policy on environmental protection as the principal environmental law. Based on the law, the GOC should manage the environment deliberately under a periodical National and Regional Management Plan which is supposed to be prepared and revised every 5 years. The requirement of the Environmental Assessment at the project is also included in the law. Private and public project should refer to the law in conducting the required study depending on the scale and location.

Under the law, the Sub-Decree on Environmental Impact Assessment (EIA) Process, 1999 (No. 72 ANRK.BK, 1999) and the Declaration on General Guideline for conducting IEIA/EIA Reports, 2009 (No. 376 BRK.BST, 2009) provide detail procedure for the environmental assessment. The sub-decree consists of Institutional Responsibilities, EIA required projects, Procedures of EIA Process, Conditions for Approving Project(s) and Penalties. The projects which require environmental assessment are listed in the Annex to the sub-decree. The declaration also provides the timeframe and required documents for submission at the approval process in IEIA and EIA in detail. Annex-1 in the declaration specifies the basic contents of IEIA/EIA Reports. The declaration also provides the demarcation between environmental authorities in the national level and the provincial level which are the Ministry of Environment (MOE) in the national level and the Department of Environment (DOE) in provincial/municipal level. In 2014, Declaration No.215 MOE on the Registration of selected local consultant companies for conducting IEIA and EIA reports is issued.

Regarding pollution control, several standards are issued by the government. Water pollution, Sub-Decree (Anukret) on Water Pollution Control, 1999 (No. 27 ANRK. BK, 1999) provides the standard for water quality. No. 36 ANRK.BK, in 1999, Sub-decree on Solid Waste Management, 1999 regulates the general standard of solid waste. No. 42 in 2000, Sub-Decree on the Control of Air Pollution and Noise Disturbance, regulate environmental air condition and noise level to be permitted.

As to environmental protection, the protected area is prescribed in the law of protected area (Royal Decree No. NS/RKM/0208/007). Based on the law, the important natural features are protected under the responsibility of the MOE.

Relative laws and regulations for Environment in Cambodia are as follows;

Table R 1.4.13 Relative Laws and Regulations for Environment and Social Considerations in Cambodia

No.	Legislation	Description
1.	Preah Reach Kram/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.
2.	No. 72 ANRK.BK, 1999, Anukret (Sub-decree) on Environmental Impact Assessment (EIA) Process (11 August 1999)	This Sub-decree provides the detailed guidelines for implementation of the IEIA/EIA Process.
3.	No. 376 BRK.BST, 2009 Prakas(Declaration) 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.
4.	No.27 ANRK/BK/1999, Anukret (Sub-decree) 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.
5.	No.36 ANRK.BK. in 1999, Anukret (Sub-decree) on Solid Waste Management, 1999	This Sub-decree regulates solid waste management to ensure the protection of human health and the conservation of biodiversity.
6.	No. 42 in 2000, Anukret (Sub-decree) 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.
7.	No. 745 MEF/MOE 2000, Prakas (Joint Declaration) between MOE and MEF (Ministry of Economy and Finance) 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.
8.	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.
9.	No. 1033, 1994, Prakas (Declaration) 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.
10.	No. 230 in 2005, Prakas (Declaration) 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,
11.	No.215 in 2014, Prakas (Declaration), Sep. MOE, May 2014	Declaration on the Registration of Selected Local Consultant Companies for studying and preparing the IEIA and EIA survey report. As of Jan. 2016, there is a list of 13 national registered companies for IEIA/EIA survey for this Declaration.

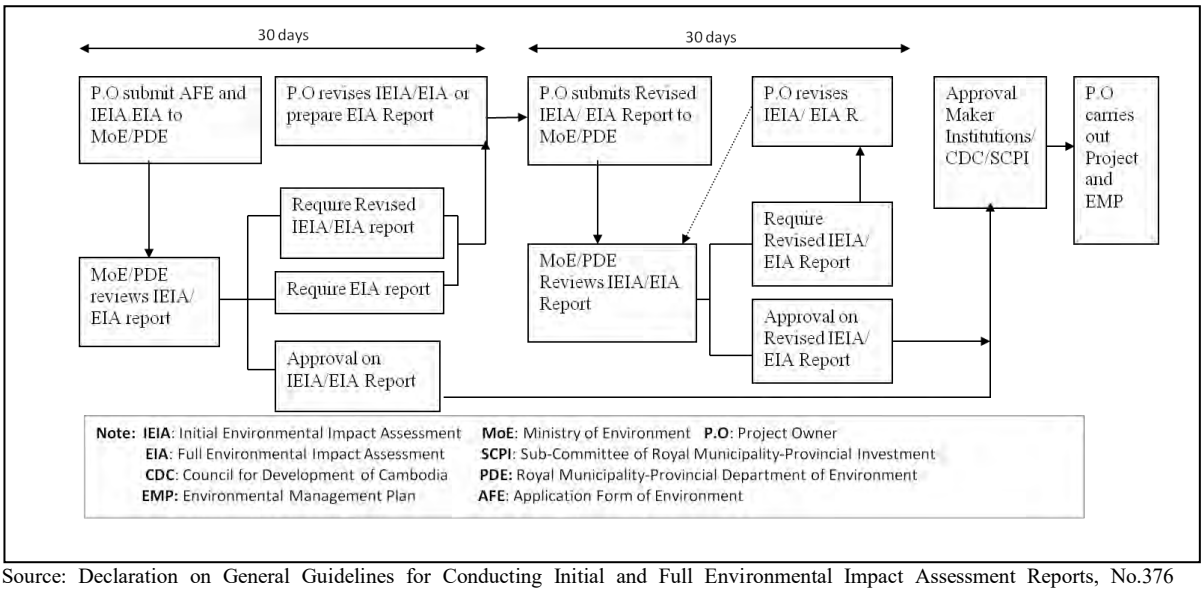
Source: "The Study on Drainage and Sewerage Improvement Project in Phnom Penth Metropolitan Area, JICA May 2016"
JICA Survey Team based on English Translation supplemented by JICA env. Profile 2013, Faolex, ADB (2014) Integrated Urban Environmental Management in the Tonle Sap Basin Project – Kampong Chhnang Urban Area Environment Improvements,

(2) Projects subject to the Provisions on 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, the drainage system is categorized as Agriculture instead of Infrastructure and the project of drainage system with 5,000 ha or more is required to carry out IEE or 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 USD 2 million. The MOE is responsible for a project with a project cost of more than USD 2 million.

As shown in the flowchart below, the project owner firstly submits the Environment Application Form together with his IEIA (IEE) report to the competent authority, which means, the MOE or DOE. After the MOE/DOE has reviewed the report, it may require the project owner to revise the report or implement further survey as the IEIA. Should the environmental survey 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, No.376 BRK.BST, 2009

Fig. R 1.4.6 Flowchart of the IEIA/EIA Process for National Level Projects

(3) Procedure of IEE or I EIA for the Project

Procedure of IEE or IEIA is as follows;

- Responsible and implementing agency (DPWT) shall prepare IEE or IEIA.
- IEE or IEIA will be submitted to MOE, Provincial Environmental Office if the project is at provincial/urban level.
- MOE examines submitted IEE or IEIA, and in case of necessary, requests to revise

the IEE/IEIA or further detailed survey as EIA.

- MOE approves the project if the environmental assessment is satisfied their requirements.

(4) Agency Setting the Principles and Procedures for Initial Environmental Impact Assessment (IEIA, IEE)

The MOE is an agency setting the principles and procedures for IEE or IEIA of the Project. DOE is responsible to review EIA for the project in PPCC under the supervision of the MOE. For the Project, MOE is the main agency for the review, evaluation and approval of IEE and/or IEIA report of the Project on schdule with supporting of DEO, especially during construction stage.

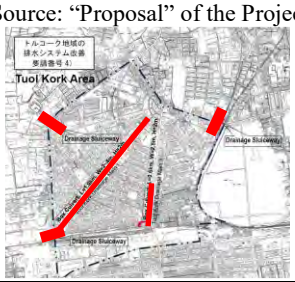
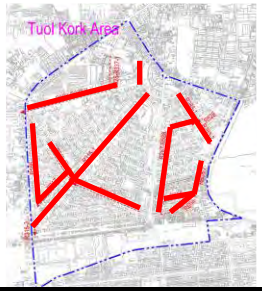
(5) Comparison between JICA Guideline and Cambodian Laws and Regulations

Environmental impact assessment process in Cambodia is basically similar to that of JICA guidelines (2010) while the importance on “Accident”, “Global warming”, “Employment” and other social considerations are not much shown in Cambodian laws and regulations. Especially, detailed procedures of land acquisition and resettlement have not been defined yet. Especially, Cambodian laws and regulations do not put emphasis on reconstruction of livelihood as previous level or more. A gap comparison between JICA Guideline (2010) and Laws and Regulation in Cambodia is shown in **Appendix-7**.

1.4.1.5 Comparison of Alternative Plans

The Project consists of laying drainage pipe and box culvert to improve a drainage network of the stormwater in the urban area and performs construction of drainage and pumping station facilities at the drainage system end. While there are no proposed relocation and resettlement structures in Wat Phnom Northern area, there were approximately more than twenty (20) project affected families proposed in Tuol Kork Area. Based on the results of the first field survey conducted by the JICA Survey Team in April 2016, an effort to minimize the number of affected families was finally made. Only two (2) land lots without any resettlement are expected for « Alternative 2 » (the Project).

Table R 1.4.14 Comparison of Alternative Plan on Relocation and Land Acquisition for Drainage Improvement Works in the Project

Item	Alternative 1 Drainage Plan in Tuol Kork Area	Alternative 2 Revised Drainage Plan in Tuol Kork Area	No Project Current condition
Outline of Drainage Facilities	**Tuol Kork Area** **Pipeline length: 2.5km in total** Box culvert: 1.9km Box culvert: 0.6km **Sluiceway: three units** (Source: “Proposal” of the Project) 	**Tuol Kork Area** **Pipeline length: 8.4km in total** Drainage Pipe: 7.0km Box culvert: 1.4km 	-
Provisional Rating	— — —	— —	Not applicable

Item		Alternative 1 Drainage Plan in Tuol Kork Area	Alternative 2 Revised Drainage Plan in Tuol Kork Area	No Project Current condition
Environmental and Social Considerations	Natural Environment	<Drainage Channel/ Drainage Pipe Lines> ・ There is no major change in the comprehensive drainage system in Tuol Kork areas conducted by the DPWT. As a positive influence, the reduction of flood damage by the Project is expected. <Enhancement of/ New Installation of Pumping Station> There is no seriously affected impact in terms of natural environment in Tuol Kork area.	<Drainage Channel/ Drainage Pipe Lines> ・ Same as on the left.	Present flood and inundation damages exist.
	Social Environment	<Improvement of Drainage Pipe Installation> ・ With the laying work of drainage pipe and culvert box under the public roads, influence on traffic such as traffic jams is assumed. <Enhancement/ New Installation of Pumping Station> ・ An additional site (occasionally with the move) is necessary with the construction of a new pumping station. ・ The rise in land value in the enforcement place is possible. ・ Due to the improvement of drainage system and reduction of inundation by the implementation of the Project, a traffic flow on roads in the wet season becomes easy. <Installation of Sluiceway> ・ A relocation plan on the proposed three (3) sluiceways in Tuol Kork area would require approximately a resettlement of more than twenty (20) affected houses.	<Improvement of Drainage Pipe Installation> ・ As for the number of relocation and land acquisition required for the Project, only two (2) housing lots are proposed successfully. No resettlement is required for the Project. ・ With the laying work of drainage pipe and box culvert under the public roads, influence on traffic such as traffic jams is assumed. It is the same as “Alternative 1”. <Enhancement/ New Installation of Pumping Station> ・ “Alternative-A (New pumping station (TK-3) and drainage pipe installation)” is compared with “Alternative-B (Box culvert)”. As a result of comparison of effectiveness and economic performance (cost of construction and land acquisition) between Alternative-A and Alternative-B, Box culvert is proposed.	A problem caused by the current flooding and inundation continues or turns worse. Those are; ・ Damages by inland inundation almost occur every year in the Wat Phnom northern area and the Tuol Kork area left behind as a drainage maintenance and operation objective. ・ The PPCC has rapidly a dense population and the areas of lakes, watersheds, streams which play the role of natural flood regulating ponds reduce their water areas recently. Reduction of such as land development areas may cause other inundation in the near future.
	Pollution	<Improvement of drainage channel / drainage pipeline> ・ Due to the interceptor pipe, which separates wastewater and rainwater will be proposed to prevent wastewater from being directly discharged to Tonle Sap River. As a result, it is expected for PPCC that a drainage flow becomes much improved.	<Improvement of drainage channel / drainage pipeline> ・ Same as on the left.	The water pollution in the existing channel may cause the healthy damage such as the infectious diseases of habitants.

Notes: Provisional rating (---: large negative influence ⇔ --: small negative influence)
Source: JICA Survey Team

1.4.1.6 Scoping Results for the Project

(a) Title of the Project

The Project for Flood Protection and Drainage Improvement in Phnom Penh (Phase IV)

(b) Categorization and its Reason

Categorization: Category B (according to the JICA's Guideline)

Reasons: The project is not located in a sensitive area, nor has sensitive characteristics, nor falls into sensitive sectors under the JICA guidelines for environmental and social considerations (April 2010), and its potential adverse impacts on the envornment are not likely to be significant.

(c) Adverse Environmental and Social Impacts

The possible adverse impacts that might be caused by the proposed Project are as shown below.

Table R 1.4.15 Possible Adverse Impact (1/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
I. Human Health & Safe and Natural Environment				
1	Air Pollution, Dust Generation	B-	D	Earthwork for pipe installation, road repairing and earth backfilling will generate dust.
2	Offensive Odor	D	D	There will be no effect on offensive odor during the construction and the operation stages.
3	Noise	B-	D	Construction equipment may cause offensive noise.
4	Vibration	B-	D	Construction equipment may cause vibration effects on nearby structure.
5	Accident	B-	D	Potential of accidents during the construction can be considered.
6	Water Pollution	D	D	There will be no effect on water quality during the construction and the operation stages.
7	Change to Drainage Pattern	B-	B+	There will be a minor impact to stormwater flooding patterns during construction, because some sewer pipe will be cut and/or diverted during new pipe installation. The drainage condition will be improved after the construction.
8	Soil Contamination	D	D	There will be no effect on soil contamination during construction and operation stages.
9	Construction Waste and Waste Soil	B-	D	There will be no significant impacts on disturbance of hazardous soil during the construction and the operation. (The asbestos pipes are not used in the existing pipe networks.) Proper management of construction work including general wastes treatment is required.
10	Soil Erosion and Slope Failure	B-	D	Improper installation work of new drainage pipe may cause soil erosion and slope failure.
11	Vegetation and Trees Removal	D	D	There will be no effect on vegetation and trees removal.
12	Impact on Endangered Species	D	D	There will be no effect on endangered species.
13	Loss of Biodiversity	D	D	There will be no effect on biodiversity.

Legend : A +/-: Serious 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: JICA Survey Team

Table R 1.4.16 Possible Adverse Impact (2/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
II.	Social Considerations			
1	Involuntary Resettlement	B-	D	There is no impact because the construction site is located within the road right of way and public lands except a need of two (2) existing relocation structures in Tuol Kork area. There is no resettlement to be relocated to resettlement site by the Project.
2	Effect on Amenity of Tourism-related Development	B-	B+	There will be a minor impact since the construction site is close to tourist attraction area. The Project will reduce stormwater inundation and will improve environment condition in the area. It will therefore support to the increased tourism development in PPCC as well as in whole country.
3	Impact on Road Safety	B-	D	Road safety during the construction is possibly decreased because of the operation of construction equipment.
4	Impact on Road Traffic and Vehicle Movement	B-	B+	During the construction stage, there will be some disruptions to traffics. During the operation stage, the traffic condition will be improved with flood mitigation.
5	Sanitation	D	B+	Reduction of stormwater inundation and dust level will reduce the incident of water borne disease and respiratory diseases.
6	Risk of Infectious Diseases such as HIV/AIDS	B-	D	Many of labors will be employed for the construction. There may be a potential of infectious diseases such as HIV/AIDS.
7	Impact on Livelihood/Income	B-, B+	B+	During the construction stage, shops and restaurants etc. alongside of the roads where sewer pipe installation is taking place will be temporary affected due to temporary road closure. The business activities will recover when the construction site move forward to the next road work section. On the other hand, there will be opportunities for local people to be employed in the construction works. During the operation stage, the Project will contribute to increased tourism development and improvement of livelihood.
8	Ethnic Minority People	D	D	There are no ethnic minority people living in the Project Area.
9	Poverty Incident	D	D	The Project will not cause any poverty incident in the Project Area.
10	Employment Opportunity	B+	B+	During the construction stage, there will be opportunities for local people to be employed in the construction works.
11	Social Activity	D	B+	The Project will improve social and commercial activities in the city because of the inundation reduction effect.
12	Destruction/Disturbance to Items or Places of Cultural and Archeological Heritage	D	D	There will be no destruction or disturbance of cultural and archeological heritage.

Legend : A +/-: Serious 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 : JICA Survey Team

(d) Mitigation Measures

The mitigation measures for the key impacts are shown below**.** The measures will be clearly specified in the technical specifications for the construction works.

Table R 1.4.17 Mitigation Measure for the Key Impacts (1/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Mitigation Measures
I. Human Health & Safe and Natural Environment				
1	Air Pollution, Dust Generation	B-	D	- Dust suppression measure will be used in urban area to minimize dust generation.
3	Noise	B-	D	- Low-noise type equipment such as the Silent Piler and vibrate hammer will be used. - Construction activities in dense residential area would be limited to daytime hours. - Due to a temporary relocation of the affected house near TK-1 to the safe place, an affect by the Project is reduced drastically.
4	Vibration	B-	D	- Low-vibration type equipment such as the Silent Piler and vibrate hammer will be used. - Construction activities in dense residential area would be limited to daytime hours. - Due to a temporary relocation of the affected house near TK-1 to the safe place, an affect by the Project is reduced drastically.
5	Accident	B-	D	- Safety measures with the installation/construction of fence around the work areas to avoid accidents to third parties. - Safety instruction carried out for every labor in every morning of working day - Safety patrol carried out by DPWT, contractor and consultant once a week
7	Change to Drainage Pattern	B-	B+	- Temporary inconvenience can be mitigated by using drainage pump or diverted pipes to drain sewage/stormwater to the city/municipal pipe line.
9	Construction Waste and General Waste	B-	D	- Soil materials suitable for backfilling works will be stockpiled temporarily at the designated stock yard. - The soil materials unsuitable for backfilling works will be transported and dumped directly into the designated dumping ground. - Reusable formwork such as steel forms will be applied as well as possible.
10	Soil Erosion and Slope Failure	B-	D	- During the installation of pipes, appropriate temporally work such as installation of steel sheet pile and/or trench sheet will be carried out.

Legend : A +/-: Serious 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: JICA Survey Team

Table R 1.4.18 Mitigation Measure for the Key Impacts (2/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Mitigation Measures
II.	Social Considerations			
1	Involuntary Resettlement	B-	D	- There were more than 20 houses to be affected by the Project in the original plan. Due to proper layout rearrangement of the Project components with the Project executing agency of DPWT/PPCC, number of affected houses were drastically reduced into 2 owners (one is a vacant shop /land, the other is an existing residential house near TK-1).
2	Effect on Amenity of Tourism-related Development	B-	B+	- Carrying out of night works to ensure the commercial activity of the surrounding markets, shops and restaurants.
3	Impact on Road Safety	B-	D	- Road safety control signs and signals will be installed especially in night time. - Security of the present traffic and safety conditions by the setting of detour roads and installation of panel decks.
4	Impact on Road Traffic and Vehicle Movement	B-	B+	- Security of the present traffic and safety conditions by the setting of detour roads and installation of panel decks. - When the construction works is carried out in heavy traffic road, detour route shall be planned clearly. - On the heavy traffic areas, such as the junction on major roads, construction works will be carried out night time, and during the daytime, steel plate will be covered the site for the normal traffic function.
6	Risk of Infectious Diseases such as HIV/AIDS	B-	D	- Proper guidance carried out for construction workers to prevent infectious diseases.
7	Impact on Livelihood/Income	B-, B+	B+	- Carrying out of night works to ensure the commercial activity of the surrounding markets, shops and restaurants

Legend : A +/-: Serious 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 : JICA Survey Team

(e) Consultation

During the Preparatory Survey of the Project, the JICA Survey Team made the subletting contract for the environmental and social considerations to follow up the required documents of IEE/IEIA and draft RAP (Resettlement Action Plan) in a tight schelue of the Preparatory Survey.

On the other hand, the Kick-off meeting was carried out on 25th April 2016. Related person for the Project such as staffs of PPCC and DPWT and Sangkat Khans participated the meeting and the Basic Design for the Project was announced. After completion of the Draft Final Report, the Project contents shall be explained to people affected by the Project. Before the construction works, the contents and detail schedule will be explained in related residences in public meetings.

1.4.1.7 Terms of Reference (TOR) for the Initial Environmental Impact Assessment (IEIA)

Based on the scoping plan mentioned in **Subsection 1.4.1.6**, the Terms of Reference (TOR) for the Initial Environmental Impact Assessment (IEIA) survey for the items having the "B" environmental and social evaluation is summarized in the following table.

In addition, the Cambodian legal formation system does not demand it about a strategic environmental evaluation as stated in the JICA environmental and social considerations guidelines (2010) in particular. It is noted here that through early information disclosure for the Project it is expected to perform the stakeholder meetings necessary for the project affected peoples and public consultation meetings for all the project related agencies during a series of the Project stages such as the JICA Preparatory Survey stage, the detailed design stage, and the construction stage.

Table R 1.4.19 TOR of IEIA

	Item	Necessary Contents	Source Information
1	Introduction	• The Project summary: Outline of the Project background, the objectives of the Project, the Project area • Purpose of the IEIA (IEE) report • The purpose of the Preparatory Survey and the investigation, necessary information, information and data collection, information analysis.	• Existing document investigation
(Influence on human health and security and influence on natural environments)			
2.	Outbreak of air pollution & dust	• Confirmation of the environmental standard values • Grasp of the influence range under construction	• Existing document survey • Collection of data & information for the construction and confirmation
3.	Noise and vibration	• Confirmation of the environmental standard value • Grasp of the influence range • Grasp of the influence range under construction	• Existing document survey • Field survey • Collection of data & information for the construction and confirmation
4.	Accident	• Road safety measures • Traffic regulation, industry action, etc.	• Existing document survey • Collection of data & information for the construction and confirmation
5.	Change in the drainage diversion system	• A temporary sewerage diversion during construction period of the drainage pipe installation	• Existing document survey • Collection of data & information for the construction and confirmation
6.	Construction waste, surplus soil disposal	• Earthwork materials for backfill are possible to be stocked at the temporary stockyard. • Unsuitable soil materials for backfill should be carried to the appointed soil dumping site for disposal appropriately. • Reuse of steel sheet piles is to be performed appropriately.	• Existing document survey • Collection of data & information for the construction and confirmation
7.	Soil erosion and slope collapse	• During the installation of pipes under the roads, appropriate temporally work such as installation of steel sheet pile and/or trench sheet will be carried out against soil erosion and slope collapse. • In particular, it is noted that a temporary design and construction for the soft and sandy ground sites.	• Existing document survey • Collection of data & information for the construction and confirmation
Social environment			
8.	Involuntary resettlement (Land acquisition and resettlement)	• In the construction work of drainage pipe laying at the Tuol Kork area, two (2) land lots are to be needed land acquisition and building relocation.	• Existing document investigation • Land Acquisition and Resettlement Action Plan (LARAP) survey and contents confirmation

	Item	Necessary Contents	Source Information
8.	Influence by the development on social infrastructure and service	• Road safety measures • Traffic regulation, setting of the temporary access, if necessary.	• Existing document investigation • Collection of data and information for the construction and confirmation
9.	Security around the road site	• Road safety measures (setting of an instruction for road safety, the setting of the signboard/a detour and the bulletin board, placement of the traffic control staff))	• Existing document investigation • Collection of data and information for the construction and confirmation
10.	Road traffic, vehicle service	• Road safety measures (setting of an instruction for road safety, the setting of the signboard/a detour and the bulletin board, placement of the traffic control staff) • The construction by night at the point with much traffic including the crossing should be considered.	• Existing document investigation • Collection of data and information for the construction and confirmation
11.	Infectious diseases such as HIV/AIDS	• Proper guidance carried out for construction workers to prevent infectious diseases.	• Existing document investigation • Collection of data and information for the construction and confirmation
12.	Living & income	• Although an inconvienience may not be happedned, any access required to shops and restaurants should be set up so that influence does not occur to living and income during construction stage more.	• Existing document investigation • Collection of data and information for the construction and confirmation
13.	Inhabitants participation in stakeholder meetings	• Report of the public consultation	• Stakeholder meeting report
Summary			
14.	Conclusions and recommendation	Conclusion of the environmental assessment minimizing environmental and socioeconomic impacts	A temporary countermeasure should be proposed by the discussion with the relevant agencies.

1.4.1.8 Results of Survey based on TOR

According to the TOR described in **Subsection 1.4.1.7**, findings are described below.

Table R 1.4.20 Findings of Environmental and Social Consideration

<table>
<tr><th>Impact Evaluations</th><th>Results</th></tr>
<tr><td>Air Pollution</td><td>
Environmental standard in Cambodia and the measurement values of air pollutions in 2014 are shown below.
<table>
<tr><th>Parameters</th><th>CO (mg/m^3)</th><th>NO$_2$ (mg/m^3)</th><th>SO$_2$ (mg/m^3)</th><th>TSP (mg/m^3)</th></tr>
<tr><td>Standards in Cambodia</td><td>20</td><td>0.1</td><td>0.3</td><td>0.33</td></tr>
<tr><td>Data measurements in 2014</td><td>3.87</td><td>0.071</td><td>0.027</td><td>0.169</td></tr>
</table>
Source : MOE

Results of air quality measurement (2016) in the Project Area can be referred to the above baseline.
<table>
<tr><th rowspan="2">Parameters</th><th rowspan="2">Unit</th><th rowspan="2">Cambodian Standards[(i)], 24h</th><th colspan="2">Measurement Results</th></tr>
<tr><th>at Kunthak Bopha Hospital, Wat Phnom Northern. date July 20-21, 2016</th><th>at Gasoline (Tela) station Tuol Kork, date July 21-22, 2016</th></tr>
<tr><td>Carbon Monoxide (CO)</td><td>mg/m^3</td><td>20[(ii)]</td><td>12.88</td><td>8.44</td></tr>
<tr><td>Nitrogen Dioxide (NO$_2$)</td><td>mg/m^3</td><td>0.1</td><td>0.028</td><td>0.025</td></tr>
<tr><td>Sulfur Dioxide (SO$_2$)</td><td>mg/m^3</td><td>0.3</td><td>0.022</td><td>0.018</td></tr>
<tr><td>Total Suspended Particles (TSP)</td><td>mg/m^3</td><td>0.33</td><td>0.285</td><td>0.243</td></tr>
<tr><td>PM10</td><td>mg/m^3</td><td>-</td><td>0.149</td><td>0.126</td></tr>
</table>
Notes: There was heavy rain at 12:30 pm during measurement.
[(i)] Sub-decree No.42, on Air Pollution Control and Noise Disturbance, Annex 1: Ambient Air, Quality Standard
[(ii)] 8hs. average
Source: JICA Survey Team, MOE's laboratory, the IEIA report on the Project, 2016.
</td></tr>
<tr><td>Noise</td><td>
• Noise standards in Cambodia are as summarized in the table below.
• According to the MOE, there are not the measurement noise data at all.

Maximum Noise Standard of Public and Residential Areas in Cambodia
<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Areas</th><th colspan="3">(dB)</th></tr>
<tr><th>6:00-18:00</th><th>18:00-22:00</th><th>22:00-6:00.</th></tr>
<tr><td>1.</td><td>Quiet Area
Hospital/library/school/Kindergarten</td><td>45</td><td>40</td><td>35</td></tr>
<tr><td>2.</td><td>Residential Area
Hotel/Admin. office/ Villa/flat</td><td>60</td><td>50</td><td>45</td></tr>
<tr><td>3.</td><td>Commercial and service areas, and multiple business</td><td>70</td><td>65</td><td>50</td></tr>
<tr><td>4.</td><td>Small industrial factories mingling in residential areas</td><td>75</td><td>70</td><td>50</td></tr>
</table>
Source: Sub-decree No.42 ANK/BK The Control of Air Pollution and Noise Disturbance, the Royal Government of Cambodia、2000 MOE

For reference purpose, the air quality measurements of noise and vibration conducted on the same location and date were shown in the table below.
Results of Noise Measurement (the Project, 2016)
<table>
<tr><th>Time</th><th>Cambodian Standard[(*)], dB(A)</th><th>Result, dB(A)</th></tr>
<tr><td colspan="3">Station 1: at Kunthak Bopha, Wat Phnom Northern, date July 20-21, 2016</td></tr>
<tr><td>Day (6:00 - 19:00)</td><td>70</td><td>63-66</td></tr>
<tr><td>Evening (19:00 - 23:00)</td><td>65</td><td>58-65</td></tr>
<tr><td>Night (23:00 - 6:00)</td><td>50</td><td>55-64</td></tr>
<tr><td colspan="3">Station 2: at Tela Station, Tuol Kork date July 21-22, 2016</td></tr>
<tr><td>Day (6:00 - 19:00)</td><td>70</td><td>68-75</td></tr>
<tr><td>Evening (19:00 - 23:00)</td><td>65</td><td>59-67</td></tr>
<tr><td>Night (23:00 - 6:00)</td><td>50</td><td>53-68</td></tr>
</table>
Note: [(*)] Sub-Decree on Air Pollution Control and Noise Disturbance, Annex 6: Maximum permitted noise in public and residential area, point 3 Commercial and service areas and mix.
Refer to Table R 1.1.11 & Table R 1.1.12.
Source: JICA Survey Team, MOE's laboratory, the IEIA report on the Project, 2016.
</td></tr>
</table>

Impact Evaluations	Results
Vibration	• There is no standared for vibration in Cambodia. • According to the MOE, there are not the measurement vibration data at all.

Results of Vibration Measurement (the Project, 2016)

Time	Japanese Standard (**), dB(A)	Result, dB(A)
Station 1: at Kunthak Bopha, date July 20-21, 2016		
Day (6:00 - 18:00)	65	25-32
Night (23:00 - 6:00)	60	22-31
Station 2: at Tela Station, date July 21-22, 2016		
Day (6:00 - 18:00)	65	21-27
Night (23:00 - 6:00)	60	17-25

Note: (**) Environmental Quality Standard of Japan
Source: JICA Survey Team, MOE's laboratory, the IEIA report on the Project, 2016.

Water Quality*1

Base on the observation levels by the DOE in the Tonle Sap River, the water quality monitoring results (2010 to 2013) is shown below.

Water Quality Monitoring Results (minimum, maximum, mean) of the Tonle Sap River

Location		pH (-)	TSS (mg/l)	BOD (mg/l)	COD (mg/l	T-N (mg/l)	T-P (mg/l)	Cr6+ (mg/l)
Tonle Sap River	Minimum	6.49	22.0	0.2	1.4	0.08	0.02	not detected
	Maximum	8.24	474.0	6.5	9.3	8.11	0.50	0.320
	Average	7.32	106.5	2.3	4.5	1.23	0.11	0.027
Standards		6.5-8.5	<100	<10	-	-	-	<0.005

- The Project does not affect the quality of drainage water in pipes at all. It is however noted that based on the request by the MOE, the Project will observe a water quality of sewerage as a baseline before the construction starts and take a monitoring a water sampling of quality from the drainage pipe for one year after completion of the Project.
- As the measuring baseline of water quality before the project implementation and based on the request by the MOE (Cambodia), the water quality measurement was carried out during the Preparatory Survey stage on the Project. The base line survey was conducted at the selected three (3) sampling points selected by the JICA Survey Team as shown in table below.

Water Quality Examination (the Project 2016)

No.	Parameters	Unit	Results of River Water Test			Results of Sewage	
			Cambodia standard 1)	R1=S1*	R2=S2*	Cambodia standard 2)	WW1=S3*
1	pH		6-9	6.7	6.9	5-9	6.9
2	Temperature	^{0}C	<45	36	29.3	<45	30.2
3	Electrical Conductivity (EC)	µS/cm	-	-	184	-	400
4	Turbidity	NTU	-	-	8.75	-	22.60
5	Dissolved Oxygen (DO)	mg/l	2.0-7.5	1.68	5.89	>1	3.27
6	Total Suspended Solid (TSS)	mg/l	25-100	180	68	<120	77
7	Biochemical Oxygen Demand (BOD5)	mg/l	1.0-10	122.40	3.46	<80	38.90
8	Chemical Oxygen Demand (COD)	mg/l	1-8	0.94	-	<100	ND (not detected)
9	Oil and Grease	mg/ l	-		4.85	<15	7.84
10	Nitrate	mg/ l	-	6.66	0.42	<20	4.69
11	Phosphate (PO4)	mg/ l	-	3.26	ND	<6	0.35
12	Total Coliform	MPN/100	<5000	$9.3x10^3$	$2.1x10^3$	-	$2.4 x10^4$

Notes: 1) Water quality standard in public areas for bio-diversity conservation for river, lake and reservoir.
2) Effluent standard for pollution sources discharging wastewater to public water area or sewer.
Three (3) water sampling locations;

*Sample code	Location	GPS point	Remarks
R1=S1	in front of water pumping station Wat Phnom	X=491743; Y=1280024	Tonle Sap River
R2=S2	Pres Komlong Station	X=492484 ; Y=1278920	Tonle Sap River
WW1=S3	Existing sewage pipeline in front of Tela gas Station	X=487712; Y=1280337	Sewage water in manhole along the main road

Sampling and testing done on 15 July 2016.
Source: JICA Survey Team, MOE's laboratory, the IEIA report on the Project, 2016.

*1 Water quality
(water quality is not included in scoping of the Project, but listed it here as an item in conjunction with the reference of the maintenance of future facilities)

Impact Evaluations	Results
Accident	The Traffic Law (2006) in Cambodia stipulates measures for maintaining order and safety in road traffic, protecting human and animal lives, curbing the effect on human health, damage and offenses stemmed from the use of the roads. On the other hand, there is no provision in the law stipulation about any obligation of setting or allocating traffic signs and related measures for preventing disturbances with the construction. There is the passing prohibition in the construction site. In other words there is only a stipulation for the dangerous evasion of the driver side.
Change in Water Diversion	Based on the findings of the field survey, the construction plan on concrete drainage pipe laying ways and the design should be prepared for proper sewerage diversion during construcion period.
Construction Waste/ Surplus Cut Soil	Based on the construction plan of the Project, a disposal area or temporary stockyard of construction waste should be planned appropriately.
Soil Erosion & Slope Collapse	When a drainage pipe is layed in the ground, it is necessary to prevent the soil erosion and slope collapse at the digging site appropriately.. Therefore the contractor in pursuance of the construction works should make appropriate preventive measures (this matter shall be stated clearly to the conditions and specifications of the contract documents).
Involuntary Resettlement & Land Acquisition	There are two (2) affected private lands and buildings near the TK-1 pumping station (under the construction) in the Tuol Kork area of the Project; namely, 1) land lot and shop structure to be acquired, and 2) a residential house to be relocated and residential people to be shifted during construction period. IRC (Inter-ministerial Resettlement Committee)-MEF and PPCC are related agencies for the land and relocation.
Infectious diseases such as HIV/AIDS	Law on the prevention and control of HIV/AIDS in Cambodia (2002) stipulates the impotance of IEC (Information, Education, Communication) activity, dissemination and prerparatiom of guidlines by the National AIDS Authority, and an exhibition are also required in the law in the country.

Notes : *1 cluded in scoping of the Project, but listed it here as an item in conjunction with the reference of the maintenance of future facilities).

1.4.1.9 Results of Evaluation

Based on the result of the environmental assessment survey described in **Table R 1.4.20** "Findings of Environmental and Social Consideration", the evaluation results as reflected the previous survey are as summarized as shown below.

Table R 1.4.21 Results of Evaluation

Category	No.	Impacts	Evaluation at Scoping		Evaluation by Survey Results		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Influence on health and security to a person and influence on resources environment	1.	Air Pollution	B-	D	B-	D	At-work: Operation of construction equipment may cause air pollution by emission of exhaust gas or dust to a certain extent. In-use: there is no impact item to produce air pollution in the Project operation time.
	2.	Noise/ Vibration	B-	D	B-	D	At-work: Laying of pipes/culverts under the roads as well as transporting materials through residential area could cause noise and vubration disturbance, even temporarily during operation time of equipment. In-use: there is no impact item to produce air pollution in the Project operation time.
	3.	Water Pollution	D	D	D	D	At-work: Drainages from the construction sites, equipment and camps are anticipated to be potential sources of water pollution. Therefoe, it may not cause quality of the water aggravation. In-use : The impact item does not exist after the Project is completed. In the dry season, sewage is not directly drained into the Tonle

Category	No.	Impacts	Evaluation at Scoping		Evaluation by Survey Results		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
							Sap River (interceptor effect). Wain water and sewerage are drained out from a drainage pipe as a combined system in wet season.
	4.	Accident	B-	D	B-	D	At-work: Construction work requires traffic control and restriction. The work could increase traffic accidents. In-use: The accident during the time of use is impossible.
Natural Environment	5.	Change in Diversion	B-	B+	B-	B+	At-work: Falseworks should be performed in conformity with an appropriate construction management plan based on construction experience of Phase III. In-use: The drainage condition will be improved after the construction.
	6.	Construction Waste/ Surplus Cut Soil	B-	D	B-	D	At-work: The excavation and surplus soil materials have to be used backfill and disposed at a suitable disposal area under the appropriate construction plan. In-use: After completion of the Project, the appropriate management of a temporary dumping site and the disposal site should be performed properly
	7.	Soil Erosion/ Slope Collapse	B-	D	B-	D	At-work: Based on the construction experience in Phase III, a proper temporary falseworks plan such as the steel sheet or the steel sheet pile should be performed. In-use: The impact item does not exist after the Project is completed.
Social Environment	8.	Involuntary Resettlement & Land Acquisition	B-	D	B-	D	At-work: About the house/ building, land area where the relocation is required and the land acquisition is necessary for, a necessary procedure should be completed before the construction work starts. In-use: Because a resident is not in the house for resettlement, the resettlement does not occur in the Project.
	9.	Social Infrastructures and Services by Developement	B-	B+	B-	B+	At-work: Influence on road traffic is big during construction. In-use : Because the inundation is reduced after the Project completion and living environment is also improved, it is thought to contribute to social services such as sightseeing
	10.	Road Safety near Construction Site	B-	D	B-	D	At-work: In around road under construction, it is expected by the operation of the construction equipment/ machine that the road safety decreases.
	11.	Road traffice/ vehicle service	B-	B+	B-	B+	At-work: Because the road traffic is restricted/ regulated during a drainage pipe laying period by one side suspension of traffic, it is necessary to plan thorough appropriate traffic control and vehicle service with the instructions of the organization concerned. During the operation stage, the traffic condition will be improved with flood mitigation.

Category	No.	Impacts	Evaluation at Scoping		Evaluation by Survey Results		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
	12.	Infectious diseases such as HIV/AIDS	B-	D	B-	D	At-work: Although the large-scale construction work is not assumed, the workers should be a contributing factor for increasing the rate of infection with related diseases because infection of the AIDS is relatively high in Cambodia
	13.	Livelihood/ Income	B-, B+	B+	B-	B+	At-work: During the laying work of the drainage pipe, the access of the inhabitants along the road should be kept free. During the operation stage, the Project will contribute to increased tourism development and improvement of livelihood.
	14.	Employment and Livelihood	B+	B+	B+	B+	At-work: On the occasion of drainage pipe laying construction within the ROW (Right-of-Way) of the road, there is not that most of the access to houses and commercial areas along the road is inhibited basically. However, for the inconvienience, DPWT/PPCC will arrange an appropriate explanation by a prior inhabitants briefing (public consultation) before the construction work and get the understanding of inhabitants.
	15.	Participation on social activity	D	D	D	D	Society, economic activities are promoted more by inundation damage in PPCC being reduced at the time of the use of the Project.

Legend : A +/-: Serious 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.

1.4.1.10 Mitigation Measures

The mitigation measures and costs is shown below.

Table R 1.4.22 Mitigation Measures for the Project

No.	Affect Items	Mitigation Measures	Existing Agencies	Responsible Agencies	Cost (US$)
1.	Air Pollution	• Keep the equipment in good condition on the site by providing proper maintenance work. • In conformity with an appropriate construction plan/ schedule, implement proper equipment operation. • Equipment suitable for the Cambodian environmental standards for air pollutions shall be selected. • For the selection of transportation route for construction materials as well as wastes, a shortest route while avoiding popullation crowded area as much as possible shall be taken. • Conduct appropriate monitoring of construction equipment periodically for verifying the conditions of equipment following Cambodian environmental standards.	Contractor	DPWT/PPCC	For the corresponden ce by the laborer in a construction plan and the construction, it is an expense-free
2.	Noise and Vibration	• Avoid the night-time construction work. If it cannot be avoided, take preventive measures like usage of noise-proof sheet in machine for minimizing noise and vibration for the sake of neighbouring inhabitants. • As soon as complaint by residents arises, abort the construction work. The Contractor shall hold meetings with the Project owner for discussing and seeking breakthrough measures. • Use noise-proof sheet covering for loud construction equipment to reduce noise generation as much as possible. For piling work, apply the method not using a hammer-type pile driver for control of noise and vibration. • Conduct monitoring arbitrarily for verifying that conditions follow Cambodian environmental standards. As soon as the condition exceeds the standard, abort construction work. The Constractor shall hld meetings withthe Project owner for discussing and seeking breakthrough measures.	Contractor	DPWT/PPCC	Included in construction cost.
3.	Water Pollution	• Keep the construction equipment parts in good condition on the site by providing proper maintenance work.	Contractor	DPWT/PPCC	For the corresponden ce by the laborer in a construction plan and the construction, it is an expense-free
4.	Accident	• Allocate traffic signs for securing smooth traffic around construction site. • Allocate traffic controllers for securing smooth traffic around construction site. • Set spped limit for construction vehicles to prevent happening of accident. • Before the measure such as construction time is imposed, consult with local authorities and the local police for seeking optimum measure for preventin traffic congestion.	Contractor	DPWT/PPCC	Included in construction cost.
5.	Drainage Water Diversion	• A temporary drainage water diversion shall be properly planned and performed in accordance with appropriate construction plans and approval.	Contractor	DPWT/PPCC	Included in temporary construction cost .
6.	Construction	• A disposal of construction waste and surplus cut soil	Contractor	DPWT/PPC	Included in construction

No.	Affect Items	Mitigation Measures	Existing Agencies	Responsible Agencies	Cost (US$)
	Waste/ Surplus Cut Soils	materials should be in accordance with an appropriate construction plan. • A constrcution waste disposal in the final disposal area should be performed properly, as well as the management of the final disposal site.		C	cost.
7.	Soil Erosion & Slope Collapse	• Based on the appropriate construction plan, a steel sheet pile or a trench steel sheet should be utilized appropriately to prevent soil erosion or slope collapse.	Contractor	DPWT/PPCC	Included in construction cost.
8.	Relocation/ Land Acquisition	• Under the Project, no resettlement of inhabitants does not exist at all while only two (2) sites to be relocated and land acquisitions are needed (Under the subcontracting work for LARAP.) • According to Cambodian laws and ordinances (RD-IRC-MEF) and the JICA guidelines (April, 2010), such as building relocation and land acquisition should be dealt with appropriately.	Contractor	DPWT/PPCC	Included in construction cost.
9.	Social Infrastructure/ Social Service by Development	• During construction of the drainage pipe laying, a necessary care should be considered so that a trouble does not occur for the access to a house or the store. • A temporary access to houses/shops/restaurants will be set up, if necessary.	Contractor	DPWT/PPCC	Included in construction cost.
10.	Road Safety near Construction Site	• An instruction and the beacon for road safety should be established, particularly for night construction. • In addition, a detour should be set and the traffic signboard.	Contractor	DPWT/PPCC	Included in construction cost.
11.	Road Traffic/ Vehicle Service	• During construction work for drainage pipe system, a detour plan should be made for traffic control properly together with setting of signboard. • On the occasion of the construction in the crossing with much traffic, construction may be required to carry out by night, if necessary. Necessary cover means such as an appropriate steel plates may be set on for normal traffic restore in the daytime.	Contractor	DPWT/PPCC	Included in construction cost.
12.	Infectious Diseases such as HIV/AIDS	• Hold appropriate training s or precaution seminars for workers to learn the correct knowledge about the diseases.	Contractor	DPWT/PPCC	It is a matter of Contractor's expence.
13.	Livelihood and Income	• Although an inconvienience may not be happedned, any access required to shops and restaurants should be set up so that influence does not occur to living and income during construction stage more.	Contractor	DPWT/PPCC	Included in construction cost.
14.	Local Economy such as Employment and Livelihood	• In excavation works at roads near local shops and market, the access to facilities should be secured always by setting covering panels or any appropriate material on the excavated area. For incommodiousness, the work schedule should be explained to the related people by a prior briefing. Also, the length of excavation should be shorter and backfill shall be conducted promptly to minimize.	Contractor	DPWT/PPCC	Included in construction cost.
15.	Active Participation by the Project Completion	• Due to reduction of inundation damage in the Project area after the Project is completed, social and economic activities will be promoted	Contractor	DPWT/PPCC	Included in construction cost.

Source : JICA Survey Team

1.4.1.11 Environmental Management and Monitoring Plan

The draft environment management plan and monitoring plan for the Project is shown below.

Table R 1.4.23 Draft Environment Management and Monitoring Plan

Environmental Item	Monitoring Item	Location	Frequency	Related Standard	Responsible Organization	Cost
Pre-work						
Noise and Vibration	Noise level	2 points : one is in Tuol Kork area, the other is in Wat Phnom Northern area.	Once	Sub-decree on Air Pollution Control and Noise Distrubance (2000)	Sub-contracting work	Cost involved in the JICA Preparatory Work
Air Pollution	CO, NO2, SO2	-	-	Sub-decree on Air Pollution Control and Noise Distrubance (2000)	MOE Quoted from Existing reports	-
Water Pollution (sampling from sewerage)	10 items （pH, turbidity, conductivity, TSS, DO, BOD5, NO3, PO4, total coliform, oil & grease）	3 sampling points : 1 point at Tuol Kork area, 2 outlet drainage points in Tonle Sap River	Once	Sub-decree on Water Pollution Control (1999)	Sub-contracting work	Cost involved in the JICA Preparatory Work
At-work						
Air Pollution	CO, NO2, SO2	2 points : 1 point in Tuol Kork area, 1 point in Wat Phnom Northern area.	Monthly	Sub-decree on Air Pollution Control and Noise Distrubance (2000)	Contractor	Involved in the Project Cost
Noise and Vibration	Noise level	2 points : 1 point in Tuol Kork area, 1 point in Wat Phnom Northern area.	Monthly	Sub-decree on Air Pollution Control and Noise Distrubance (2000)	Contractor	Involved in the Project Cost
Water Pollution (sampling from sewerage)	Drainage standard of 10 items （pH, turbidity, conductivity, TSS, DO, BOD5, NO3, PO4, total coliform, oil & grease）	3 sampling points : 1 point at Tuol Kork area, 2 outlet drainage points in Tonle Sap River	Monthly	Sub-decree on Water Pollution Control (1999)	Contractor	Involved in the Project Cost
Waste	Site survey for confirming whether or not the process of generated wastes (both general and works) is properly treated.	Waste disposal site	Monthly	Sub-decree on Solid Waste Management, (1999)	Contractor	There is no cost because of field survey.
Ecosystem	Field reconnaisance for confirming presence or absence of protected animals, plants or any precious organisms.	Project area, especially, the surrounding area of each construction site.	Once	Declaration on Protected Areas (1994) Protected Areas Laws (Royal Decree (2008)	Contractor	Involved in the Project cost
Local Economy	Hearing survey	Every project	Once	JICA Guideline	Contractor	There is no cost

Environmental Item	Monitoring Item	Location	Frequency	Related Standard	Responsible Organization	Cost
such as Employment and Livelihood, etc.	for confirming presence or absence of any complaints or disturbance on their commercial activities.	site.	(every work site)	(2010)		because of field survey.
Existing social infrastrictures and services	Field reconnaisance for confirming presence or absence of any trafic disturbance.	Each work site and its surrounding. Connecting roads.	Weekly or as work sitemoves	The Traffic Law (2006)	Contractor	Involved in the Project cost
HIV	Holding meetings for providing necessary instructions to workers.	Each construction site.	Weekly or as work site moves	The Law on Prevention and Control of HIV/AIDS	Contractor	There is no cost because of the Contractor's own expences.
Work Environment (incl. Work Safety)	Inspection for for construction sites regarding stipulated rules are followed or not.	Each construction site.	Weekly or as work site moves	The Labor Law (2002)	Contractor	There is no cost because of the Contractor's own expences.
Accident	Site investigation as accidents occure.	Each work site	Weekly or as work site moves	The Traffic Law (2006)	Contractor	There is no cost because of the Contractor's own expences.
In use						
Water pollution	Water pollution of 10 items : （pH, turbidity, conductivity, TSS, DO, BOD5, NO3, PO4, total coliform, oil & grease）	3 sampling points : 1 point at Tuol Kork area, 2 outlet drainage points in Tonle Sap River	Semi-annually (for one year after the initial operation period starts.)	Sub-decree on Water Pollution Control (1999)	DPWT/PPCC	Involved in the Project cost

Source: JICA Survey Team

1.4.1.12 Stakeholder Meeting

The JICA Survey Team requested the Cambodian side to hold stakeholder meetings together with related residents and authorities twice during the field survey period. The results of the stakeholder meetings conducted for the Project is summarized below.

Table R 1.4.24 Outline of Stakeholder Meeting (SHM) in PPCC

Stakehoder Meeting Date/Place	Participants/ Subjects	Contents of SHM, Questions from the Residents	Responses to the Comments
First Stakeholder Meeting Grand total numbers of participants Male=41 Female=54 Total= 95 Venue : KhanWat Phnom Sangkat Srah Chak Date : 2016/7/29 At Village 10 Male=11 Female=14 Total=25 2016/8/1 At Village 8, Sangkat Wat Phnom 2016/8/3 At Village 10 Male=7 Female=8 Total= 15 Venue : Khan Tuol Kork Sangkat Boeung Kok I 2016/8/5 At Village 8 Male=13 Female=22 Total= 35 2016/8/8 At Village 4 Sangkat Boeung Kok II 2016/8/10 At Village 6 2016/8/11 At Village 26 Male=10 Female=10 Total= 20	Khan Wat Phnom Sangkat Srah Chak Total 25 participants were joined in the meeting, comprising local authorities, JICA Survey Team, and 14 women local people in the Project area. Sangkat Wat Phnom Total 15 participants were joined in the meeting, comprising local authorities, JICA Survey Team, and 8 women local people in the Project area. Khan Tuol Kork, Sangkat Boeung Kok I Total 35 participants were joined in the meeting, comprising local authorities, JICA Survey Team, and 22 women local residents in the area Sangkat Boeung Kok II Total 20 participants were joined in the meeting, comprising local authorities, JICA Survey Team, and 10 women residents in the area Local governments : 29/7/2016 1st Deputy Chief of Sangkat Srah Chak Chief of village 10 Sangkat Srah Chak Village 8 menber of Sangkat Srah Chak Village 11 menber of Sangkat Srah Chak 02/8/2016 1st Deputy Chief of Sangkat Srah Chak Chief of village 10 Sangkat Srah Chak Village 8 menber of Sangkat Sras Village 11 menber of Sangkat Srah Chak 02/8/2016 Chief of Sangkat Boeung Kok I Chief of Sangkat Boeung Kok I I Village Chief 8 menber of Sangkat Boeung Kok I Village Chief 4 menber of Sangkat Boeung Kok I 03/8/2016 Director Department of Women Affair Phnom Penh 04/8/2016 Director Department of Planning of PPCC	• Description of the background of the Japan Grant Aid/ JICA Project and its current situation with 3 phases since 2001, Phase I to Phase III. • Necessity of Phase IV (the Project). • For public notice, it is informed that the measurements of air quality, noise/vibration and water quality start in July 2016 in the Project area. • Questions : • The residents welcomed the Project, but suggested that impacts should be minimized. • The residents expect a completion of the Project and hope that the effects of the Project appear early as possible. • The residents expressed a full support on the Project and want to see that all people in the Project area have access to safe environment by proper drainage services by completion of the Project. • The residents hope that during construction a trafic jam should be mitigated as much as possible.	By taking mitigation measures such as selection of area, adjustment of construction method, scale, timing, driving sheet-pile, setting panels,etc. With the conduct of monitoring, adverse impacts can be minimized. For the waste management, provide the contractors through instruction in waste management.

Stakehoder Meeting Date/Place	Participants/ Subjects	Contents of SHM, Questions from the Residents	Responses to the Comments
The Second Stakeholder Meeting SHM Venue : Phnom Penh Capital Hall Date : 24, November 2016 Numbers of participants Male=14 Female=2 Total= 16	Deputy Governor, PPCC DPWT-PPCC DOE-PPCC DOP-PPCC DOWRAM-PPCC DLMUPC-PPCC Administration Division-PPCC Urbanization Division-PPCC Waste Management Division-PPCC Chiefs of Local Authorities	• Welcome speech by the Governor. • Introduction and objectives of the 2nd public consultation. • Necessity of the Project. • Presentation on the draft IEIA/IEE results. • Discussion and comments by participants and related government offices on the draft IEIA/IEE results. • Discussion on the negative impacts on the proposed the Project. • Conclusion and closing remarks • Questions and Answers : - The installation work for drainage pipes/box-culverts for the Project shall be implemented and completed appropriately. - Based on the detailed work plan at site, the contractor shall explain about the location site, work schedule, working time, work method, etc, to local people appropreately during public consultations. - The contractor shall follow the Cambodian environmental standards, subdecrees, laws and regulations in implementation of the work. - To surround the work site with fences/nets or other means for prevention of invation of local people, accident prevention should be prepared and the necessary trafic sign and detour should be provided. - The contractor is required to follow the Cambodian MOE's sub-decrees of noise-vibration. - The contractor shall manage appropriately the disposal of construction waste and treat surplus cut soil materials well in accordance with an appropriate construction plan. Also, constrcution wastes in the final disposal area shall be disposed properly, as well as the management of the final disposal site. - The contrator shall manage and operate all construction equipment properly at the tourist site of Wat Phnom area. - The contractor shall pay attention to treat the existing trees in the area of the Project. In particular, since old and big trees are often related to a religious belief in Cambodia, they shall be preserved as much as possible. - The contractor is requested to train	By taking necessary mitigation measures to reduce and minimize adverse impacts, the conduct of monitoring at site may be requried as follows ; • Avoid the night-time construction work. If it cannot be avoided, take preventive measures like usage of noise-proof sheet in machine for minimizing noise and vibration for the sake of neighbouring inhabitants. • As soon as complaint by residents arises, abort the construction work. The contractor shall hold meetings with the Project owner for discussing and seeking breakthrough measures. • Use noise-proof sheet covering for loud construction equipment (low-vibration type equipment such as the Silent Piler and vibrate hammer will be used) to reduce noise generation as much as possible. For piling work, apply the method not using a hammer-type pile driver for control of noise and vibration. • To conduct monitoring arbitrarily for verifying that conditions follow Cambodian environmental standards. As soon as the condition exceeds the standard, abort construction work. The constractor shall hold meetings with the Project owner for discussing and seeking breakthrough measures. • The excavation and

Stakehoder Meeting Date/Place	Participants/ Subjects	Contents of SHM, Questions from the Residents	Responses to the Comments
		their subcontractors not to dispose any wastes into the Tonle Sap River. - Due to bad smell at the areas of Chaktokmuk and Tuol Kork sometimes, a waste water treatment plant might be needed. (Responses from DPWT) - At the downstream end of drainage network of Wat Phnom Northern Area, the rain/stormwater from the Area is drained out into the Tonle Sap River (i) by gravity when the water level of the River is low and (ii) by pump when the water level of the River is high. - The proposed facilities such as a pumping station, trash screen and an underground reservoir shall be constructed and maintained by DPWT-PPCC. - Also, as with Phase II, the PPCC plans that an interceptor pipe will be proposed to prevent wastewater from being directly discharged to the Tonle Sap River in rainy season. In the Project, an interceptor pipe is proposed in Wat Phnom Northern Area. (Respose to the query) The Project owner is PPCC and the executing agency of the Project is DPWT-PPCC.	surplus soil materials have to be used backfill and disposed at a suitable disposal area under the appropriate construction plan.

Source : JICA Survey Team

1st Stakeholder Meeting

2nd Stakeholder Meeting

Photo R 1.4.1 Stakeholder Meeting for Environmental & Social Considerations

1.4.2 Land Acquisition and Structure Relocation

1.4.2.1 Necessity of Land Acquisition and Structure Relocation

As mentioned in "1.4.1.5 Comparison of Alternative Plans", the number of the Project affected houses became able to decrease from approximately more than twenty (20) houses to two (2) houses in the Tuol Kork Area. Since it is found that there are no residents who live in the shelter shop or do not need to resettle to a resettlement site in the affected house, there is no permanent resettlement under the Project although one resident is required temporary moving during the installation of box culvert.

In terms of the land acquisition for the Project, the new drainage pipe/ box culvert laying, construction work of the new underground reservoir, and the new Pumping Station No. 6 in the Wat Phnom Northern Area, are all possible within the public land (ROW : Right-of-Way). On the other hand, in the Tuol Kork Area, although the construction work for the drainage pipes/box culverts laying is possible within the road public land (ROW), some expropriation of private lands are needed in two (2) Affected Households (AHs); one is for the laying work for the drainage box-culverts at a private land between Roads St. 315 and St. 608, and the other one is the residential house which seems to be definitely affected by the construction works like steel sheet piling near the new TK Pumping Station (under construction).

As a result, there is no permanent resettlement of affected houses in the Project after the reconsideration of drainage improvement plan. There are only two (2) private lands to be affected by the Project in the Tuol Kork Area after the first field survey work (in April & May 2016) was carried out as summarised in the following table.

Table R 1.4.25 Land Acquisition and Resettlement for the Project

Area of the Project	Land Acquisition for Construction Works of the Project			Resettlement
	Drainage Pipe/ Box Culvert Instalation	Underground Reservoir ($V=6,500m^3$)	Pumping Station (P.S.) ($Q=1.4m^3/s$)	
Wat Phnom Northern Area	Public land (ROW)	Public land (ROW)	P.S.No.6 Public land (ROW) without structure	There is no resettlement.
Tuol Kork Area	Public land (ROW) + AH-1 :Legal private land (lot (63 m^2) with a removal of 2 story- steel framed structure) + AH-2:Tentative relocation of building structure and residents	-	-	The residence of AH-2 will tentatively relocate during construction

Source: DPWT/PPCC, JICA Survey Team

1.4.2.2 Legislation and Legal Procedure for Relocation and Land Acquisition

(a) Legislation

Legal framework for relocation and land acquisition are mentioned in the table below.

Table R 1.4.26 Legislation related to Relocation and Land Acquisition

No.	Legislation	Description
1.	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.
2.	No. 224 in 1996 Ministry of Economy and Finance, Prakas (Declaration) 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)
3.	No. 118 in 2005, Anukret (Sub-decree) on State Land Management (2005)	The Sub-decree provides the framework for state land management with 11 chapters and 33 articles in total.
4.	Royal Decree NS/RKT/0806/339, 2006, on Provisional Guidelines and Principles Regarding the Reclassification of State Public Properties and of Public Entities (8 August 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. 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).
6.	No. 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.
7.	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.
8.	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.
9.	Sechkdey Prakas (Declaration) No. 06 BRK 1999 on the Measure of Eliminating Anarchical Land Encroachment	This provides the required measures to be taken by the government against anarchical land encroachment:
10.	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

Notes: It is 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

Source: "The Study on Drainage and Sewerage Improvement Project in Phnom Penth Metropolitan Area, JICA May 2016"

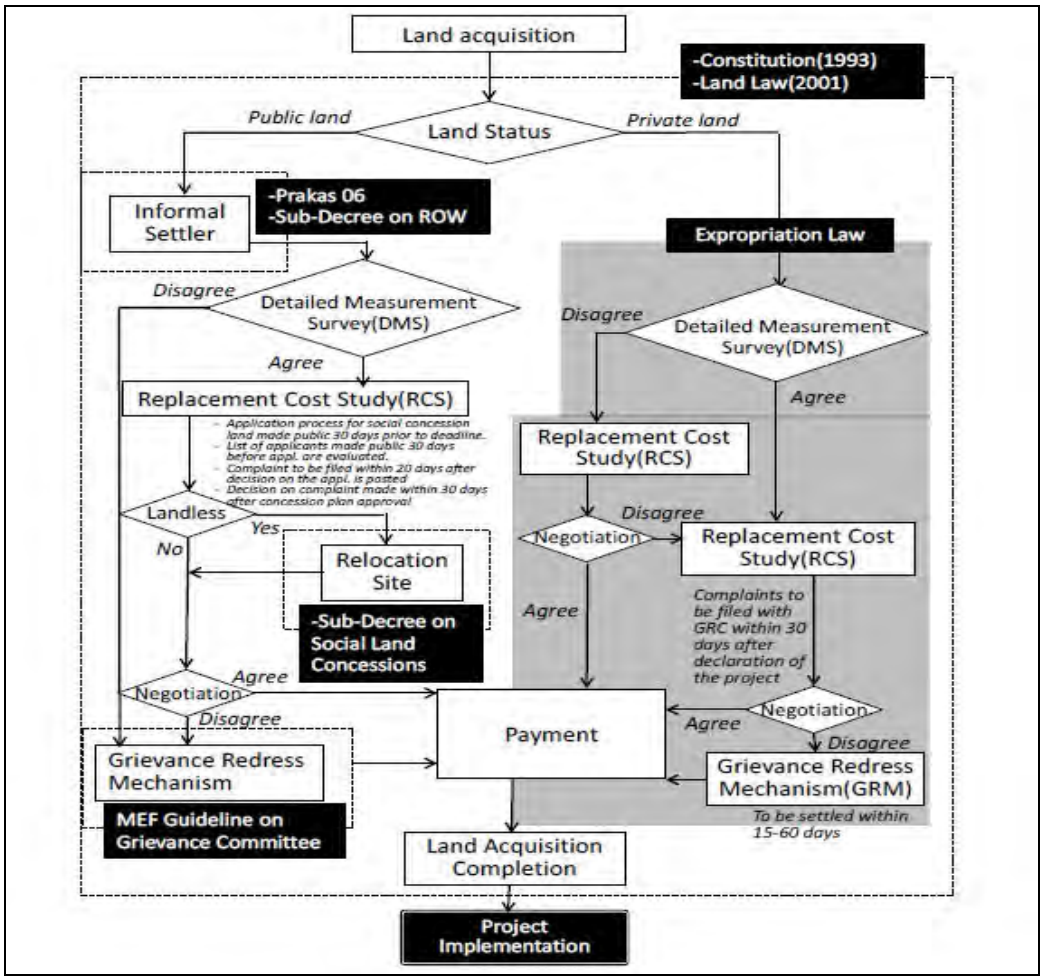
(b) Legal Procedure

Acquisition of private land for the public interest shall be in accordance with the Land Expropriation Law (2010). A flow chart of land acquisition is shown in the following figure. The amount of compensation is determined based on the market price or replacement cost as of the date of issuance of the declaration on the expropriation project as provided in Article 22. The market price or the replacement cost is supposed to be determined by an independent committee or agent appointed by the Expropriation Committee.

Expropriation Law (2010) defines the principles, mechanisms, compensation and procedures for expropriation of private properties relating to construction, rehabilitation and expansion of public physical infrastructure in Cambodia. The Expropriation Committee shall prepare an "expropriation project proposal" subjected to be reviewed and approved by Royal Government. The amount of compensation is determined based

on the market price or replacement cost as of the date of the issuance of the declaration on the expropriation project provided in the article 22. The market price or the replacement cost is supposed to be determined by an independent committee or agent appointed by the Expropriation Committee.

In case of the government project, expropriation process is implemented following the law. An Expropriation Committee is headed by a representative from the Ministry of Economy and Finance, and other representatives from concerned ministries/institutions. An Expropriation Sub-Committee is headed by the provincial/municipal governor and composed of representatives from relevant specialized provincial departments and authorities.



Source: Ministry of Economy and Finance (MEF), 2012, Basic Resettlement Procedure

Fig. R 1.4.7 Flowchart of Land Acquisition

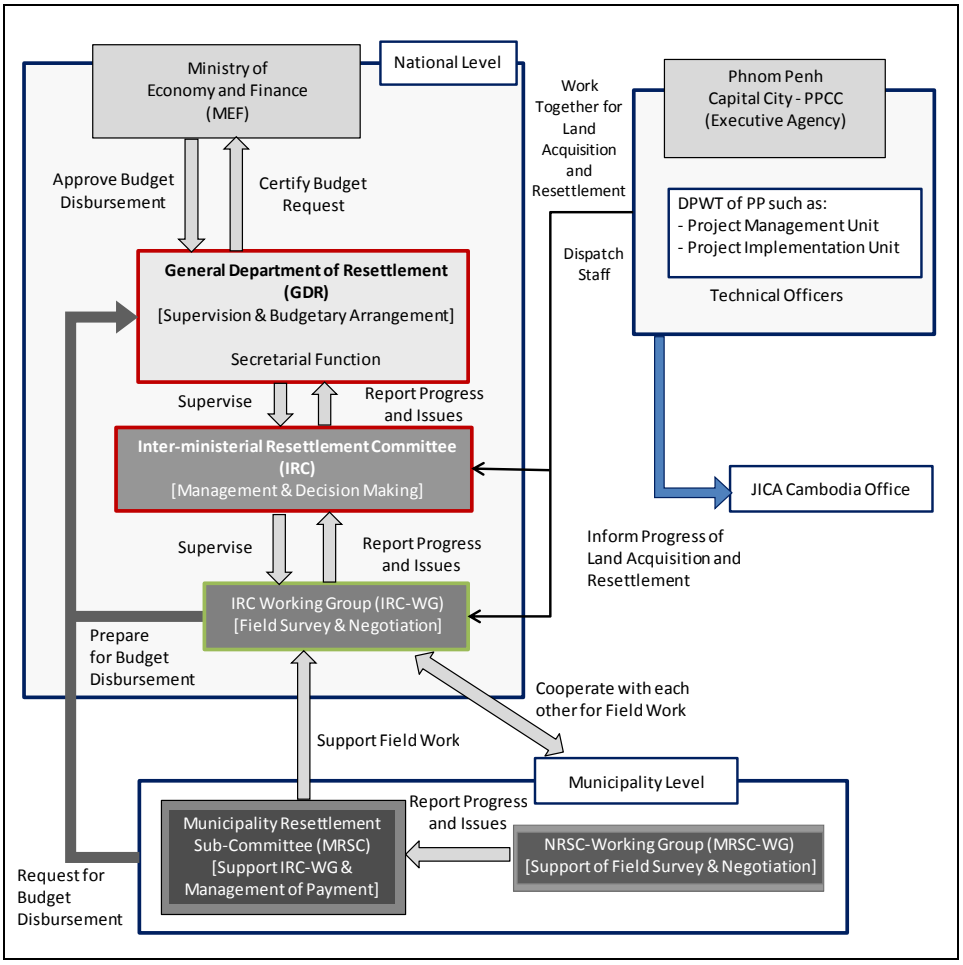
(c) Legal Procedure of Resettlement

PPCC is the Executing Agency (EA). If there are resettlement impacts caused by the Project, the PPCC requests the Inter-Ministerial Resettlement Committee (IRC) of the MEF (Ministry of Economy and Finance) to deal with the resettlement impacts.

IRC will work closely with the EA and the Municipality Resettlement Sub-Committee (MRSC) for coordinating with the Inter-Ministerial Resettlement Committee Working Group (IRC-WG) in dealing and settling with resettlement activities.

DPWT of PPCC, Project Implementation Unit (PIU) as the lead arm of PPCC under the

guidance of the IRC, will work closely with the General Department of Resettlement (GDR) of the MEF in the preparation and implementation of the ARAP (Abbreviated Resettlement Action Plan). The GDR is the secretariat of the IRC and will work closely with other relevant institutions to deal with all resettlement issues caused by the Project.



Source：JICA Survey Team, the ARAP report on the Project, 2016.

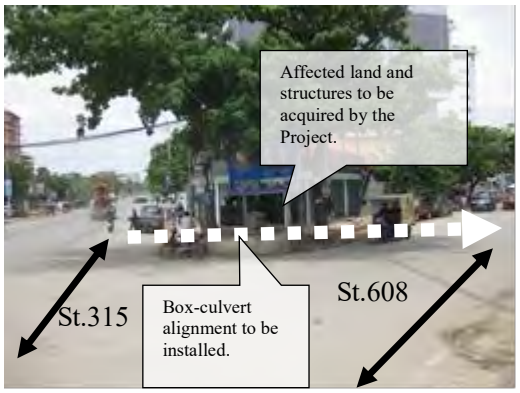
Fig. R 1.4.8 Inter-Ministerial Resettlement Committee (IRC) and Relevant Organizations

1.4.2.3 Scale of Land Acquisition and Resettlement

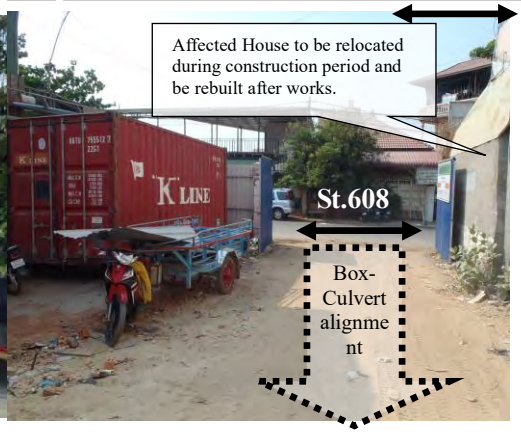
(a) Project Affected Lands and Houses/Structures

In the Project area, there are only 2 affected private households (AHs) in Tuol Kork Area while there is no AH in Wat Phnom Northern Area, as shown in **Photo R 1.4.2** and **Table R 1.4.27** to **Table R 1.4.33**. Out of 2 AHs, one AH is a parking shelter and there is no resident in the shelter. A private land and shelter structures are acquired for the Project without resettlement.

Another AH is a residential building next to the public land lot led to the under construction pumping station (TK-1 P. S.). The Project is affected the resident during the installation of box culvert. Hence, the resident will temporarily move to the safe place as close as possible during the construction. Then after the construction, the resident will relocate to the new house at the same place as before the construction.



Project affected building & lot (shop) to be acquired by the Project between St. 315 and St.608



Project affected building to be relocated during box/culvert installation and rebuilt after completion of the works. (between the shop along St.608 and the pumping station TK-1)

Photo R 1.4.2 Project Affected Lands and Structures

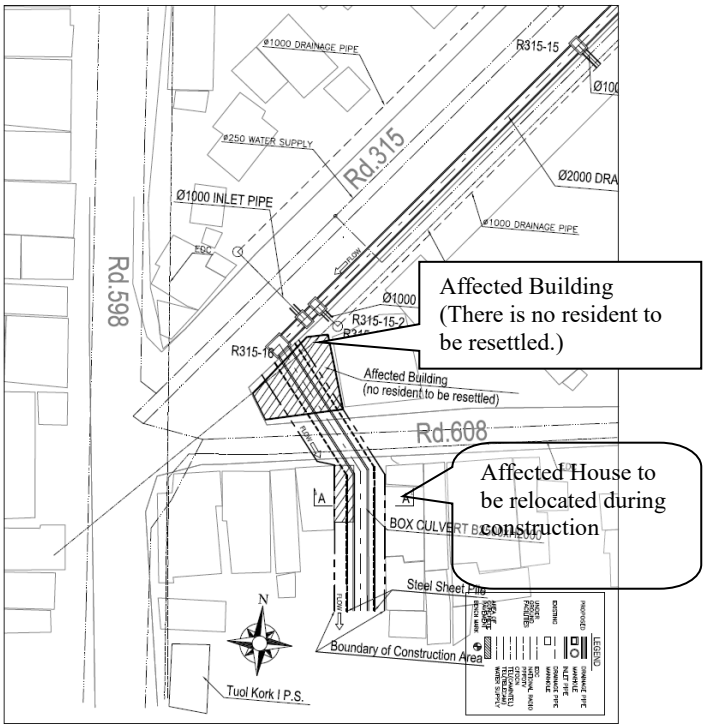


Fig. R 1.4.9 Location of Land Acquisition

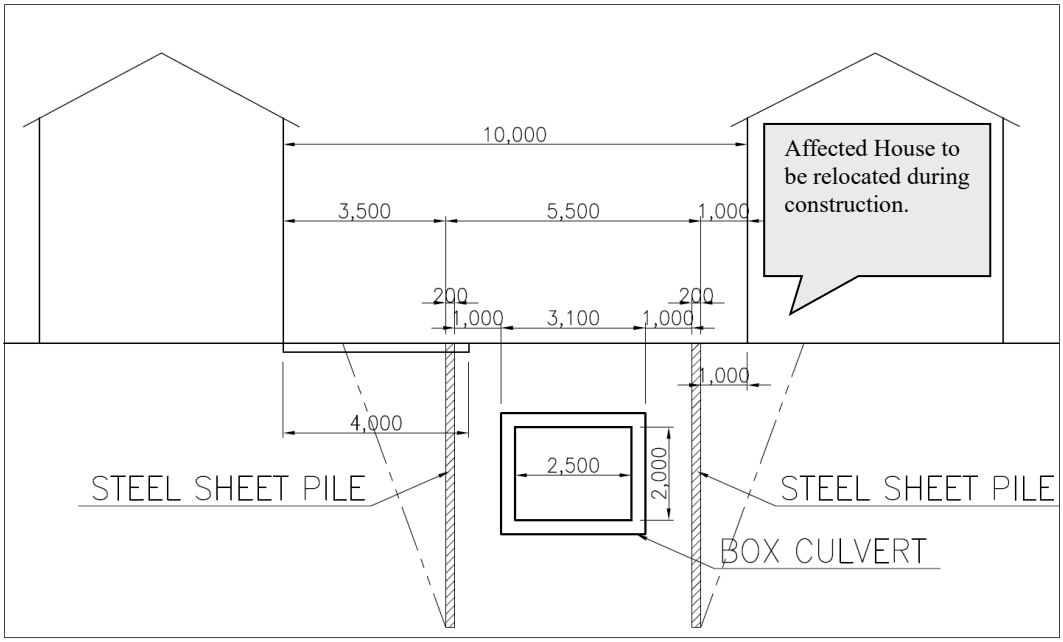


Fig. R 1.4.10 Typical Cross Section of House for Land Acquisition (A-A)

(b) Inventory of Losses Survey and Socio-economic Survey

There are two (2) affected households (AHs) for the Project based on the Inventory of Losses Survey and Socio-economic Survey on the AHs.

Table R 1.4.27 Survey Result for Residential Land Acquisition and Structure Compensation

No.	Khan	Sangkat	Village	Land	Structure	Resettlement/ Relocation	Remarks
AH-1	Khan Tuol Kork	Boeung Kak II	Village 8	Private residential area to be acquired: 63m2	Steel frames, etc.	There is no resident in this building structure and no resettlement is required.	Owner of land and structure to be acquired is under negotiation.
AH-2	Khan Tuol Kork	Boeung Kak II	Village 8	Private residential area to be relocated during the project work: 105m2.	Residential house to be relocated during the Project works and be rebuilt after completion of the works.	Temporary relocation of the affected house buildings and residents during the works.	Land owner agreed to sell his land.

Notes：Based on the socio-economic survey of the AHs, lands and structures in 2016.
Under the Project there is no resettlement of affected persons.
Source：JICA Survey Team, DPWT/PPCC, the ARAP report on the Project, 2016.

(c) Inventory of Assets Survey and Socio-Economic Survey

The Inventory of Losses (IOL) survey and a socio-economic survey of the affected households (AHs) in the Project were conducted. The investigated topics of the survey were basic demography, literacy and education, employment, possession of durable goods, household expenditure and income. There are only 2 affected private households (AHs) for the Project. One house is vacant (AH-1), and seven persons lives in another house (AH-2).

Table R 1.4.28 Population of Affected Household Size

Affected Household (AH)	Population (person)					Note
	Both	Male		Female		
		No.	%	No.	%	
AH-1	4	1	25.0	3	75.0	Information of the owner, currently nobody in the house
AH-2	7	5	71.4	2	28.6	Affected House to be relocated during construction.
Total	11	6	54.5	5	45.5	

Table R 1.4.29 Literacy of Affected Household

Affected Household (AH)	Literacy	
	Male (%)	Female (%)
AH-1	100.0	100.0
AH-2	100.0	100.0
Total	100.0	100.0

Table R 1.4.30 Main Income Source of Affected Household

Item	Total		AH-1 (4 members)		AH-2 (7 members)	
	Person	%	Person	%	Person	%
Wages/Salary	4	36.4	1	25.0	3	42.9
Business/Trade	3	27.3	0	0.0	3	42.9
House/Land renting	2	18.2	1	25.0	1	14.3
Total	9	81.8	2	50.0	7	100.0

Table R 1.4.31 Average Annual and Monthly Income of Affected Household

Items	Annual Income (USD)			
	AH-1	AH-2	Total	%
Wages/Salary	3,000.00	26,400.00	29,400.00	70.00
Business/Trade	0.00	3,600.00	3,600.00	8.60
House/Land renting	6,000.00	3,000.00	9,000.00	21.40
Total	**9,000.00**	**33,000.00**	**42,000.00**	**100.00**
Average household income (USD)	**21,000.00** (Annual)			
	1,750.00 (Monthly)			

Table R 1.4.32 Average Annual and Monthly Expenditure of Affected Household

Items	Annual Expense (USD)			
	AH-1	AH-2	Total	Percent (%)
Food (rice, water, fish, meat, vegetable, and spices)	5,400.00	3,600.00	9,000.00	30.24
Transportation	1,200.00	2,400.00	3,600.00	12.10
Education (material, tutoring, and meals at school)	120.00	300.00	420.00	1.41
Health (drug, treatment fee).	120.00	1,500.00	1,620.00	5.44
Social function	NA	300.00	300.00	1.01
Loan repayment	0.00	14,400.00	14,400.00	48.39
Tax	210.00	210.00	420.00	1.41
Other (specify)	0.00	0.00	0.00	0.00
Total	**7,050.00**	**22,710.00**	**29,760.00**	**100.00**
Annual expense per AH	**USD 14,880.00**			
Monthly expense per AH	**USD 1,240.00**			

In everywhere in Cambodia, bicycles are more common use as a transport vehicle, especially in rural areas, and motorcycles are more convenient and common use in urban areas. Mobile phone is also convenient and common household appliance in Cambodia.

The assets survey result is as shown in the following table. Some AHs have car, motorcycles, bicycle, telephones, air-conditioners, refrigerators, washing machine and televisions. The household assets are estimated at USD 22,275.

Table R 1.4.33 Affected Household's Assets and its Cost

Item	AH-1	AH-2	Total	Amount (USD)
Car	1	2	3	40,000.00
Motorbike	0	2	2	1,000.00
Bicycle	0	1	1	50.00
Telephone	2	6	8	1,500.00
Air-conditioner	1	3	4	700.00
Refrigerator	1	1	2	300.00
Television	1	4	5	900.00
Washing machine	0	1	1	100.00
Total				44,550.00
Average per AH				22,275.00

All AHs (land/house owners) consented to implementation of the Project. One AH prefers to temporarily relocate (to rent a house during construction) somewhere near the existing house/place during the construction period.

(d) Impact on Vulnerable Household

According to the IOL survey, there is only one affected household head (AH). The national poverty line in 2009 is less than US$48 per capita per month.

1.4.2.4 Compensation

(a) Loss Compensation

(i) Contents of Loss Compensation

There are contents of loss compensation for the AHs such as lands used for reseidence or commerce including dwelling units ; stalls, shops, miscellaneous structures such as fences, tolilet, etc., and allowances and assistances such as transport fees for temporary relocation/settlement, imcome loss, house rental fees during construction period, etc.

(ii) Project Cut-Off Date

During the stakeholder meeting for the Project date 24th June 2016, it was informed by the DPWT/PPCC that the Cut-off date was on 24th June 2016 and an inventory of losses (IOL) was conducted after the Cut-off date.

(b) Livelihood Plan

There are no affected households (AHs) to be resettled to a resettlement site under the Project. Only one AH is supposed to relocate during the construction period with compensation allowances and assistances given by the Grievance Redress Committee (GRC) (refer to **Table R 1.4.34** Entitlement Matrix). Furthermore, the AH is to stay a temporary house located near the curent house and is to continue the same job and business as of today.

(c) Resettlement Site

There is no Affected People (APs) to be resettled to a resettlement site for the Project, eventhough the APs will be given allowances and assistances by the GOC. (Refer to **Table R 1.4.34**).

(d) Entitlement Matrix

The Project entitlement matrix was developed and presented below.

Table R 1.4.34 Entitlement Matrix

Item No.	Type of Loss	Eligible Persons	Entitlement	Implementation Issues	Responsible Organization
A.	**Impact on Land**				
	Inside ROW (Public State Land)				
1.	Partial impact on residential and / or commercial land, in which the remaining land is **STILL VIABLE** for continued use.	AHs with main house and/or small shop (independent/ family-owned business)	- AHs should be removed entirely from ROW and no cash compensation is available for affected land in ROW. - No new permanent structures (i.e. structures on a foundation or wooden house larger than the affected one) are permitted to be constructed in the ROW.	- AHs to be notified at least 90 days in advance before the start of civil works in the actual date that the land will be acquired by the Project. - IRC will ensure the payment of all compensation and allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. - Remaining ROW is still **public state land**.	MEF PPCC
	Outside ROW (Private Land)				
2.	Loss of Land (all kinds); **Either Partial or Entire Land is Lost**	All Affected Households (AHs) with recognized proof of ownership whose land will be acquired (for the project construction).	AHs have two options: -Land replacement (land to land): Land replacement will be provided with similar land quality and productivity potential. - Cash compensation at replacement cost.	- AHs to be notified at least 90 days in advance before the start of civil works in the actual date that the land will be acquired by the project. - IRC will ensure payment of all compensation and allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. - IRC will support the AHs to separate or transform the affected land title certificate. Cost of the procedure will be borne by the GOC.	MEF PPCC
B.	**Loss of Structures**				
1.	**I.** Loss of Houses or Shop/Store**; Either Partial or Entire Structure is Lost**	All the AHs confirmed to be residing in, doing business or having right over resources within the project affected area during the conduct of IOL and census of AH (on Cut -off Date)	- Cash compensation at replacement cost without deduction for depreciation or salvageable materials (i.e. present cost of construction materials in the locality plus cost of labor). - AHs are also entitled to have transport (moving) allowance (cf. Item C).	- AHs to be notified at least 90 days in advance before the start of civil works in the actual date that the land will be acquired by the project. - AHs to get cash compensation at least 30 days ahead of civil works to have the AHs sufficient time to reorganize the house and/or shop, avoiding any disruption in their livelihood. - If the structure is found no longer viable for living, compensation can be paid for the entire structure and the AH will also be entitled to other allowances.	MEF PPCC
		Renters	Renters are entitled to get allowances as below: - Transportation (moving) allowance: USD200 - **Disruption allowance**: A lump sum cash assistance of USD300 (if it is a renting for business purpose as provided in C.IV Temporary loss of business income during relocation). - Local authority will help the renter in finding alternate rental accommodation (if requested by the AH).	- AHs to be notified at least 90 days in advance before the start of civil works in the actual date that the land will be acquired by the project. - IRC will ensure a payment of all allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. - AHs should know that a rent house and/or shop are entitled to a one-time transport allowance only. - The renter is also entitled for the disruption allowance.	
2.	**II.** Other Structures (porch,	All the AHs confirmed to be	- Cash compensation at replacement cost without	- AHs to be notified at least 90 days in advance before the start of civil	MEF PPCC

Item No.	Type of Loss	Eligible Persons	Entitlement	Implementation Issues	Responsible Organization
	extended eaves, spirit house, fence, etc.)	residing in, doing business or having right over resources within the project affected area during the conduct of IOL and census of AH (Cut- off Date)	deduction for depreciation or salvageable materials.	works in the actual date that the land will be acquired by the project. - IRC will ensure a payment of all allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works.	
C.	**Allowances and Assistances**				
1.	**I.** Transport (moving) Allowance	AHs that relocate their living house	- Houses relocating in the other village outside the ROW: USD 500	- Owners of the living houses are entitled to one time transport allowance only. - Remaining ROW is still **public state land**.	MEF PPCC
		Affected Shop	- Shop – USD 250		
2.	**II.** Vulnerable AHs Allowance	Vulnerable AHs	- One time cash assistance equivalent to USD150 per Vulnerable AHs.	- As indicated above, relocating landless AHs are entitled to replace a land with title at no cost.	MEF PPCC
3.	**III.** Disruption Allowance	Relocating shop	- Three months of the shop renting fee at one time cash assistance equivalent to USD 1,500.	- Allowance shall be paid at the same time with compensation.	MEF PPCC
		Relocating AH for renting	- Three months for the renting house fee at one time cash assistance equivalent to USD 750.		
4.	**IV.** Temporary loss of business income during relocation	Owners of shop who relocate their shop	Lump sum cash assistance of USD300.		MEF PPCC
5.	**V.** Temporary Settlement Allowance	Owner of Living House (AH-2) who will temporarily relocate by the project construction work.	- Living House rental fee is 800 USD/month. Owners of living houses (AH-2) are entitled for rental allowance up to 12 months (tentatively) until completion of the house restoration.	- IRC will ensure payment of the allowances for which AHs are entitled to at least 60 days prior to the scheduled start of civil works.	MEF PPCC
D.	**Temporary Impacts caused by the Contractor's Own Convenience or Fault**				
1.	**I.** Affected assets during construction	Owners of assets	- Compensation for lost assets in cash at replacement cost, or - Compensation as leasing fee based on replacement cost, and temporarily affected land will be returned to original owner/occupant.	- PPCC and DPWT-PPCC shall supervise the Contractor's act during construction. - Contractor shall be required by the contract to pay these costs. - Construction shall be carried out so as to minimize damage. - Construction work shall be carried out within ROW. - As part of the civil works stipulated in the contract, all access roads/ driveways to properties affected by the construction work shall be rehabilitated with the same or better condition. - Disruption period shall be minimized as much as possible. - Affected land shall be repaired to its original condition after completion of the construction work.	PPCC DPWT/PPCC Contractor
2.	**II.** Damage on private or community infrastructure including walls, drains and channels, etc.	Owners	- Repair of damage or payment for repair of damage at replacement cost.		PPCC DPWT/PPCC Contractor

Source: JICA Survey Team、the entitlements adopted in the above table were guided by the applicable national laws and regulations of Cambodia, JICA guidelines.

Based on the entitlement matrix, affected assets and allowances/assistances for the AHs for the Project are summarized below.

Table R 1.4.35 Affected Assets and Allowances / Assistances for AHs for the Project

No.	Population	Affected Assets	Affected Area	Price (US$)	Allowance (US$)						Total (US$)
					Transport	Vulnerable	Disrupt	Business Loss	Temporary Relocation	Sub-Total	
AH-1	4	Shop/Building (semi-concrete with 2 stories)	192.0m^2	22,154	250	-	1,500	-	-	1,750	23,904
		Commercial Land	63.0m^2 (US$2,600/m^2)	163,800	-	-	-	-	-	-	163,800
AH-2	7	House (semi-concrete with 3 stories)	87.1m^2	19,198	250	150	750	-	-	1,150	20,348
		House (concrete with 2 stories)	69.3m^2	32,086	250	-	-	300	9,600	10,150	42,236
			Total	237,238	750	150	2,250	300	9,600	13,050	250,288

Notes: The total amounts above do not include the costs of administration, external monitoring and contingency.
Source: JICA Survey Team

1.4.2.5 Grievance Mechanism

In connection with the implementation of the ARAP, the grievances of the AHs will be handled through negotiation with the aim of achieving consensus. Complaints will go through the following three (3) stages before they may be elevated to a court of law as a last resort. The PPCC and the IRC will shoulder all administrative and legal fees that will be incurred in the resolution of grievances and complaints.

(1) First Stage, Sangkat Level

An aggrieved AH may bring his/her complaint to the Sangkat leader. The Sangkat leader will call for a meeting of the group to decide the course of action to resolve the complaint within 15 days, following the lodging of complaint by the aggrieved AH. The meeting of the group consists of the Sangkat leader, representative/s from MRSC-WG of the Khan offices, and the aggrieved AH. The Sangkat leader is responsible for documenting and keeping file of all complaints that are coursed through him/her. If after 15 days the aggrieved AH does not hear from Village or Sangkat, or if the AH is not satisfied with the decision taken by in the first stage, the complaint may be brought to the Khan Office either in writing or verbally.

(2) Second Stage, Khan Office

The Khan office may have a decision to resolve the complaint to the satisfaction of all concerned within 15 days. If the complaints cannot be solved in this stage, the Khan office will bring the case to the Municipality Grievance Redress Committee (MGRC).

(3) Third Stage, Municipality Grievance Redress Committee, MGRC

The Municipality Grievance Redress Committee (MGRC), which consists of Municipality Governor or Deputy Governor as a committee chairman and Directors of relevant Departments as members will be established in Phnom Penh municipality prior to Detailed Measurement Survey (DMS), meets with the aggrieved party and tries to resolve the complaint. The Committee may ask for a review of the DMS by the EMA (External Monitoring Agency). Within 30 days of the submission of the grievance the Committee must make a written decision and provide the written decision to the

complainant and submit a copy of the same to PPCC and IRC

(4) Final Stage, the Court Procedures

If the aggrieved AH is not satisfied with the solution made by the Municipality Grievance Redress Committee based on the agreed policy in the ARAP, the committee shall file administrative procedures against the AHs with the participation of municipality prosecutors. The case will be brought to the Municipality Court and the same will be litigated under the rules of the court. At the same time, the AH can bring the case to the Municipality court. During the litigation of the case, the GOC will request to the court that the project proceed without disruption while the case is being heard. If any party is unsatisfied with the ruling of the municipality court, that party can bring the case to a higher court. The GOC shall implement the decision of the court.

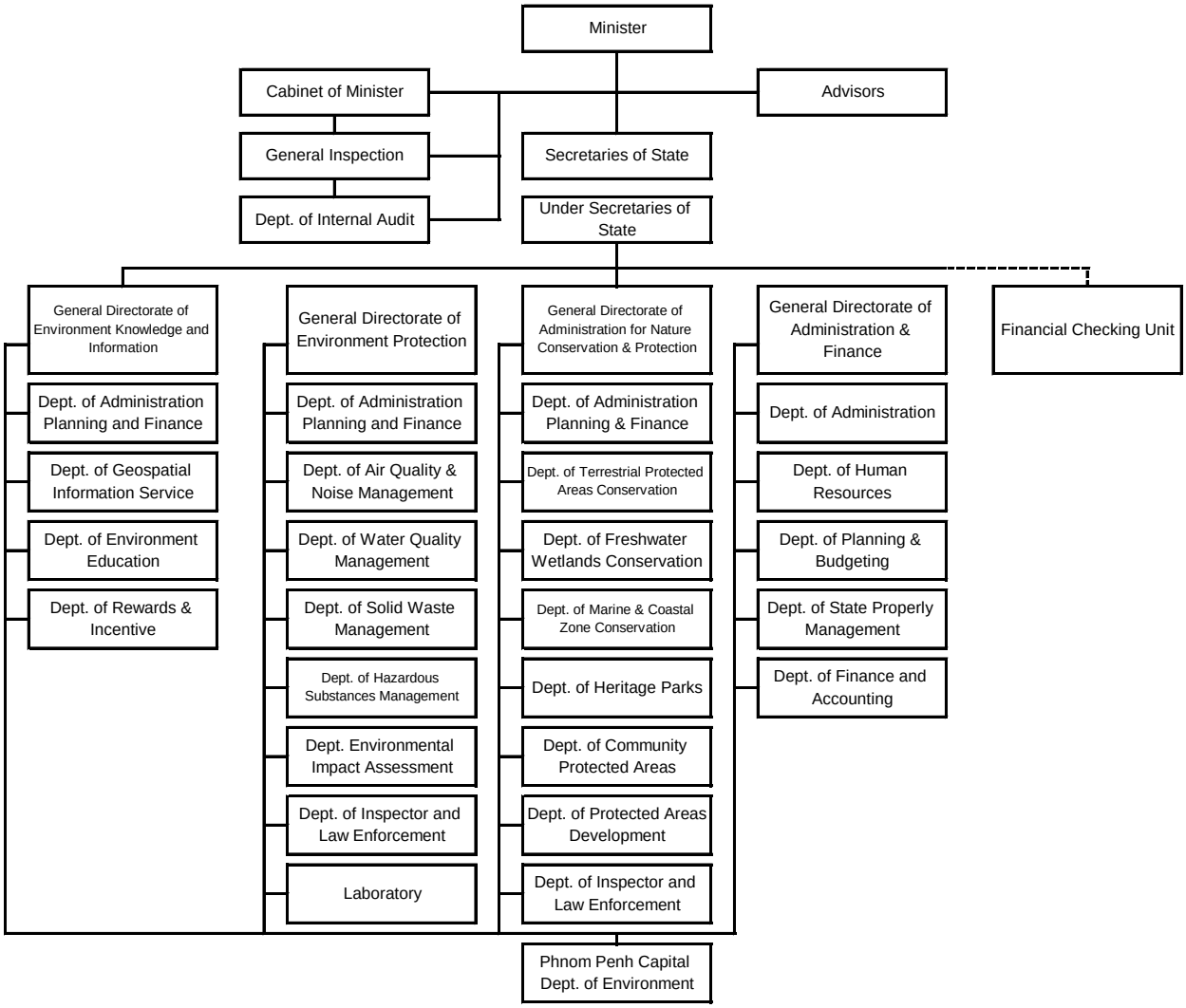
1.4.2.6 Implementation of Tentative Relocation of Affected Household during Construction Work

As for the tentative relocation of the AHs during the construction period for the Project, the GOC, especially the Ministry of Economy and Finance (MEF) has made effort for the establishment of legal basis for resettlement action in Cambodia, such as the Expropriation Law. As shown in **Fig. R 1.4.8**, the PPCC together with the DPWT-PPCC which is the line/ executing agency (EA) for the Project, if there is a tentative resettlement impact caused by the Project, requests the Inter-Ministerial Resettlement Committee (IRC) of the MEF to deal with the resettlement impacts. The IRC will work closely with the EA and the Municipality Resettlement Sub-Committee (MRSC) for coordinating with the Inter-ministerial Resettlement Committee Working Group (IRC-WG) in dealing and settling with resettlement activities. The DPWT of PPCC, Project Implementation Unit (PIU) as the lead arm of the PPCC under the guidance of the IRC, will work closely with the General Department of Resettlement (GDR) of the MEF in the preparation and implementation of the ARAP. The GDR is the secretariat of the IRC and will work closely with other relevant institutions to deal with all resettlement issues caused by the Project. The GDR changed its name from the Record of Discussion in May 2016 and has about 30 officials. The GDR is a commandery of the MEF in mission in order to solve on socio-economic impacts by the development projects and consists of 5 departments, namely, 1)Department of General Affairs (DGA), 2)Department of Internal Control and Data Management (DICDM), 3)Department of Resettlement 1 (DR 1), 4)Department of Resettlement 2 (DR 2), 5)Department of Resettlement 3 (DR 3), as shown in **Fig. R 1.4.11**. The DGA is for staff management, admission, finance, law and planning through information technology, the DICDM is for internal control, data management through information technology, receiving and observation on complains and public relationship, and the DR 1/the DR 2/the DR 3 are for resettlement impacts resolving such as land, structure and other assets and entitlement of AH which are affected by development projects.

On the other hand, the Environmental and Social Considerations (hereunder referred to as “ESC”) including tentative resettlement/relocation of the AHs is the foundation for the proper and effective implementation of the Project. The ESC for the Project, namely IEIA/IEE, was studied through the PPCC and DPWT-PPCC and the final IEIA/IEE report will be assessed and approved by the Department of Environmental Impact Assessment of the MOE within this year. The MOE is empowered by law to protect and enhance the nation’s environmental resources and implement sub-decrees related to the environmental impact assessment (EIA), air and water pollution control, and solid waste management that aim to mitigate in environmentally damaging activities. The

MOE develops then legislated rules related to the environment, involving implementation of environmental policies, promotion of environmental assessments, protection of public water areas and natural resources, and execution of water quality testing at public water areas. As of May, 2016, the MOE has official staff of over 600. Its organization structure is shown in **Fig. R 1.4.11**.

The draft environment management plan and monitoring plan for the Project was prepared for the implementation of the construction work as shown in the aforementioned **Table R 1.4.23**. The draft plan will be managed and monitored by the DPWT-PPCC and the related government agencies. As for air and noise quality management and monitoring in the Project area, it is noted that the DPWT-PPCC should be cooperated with the MOE together during the construction period for the Project.



Source：MOE

Fig. R 1.4.11 Organization Chart of MOE

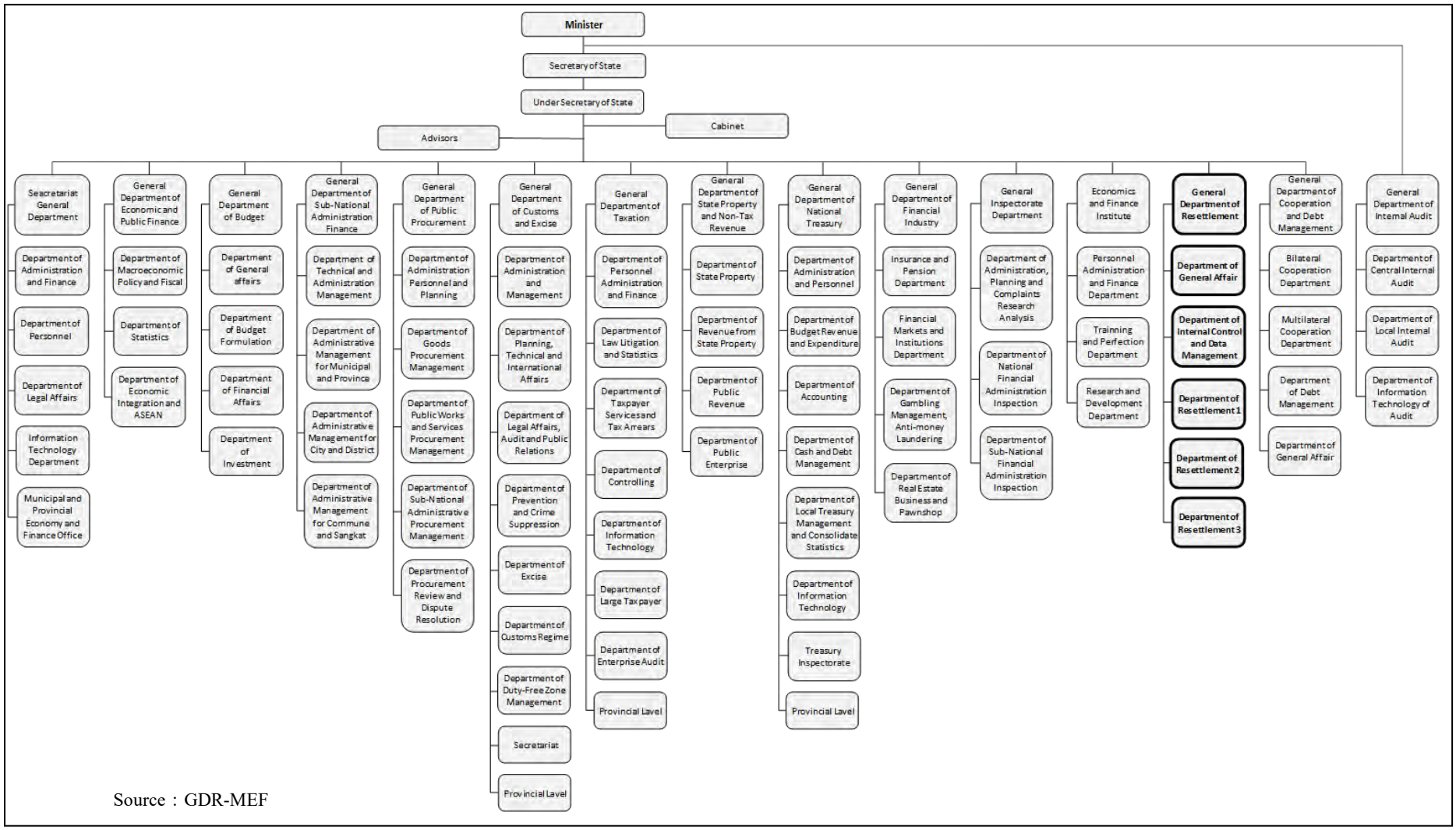
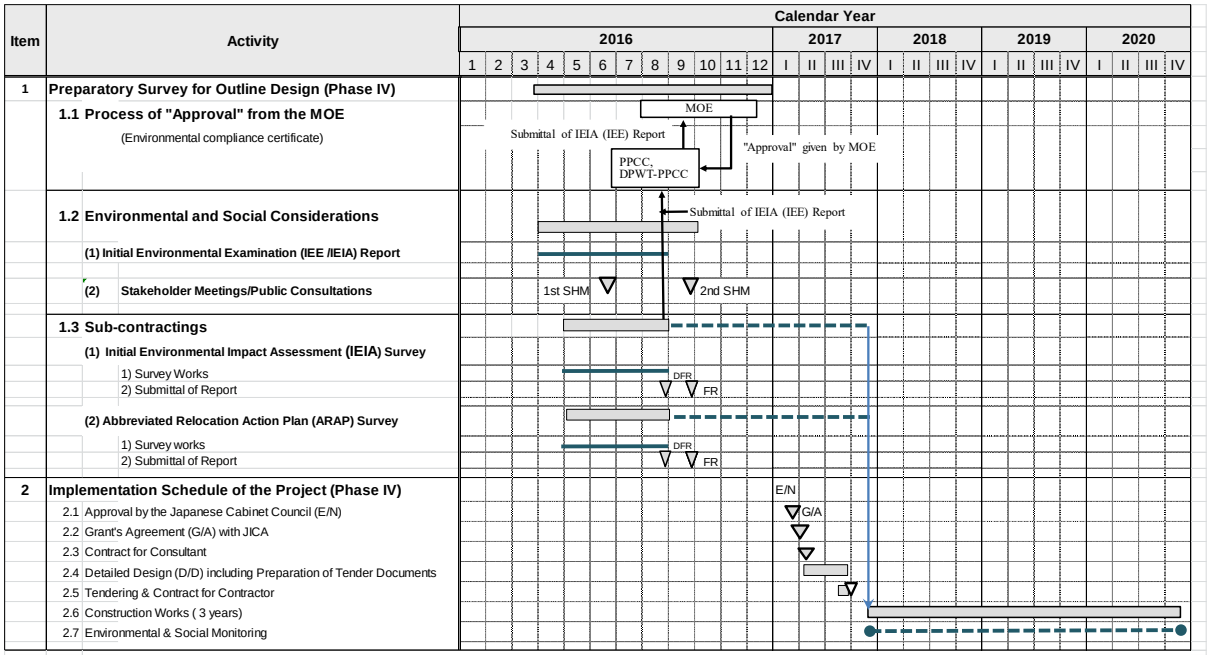


Fig. R 1.4.12 Organization Chart of GDR-MEF

1.4.2.7 Implementation Schedule

Implementation schedule of the Project including the sub-contracting works for IEIA (IEE) and ARAP including the structure relocation /land acquisition will be shown below.



Notes：MOE : Ministry of Environment, DPWT/PPCC : Department of Public Works and Transport, Phenom Penh Capital City, IEE : Initial Environmental Examination, IEIA : Initial Environmental Impact Assessment

Fig. R 1.4.13 Implementation Schedule for Environmental and Social Considerations for the Project

During detailed design stage, DMS and RCS (Replacement Cost Survey) will be conducted under the management of IRC-WG. DMS will be implemented by IRC-WG in close cooperation with MRSC-WG and relevant local authorities. RCS will be updated by an independent agency hired by IRC. Based on the result of DMS and RCS, IRC will calculate compensation amount and request budget disbursement to the GOC.

During DMS, consultation meeting will be held and project information booklet will be distributed to all AHs by IRC-WG assisted by MRSC-WG. Grievance redress procedures and its structure will be established prior to DMS. Compensations are paid at least 30days before start of construction. External monitor will be conducted during all of stages of implementation of the ARAP. Land acquisition and relocation of the AHs will not commence until the updated ARAP are reviewed and approved by both IRC and JICA.

Various inter-related activities, which relates to updating and implementation of the ARAP, are summarized in **Table R 1.4.36**.

Table R 1.4.36 Tentative Schedule of Relocation Activities

Activities	Schedule
Submission of Draft ARAP to PPCC/JICA	Sep. 2016
Review of ARAP by IRC	Nov. – Dec. 2016
Submit letter for setting IRC WG	Jan. 2017
Setting up IRC WG	Jan. 2017
DMS process	Feb. 2017
Updating ARAP	Feb. – Mar. 2017
Submit updating ARAP to JICA	Apr. 2017
Contract making process	May. 2017
Compensation process	Jun. 2017
Internal Monitoring (Submission of Quarterly Progress Reports)	Jan. – Dec. 2017
External Monitoring	Jan. – Jun. 2017
Post-evaluation	Nov. 2017
Start of Civil Works*	Dec. 2017

Note：*There is no resettlement impact in the Project.

1.4.2.8 Budget and Financial Source

The cost for land acquisition and resettlement will be covered by the government counterpart funds managed by MEF. Funds for the implementation of the ARAP are part of the Project cost. The land acquisition and resettlement cost was estimated based on the results of the IOL and the RCS conducted during the Project Survey in June 2016.

(a) Procedures for Flow of Funds

IRC will request the land acquisition and resettlement budget from MEF and the compensation amount will be transferred to PPCC for releasing compensation and allowances to AHs who will be notified through the village chiefs with regards to the schedule of payment of compensation and other entitlements. Payment of compensation and other entitlements will be in cash and will be distributed in public place (commune centre, school, pagoda etc.).

(b) Updating of the Compensation Rates

An RCS were conducted by a local consultant during the Project Preparatory Survey as a basic unit rate to estimate the cost for resettlement. Since compensation to AHs will be commenced in 2017 (tentative schedule), the conducted RCS will be updated to reflect the current market price of the affected property. The RCS updating will be conducted in parallel with the DMS.

(c) Estimated Costs for Resettlement

Based on the RCS and the IOL conducted during the Preparatory Survey for the Project, the estimated costs for resettlement is about USD 300,000 which includes the cash compensation, assistance for administration cost, external monitoring cost and contingency as shown below. The resettlement estimated cost will be updated during the resettlement implementation based on the DMS and the updated RCS.

Table R 1.4.37 Summary of Resettlement Costs

No.	Items	Unit	Quantity	Unit Cost (US$/Unit)	Amount (US$)
A	**Land**				**163,800.00**
1	Commercial land	m^2	63.00	2,600.00	163,800.00
B	**House/Building Structures**				**73,438.00**
2	Shop (semi-concrete with 2 floors)	LS	1.00	-	22,154.00
3	House for renting (semi-concrete with 3 floors)	LS	1.00	-	19,198.00
4	House for living (concrete with 2 floors)	LS	1.00	-	32,086.00
C	**Allowances**				**13,050.00**
5	Transport allowance	LS	1.00	750.00	750.00
6	Disruption allowance	LS	1.00	2,250.00	2,250.00
7	Special allowance/vulnerable	AH	1.00	150.00	150.00
8	Temporary loss of business income during relocation	AH	1.00	300.00	300.00
9	House rental fee	month	12.00	800.00	9,600.00
Subtotal					**250,288.00**
10	Administrative cost (5%)	LS	-	-	12,514.40
11	External monitoring	LS	-	-	12,000.00
12	Contingency (10%)	LS	-	-	25,028.80
Total					**299,831.20**

Notes : JICA Survey Team

1.4.2.9 Monitoring Framework of Implementation Organization and Monitoring Form

As the acting agency for the Project, the DPWT/PPCC will act on the environmental monitoring program on some environmental impact items caused by the pre-construction stage, construction stage and in-use stage. The monitoring cost will be born from the Project owner (DPWT/PPCC) and included in the Project implementation cost.

1.4.2.10 Stakeholder Meeting

Stakeholders of the Project include municipality, Khan/District, Sangkat/commune and village officials, local people around the Project area, and managers and staff of DPWT of PPCC.

(a) Participatory Activities in Resettlement Plan

The table below summarizes the participatory activities in the ARAP preparation with the responsibilities of the related agencies.

Table R 1.4.38 Participatory Activities in ARAP Preparation

Project Process Stage	Participatory Activities and Participants	Outputs	Responsible Institution
Preparatory Survey Work	Briefing of the DPWT of PPCC to Khan, Sangkat and village officials, local people around the Project area, about the Project technical assistance, the resettlement impact, and activities of the consultant (first commune stakeholder meeting).	The local population including AHs and their representatives, local government officials, and managers and technical staff of DPWT participated in the meeting and were consulted on the objectives, planning and impact of the project and of resettlement.	PPCC/DPWT and Consultant (JICA Survey Team)
	Conduct of IOL, census of AHs, social impact assessment, and replacement valuation.	An IOL, census of AHs and RCS were conducted and the results were included in the ARAP.	Consultants (JICA Survey Team), assisted by local authorities and DPWT.
	Discussion/consultation with IRC-GDR and PMU (Project Management Unit)-MPWT (Ministry of Public Works and Transport) about the proposed project resettlement policy	IRC was consulted about social impact and resettlement policy	Consultant (JICA Survey Team)
	Drafting of the ARAP and Project Information Booklet (PIB) and submission to PMU-PPCC, PIU-DPWT, IRC-GDR and JICA for review.	Drafts of ARAP and PIB would be provided to and reviewed by PPCC, DPWT, IRC-GDR and JICA.)	Consultant (JICA Survey Team)

(b) ARAP Preparation SHM

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

Table R 1.4.39 Public Meetings Held for the Project

No.	Municipality	Khan/Sangkat	Venue	Date	Participants
1st Public consultation	Public Consultation Meeting before cut-off date (1st Sangkat SHM)				
	Phnom Penh	Khan Tuol Kork - Sangkat Boeung Kak 2	Sangkat Boeung Kak 2 center	24 June 2016 at 8:30 am	Male=13 Female=12 Total=25
2nd Public consultation	Public Consultation Meeting after cut-off date (2nd Sangkat SHM)				
	Phnom Penh	Khan Tuol Kork - Sangkat Boeung Kak 2	Sangkat Boeung Kak 2 center	27 September 2016 (Scheduled) at 8:30 am	Male=20 Female=11 Total=31

1st Public Consultation

After an introduction of the local authorities, the representative of DPWT/PIU mentioned the background of the Project and its impacts, both positive and negative. During the meetings, all participants were reinformed and explained about the cut-off date is 24th June 2016、and there was also an open floor for discussion among the participants. The discussion results of the three sub-meetings are summarized below.

Table R 1.4.40 Questions and Responses of the Public Consultation Meeting (1st Sangkat SHM)

Questions	Responses
1. About the project implementation	
Question-Participant (male): Up to which year, will the project be capable to against the population growth and city development?	**Answer-DPWT:** The drainage facilities might be capable up to 2035.
Question-Participant (male): When will the IOL conduct?	**Answer-DPWT:** The survey will start on 25th June 2016. The cut-off date is 24th June 2016. It means any structure constructed after the date, it will not entitle to receive compensation.
2. About the ROW	
Question-Participant (female): At the entrance to pumping station (street 608), the project will be affected on both sides of the existing houses?	**Answer-DPWT:** By the plan, it will be temporary affected on left hand side of house to flow direction. The flat need to be relocated and can reconstruct after the project finishes. The project will compensate for the affected properties with replacement cost which the owner can reinstate it.
3. About the compensation and other assistance	
Question-Participant (male): How will the project solve for the affected properties?	**Answer-DPWT:** The compensation will be paid by the GOC/IRC (Inter-ministerial Resettlement Committee), represented by Ministry of Economy and Finance (General Department Resettlement) based on market price which will be studied by Independent Agency, who is widely experience for asset evaluation and resettlement issues. JICA will provide a Grant for construction work only. Even though, the compensation has to follow the project compensation policy which has been agreed by the GOC and JICA.
4. About the Grievance Redress	
Question-Participant (male): In case that there is a problem for resettlement implementation, who can help us?	**Answer-DPWT:** A Grievance Redress Committee (GRC) will be set up during the project implementation. The GRC will be divided into three levels: i) Grievance Committee at Sangkat Level, ii) Grievance Committee at Khan Level and iii) Grievance Committee at Municipality Level. (The final level is at the court.)

First Sangkat SHM - Cut-Off-Date announcement (24th June 2016)

Photo R 1.4.3 1st Stakeholder Meeting

2nd Public Consultation

2nd public consultation meeting led by the chairman of the representative of PIU/DPWT was performed about the meeting purposes, introduction of the participation local government agencies, explanation of affects by the Project, influence of the plus and minus by the Project. Then, the meeting was proceeded to discussions for all the participants on the significance of the cut-off date (June 24, 2016), conduct of the inventory of loss (IOL) survey, two affected houses/buildings (AHs), and explanation of compensation costs, dealing with grievances redness system. Main items discussed in the meeting were summarized below.

Table R 1.4.41 Questions and Responses of the Public Consultation Meeting (2nd Sangkat SHM)

Questions	Responses
1. About the Project Implementation	
Question-Participant (male): A contractor was requested to complete the following matters after the construction work of the Project was over; i) to reinstate the present conditions of the roadside and the house entrance, ii) to reduce the influence on inhabitants during the construction. It is noted that people request to continue the supply service of PPWSA and EDC as long as possible.	**Answer-DPWT of PPCC:** The construction of the Project is to be carried out based on the international standards. Particularly, the JICA grant project is conducted by a Japanese international contractor and the construction work is basically supervised by the international civil engineers and a Japanese expert for the Japanese engineering consultant. They are Japanese resident experts in the Project site. In addition, when a problem about water service and the electric supply occurs, as the Project executing agency, DPWT/PPCC calls the contractor, PPWSA and EDC to care their immediate repair services. Good cooperation with the inhabitants is necessary and welcome for the implementation of the Project.
Question- Sangkat chief, Boeung Kak 2 (man): Because there were some problems in the case of the construction work for the last phase, I wanted to confirm some points, say, reinstatement of the roadside and the house entrance, damage of the water pipe, and cutting of the electric wire. The contractor of the Project should take a more careful consideration on them.	**Answer- Deputy Governor, Khan Tuol Kork**: It is noted that all the related residential people and agencies will trust in the JICA grant Project which the construction works and its resettlement are carried out based on the international standards in the enforcement of construction works, policies and guidelines of engineering issues, environmental and social considerations.
2. About the Compensation	
Question-Participant (female): How much is the compensation price of the affected land per square meter?	**Answer-DPWT of PPCC:** Because the amount of compensation is estimated based on market price, the final compensation amount is determined in the Project implementation stage. As the Project implementation of the Project will be carried out in 2017, the price of the affected land is calculated with market price of 2017. A current price of 2016 is therefore not market price of the compensation. The compensation unit price of property, assets to be affected are calculated by an independent agency that has a lot of knowledges and experiences about property valuation. JICA provides the project for a grant gratuitous fund construction work, and the compensation costs are paid by the GOC represented in IRC/MEF. The compensation for the affected assets and properties are performed in conformity with the Project compensation policy agreed between the GOC and JICA.

Second Sangkat SHM - (27th September 2016)

Photo R 1.4.4 2nd Stakeholder Meeting

1.4.3 Others

1.4.3.1 Environmental and Social Monitoring Plan

(1) Monitoring Plan

As shown in **Subsection 1.4.1.6** '(c) Adverse Environmental and Social Impacts', the Project may have some negative impacts during construction stage. Mitigation measures shall be carried out and monitored. Environmental monitoring is planned as below.

Table R 1.4.42 Environmental and Social Monitoring Plan during Construction Stage

Category	Contents	Responsible Organization	Reporting
Continuous Monitoring	Self-monitoring of environmental impacts of construction works. Undertaken on an ongoing basis throughout construction period with regular monitoring frequencies.	Contractor	The activity reported to the Consultant and DPWT/PPCC every month. The contractor will prepare a self-monitoring form.
Periodical Monitoring	Monitoring by implementation authority shall be carried out periodically.	DPWT/PPCC (to be sublet)	Monitoring shall be carried out once in three month.

(2) Monitoring Form (Draft)

MOE will monitor the key impacts caused by the Project periodically. They may conduct or sublet the work because of lack of manpower or experiences with them though MOE has available equipment. Monitoring results will be recorded, and in case of necessary, the record will be submitted to JICA. Examples of monitoring forms for construction stage are shown in the following tables.

Table R 1.4.43 (Monitoring Form 1/4) Noise Measurement of the Project

Date: Place:

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards[1)]	Remarks (Measurement Point, Frequency, Method, etc.)
Noise						
Quiet Area (Hospital, library, school and kindergarten) (6 am to 6 pm)	dB (A)			45	85	
Residential Area (Hotel, admin' offices and house) (6 am to 6 pm)	dB (A)			60	85	
Commercial and service areas and mix (6 am to 6 pm)	dB (A)			70	85	
Small industrial factories in residential areas (6 am to 6 pm)	dB (A)			75	85	

Note: 1) Japanese law for construction works

Table R 1.4.44 (Monitoring Form 2/4) Vibration Measurement of the Project

Date: Place:

Place・Time	Japanese Standard (**), dB(A)	Measurement (dB(A))	
		Average	Maximum
Station 1: Wat Phnom Northern Area			
Day (6:00 - 18:00)	65		
Night (23:00 - 6:00)	60		
Station 2: Tuol Kork Area			
Day (6:00 - 18:00)	65		
Night (23:00 - 6:00)	60		

Note : (**) Environmental Quality Standard of Japan

Table R 1.4.45 (Monitoring Form 3/4) Report of Monitoring Result of the Project

Monitoring Item	Monitoring Result during Report Period
Dust generation	
Vibration	
Accident	
Change to drainage pattern	
Soil erosion and slope failure	
Construction waste and general waste	
Effect on amenity of tourism-related development	
Impact on road safety	
Impact on road traffic and vehicle movement	
Risk of infectious diseases such as HIV/AIDS	
Impact on livelihood/income	

Table R 1.4.46 (Monitoring Form 4/4) ARAP Monitoring Form of the Project

Relocation Monitoring Sheet

Name of AH:

1. Progress of Tentative Relocation during construction

Progress		Date	Check	Remarks
Official Notice				
Confirmation on survey results of inventory				
Survey on relocation if any				
Negotiation	1st			
	2nd			
	3rd			
	4th			
Agreement on compensation and relocation				
Compensation payment				

2. Record of Grievance / Perception and Redress

Date	Record of Grievance / Perception and Redress	Remarks

1.4.3.2 Environmental Checklist

Environmental checklists are shown in following tables.

Table R 1.4.47 Environmental Checklist for the Project (1/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1. Approval in Permits and Explanation	(1) IEIA/EIA and Environmental Permits	1) Was IEIA (IEE) or EIA for the Project officially confirmed?	1) In May 6, 2016, the MOE confirmed that IEIA (IEE) report was needed for the Project not EIA.
	(2) Explanation to the Public	1) Are the contents of the Project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public? 2) Are the proper responses made to comments from the public and regulatory authorities?	1) The Project contents and the potential impacts shall be explained to affected people after before and completion of the Draft Final Report of the Project to obtain the understanding of the public. 2) In the environmental and social consideration survey for in the Project, twice stakeholder meetings are to be made in May and August 2016 through subletting to comments from the public and regulatory authorities.
2. Pollution Measures	(1) Air Quality	1) Do air pollutants, (such as sulfur oxides (SOx), nitrogen oxides (NOx), Carbon Monoxide (CO), and soot and dust) emitted from the proposed infrastructure facilities and ancillary facilities comply with the country's emission standards and ambient air quality standards?	1) There will no effect on air pollution.
	(2) Water Quality	1) Do effluents or leachates from various facilities, such as infrastructure facilities and the ancillary facilities comply with the country's effluent standards and ambient water quality standards?	1) The Project will flow the waste water from the PPCC.
	(3) Wastes	1) Are wastes from the infrastructure facilities and ancillary facilities properly treated and disposed of in accordance with the country's standards?	1) The Project will not product any wastes.
	(4) Soil Contamination	1) Are adequate measures taken to prevent contamination of soil and groundwater by the effluents or leachates from the infrastructure facilities and the ancillary facilities?	1) There will no effect on soil contamination.
	(5) Noise and Vibration	1) Do noise and vibrations comply with the country's standards?	1) The Project will not make noise and vibrations during the operation stage.
	(6) Subsidence	1) In the case of extraction of a large volume of groundwater, is there a possibility that the extraction of groundwater will cause subsidence?	1) The Project will not extract groundwater.
	(7) Odor	1) Are there any odor sources? Are adequate odor control measures taken?	1) There will no effect on offensive odor.

Table R 1.4.48 Environmental Checklist for the Project (2/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
3. Natural Environment	(1) Protected Areas	1) Is the Project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the Project will affect the protected areas?	1) The Project is not located in protected areas. There is no possibility that the Project will affect the protected areas.
	(2) Ecosystem	1) Does the Project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? 2) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? 3) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? 4) Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	1) The Project site does not encompass ecologically valuable habitats. 2) The Project site does not encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions. 3) There is no significant ecological impacts. 4) The Project will not use water.
	(3) Hydrology	1) Is there a possibility that hydrologic changes due to the Project will adversely affect surface water and groundwater flows?	1) There are the positive changes on drainage condition in the Project Area.
	(4) Topography and Geology	1) Is there a possibility the Project will cause large-scale alteration of the topographic features and geologic structures in the project site and surrounding areas?	1) There is no possibility the Project will cause large-scale alteration of the topographic features and geologic structures in the Project site and surrounding areas

Table R 1.4.49 Environmental Checklist for the Project (3/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4. Social Environment	(1) Resettlement	1) Is involuntary resettlement caused by the Project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? 2) Is adequate explanation on relocation and compensation given to affected persons prior to resettlement? 3) Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? 4) Does the resettlement plan pay special attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? 5) Are agreements with the affected persons obtained prior to resettlement? 6) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? 7) Is a plan developed to monitor the impacts of resettlement?	1) In the initial stage of the Preparatory Survey of the Project, more than 20 AHs were considered. Effort was made to reduce the Project affected buildings into only 2 structure-owners (No resettlement is required for the Project.) by proper rearrangement of drainage pipe installation with PPCC and DPWT. 2) Through a subletting contract for relocation the necessary meetings with affected houses & stakeholders were conducted in June and September 2016. 3) Following proper procedure for land acquisition and relocation process with DPWT-PPCC & RD-IRC-MEF, relocation plan and payment will be discussed and carried out. 4) Relocation plan to vulnerable groups is considered by the related law for the Project. 5) Same as the above 4). 6) Proper relocation framework is under process of IRC-GDR-MEF. 7) A monitoring plan on relocation will be developed by the relevant agencies such as DPWT, MOE, etc.
	(2) Living and Livelihood	1) Is there a possibility that the Project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	1) The Project will improve the living conditions of inhabitants during the operation stage.
	(3) Heritage	1) Is there a possibility that the Project will damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	1) There is no possibility that the Project will damage the local archeological, historical, cultural, and religious heritage sites.
	(4) Landscape	1) Is there a possibility that the Project will adversely affect the local landscape? Are necessary measures taken?	1) There is no possibility that the Project will adversely affect the local landscape.
	(5) Ethnic Minorities and Indigenous Peoples	1) Does the Project comply with the country's laws for rights of ethnic minorities and indigenous peoples? 2) Are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous peoples?	1) There are no ethic minority people living in the Project Area.

Table R 1.4.50 Environmental Checklist for the Project (4/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
5. Others	(1) Impacts during Construction	1) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? 2) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? 3) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? 4) If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	1) Adequate measures considered to reduce impacts during construction stage.(Refer to tables of Mitigation Measure for the Key impacts). 2) The construction activities will not adversely affect the natural environment. 3) Adequate measures considered to reduce the impacts. 4) Health and safety education is necessary and provided for project personnel, including workers.
	(2) Monitoring	1) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? 2) Are the items, methods and frequencies included in the monitoring program judged to be appropriate? 3) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? 4) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	1) The implementation plan of monitoring program for the environmental items will be prepared by the implementation authority (DPWT/PPCC). 2) The items, methods and frequencies included in the monitoring program are judged to be appropriate. 3) DPWT/PPCC will establish an adequate monitoring framework including budget. 4) There are some regulatory requirements pertaining to the monitoring report system identified.

1.4.3.3 Necessary Action

(1) Explanation Meeting with Local Residents

In the construction stage of the Project, explanation meetings with local residents are to be held by the relevant agencies including the DPWT/PPCC and local residents at site before the construction works start in Wat Phnom Northern Area and Tuol Kork Area, both are highly-dense populated areas in the PPCC. The explanation meeting with local residents is indispensable for the public infrastructures to carry out the construction works in the urban area especially in such highly-dense population area.

The DPWT has a good experience obtained from Phase III that the Project received no claims from the local residents during construction. Most construction works of Phase III were also executed in the urban area of the PPCC.

Since some portions of the drainage pipe are adjacent to houses, shops and restaurants, the Cambodian side is required to hold meetings with the local residents to explain the works of the Project before the commencement of construction work. These explanation meetings shall be held for each “Khan” or “Sangkat” concerned. The resident’s opinion shall be

taken into consideration, and it is necessary to facilitate the understanding and cooperation of the inhabitants on project implementation.

(2) Securing the Environmental Monitoring

The DPWT/PPCC, responsible and implementing agencies of the Project, has to carry out the environmental monitoring during construction and operation stages. However, the DPWT/PPCC has no equipment and skills to measure the adverse impacts quantitatively such as noise level, while the MOE has equipment enough to measure noise and vibration. Therefore, the MOE together with the DPWT/PPCC have to carry out the monitoring works each other for manpower development.

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Objective

Phnom Penh City is prone to flooding and inundation because of its topography. Besides, flood protection and urban drainage facilities are not functioning well because of old age and insufficient maintenance.

Although the drainage condition in some parts of the city had gradually improved in the past decade, the other areas such as the northern part of city core area and surrounding area of inner ring dike still suffer from inundation in the rainy season. As a result, the city is beset with poor environmental conditions caused by stagnant wastewaters in the lowland areas causing deterioration of the residents' living environment and posing a serious constraint to social and economic development.

To find a solution to these issues, the GOC and the PPCC have been conducting various efforts for flood protection and drainage improvement to achieve the following goal:

Overall Goal

- Stabilization of the livelihood of people in the Phnom Penh Capital City;
- Development of the city through the mitigation of flood damage; and
- Improvement of sanitary and environmental conditions in the city.

The Project has the following objective under the overall goal mentioned above:

Project Objective

- To minimize inundation and damage in the Project area caused by local rainfall by improving the drainage system and providing equipment for emergency drainage works.

2.1.2 Basic Concept of the Project

The Project is to be implemented as a part of master plan which was formulated in "the Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh" (1998~1999) (hereinafter referred to as "MP1999") and revised in "the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area" (2014~2016).

This Project is to succeed the three (3) previous Japan's Grant Aid projects for Flood Protection and Drainage Improvement in the Phnom Penh Capital City.

To achieve the objective of the Project, drainage facilities in the Project area, including drainage pipe, drainage pump and underground reservoir, shall be installed or improved at the planning scale of 2-year probability, and equipment such as the Vehicle-Mounted Drainage Pump shall be procured.

As a result of "the Preparatory Survey on the Project for Flood Protection and Drainage Improvement in Phnom Penh (Phase IV)", following construction of structures, procurement of equipment and soft components shall be implemented by the Project as the Japan's Grant Aid.

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

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

Items		Description		Quantity
Construction Works				
	Improvement of Wat Phnom Northern Area Drainage System	Drainage Main	Pipe	2.7 km
			Box Culvert	0.5 km
		Interceptor	Pipe	1.6 km
			Manhole Pump	1 unit
		Pumping Station	Pump	1.4 m^3/sec
			Underground Reservoir	6,500 m^3
			Mechanical Screen	1 unit
	Improvement of Tuol Kork Area Drainage System	Drainage Main	Pipe	7.0 km
			Box Culvert	1.4 km
	Mechanical Screen Cleaning Facilities to Screen Pits at Pumping Stations Constructed in Phase II	Auto Raking Machine	Chak Tomuk PS Preah Kumlung PS Phsar Kandal PS Phsar Chas PS	4 units
Procurement Works				
	Procurement of Drainage Improvement Equipment	Vehicle-Mounted Drainage Pump		2 units
Soft Component				
	The soft component (technical assistance) aims to enable the DSD carry out the systematic and scheduled maintenance work and to utilize drainage facilities/equipment constructed/procured by Japan's Grant Aid Projects. PPCC is required to install garbage boxes and to carry out activities for raising public awareness to stop garbage dumping in and around the markets during the soft component (technical assistance) of the Project.			

Note) PS: Pumping Station

2.2 Outline Design of the Japanese Assistance

2.2.1 Design Policy

(1) Basic Design Policy

This Project was requested by the GOC based on the development plan proposed in the Final Report of MP1999. The GOC had requested assistance for reduction of inundation damages in Wat Phnom Northern area and Tuol Kork area in the urban area of Phnom Penh Capital City. In order to improve drainage system, the Project will implement the construction of drainage pipes, pumping station and underground reservoir. In addition, the mechanical screens will be installed at four pumping stations which were constructed in Phase II and vehicle-mounted drainage pump vehicles will be also procured.

In principle, project components are studied based on the request from the PPCC, and their quantity and specification are determined considering urgency and effectiveness to reduce the inundation damages.

The development plan of drainage facilities is based on the flood/drainage simulation. As a result of this, the layout plan of drainage pipes, pumping station and underground reservoir is examined, and scale and specification of the drainage facilities are determined.

Basic design policy for each component is as described below.

(a) Basic Design Policy for Improvement of Drainage System in Wat Phnom Northern Area

As the goal of mitigation of inundation damages, construction of pumping station, and underground reservoir, as well as rehabilitation/construction of drainage facilities such

as drainage pipes, are proposed. The objective of the construction of these facilities is to reduce inundation area and duration caused by heavy rain, to minimize the damage, and thus to promptly recover sound living condition of the residents.

In the area, it is proposed to construct or install a pumping station and drainage pipes in order to collect stormwater in the area and discharge them to the Tonle Sap River which is close to the area. In addition, the drainage facilities in the area are proposed to minimize construction as well as operation and maintenance cost for such equipment as pump facilities. The pumping station therefore will be equipped in the site of underground reservoir which regulate stormwater and thus reduce the capacity requirement of pumping equipment.

Currently, the wastewater from this area has been discharged directly into the Tonle Sap River without treatment. The wastewater is a source of negative impact to Tonle Sap River in PPCC. In addition, the intake of water supply operated by Phnom Penh Water Supply Authority (hereinafter referred to as "PPWSA") is located along Tonle Sap River. Impact on the raw water of the Phum Prek water treatment plant which takes water from the river has also been a concern. In order to solve these issues, the wastewater from the drainage network should be intercepted before discharging to the river, and then, discharged into the wetland located northern area of PPCC through the newly constructed interceptor.

The project area and scale shall be determined in consideration of emergency, necessity, benefit and cost effective on the basis of the result of topographic survey, boring survey, manhole survey, interview survey on the present inundation condition and drainage simulation.

(b) Basic Design Policy for Improvement of Drainage System in Tuol Kork Area

The policy in the area is to mitigate inundation damages through setting up appropriate target area depending on the current inundation damages identified by the interview survey.

The target area of Tuol Kork is divided into three drainage areas, Northern drainage area, Central drainage area and Southern drainage area. Stormwater in the drainage areas discharged to the Poung Peay lake, Tuol Kork-1 pumping station and Tuol Kork-2 pumping station, respectively.

The length of pipelines and diameter shall be determined in consideration of emergency, necessity, benefit on the basis of the result of topographic survey, boring survey, manhole survey, interview survey on the present inundation condition and drainage simulation.

(c) Basic Design Policy for Installation of Mechanical Screens in Pumping Stations constructed in Phase II

Chak Tomuk pumping station (PS1), Preah Kumlung pumping station (PS2), Phsar Kandal pumping station (PS4) and Phsar Chas pumping station (PS5) were constructed in Phase II. In the pumping stations, in order to prevent clogging of the wastes in the impeller of the pump, stationary bar screens were installed at inlet of their pump. The bar screen catches wastes, garbage, plants and so on flowing from the drainage pipe. Those wastes are manually removed by DPWT staff with a rake.

In the rainy season, the staff works every day to remove the wastes. However, the wastes flow fast and are big in volume, especially in the rainy days. Furthermore, many plastic wastes are easily caught on the screen. Therefore, the wastes make removal work difficult and thus disturb smooth flow of stormwater to the underground reservoir. DPWT has been tried to assign more staff and start the removal work as fast as possible, but the problem cannot be solved without structural measures.

The policy is to install mechanical screen to improve current condition. There is no enough space to install mechanical screens at existing screen chamber. It is proposed to demolish the existing bar screen and screen chamber, and to construct extended screen chamber and install mechanical screen.

(d) Basic Design Policy for Procurement of Equipment related to Drainage Management

The drainage facilities have been constructed with assistance from Japan and other donners as well as Government of Cambodia (hereinafter referred to as "the GOC") funds since 2000. However, the inundation damages still occur in the areas where improvement of drainage facilities are not in progress, areas where drainage does not function well due to aged pipes, and areas where the ground elevation is lower than that of neighbours. In addition, landfill of lowland and wetland in the new development area, induce inundation in the area where no inundation occurs in past days. In these areas, mitigation of inundation damages has been done by emergent drainage works.

The emergent drainage work is implemented by DSD (Drainage and Sewerage Division) under the responsibility of DPWT. DSD is also in charge of cleaning work of drainage pipes, channels, and other related facilities such as pumping stations. When the emergent drainage work is required, under the instructions by DPWT, DSD dispatches drainage pump vehicle. But currently PPCC has only one vehicle and the following issues exist.

- DSD has only one drainage pump vehicle, aged more than 30 years, with inadequate drainage capacity. Often the emergency drainage work is required at a plurality of locations at the same time. However, DSD could not dispatch the drainage pump vehicle timely due to lack of the vehicle.
- DSD has drainage pumps at their workshop but they are stationary type. In addition, they need to be equipped with power supply device, pipes and control panel. Therefore, these pumps cannot be used in emergency.

The policy for procurement of drainage equipment is to improve emergency drainage work for the mitigation of the inundation damages.

The equipment of emergency drainage shall be mobile type and the specification and quantity of the equipment should be determined in consideration of its use, needs, DSD's capacity for operation and maintenance of the equipment and so on.

(2) Policy on Design Conditions

The policy on design conditions for drainage facilities is set based on the existing data such as MP1999 and the result of natural condition surveys conducted in the Preparatory Survey.

(a) Design High Water Level of Tonle Sap River

The design high water level of Tonle Sap River is utilized for designing the pumping station which will be constructed along the Tonle Sap River of the Wat Phnom Northern Area. The design high water level of Tonle Sap River is set at 10.00 m based on the water level of 30-year return period which is computed by the observation data at Chaktomuk Hydrological Station.

Table R 2.2.1 Probable High Water Level of Tonle Sap River

Return Period (year)	High Water Level (EL. m) at Chaktomuk Hydrological Station
2	8.9
5	9.4
10	9.7
20	9.9
30	10.0
50	10.1

Source: JICA M/P1999

(b) Protection Level of Drainage Facilities

The following table shows the protection levels which are applied to drainage plan and design of similar cities in the neighbouring countries.

Table R 2.2.2 Protection Level Applied to Drainage Plan of Neighbouring Countries

City (Country)	Protection Level (A: Area of Catchment Basin)		
Bang Kok (Thailand)	A<0.2km^2	A=0.2～1.0km^2	A>1.0km^2
	1-year return period of rainfall	2-year return period of rainfall	5-year return period of rainfall
Hanoi (Viet Nam)	10-year return period of rainfall		
Jakarta (Indonesia)	A<0.1km^2	A=0.1～1.0km^2	A>1.0km^2
	1 to 2-year return period of rainfall	2 to 5-year return period of rainfall	5 to10-year return period of rainfall
Manila(Philippines)	A<5km^2	A>5km^2	
	3-year return period of rainfall	5-year return period of rainfall	
Dacca (Bangladesh)	2-year return period of rainfall		

The following table shows the protection levels for each scale of facilities, which were set in the MP1999 in consideration of similar cities in the neighbouring countries.

Table R 2.2.3 Protection Level for Each Facility

Structure or Facility	Protection Level
Major drainage facilities such as pumping stations, floodgates/sluiceways, reservoirs and drainage mains, with a catchment area more than 1 km^2 (approximately).	5-year return period of rainfall
Minor drainage facilities and sewer systems with a catchment area less than 1 km^2 (approximately).	2-year return period of rainfall

In Phase I, Phase II and Phase III of Japan' Grant Aid Project, above protection level was set in accordance with MP1999. In order to ensure consistency in flood protection and drainage improvement level in the same city, the Project follows those this protection in the preceding Project. The catchment area of drainage pipeline in the Project shall be less than 1 km^2. The protection level in the Project is set at 2-year return period of rainfall.

(c) Rainfall Intensity Curve

The adopted value of probable rainfalls for the design of drainage facilities in MP1999,

Phase I, Phase II and Phase III of Japan' Grant Aid Project are as summarized in the following table.

Table R 2.2.4 Probable Rainfall

Return Period (years)	Hourly Rainfall (mm/hr)	Daily Rainfall (mm/hr)	Rainfall Intensity Curve
2	44.8	87.8	$I=2,566.07x(T+25.48)^{-0.93}$
5	63.2	112.3	$I=5,009.12x(T+31.38)^{-0.98}$

The above value is based on the observation data of Pochentong Meteorological Station
I: Rainfall Intensity (mm/hr), T: Rainfall Duration (minutes)
Source: MP1999 and Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area

The above rainfall is computed based on the observation record duration between 1981 to 1997. The rainfall is re-evaluated by the combined data the above observation record with recent observation record. The result of rainfall analysis is as shown below.

Table R 2.2.5 Result of Rainfall Analysis per Return Period

Return Period	Computed Daily Rainfall (mm/day) per Duration		Difference
	From 1981 to 1997 (①)	From 1981 to 2013 (②)	②－①
2	87.8	90.1	+2.3
5	112.3	109.6	-2.7
10	128.4	125.4	-3.0
30	152.9	154.5	+1.6
50	164.0	170.3	+6.3

Source: JICA Survey Team

There is a variation in the difference of computed rainfall per return period but no significant difference. Based on the above result and consistency of the past projects, the 2-year return period of rainfall on MP1999 (hourly rainfall: 44.8mm/hr, daily rainfall: 87.8 mm/day) is applied.

(d) Rainfall Duration

The hourly rainfall data during heavy rain was available duration between 1981 to 1997 in MP1999. The analysed waveform of rainfall on MP1999 indicated that the all rainfall duration is within six (6) hours. Thus, the duration of design rainfall was defined in MP1999 as six (6) hours based on single rainfall patterns of recent heavy rains causing severe inundation in the Project area.

On the other hand, there was not available hourly rainfall data in Phase I, Phase II and Phase III of Japan' Grant Aid Project. Hence, the duration of the design rainfall in the past projects were set at six (6) hours.

The hourly rainfall data are not published and authorized due to lack of the credibility although MOWRAM have recorded the hourly rainfall data by automatic observation since 2012.

Based on the above result and consistency of the past projects, the design rainfall duration in the Preparatory Survey is set at six (6) hours.

(3) Policy on Socio-Economic Condition

The acquisition of private land and house relocation often cause social conflicts. To avoid such conflicts, the right of way for the improvement of drainage pipes shall be set within the area of road and pavement. The location of the existing underground facilities shall be carefully examined in determination of drainage pipes' alignment. The location of pumping station and underground reservoir should be planned in the public land or the park along the river.

The project area is located in a densely-populated area, economic center and tourist zone. Therefore, the facilities shall be designed paying attention to the landscape. The implementation plan of construction works shall pay special attention to minimize noise, vibration and negative impact to economic activities.

(4) Policy on Construction/Procurement

(a) Design Standard

The Ministry of Public Works and Transport established design standards for bridges and national roads in 2003. Since the other structural design standards in Cambodia have not yet been established, well known standards of advanced nations such as Japan, the European Union, Australia and the USA are adopted.

Since previous Japan's Grant Aid projects have adopted Japanese design standards, the Preparatory Survey also adopted the Japanese design standards.

(b) Procurement Situation

Main construction materials such as cement, reinforcing bars, aggregates and so on, and basic construction equipment are available in Cambodia, but the local availability of particular construction components like steel sheet pile, drainage pump and so on is difficult. 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 considered the future improvement plan to avoid the duplication of investment.

Mechanical screen, gate-mounted pump, special electrical materials and vehicle-mounted drainage pump will be procured in Japan or another country and disembarkation point will be the port in Sihanouk Ville.

(c) Related Law/Regulation

The Phnom Penh Capital City (PPCC) is vested with the right to approve the execution of various construction works in public spaces including road works in the city. Since the superintendence organization of this Project is PPCC, there will be no obstacle to project execution.

The Project should implement the Initial Environment Impact assessment (hereinafter referred to as "IEIA") before commencement of the Project based on the environmental standard of Cambodia. It is also required to be approved by the Ministry of Environment.

(5) Policy on the 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) Pump Installation

It is limited availability of the engineers who has experiences for installation of large sized pump, and related electrical and mechanical works. In these special works, the engineers could be dispatched from japan.

(6) Policy on Operation and Maintenance Condition of the Implementing Agency

The pumping station, underground reservoir, drainage pipes, manholes, mechanical screens and related facilities should be designed in consideration of the capability and budget for operation and maintenance of the implementing agency. To enable the appropriate management and maintenance in present budget, structure and staff of the implementing agency shall be considered in the Preparatory Survey. The operation and maintenance of the equipment related to drainage management should be provided technical assistance by the soft component of the Project.

(7) Policy on Determination of Planning Scale of the Objective Facilities and Equipment

The locations, dimensions, specification and so on of the objective facilities/equipment are to be optimized based on the present inundation condition and the result of the hydraulic analysis in the Preparatory Survey. However, Japan's Grant Aid shall be extended for projects where grant aid is urgently necessary in the present situation.

(a) Improvement of Drainage Network

It is desirable to achieve 'Inundation duration and Inundation depth becomes zero, i.e. there is no longer inundation occurred' after improvement of drainage pipe, pumping station and underground reservoir. In order to achieve this condition, it is needed huge size of objective facilities. However, there are many negative factors for huge drainage facilities to achieve "no inundation", such as limited construction space for new facilities, excessive costs, lengthy construction period, relocation of obstructive existing underground facilities. Therefore, it is realistically set at "toleration of flood depth is less than 20 cm and flood duration is 2 hours under the condition of 2-year return period" which is same condition with drainage improvement in Phase II and Phase III. It is decided to follow the target same as previous Project from the following points of view.

- Drainage improvement plan in the same city should be consistency and coherency.
- In Tuol Kork area, discharge destinations are existing pumping stations and lake through existing drainage pipe line. Drainage capacities of existing facilities shall be design conditions for outline design of new drainage facilities. There is no space to install large size of drainage pipes in the area.
- In Wat Phnom Northern area, to achieve "no inundation, it is required to construct excessive size of facilities, such as drainage pump with discharge capacity of $5m^3/s$ and underground reservoir with excessive storage capacity of 70,000 m^3 or more.
- Toleration of flood depth is set as "no inundation damage in the house" and "no traffic closure and ensure walking access".

Size of objective facilities shall be decided based on the result of drainage simulation with the condition of above.

(b) Improvement of Mechanical Screen

Specifications of mechanical screen should be decided to match designed flow rate at screen. In order to secure the function of the drainage facilities constructed in Phase II, the following items should be satisfied in the outline design.

- Screen should be constructed at same location of existing one. Existing facilities could be demolished, and newly constructed with auto-raking machine.
- New screen should not block wastewater flow from the drainage pipe to underground reservoir.
- Screen should be designed to ease operation and maintenance.

(c) Procurement of Equipment for Drainage Management

As the result of field survey, the following functions are required for the equipment.

Table R 2.2.6 Function required for the Equipment

Function	Note
Pumping Function	To discharge stormwater at localized flooding and to reduce flooding duration
Ambulatory	To rapidly move to the scattered locations in which urgent drain of stormwater is required
Left-Handle Drive	Right-handle drive vehicles are not permitted in Cambodia

Specifications of the equipment should be determined by consideration of following conditions, considering work efficiency, durability, operability and minimum quantity for the operation and maintenance.

- Number of government staff to operate the equipment
- Space for the garage with roof for safety store of the equipment
- Budget to operate and maintain the equipment

(8) Policy on the Procurement Plan

Based on the following reasons, Japan shall be the country of origin of equipment to be procured in the Project.

- There is an agency in Cambodia or in neighbouring country to procure main parts of truck body;
- There is less possibility for equipment breakdown and it is easy to procure spare parts; and
- Japanese products are strongly requested by DSD because it is more reliable than those of other countries based on the DSD's experience of operating the existing equipment.

(9) Policy on the Construction Plan

(a) Construction of Drainage Network (Drainage and Interceptor)

- New drainage pipes shall be laid underneath of existing road. Test excavations at each construction site of the proposed drainage pipeline shall be carried out prior to implementation in order to locate the exact position of existing underground facilities.
- The whole objective area of drainage network improvement in the Project shall be

divided into four (4) drainage areas, and each drainage area shall have a different and independent drainage function. The construction work at one drainage area shall be completed basically to make its drainage function effective before the construction team moves to another drainage area.

- Construction areas are located in the urban area. From the environmental and safety points of view, construction equipment to be used in the Project shall be the low noise and low vibration types to minimize the negative impact to houses and buildings.
- The working hours in this Project site are basically from 8:00AM to 5:00PM for safety reasons. However, night time work shall also be planned to minimize the influence against the present traffic and the residents' living conditions.
- The jacking method may be adopted at sites where traffic volume is rather heavy to avoid the negative impact of traffic control.

(b) Construction of Pumping station, Underground Reservoir and Mechanical Screen

- The objective facilities are constructed inside the public park. As there are several buildings near the site, construction work shall be carries out using steel sheet-piles method for earth retaining.
- The foundation pile of the underground reservoir is designed as the PC pile. The hydraulic hammer shall be adopted for driving the PC piles considering the prevention of noise and the problem on oil or soot.

(10) Policy on the Implementation Schedule

The Project includes the improvement of drainage network and the construction of pumping station, underground reservoir, and the construction work could be affected easily by rain. During the rainy season, work efficiency certainly becomes low and work progress will decline as a result.

Especially, the foundation work of pumping station and underground reservoir shall not manage during the rainy season because of water level raising. All the above work shall be implemented in the dry season as well as installation work of the mechanical screen.

Implementation schedule shall be set with above mentioned conditions. The construction work shall be needed at least three dry seasons. Therefore, it may be for four years period.

2.2.2 Basic Plan (Construction Plan/Equipment Plan)

The following facilities and equipment have been requested by the Cambodian side for the Project:

- Improvement of Wat Phnom Northern area and Tuol Kork area drainage system;
- Mechanical screen cleaning facilities to screen pits at pumping stations constructed in Phase II; and
- Procurement of drainage improvement equipment.

Results of analysis, design and implementation plan for the requested facilities and equipment are described below.

2.2.2.1 Hydraulic Model Analysis

(1) Existing Drainage System and Flood Prone Area in the Project Area

Phnom Penh Capital is located on natural flood plain area, where alluvial plain has been widely distributed. The land elevation of the target area ranges between 0 and 14 m. The topological condition indicates that Phnom Penh Capital has high risk of flood/inundation taking into account meteorological condition mentioned in **Section 1.3**. Sewerage and urban drainage system in Phnom Penh Capital was established during France's colonial. However, due to rapid urbanization in recent years, the existing drainage cannot convey stormwater, which was originally infiltrated, and hence inundation frequently occurs. Also, after demise of the colonial, neither sufficient maintenance nor reconstructing has been conducted for even 20 years due to civil war. As a result, aged and degraded drainage system due to deposition of garbage, sedimentation of sand, mad and sludge, has frequently caused serious flood in such area as Wat Phnom Northern Area in every rainy season, especially when water level of Tonle Sap River is high.

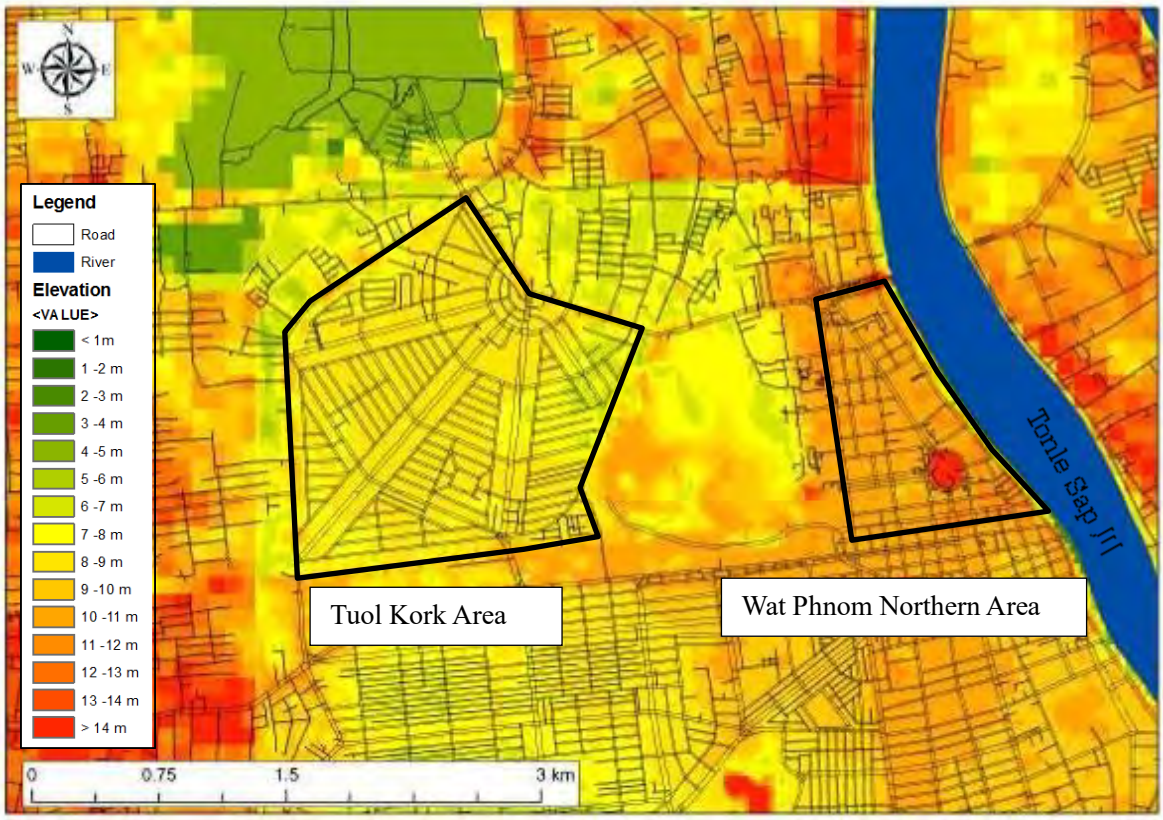


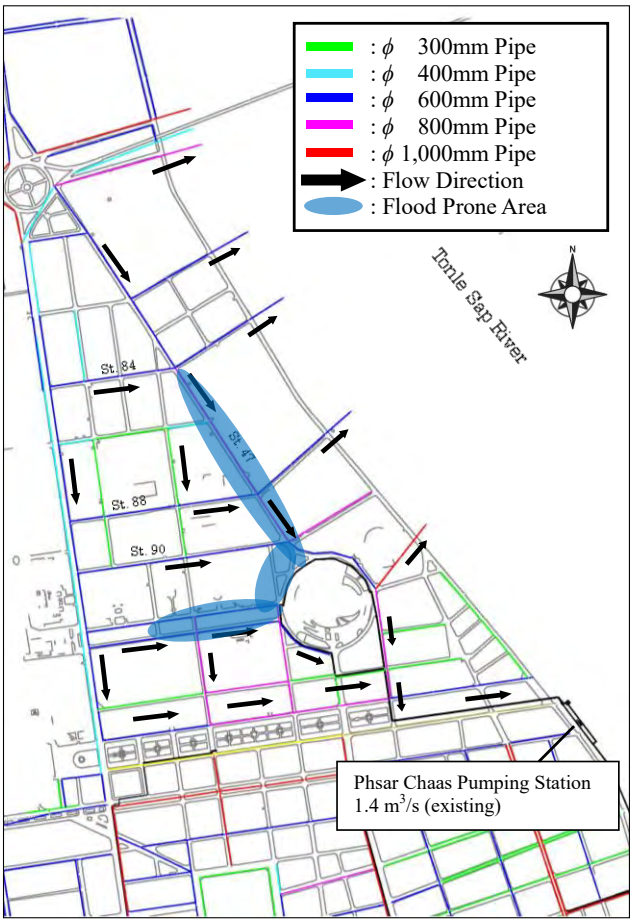
Fig. R 2.2.1 Elevation around the Target Areas

The flooding status testified by staff of Department of Water Resources and Meteorology (DOWRAM) and existing drainage system are described below.

(2) Wat Phnom Northern Area

Drainage pipes (approximately 70 manholes and 10 km of pipe length, ϕ 600-1,200 mm) are installed in Wat Phnom Northern Area (see **Fig. R 2.2.2**) When rainfall occurs, stormwater is drained into the drainage pipe of ϕ 800 mm along St. 47 from neighboring branch pipes (ϕ 300-600 mm) and inlets, and discharged southward. Finally, collected stormwater in the catchment area is pumped up and discharged into Tonle Sap River at

Phsar Chas Pumping Station (No. 5 PS) which was constructed in Phase II. East side area of St.47 is slightly higher than that of west side, so the stormwater in the area is partly discharged directly into Tonle Sap River through outlets along the river. However, these pipes' invert level may be lower than that of the water level in the rainy season and stormwater cannot be discharged into the river due to backwater. In Wat Phnom Northern area, inundation occurs especially in lower area, including Wat Phnom, St. 47 and US embassy, with duration of 1 hour. Before construction of Phsar Chas Pumping Station, duration of inundation was more than 4 hours, which indicates that Phsar Chas Pumping Station (No. 5 PS) mitigates inundation in this area.

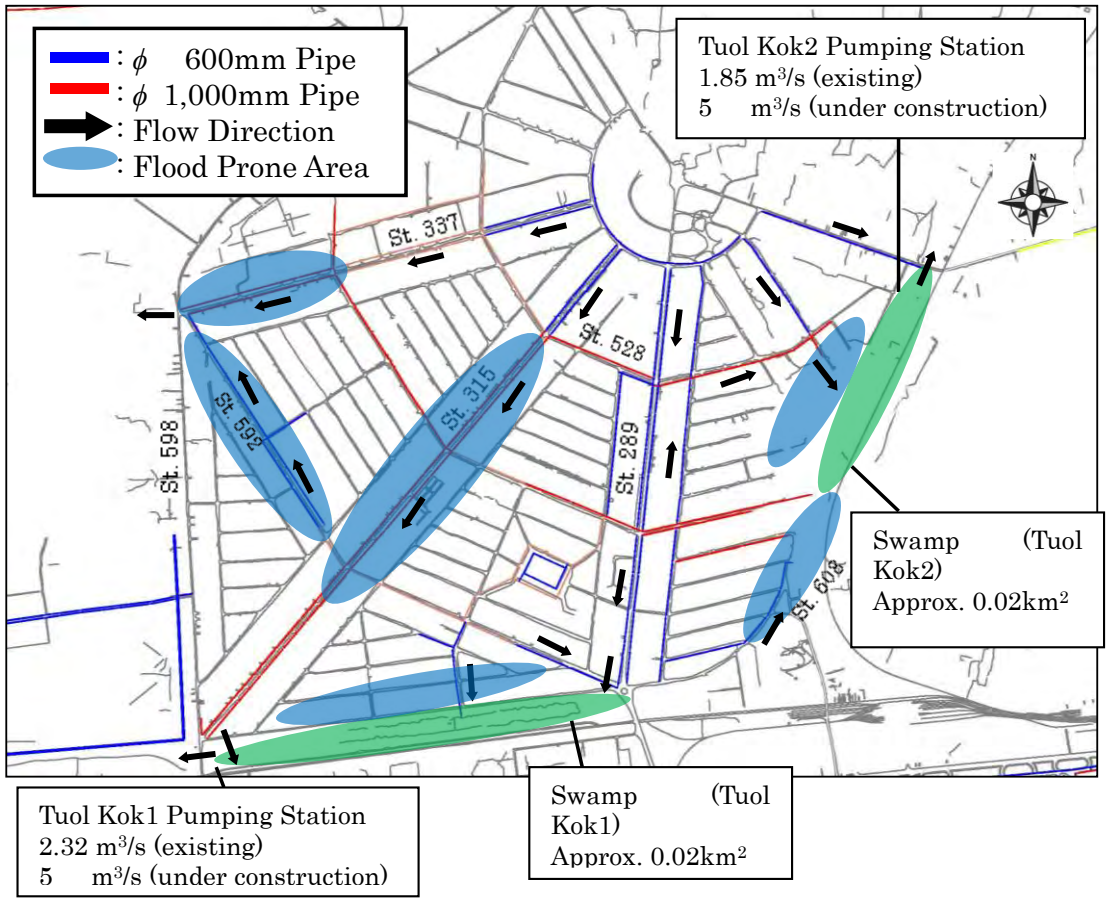


Source: DPWT, DOWRAM and JICA Survey Team

Fig. R 2.2.2 Flood Prone Area and Existing Drainage System of Wat Phnom Northern Area

(3) Tuol Kork Area

Drainage pipes (approximately 250 manholes and 20 km of pipe length, ϕ600-1,000mm) are installed in Tuol Kork Area. Drainage pipes with ϕ1,000 mm of diameter are installed along St. 337, St. 315 and St. 528 in which stormwater have been collected. There exist two swamps at the lower land, collecting stormwater and discharging them through outlets. One is located near Tuol Kork 1 Pumping Station with capacity of 2.32 m^3/s and the other is Tuol Kork 2 Pumping Station with capacity 1.85 m^3/s. At present, additional 5 m^3/s of pumping stations are under construction next to the two pumping stations. In this area, inundation frequently occurs due to insufficient capacity of drainage along St. 337 and St. 315, in which ϕ 1,000 mm drainage pipes are already installed. According to the staff of DOWRAM, inundation in the area continues for approximately 5-8 hours at a maximum.



Source: DPWT, DOWRAM and JICA Survey Team

Fig. R 2.2.3 Flood Prone Area and Existing Drainage System of Tuol Kork Area

Swamp (Tuol Kork 1)

Swamp (Tuol Kork 2)

Photo R 2.2.1 Swamp Area in Tuol Kork Area

(4) Evaluation of Hydraulic Condition of Drainage System by Model Simulation

Hydraulic condition of existing drainage system in target areas: (i) Phnom Penh Northern Area and (ii) Tuol Kork Area, were evaluated based on hydraulic model simulation. Modelling conditions for both areas were summarized in table below and working procedure for the analysis is shown in **Fig. R 2.2.4**.

Table R 2.2.7 Modeling Condition of the Target Areas

Items	Wat Phnom Northern Area	Tuol Kork Area
Drainage Area	117 ha	334.7 ha
Number of manhole to be modelled	70	250
Total length of drainage Pipe	10 km (ϕ 300-1,200mm)	20.4 km (ϕ 600-1,000mm)
Completion of modelling of drainage network	✓ Piping network and manhole were modelled based on database of drainage system provided by DPWT, manhole survey and field investigation. ✓ Specific information on elevation (e.g. ground level, invert level, etc.) are input based on manhole survey.	
Drainage structure (Existing)	■Phsar Chas 1.4 m^3/s (existing)	■Tuol Kork 2 Pumping Station 2.32 m^3/s (existing) ■Tuol Kork 2 Pumping Station 1.85 m^3/s (existing)
Drainage structure (Future)	■Phsar Chas 1.4 m^3/s (existing)	■Tuol Kork 2 Pumping Station 2.32 m^3/s (existing) 5 m^3/s (under construction) ■Tuol Kork 2 Pumping Station 1.85 m^3/s (existing) 5 m^3/s (under construction)
Catchment Area	Delineated based on road, building and manhole	
Runoff Model	Time-Area method	
Completion of modelling of land surface elevation	30 m grid model	

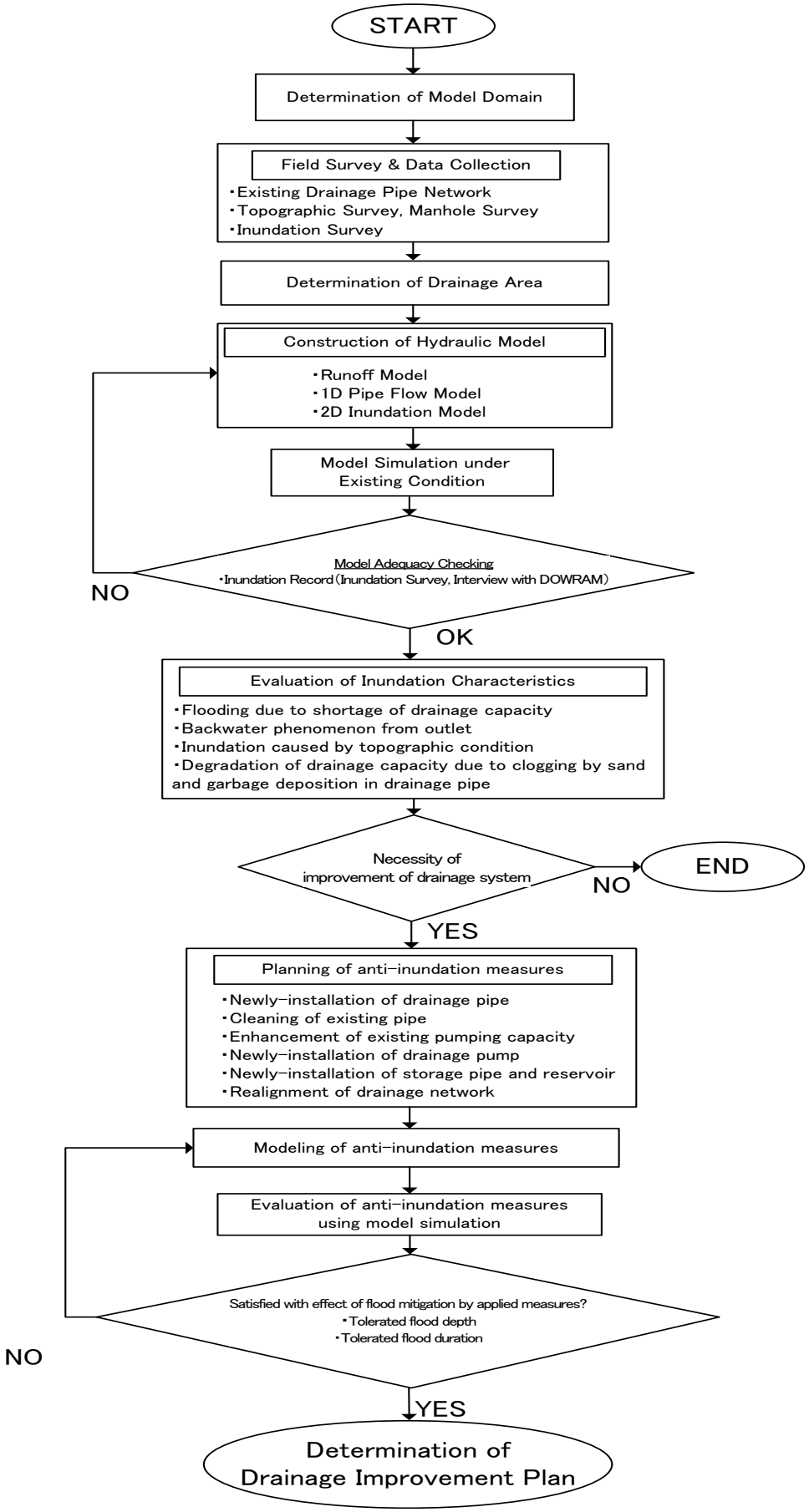


Fig. R 2.2.4 Working Procedure for Hydraulic Analysis

(5) Applied Hydraulic Model

In order to simulate a series of water behaviour among rainfall- runoff- pipe flow -surface flow (inundation), a coupling model of MOUSE and MIKE 21, which are released by DHI, was applied in this study. The MOUSE Pipe Flow Model is a computational tool for simulations of one-dimensional unsteady flows in pipe networks, which is operated with user interface called as MIKE URBAN. Computation of this model is based on an implicit, finite difference numerical solution of free surface flow equations (Saint Venant, DHI, 1999). MIKE 21 deals with 2-dimensional unsteady overland flow. Above-mentioned two models were coupled to simultaneously simulate flow in sewer, drainage system and surface flow. **Fig. R 2.2.5** illustrates the coupling model of MOUSE and MIKE 21.

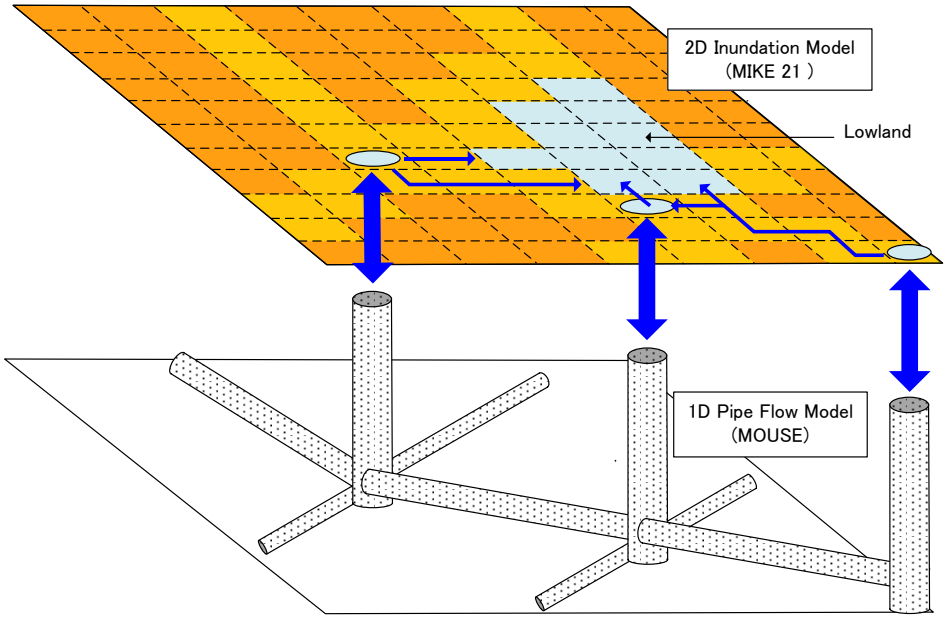


Fig. R 2.2.5 Illustration of Coupling model of MOUSE and MIKE21

(6) Runoff Model

For runoff calculation, or analysis on conversion process of rainfall into runoff discharge, Time-Area method was applied as a calculation module in MOUSE. In this method, the catchment area is delineated into areas depending on travel time. Calculated discharge hydrographs for the delineated areas are summed up with the unit-hydrograph method. These time series data of calculated discharge are input into each calculation node in the model[1]. This method can process discharge hydrograph for each node taking concentration time into consideration.

(7) Drainage Network Model

Existing drainage networks were modeled based on the survey result for Wat Phnom Northern Area and Tuol Kork Area. In Wat Phnom Northern Area, the model was established, modifying the one established in the preceding Studies. On the other hand, drainage network model for Tuol Kork Area was newly established based on horizontal base map of DPWT and information on pipe and manhole such as invert level and ground level obtained in the manhole survey conducted in the Preparatory Survey.

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[1] Association of Water and Sewage Works Consultants Japan, 2012

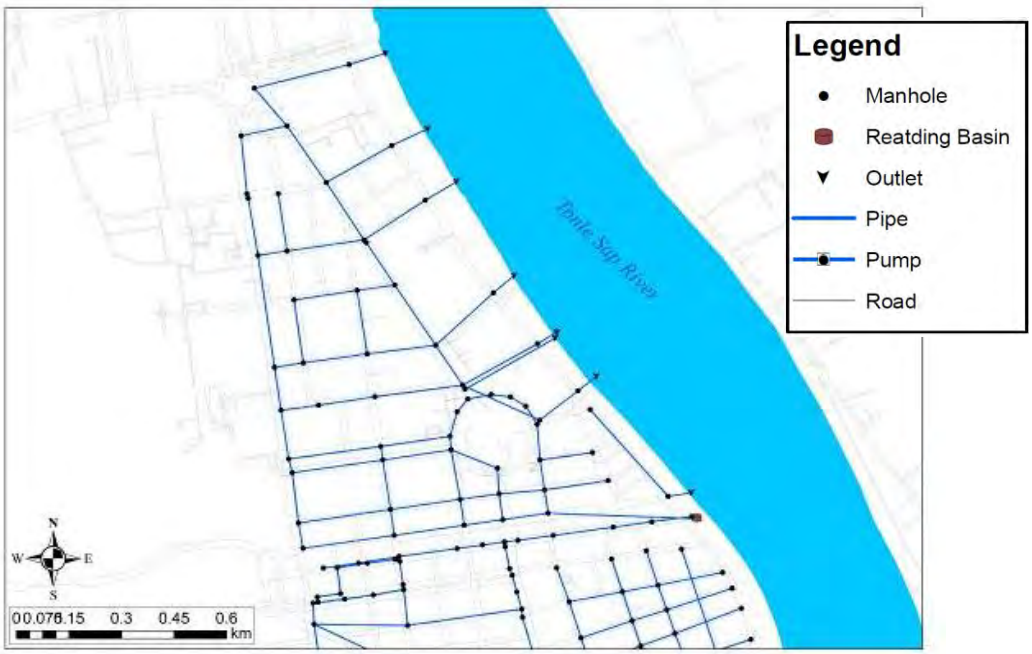


Fig. R 2.2.6 Modelled Drainage Network (Wat Phnom Northern Area)

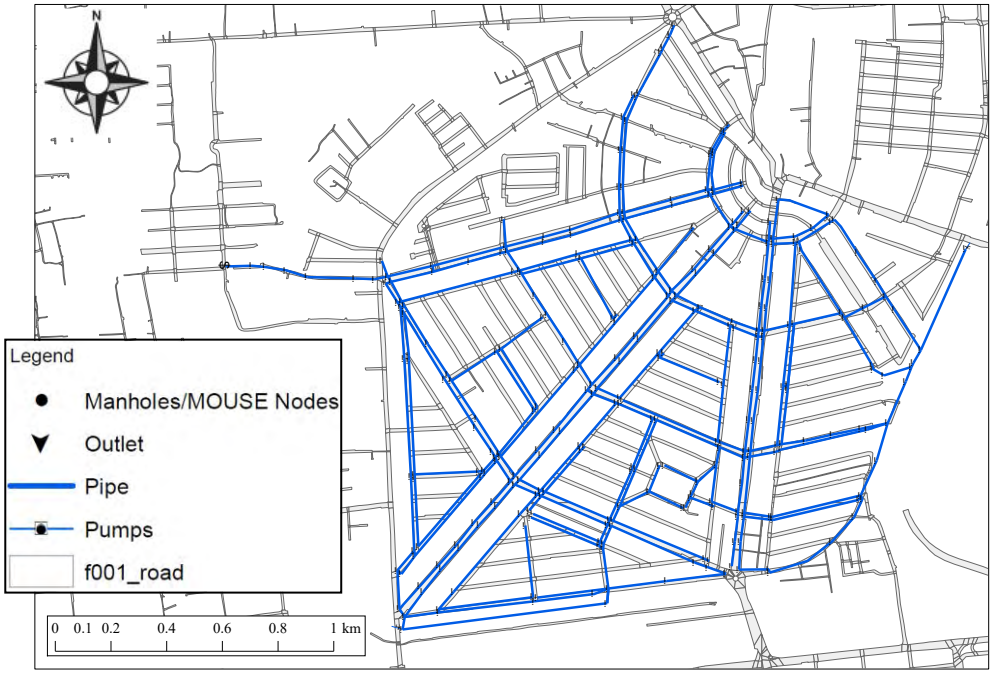


Fig. R 2.2.7 Modelled Drainage Network (Tuol Kork Area)

(8) Drainage Structures

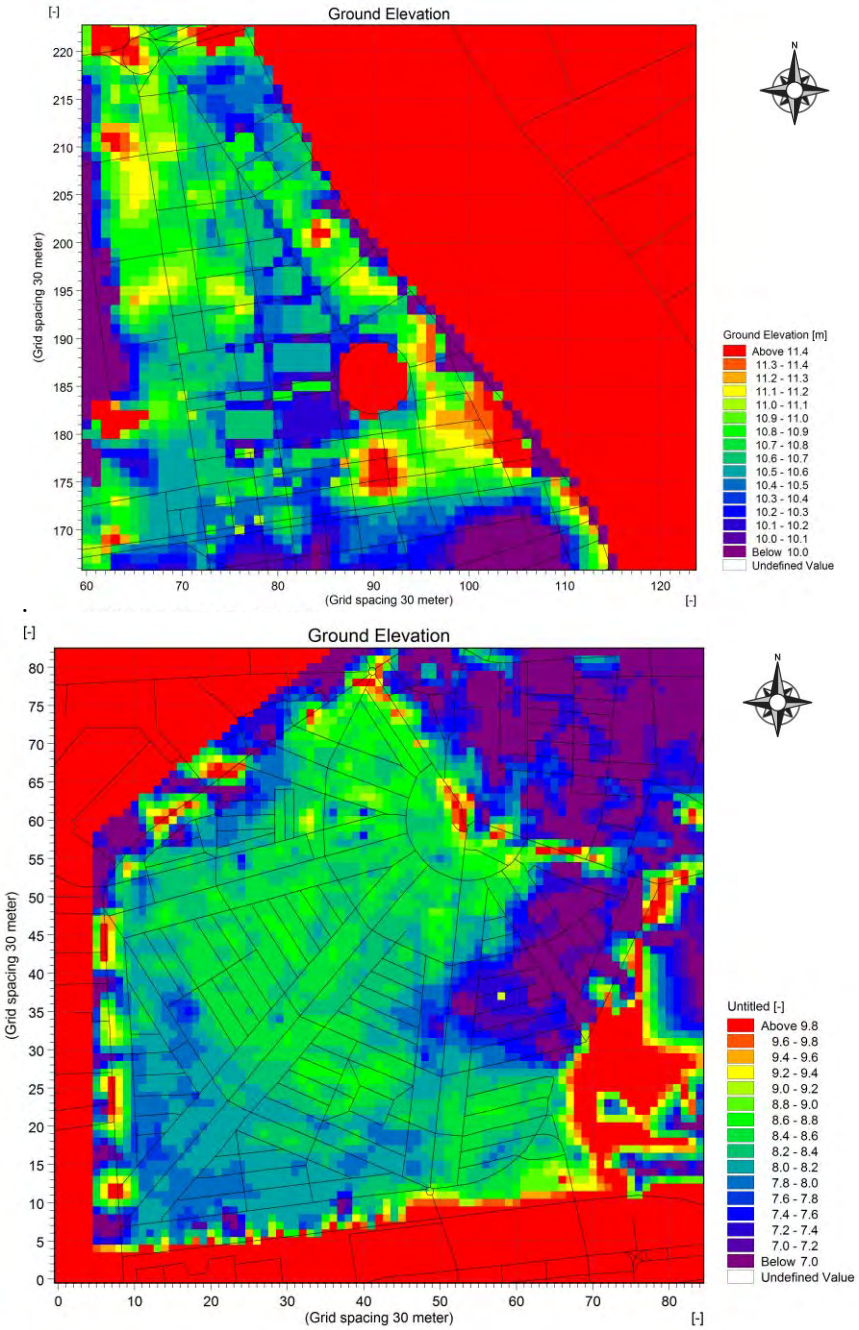
In the established model, drainage structures such as pumps and reservoirs were or are to be modelled based on the existing condition. The modelled structures are tabulated below. In Tuol Kork area, two pumping stations under construction were included in the model as given condition, as tabulated in **Table R 2.2.8**.

Table R 2.2.8 Modeled Hydraulic Structures

Item	Wat Phnom Northern Area	Tuol Kork Area
Drainage structure (Existing)	■Phsar Chas: 1.4 m^3/s (existing)	■Tuol Kork2 Pumping Station: 2.32 m^3/s (existing) ■Tuol Kork2 Pumping Station: 1.85 m^3/s (existing)

(9) Land Surface Digital Elevation Model (DEM)

Land surface Digital Elevation Model (DEM) prepared by JICA M/P 2015 was basically applied for hydraulic models in the both areas. DEM was established with 100 m grid and integrated SRTM DEM data (3 sec) and the topographic survey result conducted by JICA (2015) and KOICA (Korea International Cooperation Agency) (2011). Accuracy of the DEM was checked in the M/P 2015. In the Project, based on this, DEM data with 30 m grid size was established and modified with the topographic survey result by the JICA M/P Study Team (1998). Established DEM for both areas are shown in **Fig. R 2.2.8**.



*Prepared by JICA Survey Team
*DEM data were prepared by integrating 1) Shuttle Rader Topography Mission, 2) KOICA DEM by the Project of the production the National Base Map and the Establishment of the master Plan for the National Spatial Data Infrastructure in Cambodia (2010-2011) and Topographic Survey conducted JICA (1998and 2015)

Fig. R 2.2.8 Land Surface Digital Elevation Model (DEM)
(Upper: Wat Phnom Northern Area, Lower: Tuol Kork Area)

(10) Swamp Area

In Tuol Kork Area, two swamp areas are located at southwest and northeast of the drainage area (see **Fig. R 2.2.9**), to which collected stormwater in the existing drainage system is discharged from their outlets. These swamps deem to play significant roles as retarding ponds for the drainage area, so they are modeled in the established hydraulic model.

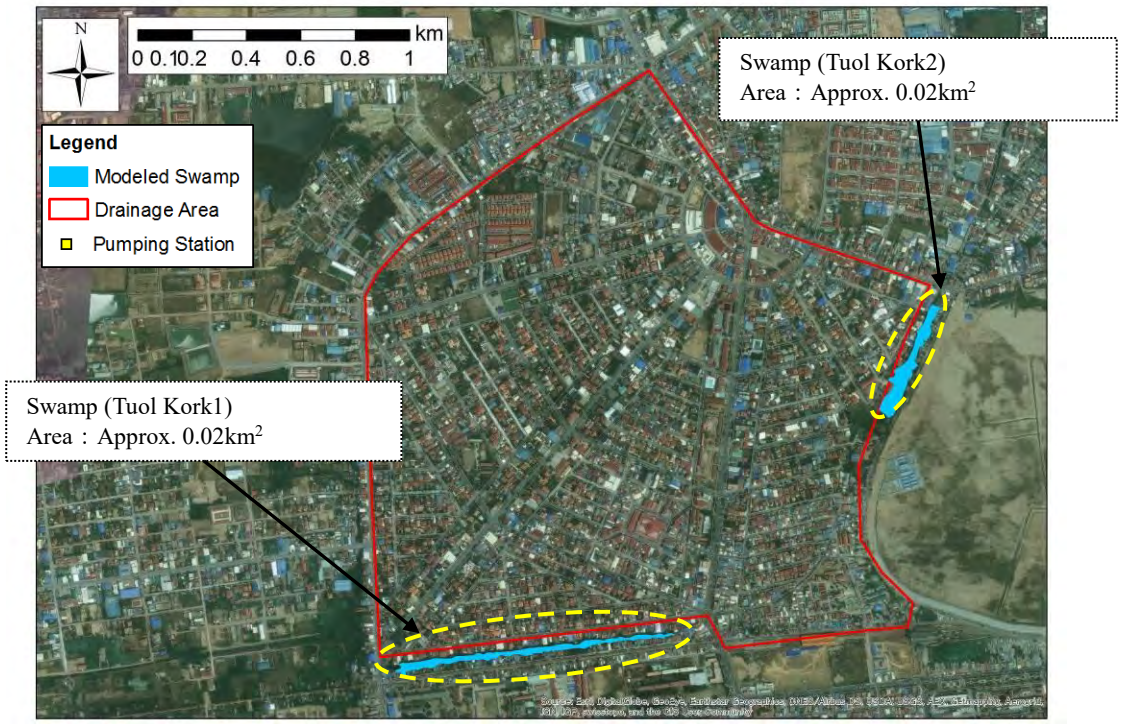


Fig. R 2.2.9 Distribution of Swamp Area in Tuol Kork Area

Open drainage channel was excavated along the swamp near Tuol Kork 2 pumping station, whose surrounding area is transformed into swamp area in the rainy season (see **Fig. R 2.2.10**). This channel was also modelled.

Fig. R 2.2.10 Open Channel Distribution Surrounding Tuol Kork2 (Left: Route of Channel, Right: Photo of Open Channel)

(11) Boundary Condition

(a) Return Period for Drainage Design

In order to calibrate the established model, observed short-term rainfall (e.g. such as 10 minutes, 15 minutes) is indispensable for input data as boundary condition. Ideally, the time interval of rainfall data with less than concentration time is required. However, DOWRAM only conducts daily observation of rainfall on a daily basis. Therefore, hyetograph of rainfall intensity was prepared based on the prior survey result and input to the model as data.

In JICA M/P 1999, 2-year return period was employed for the main drainage channel. To ensure consistency with the preceding Studies consideration, 2-year return period and its rainfall intensity curve was applied in the Project.

Table R 2.2.9 Applied Rainfall Intensity Formula

Return Period (year)	Hourly Rainfall (mm)	Daily Rainfall (mm)	Rainfall Intensity Formula	Rainfall Duration
2	44.8	87.8	$I=2,566.07 \times (T + 25.48)^{-0.93}$	6 hours

Source: JICA M/P1999

(b) Water Level

30-year probable water level (EL. 10.0m) of Tonle Sap River at Chaktomuk hydrological station was applied as an outer boundary condition of the model for Wat Phnom North Area. This condition is the same water level applied in the preceding Grant Aid projects. In Tuol Kork Area, highest water level of open channel, which flows into Poung Peay Lake located at northwest of target area, was set based on interview with neighbours and topological survey results, as shown in **Fig. R 2.2.11** and **Table R 2.2.10.**

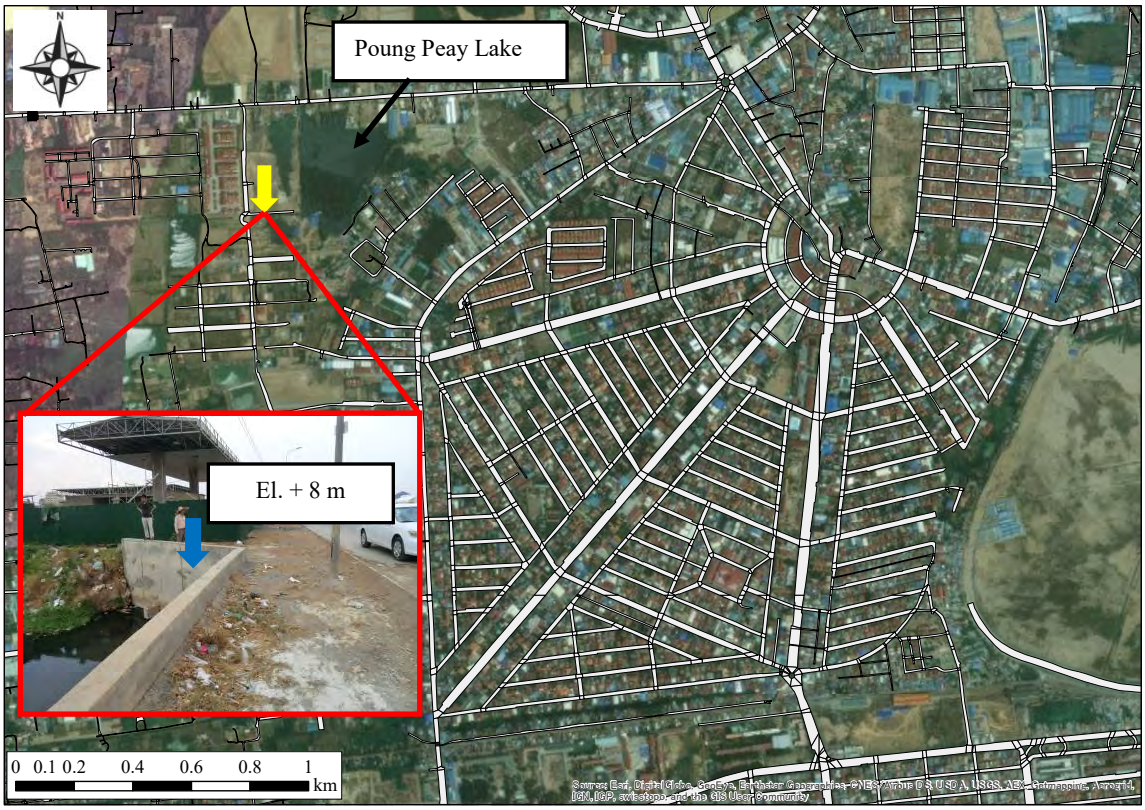


Fig. R 2.2.11 Location of Surveyed Point for Outer Level for Tuol Kork Area

Table R 2.2.10 Design Water Level for Outer Boundary Condition

Target Area	Location	Water Level (EL. m)
Wat Phnom North Area	Tonle Sap River	10.0
Tuol Kork Area (North)	Drainage Channel of Poung Peay Lake	8.0

The water level reaches crown of river bank in the rainy season.

(12) Calibration Result

In calibration, validity of the model was confirmed by comparing the simulation result under 2-year of return period for rainfall and the result of inundation survey result. **Fig. R 2.2.12** and **Fig. R 2.2.13** show maximum flood depth and duration of inundation for both areas in simulation results under 2-year return period.

The established model for Wat Phnom Northern Area appears to be well-calibrated because the spatial distribution matches that of inundation survey result. Occurrence of road inundation was confirmed on such roads as St. 47, St. 84, St. 88 and around Wat Phnom. As a result, duration of inundation duration was estimated at about 1.5 hours, which matches inundation status testified by office staff of DOWRAM.

In Tuol Kork Area, the established model was also well-calibrated because the spatial distributions for both items match those of inundation survey result. Occurrence of road inundation was confirmed on such roads as St. 337, St. 315, St. 592 and so on, in which occurrence of inundation was testified by office staff of DOWRAM. Duration of inundation was estimated at about 6-8 hours as longest, which matches the interview result.

These calibration results for the both areas indicate the established models in this Preparatory Survey have efficient reproducibility.

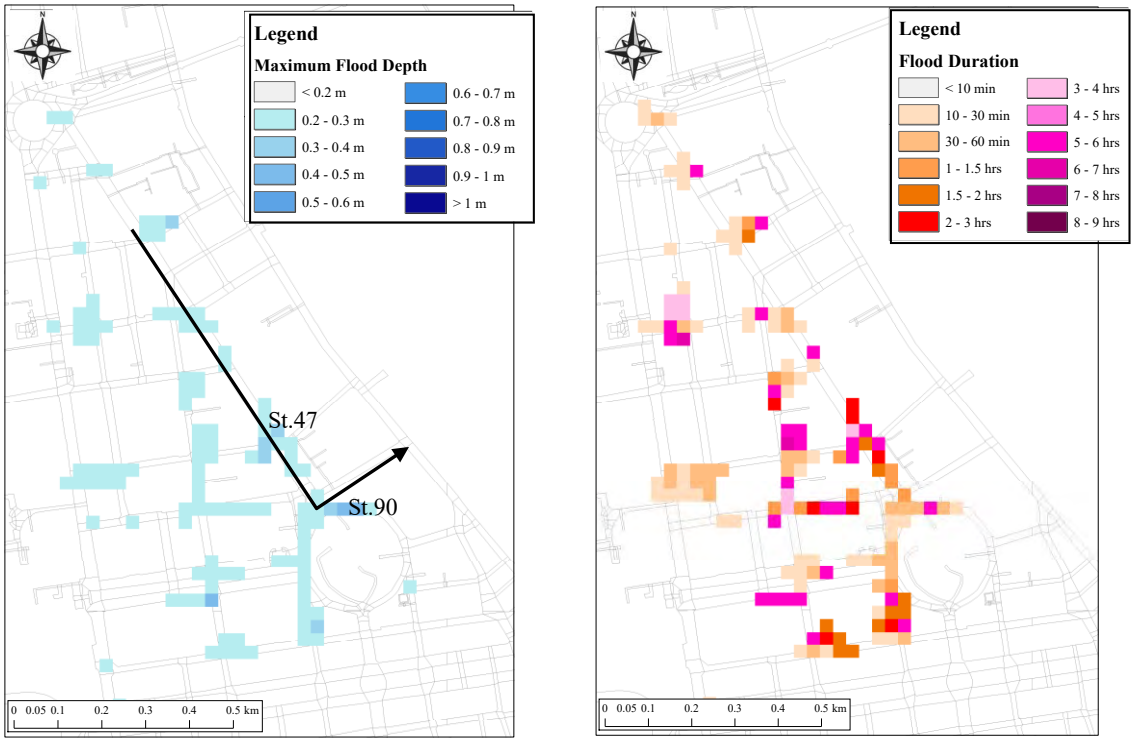


Fig. R 2.2.12 Calculation Result under 2year of Return Period for Wat Phnom Northern Area (Left: Maximum Inundation Depth, Right Duration of Inundation)

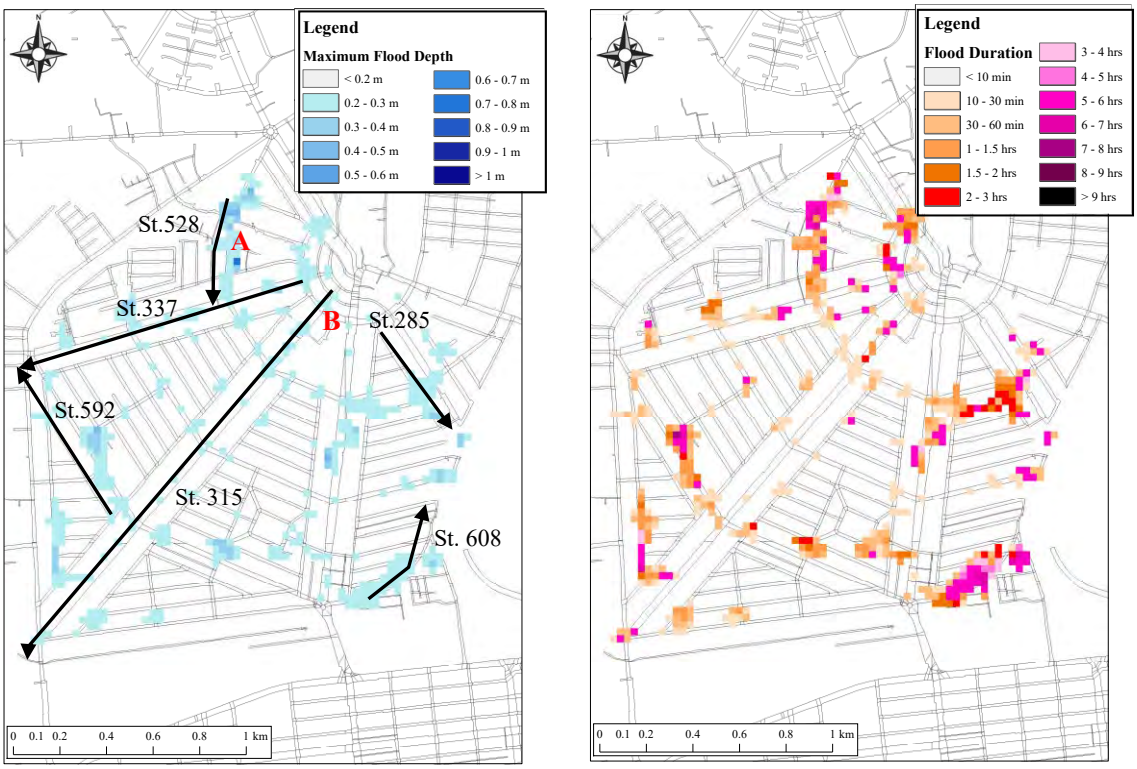
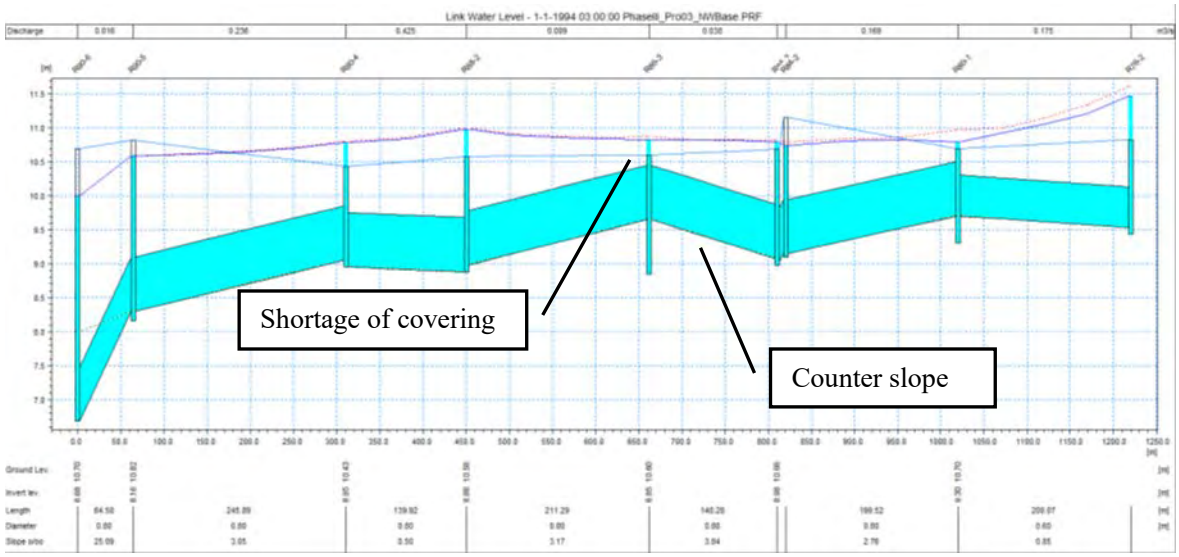


Fig. R 2.2.13 Calculation Result under 2year of Return Period for Tuol Kork Area (Left: Maximum Inundation Depth, Right Duration of Inundation)

(13) Evaluation of Flood Characteristics under Existing Drainage Condition

Based on the simulation results, flood characteristics and existing drainage capacity for Wat Phnom Northern Area is evaluated as below.

- Existing drainage system has capacity for flood event of less than 2- year return period. Occurrence of road inundation was confirmed on such roads as St. 47, St. 84, St. 88 and around Wat Phnom. As a result, inundation continues for approximately 1.5 hour for 2-year return period.
- Although Phsar Chas Pumping station contributes to drainage improvement in this area, temporal inundation is inevitable due to insufficient capacity of the existing drainage pipe.
- Stormwater around Wat Phnom is deemed to be gathered into Phsar Chas Pumping Station through drainage pipe under St. 90 or side ditch around Wat Phnom (750x750mm). These facilities also contribute to drainage improvement in this area.
- Shortage of covering of pipes and counter slope were partly confirmed, as shown in **Fig. R 2.2.14,** which shows longitudinal profile from St. 47 to St. 90.



*Locations are referred to **Fig. R 2.2.12**

Fig. R 2.2.14 Longitudinal Profile and Water Level from St.47 to St.90 (under 2-year Return Period)

Existing drainage system for Tuol Kork Area is evaluated as below.

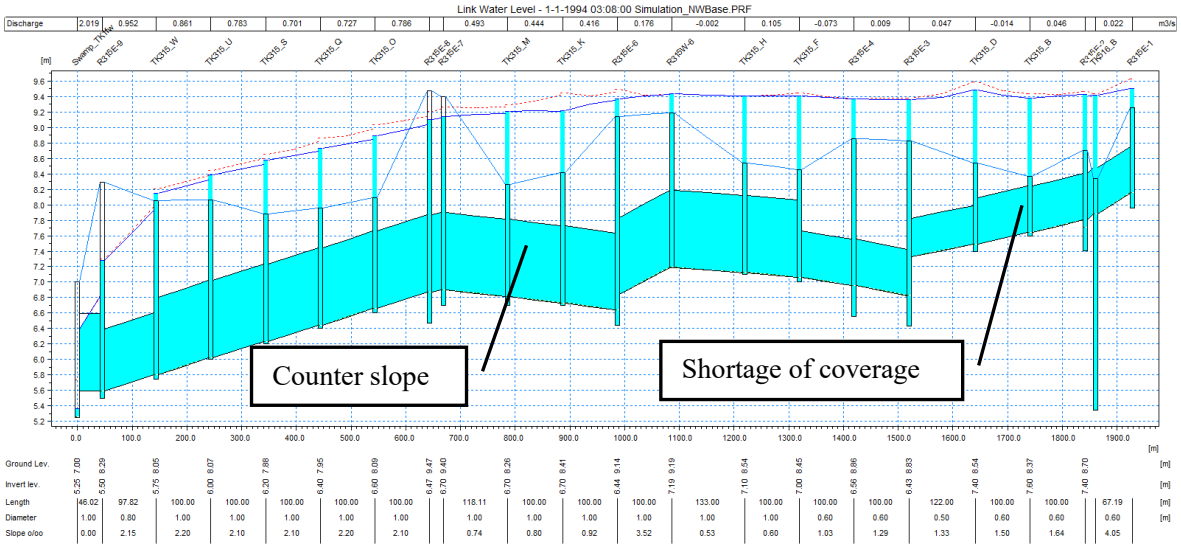
- As with Wat Phnom Northern Area, existing drainage system has capacity for the flood event of less than 2-year return period. Occurrence of road inundation was confirmed in areas having low drainage capacity due to small drainage pipe and lower area. Clogging in pipes and manholes were also confirmed in manholes along such roads as St. 528 and St. 289, which cause drainage difficulties (See **Fig. R 2.2.15**).

*Locations are referred to **Fig. R 2.2.13**.

Fig. R 2.2.15 Clogging due to Deposition in Manhole (Left: St.528, Right: St.289)

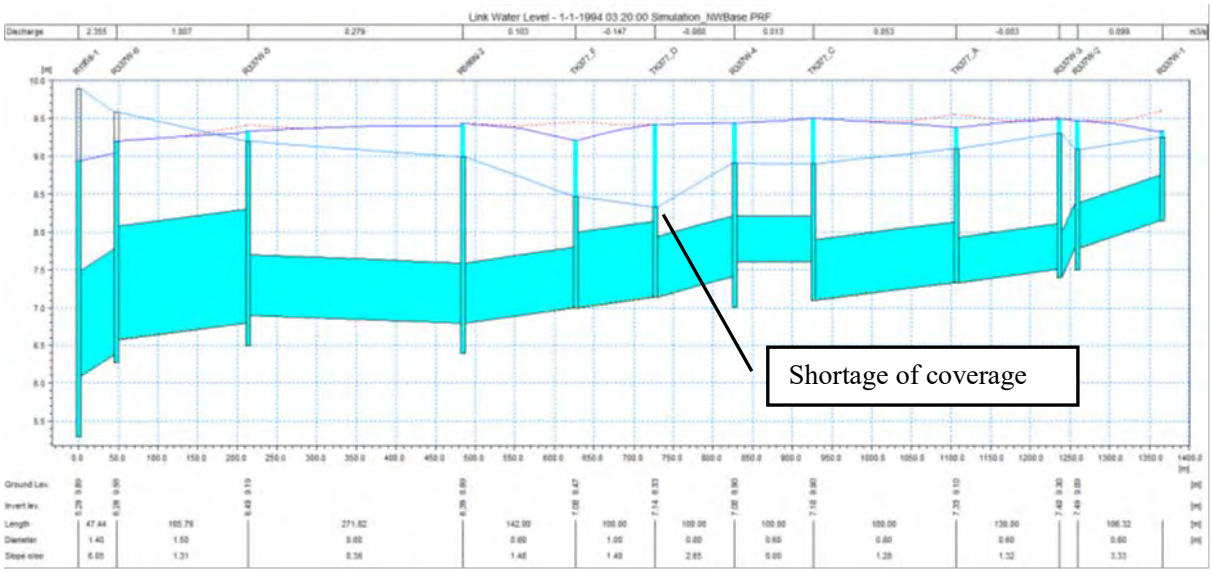
- Low topographic condition and embankment road, as well as gentle ground slope in and around the target area, prevent stormwater from being discharged by gravity and thus accelerate inundation. Although pumping stations are installed in the area, temporal inundation is inevitable due to insufficient capacity of existing drainage pipe. Occurrence of road inundation was confirmed on such roads as St. 608 and St. 285. As a result, duration of inundation is estimated at approximately 6-8 hour at maximum for 2-year return period.

- According to survey, shortage of coverage and counter slope were partly confirmed. For example, **Fig. R 2.2.16** and **Fig. R 2.2.17** show longitudinal profile and defective parts of St. 315 and St. 337, respectively.



*Locations are referred to **Fig. R 2.2.13**.

Fig. R 2.2.16 Longitudinal Profile and Water Level at St.315 (under 2-year Return Period)



*Locations are referred to **Fig. R 2.2.13**.

Fig. R 2.2.17 Longitudinal Profile and Water Level at St.337 (under 2-year Return Period)

(14) Preliminary Design of Improved Drainage System

Drainage pipe and pumping station were preliminarily designed for both target areas to mitigate inundation. In preliminary design, the specification and their effect were evaluated based on the model simulation with the constructed hydraulic model.

(15) Target for Drainage Improvement

Indices for evaluating drainage improvement plan consist of “flood frequency”, “flood depth” and “flood duration”. Considering the cost for implementation, targets for mitigation of inundation by drainage facilities were determined as shown in **Table R 2.2.11**. Basically, their indices and tolerance value are set taking into account of that determined in the prior studies.

Table R 2.2.11 Target for Mitigation of Inundation

Item	Existing	Target
Frequency of Inundation	4 times in a year	2 years of return period
Tolerated Inundation Depth	20 – 40cm	Less than 20cm
Tolerated Duration of Inundation	Longer than 2 hours	Within 2 hours

(16) Design Condition

The following design conditions were applied.

(a) Target Return Period

To assure consistency with the preceding studies, 2-year return period was applied.

(b) Runoff Coefficient

The runoff coefficients shown in **Table R 2.2.12** were applied.

Table R 2.2.12 Runoff Coefficient

Classification	Runoff Coefficient
High Density Urban Area	0.80
High Density Residential Area	0.65
Low Density Residential Area	0.50
Commercial Area	0.35
Agricultural Area	0.05
Park, Greenery Area	0.10
Water Area	1.00

Source: JICA M/P1999

(c) Roughness Coefficient

The material of the proposed drainage pipes will be reinforced concrete. The roughness coefficient of concrete is generally n=0.011 to 0.016. In Phase II, the roughness coefficient of n=0.015 was applied in the design stage to consider the pipe condition such as garbage and soil and sand sedimentation. The Preparatory Survey also refers to this value, which is higher than that of the new pipes.

(d) Covering of Pipes

The covering of pipes empirically is set 1 m for drainage main and 0.75 m for collecting pipes in Cambodia. Japanese guideline which is 1.0 m for drainage main and 0.6 m for branch pipes. Considering the above setting, covering for drainage main is set at 1.0 m in the Preparatory Survey.

(17) Preliminary Designed Drainage Facilities and Validation of Their Effect

Based on mention-above design condition and in accordance with the working procedure shown in **Fig. R 2.2.4**, design of drainage facilities was examined with try-and-error approach to satisfy the target for mitigation of inundation.

(a) Wat Phnom Northern Area

Layout plan of proposed drainage facilities in Wat Phnom Northern Area was illustrated in **Fig. R 2.2.18**. In this area, stormwater is to be collected with ϕ 1,200-1,500 mm of drainage pipe on St.47 and St.84 where severe inundation occurs, ϕ 1,200 mm on St.88, ϕ 1,500-1,800 mm on St.90 and St.92 and ϕ 2,000 mm in west side of Wat Phnom. The collected stormwater by the pipes are to be collected at the cross section of St.47 and

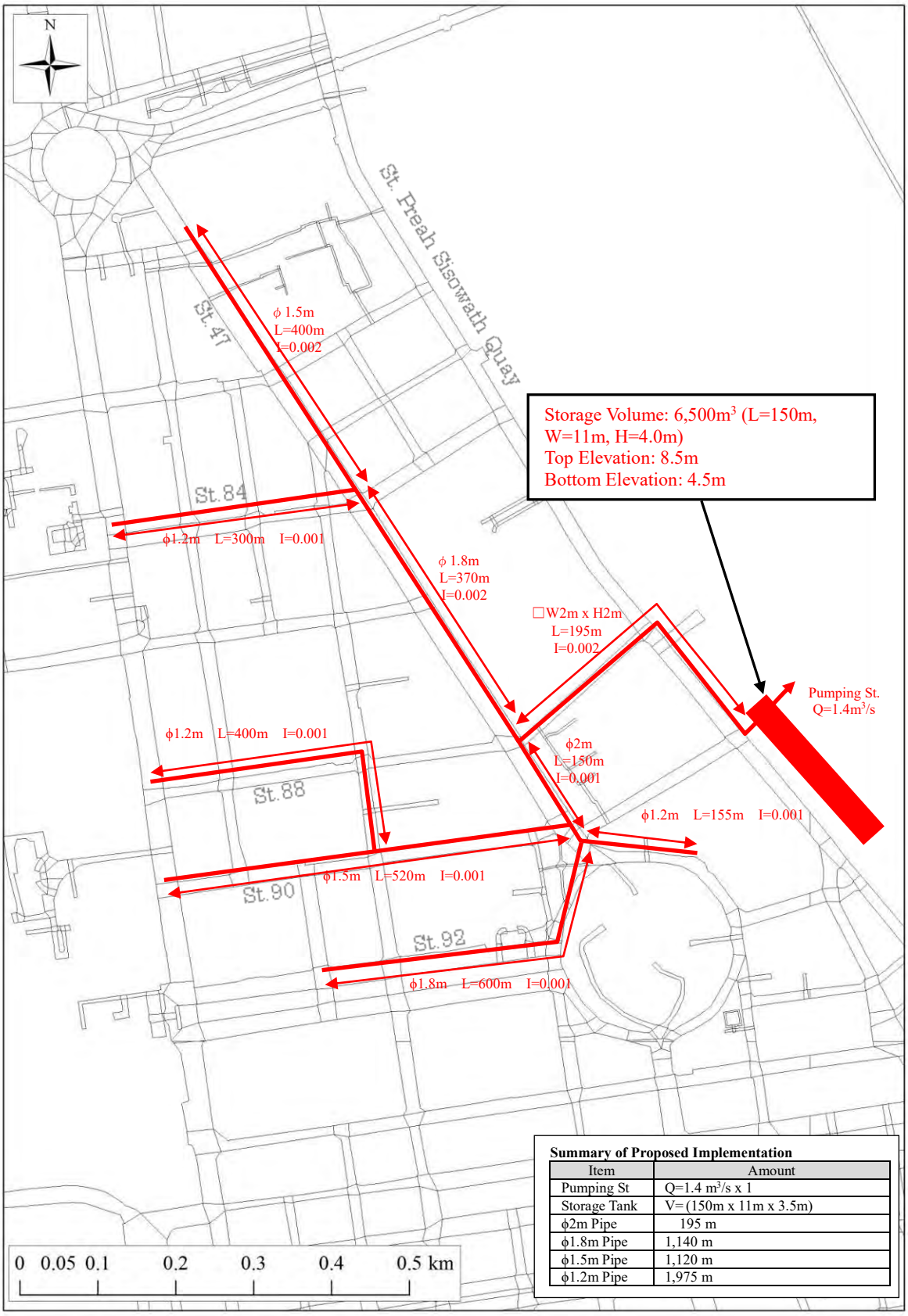
St.84, and then discharged to the eastward with box culvert of W2 m x H2 m through St.88 and St. Preah Sisowath Quay. The water is to be temporarily stored in 6,500 m^3 of underground reservoir of the newly-installed pumping station, which has the pumping capacity of 1.4 m^3/s and discharged into Tonle Sap River.

In order to evaluate the effect for these drainage facilities, spatial distribution of maximum inundation depth and duration of inundation with/without project in simulation result were shown in **Fig. R 2.2.19**.

Distribution of the maximum inundation depth in simulation result indicates that inundation depth in the most part of flooding area will be less than 20cm after the Project. At St.47 and western area of Wat Phnom in the result of simulation with Project, there are still small inundation areas where maximum inundation depth is more than 20cm. However, the inundation depth is less than 30cm and the duration of inundation with the depth of 20cm or more is about 10minutes or shorter. The maximum inundation depth 32cm in this area occurs at the intersection of St.61 and St.92 and the duration of inundation with the depth of 20cm or more is about 9 minutes.

To eliminate the inundation with 20cm or more in depth, it is necessary to expand the scale of overall drainage facilities to improve at the downstream area, and the project cost will be extremely increased. To avoid excessive investment, the inundation with the depth of 20cm or more for short time is permitted in the Preparatory Survey.

Distribution of the duration of inundation in simulation result indicates that duration of inundation was estimated at less than 2 hours in the whole inundation areas. This result shows that inundation was substantially mitigated and proposed facilities will contribute to drainage improvement in this area.



Summary of Proposed Implementation

Item	Amount
Pumping St	Q=1.4 m³/s x 1
Storage Tank	V= (150m x 11m x 3.5m)
ϕ2m Pipe	195 m
ϕ1.8m Pipe	1,140 m
ϕ1.5m Pipe	1,120 m
ϕ1.2m Pipe	1,975 m

Fig. R 2.2.18 Horizontal Plan of Proposed Drainage Facilities (Wat Phnom Northern Area)

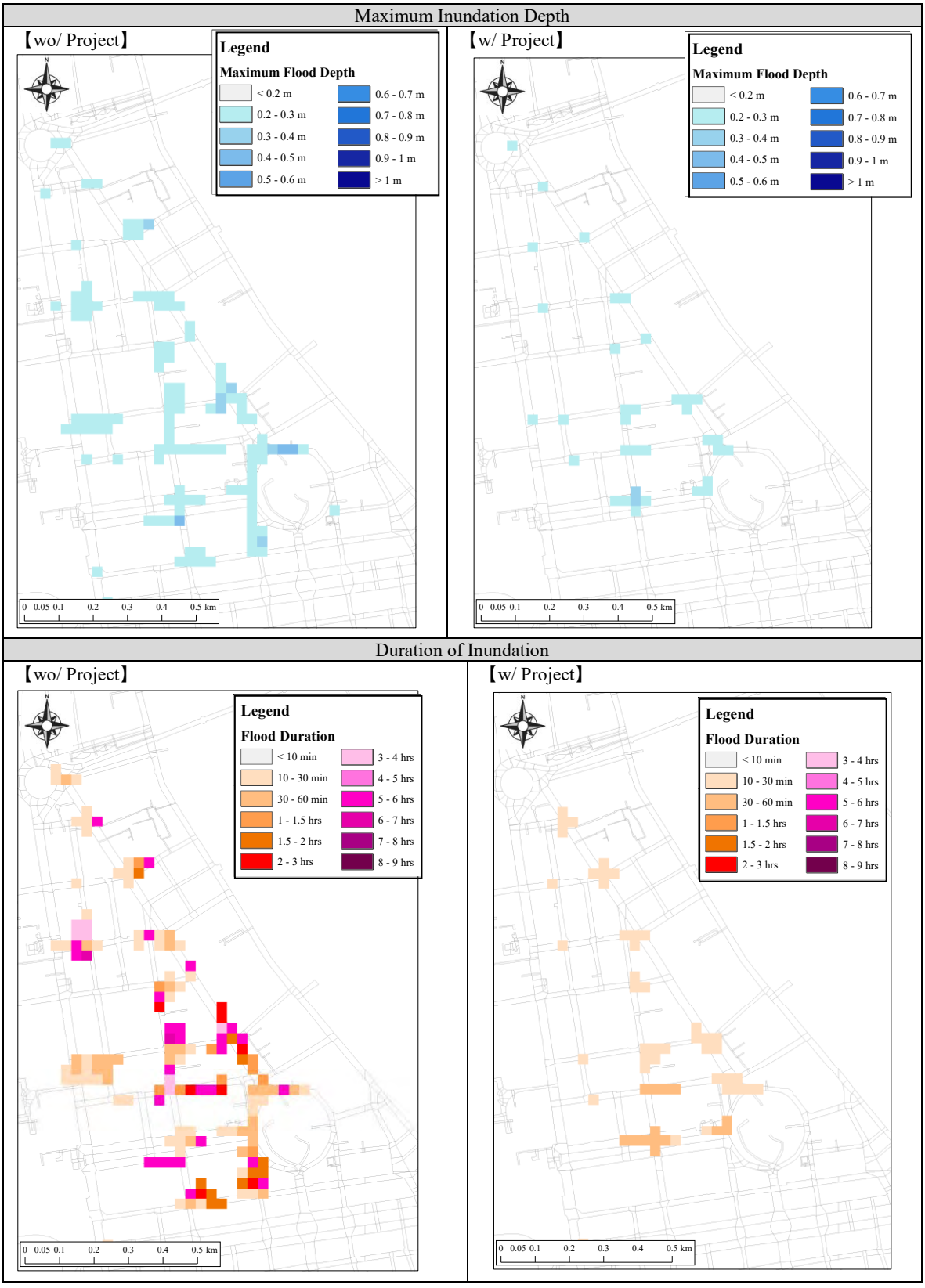


Fig. R 2.2.19 Effect of the Measures for Mitigation of Inundation (Wat Phnom Northern Area)

(b) Tuol Kork Area

Layout plan of proposed drainage facilities for Tuol Kork Area was illustrated in **Fig. R 2.2.20**. This area is initially subdivided into three areas based on the current status of inundation and existing drainage system. Then drainage facilities for each area were examined. Proposed drainage route for each area was described below.

- Stormwater from St.528 to St.337 is collected with drainage pipe of ϕ 1,500 mm and box culvert of W2,700 mm x H1,500 mm and then discharged to outer area by gravity through the existing pipe under St.1958.
- Stormwater from St.596 and St.592 are collected by ϕ 2,000 mm drainage main installed under St.315 and discharged to swamp near Tuol Kork1 pumping station with box culvert of W2,000mm x H1,500mm to be regulated in the swamp. The stormwater is finally discharged to outer area by pumps in Tuol Kork1 pumping station of existing (2.32m^3/s) and under construction (5m^3/s).
- Stormwater is collected with ϕ 1,000 mm of drainage pipe from St.287 to St.528, and then discharged to swamp area near Tuol Kork2 pumping station with the box culvert. The stormwater is finally discharged to outer area by the pumps in Tuol Kork2 with capacity of existing (1.4 m^3/s) and under construction (5 m^3/s). On the other hand, stormwater from St.608 and St.287 is collected and discharged to the swamp near Tuol Kork2 pumping station with ϕ 1,000 mm drainage main and augmented existing pipe.

In order to evaluate the effect for these drainage facilities, spatial distribution of maximum inundation depth and duration of inundation with/without measures in the simulation result were shown in **Fig. R 2.2.21**.

Distribution of the maximum inundation depth in simulation result indicates that inundation depth in the most part of flooding area will be less than 20cm after the Project. At the intersection of St.339 and St.566 in the result of simulation with Project, there are small inundation area where the maximum inundation depth is about 31cm and duration of inundation with the depth of 20cm or more is approximately 15 minutes. Inundation of this area has small influence on the local residents and the traffic due to depopulated and less traffic area. St.337 can be an alternate road during flood.

There are some inundation areas where the maximum inundation depth is 20cm~30cm. However, duration of inundation at these area is approximately 5 to 20 minutes with the depth of 20cm or more.

To eliminate the inundation with 20cm or more in depth, it is necessary to expand the scale of overall drainage facilities to improve at the downstream area with excavation at swamp area as well as the construction of underground retention facility at the inundation points. It requires huge amount of project cost. To avoid excessive investment, the inundation with the depth of 20cm or more for short time is permitted in the Preparatory Survey.

Distribution of the duration of inundation in simulation result indicates that duration of inundation was estimated at less than 2 hours in the whole inundation areas. Duration of inundation at Tuol Kork Area is generally longer than duration of inundation at Wat Phnom Northern Area. This result shows that inundation was substantially mitigated and proposed facilities will contribute to drainage improvement in this area.

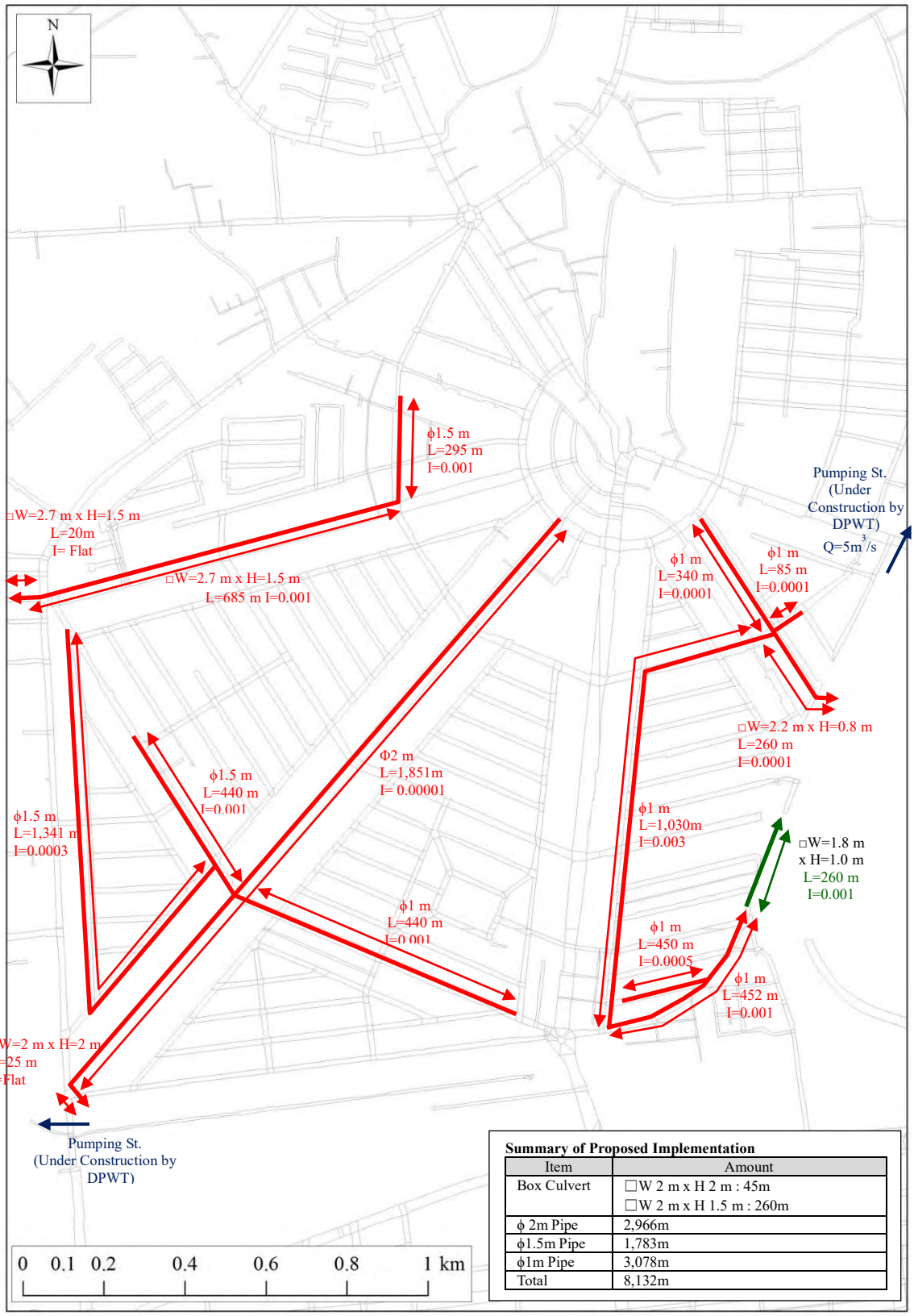


Fig. R 2.2.20 Layout Plan of Proposed Drainage Facilities (Tuol Kork Area)

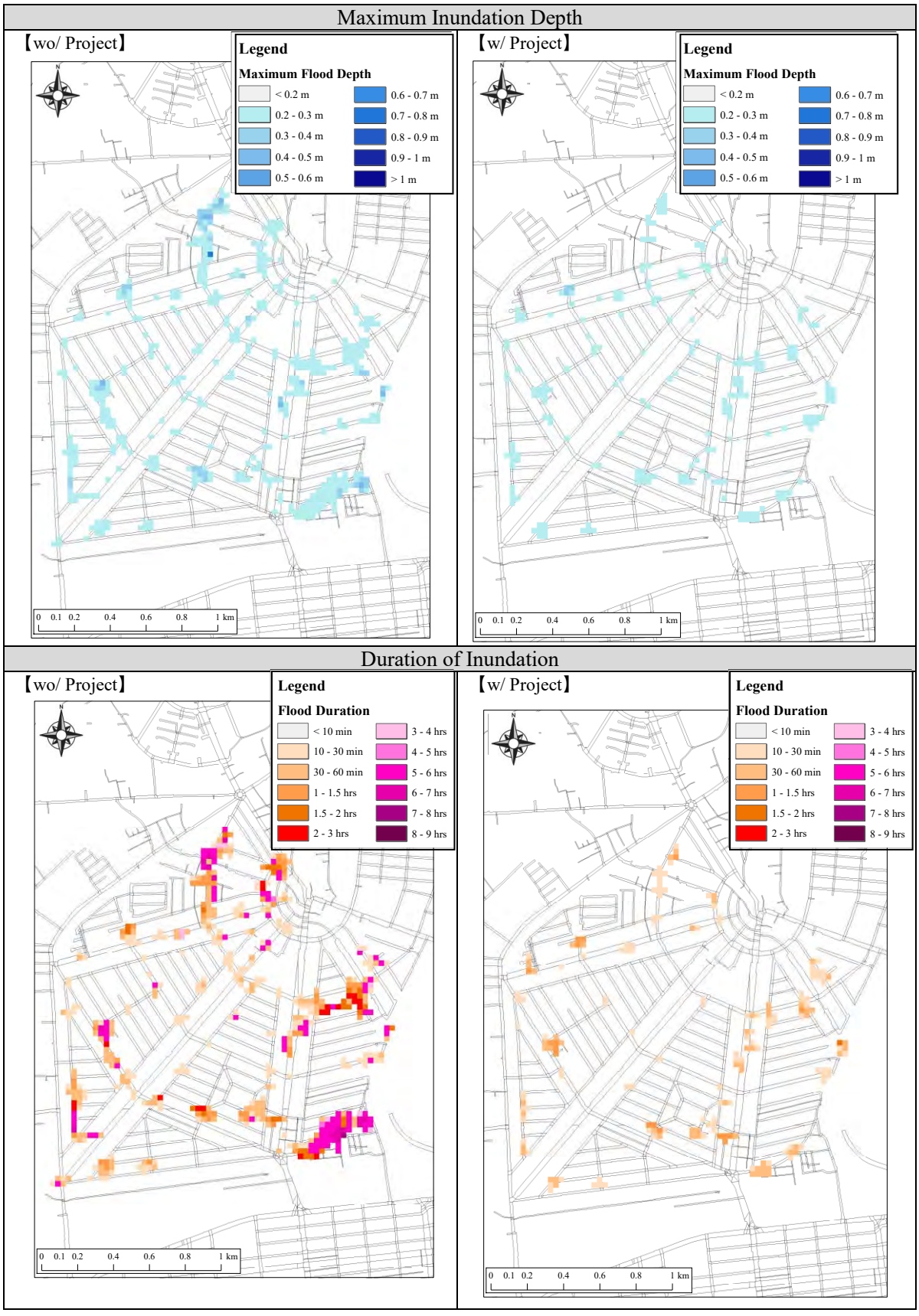


Fig. R 2.2.21 Effect of the Mitigation Measures (Tuol Kork Area)

2.2.2.2 Development of Drainage Main for Improvement of Wat Phnom Northern Area and Tuol Kork Area Drainage Systems

Based on the results of hydraulic analysis in **Subsection 2.2.2.1**, type and size of drainage mains in Wat Phnom Northern and Tuol Kork areas are analyzed. As a result, total length of the drainage mains, based on the design policy of 2-year return period with no more than 0.2 of inundation depth and 1 to 2 hours duration, amounts to **11.51 km**. The following table summarizes the type and size of the proposed drainage mains in the two drainage areas.

Table R 2.2.13 Summary of Type, Size and Length of Drainage Main

Type and Size	Wat Phnom Northern Area	Tuol Kork Area	Total Length (m)
Circular Pipe φ700mm×2 Lines	-	93	93
Circular Pipe φ1,000mm	-	3,026	3,026
Circular Pipe φ1,200mm	816	-	816
Circular Pipe φ1,500mm	899	2,011	2,910
Circular Pipe φ1,800mm	788	-	788
Circular Pipe φ2,000mm	161	1,829	1,990
Box Culvert B1,800mm×H1,000mm	-	188	188
Box Culvert B2,000mm×H2,000mm	485	60	545
Box Culvert B2,200mm×H 800mm	-	243	243
Box Culvert B2,700mm×H1,500mm	-	907	907
Total	3,149	8,357	11,506

Proposed drainage main systems in the two drainage areas are outlined as follows.

(1) Wat Phnom Northern Area

Location, type, size and length of Drainage Mains in Wat Phnom Northern Area are shown in **Table R 2.2.14** and **Fig. R 2.2.22**.

Table R 2.2.14 Summary of Type, Size and Length of Drainage Pipe (Wat Phnom Northern Area)

Drainage Main	Type	Length (m)	Reasons for installation	Considerations for Installation
R47-1	Circular Pipe φ1,500mm	389	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee	- Crossing of water supply pipe - Heavy traffic
R47-2	Circular Pipe φ1,800mm	373	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of raw water pipe of φ700 mm - Heavy traffic
R84	Circular Pipe φ1,200mm	305	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, electric and optical cable
R88	Circular Pipe φ1,200mm	383	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, electric and optical cable
R90	Circular Pipe φ1,500mm	510	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe and electric cable
R92-R47-1	Circular Pipe φ1,800mm	415	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, electric and optical cable
R92-R47-2	Circular Pipe φ2,000mm	161	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe including raw water pipe of φ700 mm, and optical cable - Heavy traffic
R19	Circular Pipe φ1,200mm	128	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Heavy traffic
R88-Sisowath	Box Culvert B2,000mm ×H2,000mm	485	- Convey stormwater from the entire Wat Phnom Northern area to the proposed UGR (Underground Reservoir) along Tonle Sap River	- Crossing of water supply pipe including raw water pipe of φ700 mm and φ1,200 mm, as well as electric and optical cables - Crossing of PPWSA's drainage pipe of φ800 mm at Sisowath boulevard - Running parallel to raw water pipe of φ700 mm along Rd. 88
Total		3,149		

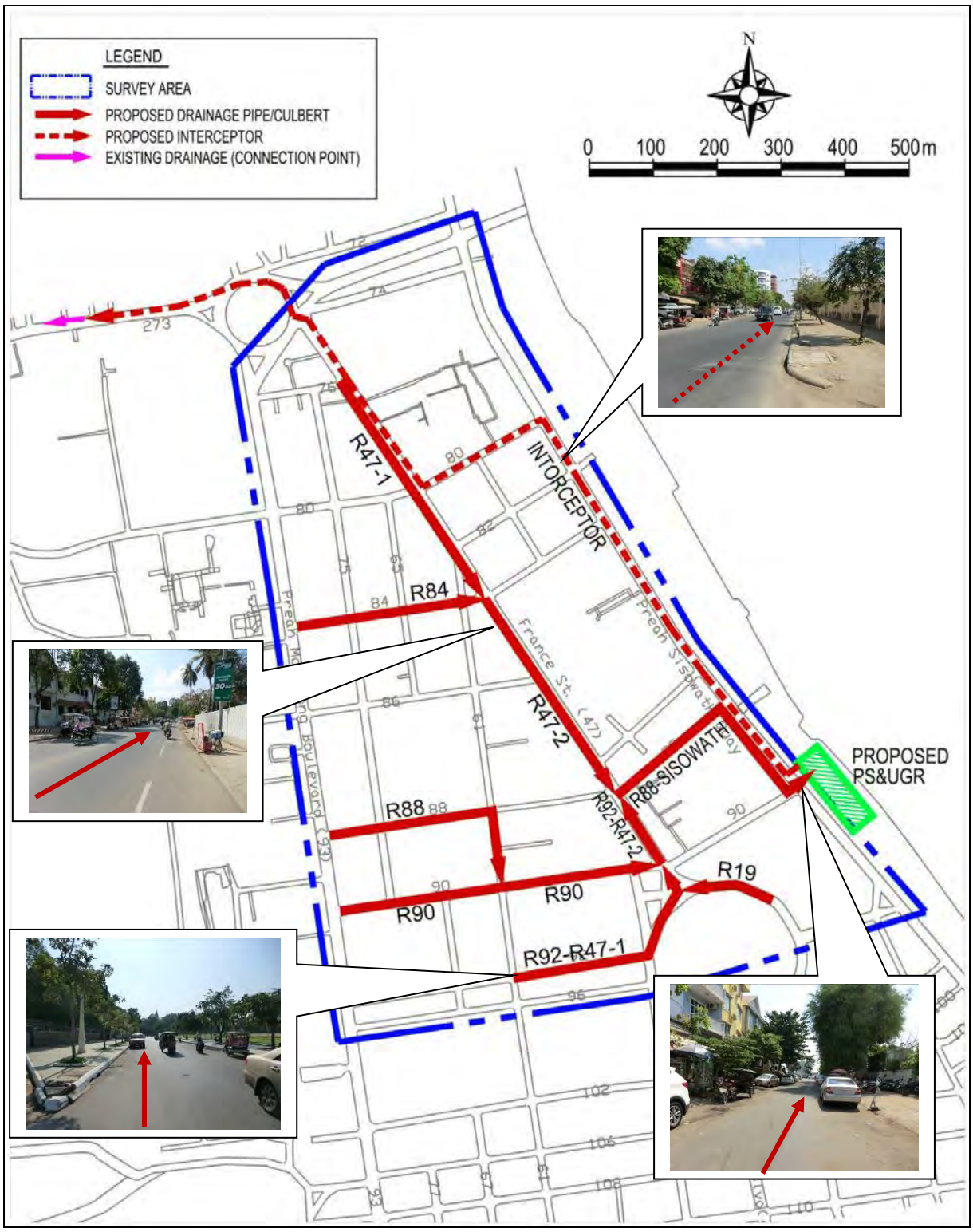


Fig. R 2.2.22 Layout Plan of Drainage Main (Wat Phnom Northern Area)

(2) Tuol Kork Area

Location, type, size and length of Drainage Mains in Wat Phnom Northern Area are shown in **Table R 2.2.15** and **Fig. R 2.2.23**.

Table R 2.2.15 Summary of Type, Size and Length of Drainage Pipe (Tuol Kork Area)

Drainage Main	Type	Length (m)	Reasons for installation	Considerations for Installation
R287-R528	Circular Pipe φ1,000mm	1,177	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, electric, optical and telephone cable
R528	Circular Pipe φ700mm×2 lines	93	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee	- Crossing of water supply pipe
R283-1	Circular Pipe φ1,000mm	349	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, optical and telephone cable
R283-2	Box Culvert B2,200mm× H 800mm	243	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of optical cable - Connection to existing drainage pipe
R608-1	Circular Pipe φ1,000mm	544	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, optical and electric cable
R608-2	Box Culvert B1,800mm× H1,000mm	188	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe and electric cable - Connection to existing drainage channel
R618	Circular Pipe φ1,000mm	224	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe
R315-1	Circular Pipe φ2,000mm	1,829	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe, optical and electric cable - Heavy traffic
R315-2	Box Culvert B2,000mm× H2,000mm	60	- Convey stormwater collected to R315-1 and R315-2 and discharge them to Tuol Kork 1 pumping station	- Resettlement (1 household)
R592 North	Circular Pipe φ1,500mm	462	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe including water pipe of φ900 mm, and electric/optical/telephone cable
R592 South	Circular Pipe φ1,000mm	732	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe and electric/optical/telephone cable
R596	Circular Pipe φ1,500mm	865	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe and optical/telephone cable
R317	Circular Pipe φ1,500mm	452	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe
R528-R337-1	Circular Pipe φ1,500mm	232	- Size and slope of existing pipe are insufficient to convey design flow - Inundation depth: knee - Inundation duration: more than 2 to 3 hours	- Crossing of water supply pipe and optical cable
R528-R337-2	Box Culvert B2,700mm× H1,500mm	907	- Convey stormwater collected to R528-R337 and discharge them to the existing drainage pipe	- Crossing of water supply pipe and electric/optical/telephone cable
Total		8,357		

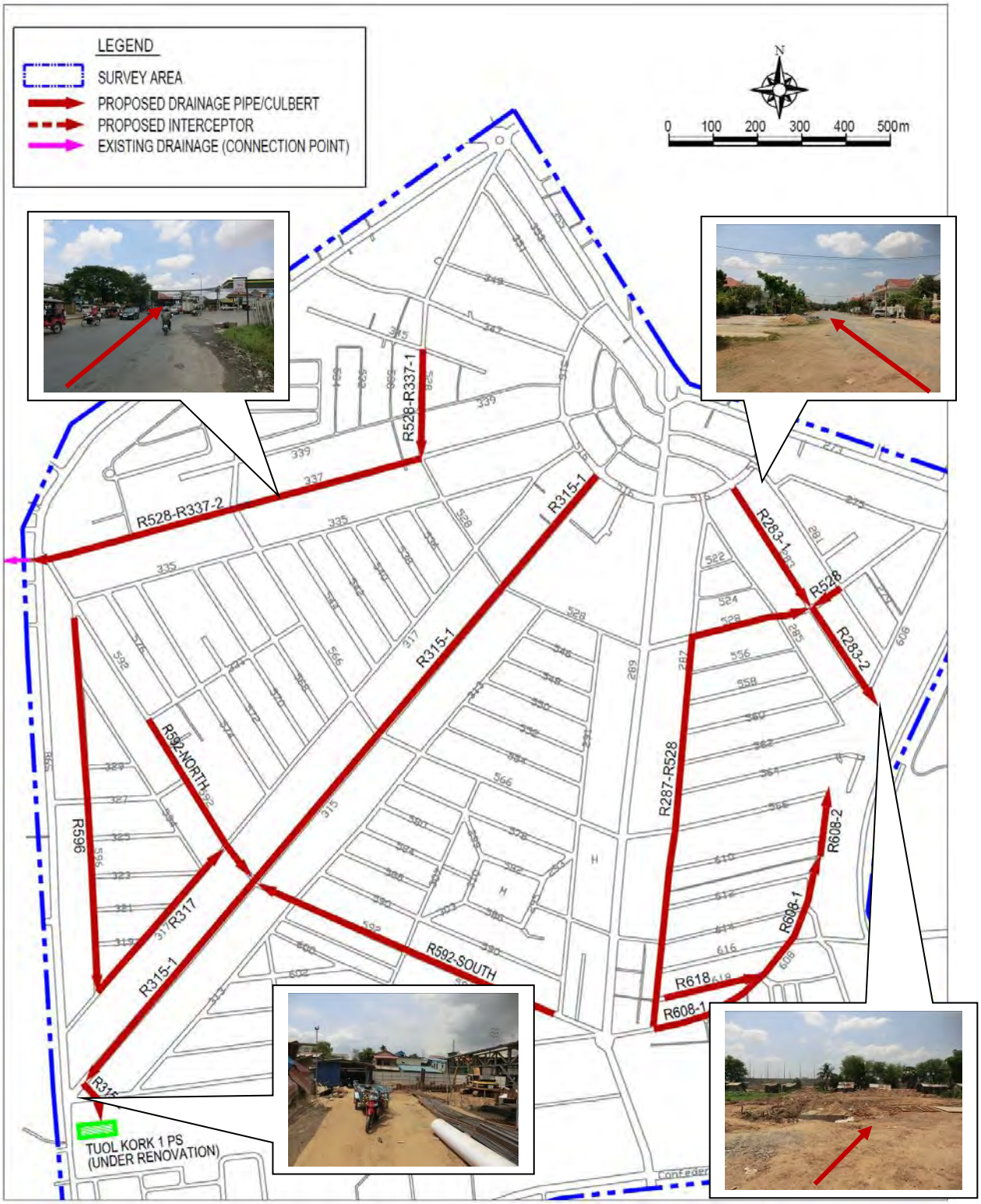


Fig. R 2.2.23 Layout Plan of Drainage Main (Tuol Kork Area)

2.2.2.3 Construction of Pumping Station and Underground Reservoir for Improvement of Wat Phnom Northern Area Drainage Systems

(1) Necessity of Pumping Station and Underground Reservoir

Central area of Phnom Penh frequently suffers from inundation due to topological constrains as well as aged drainage system, especially in the rainy season. Water level of Tonle Sap River fluctuates in about 10 m. Stormwater in Phnom Penh can be drained out into the River by gravity in the dry season when river water level is low. On the other hand, the stormwater cannot be drained out into the River by gravity in the rainy season when the water level is high and rises up to almost the same level as the ground surface elevation, and thus the stormwater shall be compulsory drained out into the River by pump.

Underground reservoir temporarily stores stormwater to reduce the amount of stormwater and capacity requirement of pumping equipment.

In consideration of the above conditions, underground reservoir and pumping station is proposed at the downstream end of drainage network of Wat Phnom Northern Area, and the stormwater from the Area is drained out into Tonle Sap River (i) by gravity when the water level of the River is low and (ii) by pump when the water level of the River is high.

(2) Basic Design Criteria of Pumping Station and Underground Reservoir

Stormwater is collected by the drainage pipe network, passed through trash screen, stored in underground reservoir, and drained out into the river.

Area along right bank of Tonle Sap River is located at the central area of Phnom Penh, encompassing important facilities of the capital city, as well as tourist spots. In addition, so many people visit the area throughout the year for relaxation and site seeing. Therefore, the following design criteria are considered to design underground reservoir and pumping station in terms of layout, size and structures.

(a) Major Features of Site of Pumping Station and Plan/Design Criteria

Pumping stations are to be planned and designed in accordance with the following criteria:

- The underground reservoir and pumping station is designed under the park along Tonle Sap River, and shall be located at the southern area of intake tower of PPWSA.
- Since the site of underground reservoir and pumping station is located at tourist spot, the facilities/equipment shall be designed not to damage the surrounding landscape, to minimize height and size of building and to minimize such facilities as crane.
- Stormwater shall be discharged by gravity as much as possible, which must result in reduction and/or minimization of electric power consumption for pumping up operation.
- Same type and size of pump installed in Phase II shall be equipped in consideration of: (i) easiness of operation and maintenance, (ii) compatibility of spare parts and (iii) risk distribution. A pair of drainage pump having the same capacity shall be mounted on the gate of the pumping station on account of risk management, etc.

- Main power source of pumping station shall be commercial electric power of EDC, which is easily obtainable. In case of power failure, an Emergency Diesel-Engine Drive Generator Set (EGS) shall be provided to operate pumping equipment.
- In the dry season, wastewater from the Wat Phnom Northern Area is not conveyed to underground reservoir but is conveyed by interceptor and discharged to existing drainage pipe, which is connected to Tamok Lake at the downstream end.

(b) Layout Plan/Design Criteria

- Trash screen is installed before entrance of underground reservoir, to prevent garbage from entering into the reservoir. The water introduced to the reservoir is drained out into Tonle Sap River.
- The layout plan of pumping station, trash screen and underground reservoir shall be formulated considering the location of existing drainage outlet to Tonle Sap River.
- Bottom elevation of underground reservoir shall be set in consideration of invert level of connected drainpipe main.
- Area and depth of the underground reservoir is determined in comparison between the storage requirement obtained from the hydraulic analysis and available land in the site. The space of the site shall be minimized as much as possible.
- Since transfer/removal of existing facilities (house, Buddhist Temple, pumping station, electric distribution line, phone wire, water supply pipe, etc.) within the project area causes extension of construction term and increase of construction cost, those transfer/removals shall be avoided as much as possible. Since old/large trees are often related to a religious belief in Cambodia, they shall be preserved as much as possible.
- The soil thickness at the underground reservoir shall be secured in consideration of the promotion of vegetation.

The layout plan of pumping station, trash screen and underground reservoir is as illustrated in the following figure.

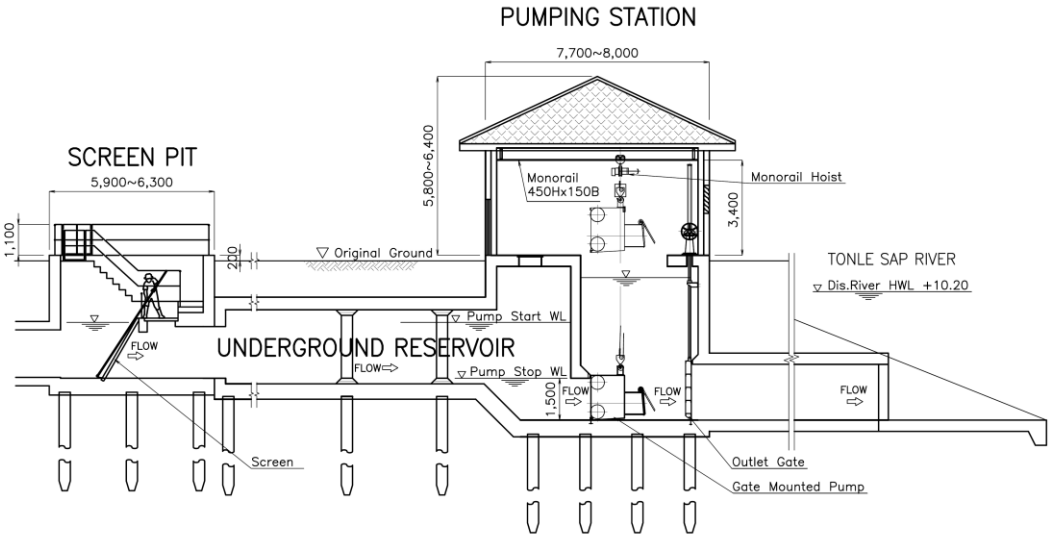


Fig. R 2.2.24 Layout Image of Pumping Station and Underground Reservoir

(3) Major Specification of Pumping Station and Underground Reservoir

The major specification and composition of drainage facilities constructed by the Project such as pumping station and underground reservoir are as shown in the following table.

Table R 2.2.16 Major Specification of Pumping Station and Underground Reservoir

Facilities	Capacity	Remarks
No.6 Pumping Station (P6)	Discharge Capacity:1.4 m^3/s	0.70 $m^3/s \times 2$ pump
No.6 Underground Reservoir (UGR6)	Storage Capacity: 6,500 m^3	L:140m×W:12m×H:4m
Mechanical Screen	Automatic raking screen	

To follow serial number of the existing pumping station and underground reservoir, names of No.6 Pumping Station (P6) and No.6 Underground Reservoir (UGR6) are given to the pumping station and underground reservoir proposed in the Project.

(4) Design of Underground Reservoir

UGR6 will be located under the park along Tonle Sap River. The park is located along Sisowath boulevard near the intersection of Sisowath boulevard and St.88. Layout of UGR6 and P6, including trash screen is shown in **Fig. R 2.2.25** and major considerations for the designing is enumerated below.

- The trash screen is arranged at the connection point of proposed drainage main (R88-Sisowath drainage main).
- The basic structure of UGR6 is the flat slab structure, which is a rigid structure consisting of slab, wall and pillar.
- Structure of UGR6 is designed in consideration of the buoyancy with residual underground water.
- Since bearing capacity of ground is small, the pile foundation shall be applied.
- Three trees shall permanently be removed and a part of the existing revetment shall temporally be removed and reconstructed for the construction works.

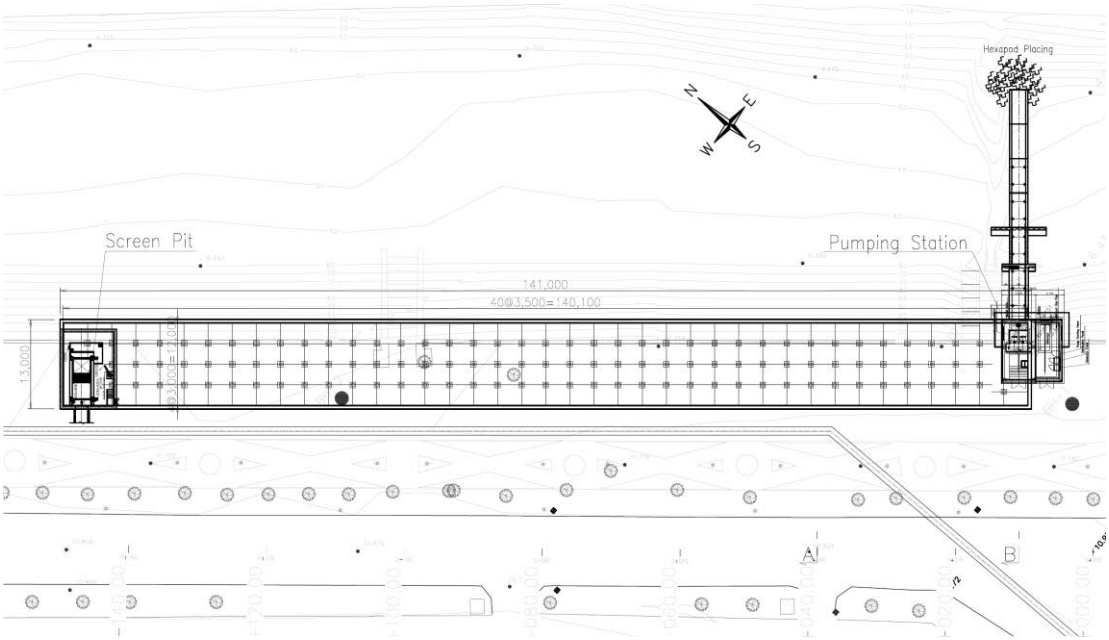


Fig. R 2.2.25 Layout of No.6 Underground Reservoir and No.6 Pumping Station

(5) Outlet and Outlet Gate

Outlet gate shall be installed at the entrance of outlet to prevent influx of river water into the underground reservoir. This gate shall be closed in the case of emergency or maintenance and operation of pump. Normally, an outlet gate of sluiceway is installed outside of the dike (riverside). However, the outlet gate of this project shall be installed at the entrance of outlet in pump pit (inside of the dike, landside) in consideration of structure of existing revetment and landscape. Basic design criteria for outlet and outlet gate are enumerated as follows:

- The outlet shall be installed at the farthest south to keep distance as much as possible from the intake of PPWSA.
- Dimension of the outlet shall be concrete box culvert of 2.0 m×2.0 m.
- Outlet gate shall be the steel made slide gate, and have 4-sealing edges.
- Hoisting equipment of outlet gate shall be manual spindle type. Gate shall be operated by manpower.

(6) Pump, Electric Equipment, Pump Operation & Maintenance House

(a) Applicable Type of Pump

Since design conditions of pump require a large discharge capacity under low pumping up head in this Project, horizontal/vertical shaft - axial/mixed flow type and submergible type pumps shall be adopted for alternatives. The selection process is described hereinafter.

Table R 2.2.17 Selection of Pump Type

Contents of Comparison
Gate-Mounted Pump Type (Selected) This type of pump is composed mainly of a steel roller-gate on which 1 or a pair of submergible pump with flap valve is mounted. The steel roller-gate is provided at a part of the standardized discharge canal to make a sluiceway that connects up to the outlet to the river. With these arrangements, the gate-mounted pump type pumping station functions as follows: - Upon lifting the gate-mounted pump by the electric drive hoist machine over its clear opening, stormwater gathered in UGR can discharge freely by gravity flow to the river whenever water level of Tonle Sap River is lower than outlet. This gravity flow discharge, i.e., non-electric discharge operation will be possible during 6 months between January and June, and thus contributes considerably to save operation cost on electricity consumption; - When water level of Tonle Sap River rises higher than outlet during rainy season, the gate-mounted pump must be closed to prevent reflux of river water. Then, the submergible pumps mounted on the gate can operate electrically to discharge stormwater gathered in UGR; - There is an advantage that cost can be reduced, like equipment cost, site acquisition cost, etc.; and - The pump O&M house becomes compact. It is therefore concluded that selection of the gate-mounted pump type is technically and scenically sound in design and economically feasible.
Horizontal Shaft - Axial/Mixed Flow Type Pump This type of pump is unable to create self-priming condition alone due to the impeller's position in air space, so that it is impossible to start operation quickly in response to demand on stormwater discharge. To attain such self-priming condition, the pump must be equipped with a lot of auxiliary equipment, which will be more expensive. Size of facilities on the ground will be tall and wide. Hence, this type is not suitable for the Project.
Vertical Shaft - Axial/Mixed Flow Type Pump Vertical shaft - axial/mixed flow type pumps are easy to start because of their impellers are always in the submerged position. And cavitation does not happen easily. However, they must be equipped with a lot of auxiliary equipment, which will be costlier, and size of facilities on the ground will be tall and wide. Hence, this type is not suitable for the Project.

Contents of Comparison
Submerged Type Pump This type of pump is a kind of vertical shaft - axial/mixed flow type pump, submerged and encased into the steel column. The same type was installed in the Boeung Tumpun Pumping Station in 2004 under Phase I. These pumps can quickly respond for the discharge of stormwater on demand because they are submergible. However, this pump type is unable to discharge stormwater by gravity flow during rainy season and even the early part of the rainy season. This results in a large amount of electricity consumption. Further, it needs a large plain area because each pumping equipment unit requires an independent pump suction pit structure. Hence, this type is not suitable for the Project.

As a result, Gate-Mounted Pump Type is selected in the Project because: (i) gate-mounted pump is most preferable in terms of space requirement and reduction of cost, (ii) the gate-mounted pump is installed in the existing four pumping stations constructed in Phase II and they are well operated and (iii) effective operation and maintenance is expected by applying the same type of pump as in Phase II.

(b) Design of Pumping Station

Their basic dimensions of pumping station are as given below.

Table R 2.2.18 Basic Dimensions of Pumping Station and Gate-Mounted Pump

Pumping Station (P.S.)	Specifications	Gate-Mounted Pump	Specifications
Max. River Water Level (EL.m)	EL.10.2m	Pump Discharge Volume in Total (Q m^3/s) *1	1.4m^3/s
Ground Level (EL.m)	EL.11.0m	Water Tank: L (m) x W (m)	L3.9m×W2.7m
SWL of UGR (EL.m)	EL.8.5m	Gate: W (m) x H (m)	1 (No), W2.7m×H1.5m
Pump Start WL (EL.m)	EL.5.0m	Number of Gate Leaf (No.)	2
Pump Stop WL (EL.m)	EL.4.6m	Pump Type	Submergible-horizontal-shaft axial flow type, with flap valve
Sill of Rake Pit (EL.m)	EL.4.5m		
Sill of UGR (EL.m)	EL.4.5m	Pump Discharge/ set (Q/2 m^3/s)	0.7m^3/s
Sill of Pump Suction Pit (EL.m)	EL.3.1m	Pump Total Head (m)*2	5.75 m
Sill of Gate (EL.m)	Ditto	Maximum Pump Total Head (m)*3	6.15 m
Clear Height of Gate (m)	1.5 m	Pump Starting Method	Condorfare & Time Lag
Sill of Pump Discharge Pit (EL.m)	EL.3.1m		
Sill of Outlet Gate (EL.m)	Ditto	Drive Motor (kW)/pump	45 kW
Sectional Dimension of Outlet (m)	2.0m x 2.0m	Emergency Generator	200 kVA
Length of Outlet Conduit (m)	15 m		

Notes : *1 : Guaranteed capacity at the start-up water level in UGR
*2 : River water level (10.2 m) - start-up water level in UGR + head loss in the outlet channel (0.55 m)
*3 : River water level (10.2 m) - shutdown water level in UGR + head loss in the outlet channel (0.55 m)

- Each pump shall have its suction water depth set at 1.5 m, which is the water depth at the pump auto stop water level from sill of pump pit.
- Two submergible pumps are mounted on each roller gate type steel gate, which runs up and down inside the pump pit structure.
- The gate is handled with monorail hoist, which travels along the I-beam type monorail fixed beneath the O&M house slab beams. The hoists shall have a hoisting capacity of around 15 ton, and shall be controlled by means of pendant type push-button switches.
- Water level detector shall be equipped to control pump operation.
- Whenever water level of underground reservoir rises up to the pump starting water level, a buzzer will be rung to inform the operator. Then the operator must start pumps

with a time lag accordingly.

- The pumps shall stop automatically whenever water level of underground reservoir goes down to the pump stop water level.
- Each gate is kept at the fully closed position during the rainy season to stand by pump up operation, and gate is taken out from the pump pit and rested on the floor of O&M house during the dry season.
- Maintenance and repair of the gate-mounted pump is conducted on the ground floor and the conveyance of the pump is conducted using the monorail hoist.

(c) Design of Pump Operation/Maintenance House

Pump Operation/Maintenance House (Pump O&M House) are provided for each pumping station. Design criteria for the Pump O&M House are as described below.

- Floor elevation of Pump O&M House shall be set based on comparison of the following elevation. The higher elevation is chosen as floor elevation.

Table R 2.2.19 Floor Elevation of Pump Operation/Maintenance House

Criteria	Objectives	Results
Upsurge water level ＋0.4m	To prevent inundation in the house	EL.10.8m + 0.4m = EL.11.2m
Surface ground elevation GL＋0.3m	To prevent stormwater from coming into the house	EL.11.0m + 0.3m = EL.11.3m
Floor elevation		EL. 11.3 m

- One set of main distribution panel to receive electric power from EDC's existing line and the Emergency Diesel-Engine Drive Generator Set (EGS), one set of generator panel and one set of pump operation panel are put on the floor of Pump O&M house.
- Pump, monorail hoist, EGS and each electric panel shall be connected by floor duct.
- Entrance door with louver and wall louver are installed for air ventilation. The shutter is installed on the rejection heat side of the generator (river side), and the shutter shall be opened completely before engine start. The exhaust pipe shall be the structure that can expand and contract. The Pump O&M house shall have light windows.
- Structural design of Pump O&M house shall take the operation load with the monorail hoist in consideration. Appearance of Pump O&M house shall be in harmony with the surrounding landscape.

(d) Electric Power Supply System

Electric power requirement for No.6 Pumping Station is about 45 kW through 400 V/230 V. Transformer capacity shall be 200 kVA.

Table R 2.2.20 Comparison between Electric Power Requirement and Capacity of Existing Substation

Item	No.6 Pumping Station
Pump motor (kW)	45kW×2 sets
Motor of rake screen (kW)	1.5
Required capacity of transformer (kVA)	200
Capacity of existing transformer (kVA)	1,000

EDC has Compact Transformer Substation (CTS), being 360 m away from the No.6 Pumping Station. The CTS have enough capacity to supply power to the pumping station and hence the power for the pumping station shall be obtained from the CTS. Permission of power supply from the CTS is tentatively obtained in the consultation with EDC.

No.6 Pumping Station and the CTS is connected by laying underground cable, as shown in the following figure.

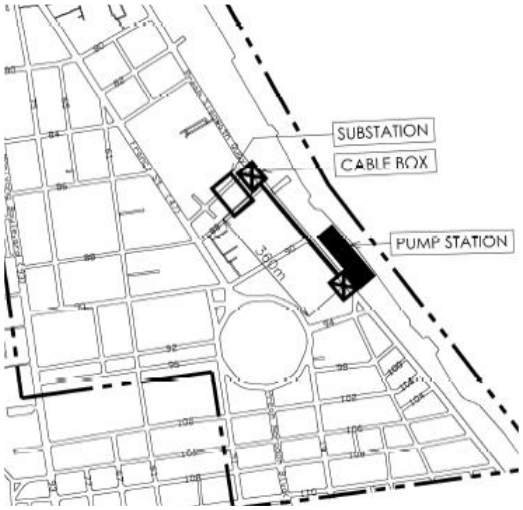


Fig. R 2.2.26 Electric Power Supply Route for No.6 Pumping Station (P6)


Existing Substation


1000kVA transformer


400V terminals for feeders

Photo R 2.2.2 Nearest Existing Substation of No.6 Pumping Station (P6)

Design standard provided by EDC (Electricite du Cambodge : EDC), is shown in the following table.

Table R 2.2.21 Design Standard of EDC

Item	Criteria
Design criteria	International standard including that of Japan (No criteria in EDC)
Electrical source	400kV, 3 phases, 50Hz
Method for connection	Y-connection
Power meter	Installed by EDC
Fluctuation of power voltage	±10%
Frequency of power failure	19.88hr/year, 22 times/year (based on actual data in year 2015)
Electrical power charge	780Riel/kWh

(e) Emergency Power Supply

To cope with EDC's electric power failure, one set of EGS shall be equipped to supply emergency power to the pumping equipment, as well as mechanical screen to maintain the drain ability in any emergency case.

The same type of EGS as installed in Phase II, shall be selected as shown in the following table.

Table R 2.2.22 Specifications of Emergency Diesel-Engine Drive Generator Set (EGS)

Item	Specifications
Type	Radiator cooling, low noise, with bonnet
Voltage	400/230 V, 3-phase/ 1-Phase, 4-wire
Starting method	Manual using cell-motor
Charger	System power supply and dynamo
Noise level 7mdB(A)	70dB
Fuel type	Diesel oil (Light mineral oil)
Exciter	Blush less type
Power factor	More than 0.8
Fuel tank	More than 10 hours, on board
Capacity	More than 200kVA

- Switch over to EGS and commercial power shall be done manually. In case of power failure in rainy days, the EGS shall be started depends on the water level checked by operating staff.
- EGS shall be packaged-type. Fuel tank of small lots is not equipped in the Pump O&M house. Instead, fuel from oil drum shall be filled up by hand pump.

(7) Design of Mechanical Screen

Design of mechanical screen for No.6 Pumping Station is described in **Subsection 2.2.2.5 "Construction of Mechanical Screen at Pumping Stations constructed in Phase II"**.

2.2.2.4 Development of Interceptor Pipe for Improvement of Wat Phnom Northern Area Drainage System

As with Phase II, interceptor pipe (schematic diagram of interceptor is shown in **Fig. R 2.2.28**) will be proposed to prevent wastewater from being directly discharged to Tonle Sap River. In the Project, an interceptor pipe is proposed in Wat Phnom Northern Area.

Alignment of the interceptor pipe is proposed with the **total length of 1,620 m**, as shown in **Fig. R 2.2.22**. The alignment is set based on the consultation with DPWT. The interceptor is connected to drainage pipe along Rd. 273, which is being installed by DPWT. The interceptor cannot be connected to the drainage pipe along Rd. 273 by gravity, manhole type pump will be proposed at the connecting point (image of manhole type pump is shown in **Fig. R 2.2.27**).

In principle, the interceptor is not designed to accomodate backwasing and sedimentattion basin cleaning water from Phum Prek Water Treatment Plant because (i) backwasing water contains only silt and sand originated from Tonle Sap River, (ii) amount of the water is large in volume compared to that of wastewater from Wat Phnom Northern Area, and thus (iii) interceptor will easily be clogged and overloaded.

Fig. R 2.2.27 Image of Manhole Type Pump

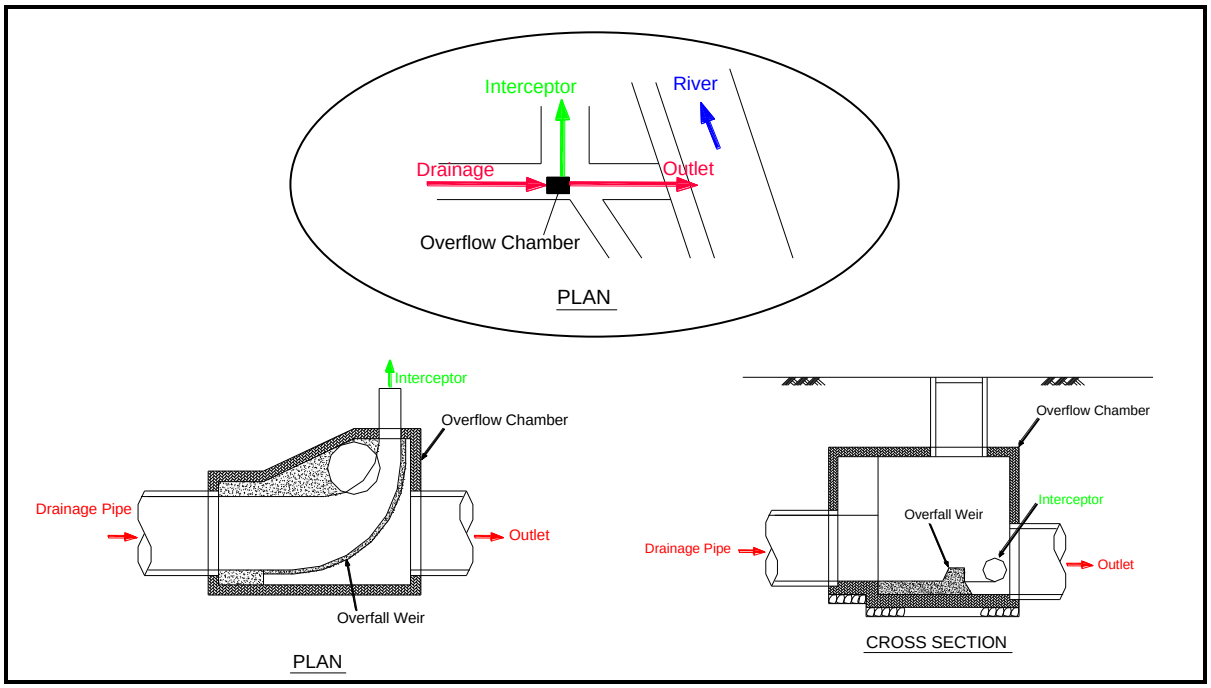


Fig. R 2.2.28 Schematic Diagram of Interceptor

Based on the above conditions, tentatively assumed specification of the interceptor is summarised in **Table R 2.2.23.**

Table R 2.2.23 Outline of Tentatively Assumed Interceptor

Item	Unit	Contents	Remarks
Population	Person	15,240	Source: The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area
Hourly max wastewater generation per capita	L/day/capita	340	
Amount of wastewater	m^3/day	5,200	Estimated based on the Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area
	m^3/s	0.060	
Length	m	1,620	Considerations for Construction - Crossing of water pipe, including φ700 mm, φ800 mm, φ1,200 mm and φ1,600 mm of raw water pipe, as well as electric cable - Heavy traffic on Sisowath boulevard, St. 47 and St. 273
Velocity required	m/s	0.6	Based on "Guideline for Planning and Designing of Sewerage facilities", Japan
Diameter		700	

2.2.2.5 Construction of Mechanical Screen at Pumping Stations constructed in Phase II

(1) Design Policy

The design policy and design Standards on the Project required by PPCC, DPWT, EDC, etc. are of International Standards or equivalent standards, and the design policy used in the projects in Cambodia covered by Japanese International Grant Aid is also approved. Thus, this project is based upon these design policies.

(2) Location for Installation

Trash removal equipment is installed before pumps to prevent clogging of trash in the impeller of pump and manually raking bar screens were installed in four existing pumping

stations of Chak Tomuk Pumping Station (P1), Preah Kumlung Pumping Station (P2), Phsar Kandal Pumping Station (P4) and Phsar Chas Pumping Station (P5) at Phase II. The manual operation, however, is not suitable for incoming large flow to the pump stations.

In this project, mechanical screens (automatic raking screens) are installed at the existing screen rooms after taking the existing bar screens away. However, the construction space for the automatic raking screens is not enough for the existing spaces. Thus, the modification of screen rooms is required.

At the new pumping station (No.6 Pumping Station (P6)), the new automatic raking screen is installed by the same reason of above.

(3) Specification of Automatic Raking Screen

The type of screen is selected of an automatic rotation rake screen with kick up equipment as shown **Fig. R 2.2.29** which is suitable for large incoming flow. This type is stipulated in "Design (plan) Manual and Explanation" of Japan Construction Engineers Association. Not to prevent gravity flowing, the raking screen itself is lifted up over the maximum water by the wire winch facilities. The trash picked up by rakes is brought up into the buckets. The buckets containing the trash are manually lifted above ground level by crane.

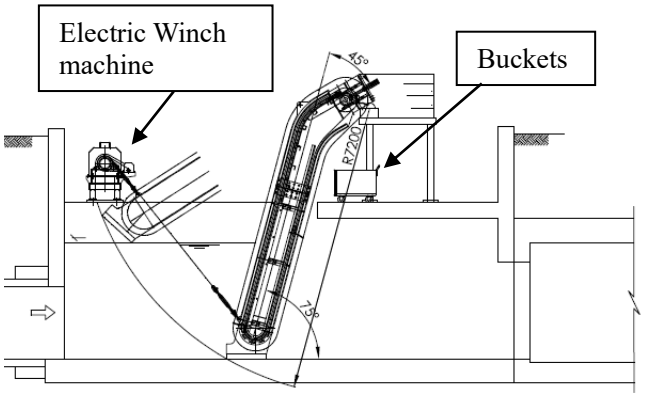


Fig. R 2.2.29 Automatic Rotation Rake Screen with Kick Up Equipment

(4) Material of Automatic Raking Screen

New automatic raking screen must be made with stainless steel for the purpose of anticorrosion. The existing steel bar screens have been severely corroded by hydrogen sulfide as shown **Photo R 2.2.3**.

Photo R 2.2.3 Condition of Existing Bar Screen

(5) Design Condition

Automatic rotary rake screen is designed based on the volume and size of trash (**Photo R 2.2.4**) picked up by the existing bar screens. The design condition is as shown in the **Table R 2.2.24**.

Photo R 2.2.4 Typical Trashes Caught Before Bar Screen

Table R 2.2.24 Design Condition of Automatic Rotary Rakes Screen

Item	Design Condition	Remarks
Max. size of domestic garbage	300 mm	
Max. velocity trough screen	1 m/sec	
	Vg =K・Q Here In Vg: Volume of Trash (m3/h) K: Coefficient of Trash Incoming Q: Incoming Drainage Volume (m^3/s)	Criteria of Japanese coefficient of trash incoming In Japan, it is between 2.0 and 2.5. The existing condition is worse than in Japan, thus it is better to select 2.5.
Rake Speed	5 m/min.	Criteria 3 to 8
Angle of Installation	75 degree	Criteria 70 to 80 degree
Length of Rakes	300mm	
Clear Bar Span	Based on Pump Size	

(6) Capability of Automatic Raking Screen

The capability of automatic raking screen calculated based on the above design data is shown in **Table R 2.2.25**.

Table R 2.2.25 Specifications of Automatic Raking Screen

Station No.	P1	P2	P4	P5	P6
Incoming flow volume (m^3/s)	2.5	3.3	4.3	5.2	6.9
Screen width (m)	1.8	1.5	2.4	2.7	2.7
Screen depth (m)	2.9	2.45	2.8	2.35	2.8
Passing velocity (m/s)	0.479	0.898	0.64	0.82	0.91
Incoming trashes volume (m^3/hr)	6.25	8.25	10.75	13	17.25
Transaction capability of automatic raking screen	9.51	8.37	12.83	15.86	18.06
Rating of capability	OK	OK	OK	OK	OK

(7) Installation Dimension and Ground Level of Automatic Raking Screen

The installation dimension and ground level of automatic raking screen for each station is shown in **Table R 2.2.26**.

Table R 2.2.26 Installation Dimension and Ground Level

Items	P1	P2	P4	P5	P6
Width (m)	7.5	7.3	8.1	8.2	8.2
Length (m)	11.6	11.0	11.5	11.3	11.3
Ground Level (m)	1.5	2.0	2.5	2.4	2.4

(8) Electric Power Supply System

(a) Power Demand of Pumping Station with Automatic Rake Screen

The power demand of each pumping station with automatic rake screen is shown in **Table R 2.2.27**. The capacity of existing transformer is enough for the required power capacity in pumping station as shown in the following table.

Table R 2.2.27 Installation Dimension and Ground Level

Items	P1	P2	P4	P5	P6
Pump motor (kW)	@45 2 sets	@22 2 sets	@37 2 sets	@37 2 sets	@37 2 sets
Motor of rake screen (kW)	1.5	1.5	1.5	1.5	1.5
Required power capacity (kVA)	150	140		120	120
Capacity of existing transformer (kVA)	600	200		600	1000

(b) Power Source

The motor power demand for each automatic lake screen is 1.5kW which is not big power. Thus, the power sauce for it can receive from the existing incoming panel in which new breaker and new terminal are equipped.

(c) Cable Route

The cable routes from the existing P1, P2, P4 and P5 to each automatic rake screen are as shown on **Fig. R 2.2.30** to **Fig. R 2.2.33**. The new panel of automatic rake screen for each is as shown in **Fig. R 2.2.34**.

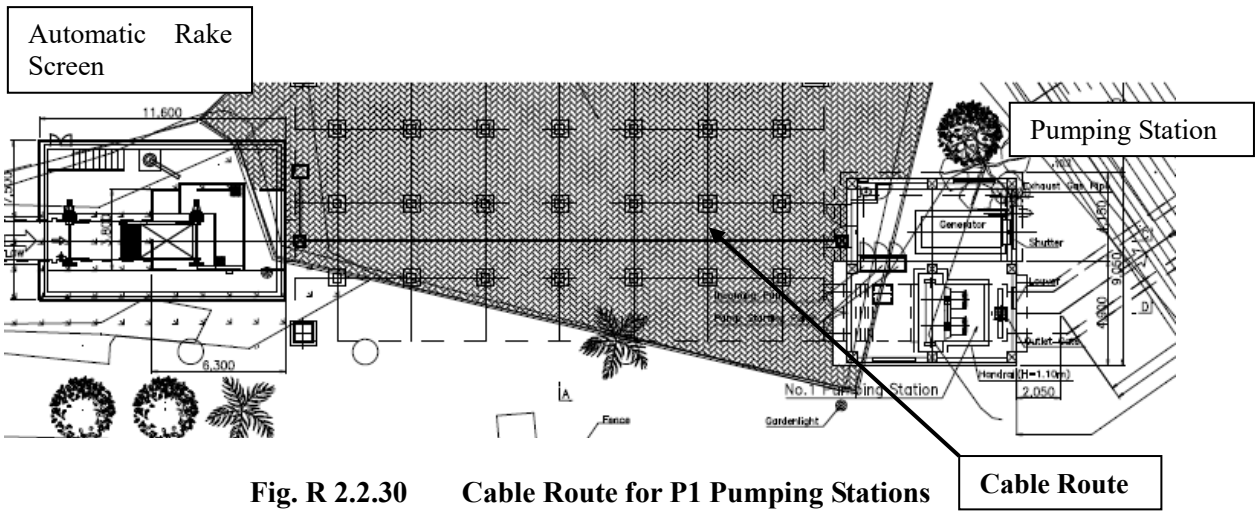


Fig. R 2.2.30 Cable Route for P1 Pumping Stations

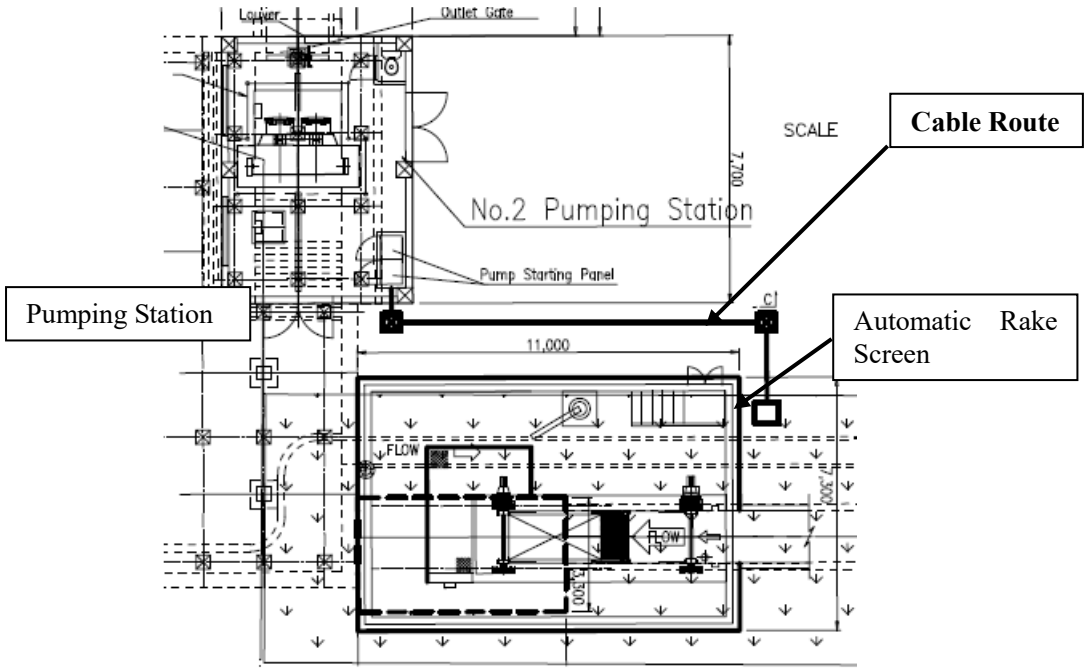


Fig. R 2.2.31 Cable Route for P2 Pumping Stations

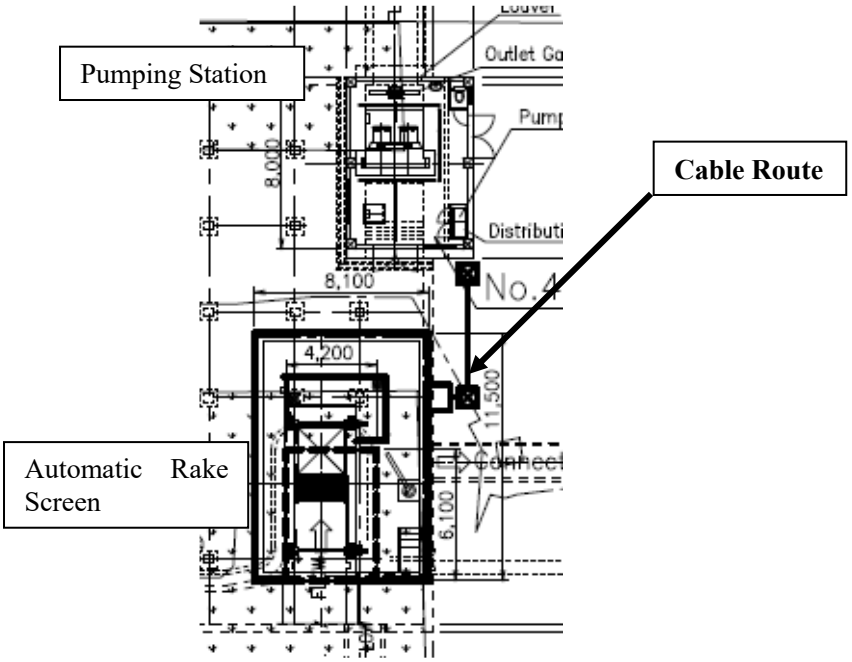


Fig. R 2.2.32 Cable Route for P4 Pumping Stations

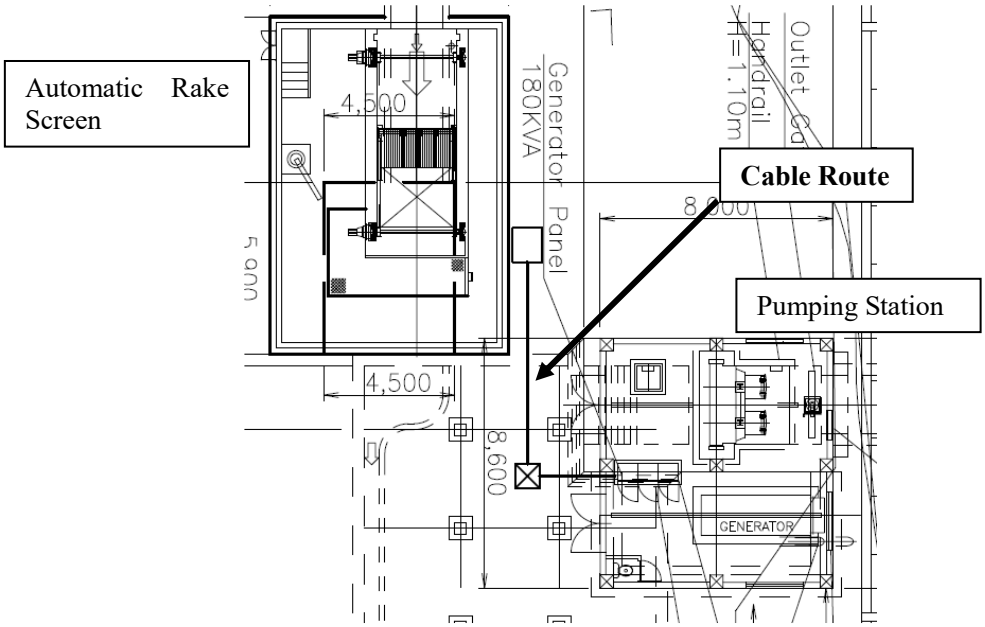


Fig. R 2.2.33 Cable Route for P5 Pumping Stations

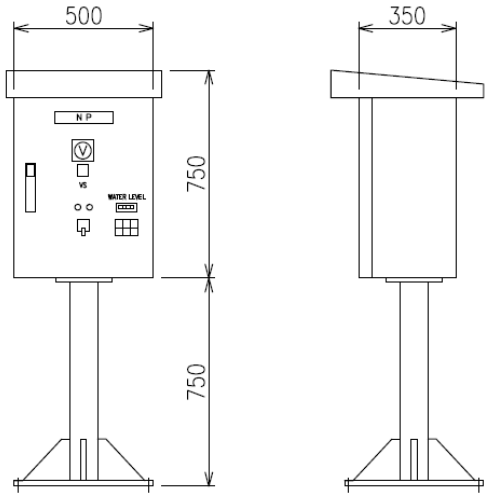


Fig. R 2.2.34 Outline Drawing for the Automatic Raking Screens

2.2.2.6 Procurement of Equipment

(1) Selection of Equipment to be Procured

As mentioned in **Section 2.1**, the equipment should be mobile type. The equipment shall be selected from three options as bellow.

Table R 2.2.28 Options of the Type of the Equipment

Option	Type	Note
Option 1	**Vehicle-mounted Drainage Pump**	**Requested Equipment, Drainage capacity of 30m^3/min**
Option 2	Drainage Pump Trailer	Self-priming pump, Drainage capacity of 15-30 m^3/min
Option 3	No Procurement	-

It is certainly needed the equipment for emergency drainage work, because the only equipment that DSD-owned is tremendously aging and drainage capacity becomes lower.

Therefore, Option 3 is unqualified. Then Option 1 and Option 2 are compared as shown in Table R 2.2.29.

Table R 2.2.29 Comparison of Options

Parameter	Option 1: Vehicle-mounted Drainage Pump	Option 2: Drainage Pump Trailer
Cost	High	Low
Possibility	Same as 10t Truck	Same as Pick-up vehicle It must need a traction vehicle.
Mobility of pump	High (pump weight is less than 40kg) Easy for carry with manpower	Low (pump is fixed on the trailer) Need other materials such as hosepipes
Installation Time	About 30 min	About 2 hours
Existing Equipment	Same type as existing	Never used in DPWT, DSD

Considering above conditions, **Option 1 is selected** from the point of view of urgency, ease of operation and maintenance.

(2) Selection of Quantity

DSD drain stormwater in emergency using only one drainage pump vehicle. However, the drainage pump vehicle is aging with insufficient capacity and thus not suitable for improving current inundation conditions.

Therefore, procurement of additional equipment is urgent and necessary to cope with the inundation conditions in PPCC.

At present, a team of emergency drainage work consists of one drainage pump vehicle with a driver and 7-8 technical staff. Normally, the team works drainage pipe cleaning during the dry season. Only when inundation occurred, they work for emergency drainage work. There are five (5) teams in DSD for drainage pipe cleaning work.

Emergency drainage works are currently executed in mainly five locations of two areas, namely, eastern and western side of the Tonle Sap River. At least, one equipment shall be required at each area. When inundations occur in the several spots in the same area, the emergency work should be executed focusing on high prioritized spot, observing inundation conditions at other spots.

In view of the current emergency work and operation and maintenance structure in DSD, two vehicle-mounted drainage pumps shall be procured in the Project.

Table R 2.2.30 Type and Quantity of the Equipment to be procured in the Project

Equipment	Purpose	Quantity
Vehicle-mounted Drainage Pump	To execute emergency drainage work at flooded area	2

(3) County of Origin of Equipment

The country of origin of procured equipment should be selected considering the following conditions:

- There is an agency in Cambodia or in neighboring country to procure the main parts of truck body;
- There is less possibility for equipment breakdown and it is easy to procure spare parts; and
- Japanese products are more reliable than other countries based on the experience of DSD with its existing equipment.

From the above reasons, Japan shall be the country of origin of equipment to be procured in the Project.

Since vehicle-mounted drainage pump is specialized vehicle, the equipment is not procured in Cambodia and neighboring countries. The equipment shall be procured from Japanese manufacture which has agency for the maintenance in Cambodia or neighboring countries.

(4) Specification of Equipment

The following conditions shall be considered for the specification of the equipment.

- The equipment has high work efficiency and durability, as well as good operability.
- The equipment can be easily maintained by DPWT and DSD
- The equipment can be parked in the existing garage of DSD
- The equipment is to be left-hand drive

On the other hand, drainage capacity of the existing equipment is 12 m3/min with average working hour of 8 to 12 hours per day. In case that the equipment should improve several inundations occur in same area, the equipment drain stormwater faster and it should have high capacity for drain. However, equipment with high drainage capacity has large body and low mobility due to its weight. In consideration of the above conditions, the specification of the equipment is determined as shown in **Table R 2.2.31**.

Table R 2.2.31 Specification of the Equipment

Equipment	Specification
Drainage Pump Vehicle	1) Left-Hand Drive 2) Drainage capacity is 30 m^3/min per vehicle 3) Truck is 10 ton based 4) Generator is 125kVA

(5) Procurement of Spare Parts

It is difficult to find original spare parts of the equipment in Cambodia. If the imitation spare parts could be used for the equipment, it might cause failure.

It is important to establish reliable system to order spare parts for the vehicle-mounted drainage pump. Agency agreement with contact person in Phnom Penh is a method to establish the system and to secure the procurement of spare parts. Actually, many spare parts of Japanese products such as generator, telephone exchanger, polishing rice machine of rice, pump, are procured to Phnom Penh using this method. Procedure to obtain spare parts is shown as below.

- DSD orders the necessary spare parts to the contracted agent.
- The contracted agent orders the necessary spare parts to the manufacturer in neighboring country (Vietnam, Thailand or Japan).
- The manufacturer provides the spare parts to DSD.
- DSD receives the spare parts and repairs the related equipment.

2.2.3 Outline Design Drawings

Outline design drawings are attached as the “Annex”. The list of the outline design drawings is as shown in the table below.

Table R 2.2.32 List of Outline Design Drawings

No	Title	Drawing No.
	GENERAL MAP	
1	General Map	GM-001
	DRAINAGE MAIN	
	General	
2	General Plan of Drainage Main	DM-GN-001
3	Detail of Manhole & Drainage Pipe (1/2)	DM-GN-002
4	Detail of Manhole & Drainage Pipe (2/2)	DM-GN-003
	1. Wat Phnom Northern Area	
5	Plan & Profile R47-1 Drainage Main	DM-WP-001
6	Plan & Profile R47-2 Drainage Main	DM-WP-002
7	Plan & Profile R88-Sisowath Drainage Main (1/2)	DM-WP-003
8	Plan & Profile R88-Sisowath Drainage Main (2/2)	DM-WP-004
9	Plan & Profile R92-R47-1 Drainage Main	DM-WP-005
10	Plan & Profile R92-R47-2 Drainage Main	DM-WP-006
11	Plan & Profile R19 Drainage Main	DM-WP-007
12	Plan & Profile R90 Drainage Main	DM-WP-008
13	Plan & Profile R88 Drainage Main	DM-WP-009
14	Plan & Profile R84 Drainage Main	DM-WP-010
	2. Tuol Kork Area	
15	Plan & Profile R528-R337-1 Drainage Main	DM-TK-001
16	Plan & Profile R528-R337-2 Drainage Main (1/2)	DM-TK-002
17	Plan & Profile R528-R337-2 Drainage Main (2/2)	DM-TK-003
18	Plan & Profile R592 South Drainage Main (1/2)	DM-TK-004
19	Plan & Profile R592 South Drainage Main (2/2)	DM-TK-005
20	Plan & Profile R592 North Drainage Main	DM-TK-006
21	Plan & Profile R596 Drainage Main (1/2)	DM-TK-007
22	Plan & Profile R596 Drainage Main (2/2)	DM-TK-008
23	Plan & Profile R317 Drainage Main	DM-TK-009
24	Plan & Profile R315-1 Drainage Main (1/5)	DM-TK-010
25	Plan & Profile R315-1 Drainage Main (2/5)	DM-TK-011
26	Plan & Profile R315-1 Drainage Main (3/5)	DM-TK-012
27	Plan & Profile R315-1 Drainage Main (4/5)	DM-TK-013
28	Plan & Profile R315-1 Drainage Main (5/5), R315-2 Drainage Main	DM-TK-014
29	Plan & Profile R287-R528 Drainage Main (1/3)	DM-TK-015
30	Plan & Profile R287-R528 Drainage Main (2/3)	DM-TK-016
31	Plan & Profile R287-R528 Drainage Main (3/3)	DM-TK-017
32	Plan & Profile R283-1 Drainage Main	DM-TK-018
33	Plan & Profile R283-2 Drainage Main	DM-TK-019
34	Plan & Profile R528 Drainage Main	DM-TK-020
35	Plan & Profile R618 Drainage Main	DM-TK-021
36	Plan & Profile R608-1 Drainage Main (1/2)	DM-TK-022
37	Plan & Profile R608-1 Drainage Main (2/2)	DM-TK-023
38	Plan & Profile R608-2 Drainage Main	DM-TK-024
	3. Interceptor	
39	Plan & Profile Interceptor (1/5)	IC-001
40	Plan & Profile Interceptor (2/5)	IC-002
41	Plan & Profile Interceptor (3/5)	IC-003
42	Plan & Profile Interceptor (4/5)	IC-004
43	Plan & Profile Interceptor (5/5)	IC-005
	No.6 PUMPING STATION AND No.6 UNDERGROUND RESERVOIR	
44	General Plan	PR-001
45	Typical Sections	PR-002
46	Layout of Foundation Pile	PR-003

No	Title	Drawing No.
47	Pump Operation & Maintenance House	PR-004
	MECHANICAL SCREEN	
48	Mechanical Screen S.P-1 Chaktomuk	MS-001
49	Mechanical Screen S.P-2 Preah Kumlung	MS-002
50	Mechanical Screen S.P-4 Phsar Kandal	MS-003
51	Mechanical Screen S.P-5 Phsar Chas	MS-004
52	Mechanical Screen S.P-6	MS-005

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 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 and Sewerage Division (DSD) 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

Construction materials and labor are basically procured in Cambodia. Common technique is required for civil works for construction of underground reservoirs and pumping stations, installation of drainage pipe, construction of interceptor and installation of mechanical screens. However, construction works will be executed in the neighbouring area of business centre of Phnom Penh, as well as congested residential area. Therefore, it is necessary to dispatch Japanese experts/engineers to the Project to ensure that the works are properly performed in accordance with plan and design. Japanese experts/engineers shall also be dispatched to install and adjust of pumping station and mechanical screen and electrical accessories, and to engage in technical transfer for operation at start-up.

In Phnom Penh, there are over 15 local construction firms, some of which has experience to participate in the Japan's Grant Aid Project as subcontractor of the Japanese general contractor. Those 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) Construction Conditions

(a) Installation of Pipes

Pipes with total length of about 13 km are installed in the Project. Since the site for the pipe installation covers large area, the area is subdivided into four (4) drainage areas for smooth implementation of the pipes, as shown in the following figure.

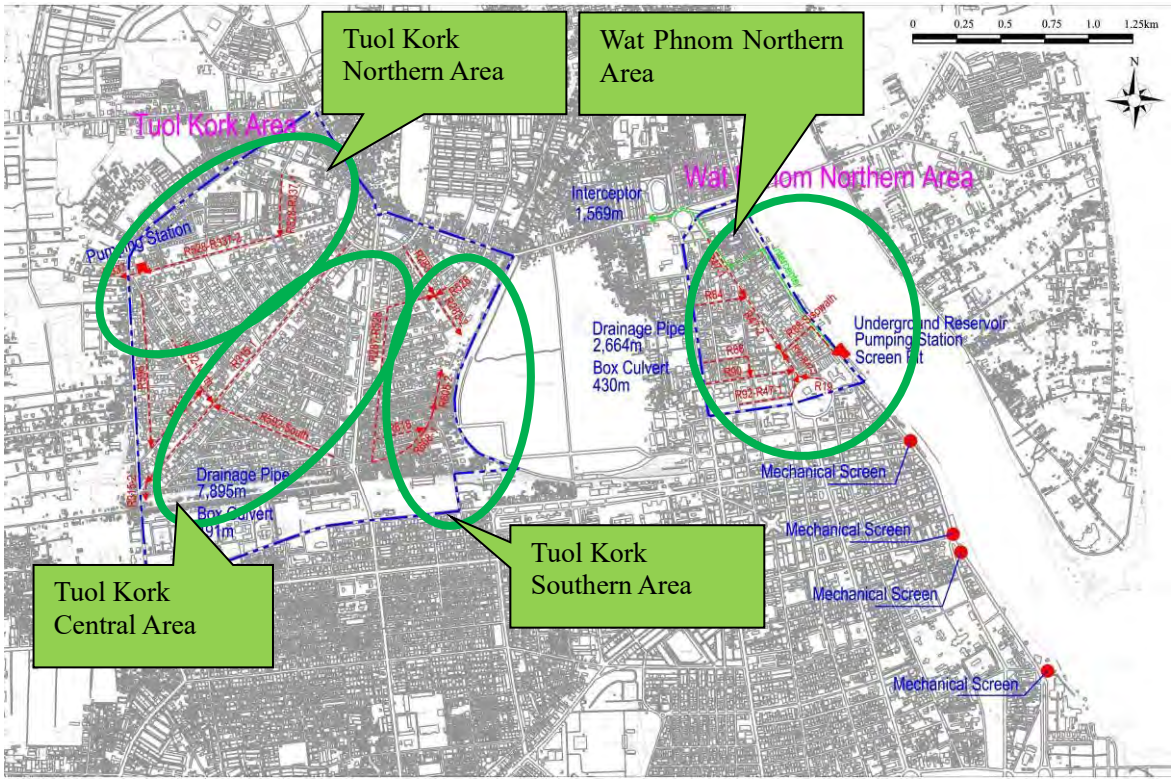


Fig. R 2.2.35 Drainage Areas

Conditions for the construction works are enumerated below.

- Drainage pipes shall be installed from downstream to upstream.
- Construction of one stretch, consisting of a stretch of pipe from one manhole to the neighbouring manhole, shall be done before entering into the next stretch.
- Sheet pipes shall be employed as temporary works, regardless of the covering of the pipes.
- Before commencement of each pipe installation, DPWT/PPCC shall hold explanatory meeting with residents living near Project sites in collaboration with communes to share information on objectives, contents and duration of the construction works.
- Adverse impacts, arising from noise, vibration, shall be minimized and special attention shall be paid to safety and traffic control in the Project, because the construction site of the Project encompasses business center and tourist spots.

[Countermeasures for the above conditions]

- Construction works under the heavily-trafficked roads such as St.47, Sisowath boulevard, as well as main roads shall be done in the night time. To minimize traffic hindrance on the roads, multiple construction on each road shall be prohibited (construction site of each road shall be limited to one location).
- Covering plate shall be placed on the night work site to prevent traffic hindrance in the day time.
- Construction works shall be done under the conditions that; (i) road are fully or partially closed, (ii) bypass road is established, (iii) notice board is placed and (iv) guards are dispatched.
- Temporary sheet piles shall be driven applying hydraulic press-fit driving. Low-noise type generator shall be equipped for power source of the driving machine.
- Each construction site shall be fenced and notice board and safety equipment shall fully be equipped to reduce risk of injury. Safety net shall be equipped in the night time to prevent people from falling.

(b) Construction of Underground Reservoir and Pumping Station

In the Wat Phnom Northern Area, construction site of UGR 6, P6 and mechanical screen, are located in the area bounded by Tonle Sap River, Sisowath boulevard, at which Cambodia Development Council (CDC) is located, intake of PPWSA and a restaurant in the south.

PPWSA's raw water pipe of φ1,200 mm is installed under the construction site; and hence the UGR 6 shall be constructed bypassing the pipe. Therefore, a part of existing revetment constructed by DPWT shall temporally be demolished. Due to the constrains of area, excavation work with sheet piles supported by tie-rod shall be applied (see **Fig. R 2.2.36**). The demolished revetment is reconstructed after the completion of UGR 6.

The construction works for the UGR 6, including excavation, pile driving, concrete placing for underground structure and installation of outlet, shall be done in the dry

season when the water level of Tonle Sap River is low.

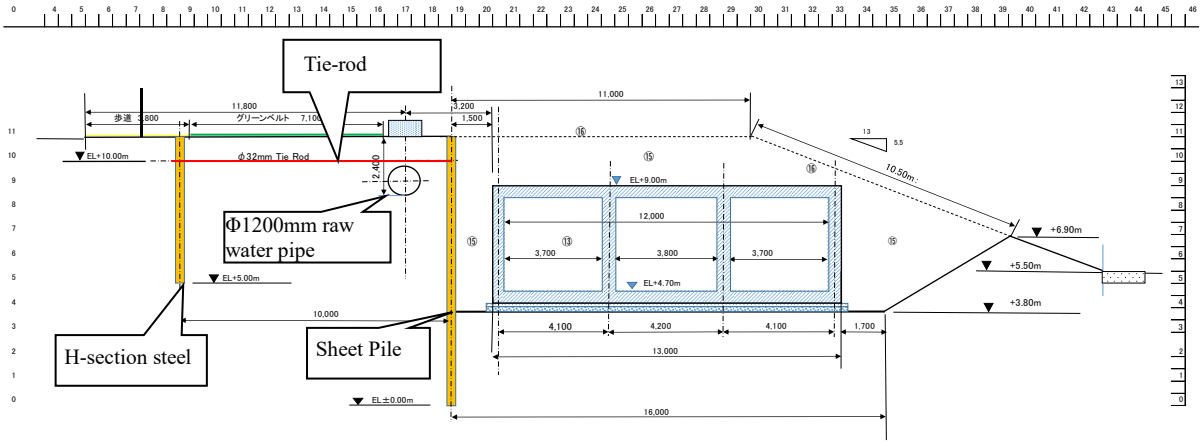


Fig. R 2.2.36 Typical Cross Section of Construction of UGR 6

Stage 3

⑬ ＰＣ基礎杭打設後の施工工程は、基礎砕石投入、同転圧、捨コンクリート打設、底版コンクリート打設、柱及び壁コンクリート打設、天盤コンクリート打設

⑭ 前記⑬の施工順序に従って、地下貯留構築造工では、南北に長いことから、施工は、北側と南側の２つに分けて行う。従うく施工は、２班編成とする。

⑮ 埋戻し土は、締固めに際しては、転圧に留意し、一層仕上り厚は10cm以下と規定して、十分に転圧と圧密に留意しながら施工する

⑯ 護岸法面部及び護岸上部の復旧工、　地下貯留構上部の整地を実施

⑰ タイロッドの撤去、腹起し材の撤去が完了した箇所から、矢板及び控え鋼矢板を引き抜く

Fabricated piles are employed and hydraulic hammer method shall be applied for pipe driving to reduce noise.

Before commencement of the construction work, the site shall be yarded by temporary fence because the site is located adjacent to the heavily-trafficked road in tourist area, and the construction work shall be done, avoiding adverse impact to the neighboring area and minimizing risk of injury.

(c) Installation of Mechanical Screen

In four pumping stations constructed in Phase II, mechanical screens are installed replacing existing manual screens.

The mechanical screen shall be installed in the dry season, establishing temporary drainage channel to secure waterway for incoming wastewater and stormwater during construction works.

Fabricated piles are employed and hydraulic hammer method shall be applied for pipe driving to reduce noise.

During the construction work, the site shall be yarded by temporary fence because the site is located along heavily-trafficked road in tourist area. The construction work shall be done, avoiding adverse impact to the neighboring area and minimizing risk of injury.

(2) Procurement Conditions

Hand-over of the vehicle-mounted drainage pump (2 sets) shall be done after unloading at the Sihanoukville Port. Therefore, transportation cost for the equipment, which shall be borne by the Japan's Grant Aid, is transportation and shipment of the equipment from the factory to Sihanoukville Port. On the other hand, cost for customs clearance and transportation of the equipment from Sihanoukville Port to Phnom Penh, shall be borne by the GOC.

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 2.2.33 Major Undertakings for Construction and Procurement by Each Government

Item	Contents		Responsibility	
			Japanese Side	Cambodian Side
Procurement of Materials and Equipment	Procurement and transportation of construction materials		O	-
	Shipping of procured cleaning equipment	Vehicle-mounted drainage pump: 2 units	O	-
	Customs clearance of the procured cleaning equipment		-	O
	Land transportation of the procured cleaning equipment		-	O
	Land transportation of construction materials		O	
Preparation Work	Land acquisition for construction site		-	O
	Land acquisition for site office, stockyard, workshop and disposal site		-	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 underground reservoir and pumping station, and Installation of drainage pipes and interceptor		O	-

Note: "O" Responsible; "-" Not Responsible

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
- Confirmation of details of existing drainage network and additional manhole survey
- 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 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 36 months. Fourteen (14) parties will work in parallel at maximum.

To supervise the construction work properly, a Japanese qualified representative (1 person) and local inspectors (6 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) Procurement Supervision

The Consultant will supervise the manufacturing schedule and quality of equipment for drainage management to be procured. The Consultant will also confirm the function and condition of equipment at site, and provide appropriate guidance for the operation and maintenance of the procured equipment. For the proper procurement service, the Consultant will carry out the following:

- Negotiate with manufacturer about design, manufacturing schedule and quality control of the equipment
- Participate and observe factory inspections and pre-shipment inspections
- Communicate with DSD and agencies concerned
- Supervise procurement status
- Confirm and follow-up Customs clearance
- Inspect and hand-over products in the course of project implementation
- Issue inspection results and certificate of completion
- Submit completion report

The Consultant will dispatch a procurement supervisor for the factory inspection and

pre-shipment inspection (in Japan), and to the initial operation guidance and technical assistance for operation and maintenance (in Cambodia) to ensure smooth and certain implementation of procurement for the Project.

On the other hand, the equipment manufacturer shall dispatch a mechanical engineer(s) to provide guidance/instructions on how to operate, manage and maintain the equipment to DSD staff in the initial operation guidance services.

(5) Engineers for the Supervision Services

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

(a) Project Manager

Project Manage shall engage in overall management in technical and operational aspects. Especially, 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. 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 Supervision, Construction Management)

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

(c) Civil Engineer-1 (Drainage Pipe and Drainage Box Culvert Installation, and UGR6)

Civil Engineer-1 shall be dispatched to Cambodia before commencement of the construction works to establish working system of consultant's supervision, to attend meetings with agencies concerned, to make quality and schedule control program for construction works of drainage pipe installation and UGR6.

Civil Engineer-1 shall supervise installation of drainage in the night time and interceptor pipes from time to time, depends on the progress of the construction works.

(d) Civil Engineer-2 (Underground Reservoir, Pumping Station and Mechanical Screen)

Civil Engineer-2 shall supervise piling work, structure construction and installation of mechanical screen, because these works shall simultaneously be done in short term and hence needs specialized skills. Civil Engineer-2 shall attend meetings with agencies concerned, engaging in coordination, safety, quality and schedule control, as well as giving advises to the Contractor.

(e) Mechanical and Electrical Engineer (Pumping Equipment and Mechanical Screen)

Mechanical and Electrical Engineer shall inspect mechanical screen and gate-mounted pump in the factory and shipment of them in Japan, and shall supervise installation work of those machinery or system at site, operate and adjust the equipment after installation from time to time.

(f) Procurement Engineer (Supervision of Procurement of Drainage Equipment)

Procurement Engineer shall inspect vehicle-mounted drainage pump in the factory in Japan before shipment and supervise hand-over, test run and adjustment of the equipment from time to time.

(g) Defect Inspection Engineer

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 2.2.34 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.

Note: (*) Other equivalent international standards could be applied.
JIS (Japanese Industrial Standards)
AASHTO (American Association of State Highway and Transportation Officials)
ASTM (American Society for Testing and Materials)
CBR (California Bearing Ratio)

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 and (iv) storage of the equipment after disembarkation at the Sihanoukville port shall be controlled by the execution agency of Cambodia and inspection at disembarkation port shall be done by the Cambodian side

Initial operation guidance for the equipment is implemented after transportation to DSD workshop. Qualified engineers shall attend the guidance to cope with issues and/or defects identified in the course of the guidance.

2.2.4.6 Procurement Plan

(1) Procurement in Cambodia

(a) Cement and Concrete

Cement products of Thailand circulate freely 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 the capital city, all of which were established with foreign investment. Under these circumstances, the ready-mixed concrete will be used commonly in the construction site in Phnom Penh. Among the concrete suppliers mentioned above, the CPAC which has been established with Thai capital and has four (4) plants is considered to be the most reliable company.

(b) Steel Materials

Common steel material, such as reinforcing bars, are available in local market of Cambodia. Those products are imported from Thai and Vietnam. Recently, Vietnamese iron bars are popular in PPCC.

(c) Construction Equipment

Common construction equipment, such as backhoe, dump truck, rough terrain crane, is available in Cambodia. Recently, Silent Pile Driver is also available in Cambodia.

(2) Import Item

Construction materials and equipment, which are not available locally or quality is not reliable or their supply amount is insufficient in Cambodia, shall be imported from Japan.

Major items imported from Japan are (i) gate-mounted pump, (ii) mechanical screen, (iii) manhole pump, (iv) cast-iron manhole cover and (v) tie-rod.

Materials and equipment procured in Japan will be transport from Japan to Sihanoukville port via Singapore by marine transport. Land transportation route from Sihanoukville port to Phnom Penh City shall be national road No. 4 by trailer.

2.2.4.7 Operational Guidance Plan

The DSD of DPWT has operated their existing cleaning equipment and maintained existing drainage system. The DSD has basic knowledge and skills about operation and maintenance of equipment for drainage pipe cleaning.

However, the DSD has no experience to operate equipment made in Japan, such as Mechanical Screen and Vehicle-mounted Drainage Pump. It is necessary to attempt technology transfer to operating staff through the initial operation guidance carried out by the supplier/manufacturer of equipment newly introduced. The technical transfer shall be implemented at the times of installation of mechanical screens, hand-over of vehicle-mounted drainage pump with duration of one week for each.

The pumping equipment installed in No.6 Pumping Station is similar to the ones installed in the existing pumping station but technology transfer of pumps in No.6 Pumping Station shall be conducted at the arrival of the equipment, because new staff might be assigned to O&M of the pumping station.

2.2.4.8 Soft Component (Technical Assistance) Plan

The DSD of DPWT will be responsible to operate and maintain the cleaning equipment procured by the Project and drainage facilities constructed by the Project. The DSD has maintained the existing drainage system by using its existing cleaning equipment, and the DSD has basic knowledge and skills about operation and maintenance (O&M) of the cleaning equipment.

Most of their cleaning works, however, are limited to symptomatic treatment such as cleaning works at site where inundation happens frequently or claimed by the residents, although they establish cleaning plan and just starts systematic pipe cleaning in accordance with the cleaning plan.

In response, soft component is proposed in the Project to develop DSD's capacity of O&M of drainage facilities and improve symptomatic approach. In the soft component, work plan for O&M of facilities constructed or installed in the Project, is formulated aiming to disseminate systematic cleaning work, to sustainably operate and maintain the drainage facilities utilizing the systematic cleaning plan.

DPWT and DSD have no O&M experience of mechanical screen because the screen is equipped for the first time in drainage system in PPCC. In addition, DPWT and DSD have not yet been given technical guidance for vehicle-mounted drainage pump. To appropriately and sustainably operate and maintain the facilities, technical transfer through On-the-Job Training (OJT) is proposed in the Project.

People in Phnom Penh have been dumping their garbage to the drainage channels/pipes and thus drainage function in the drainage channels has been deteriorated. To sustainably operate and maintain drainage pipes installed in the Project, prevention and reduction of garbage dumping to drainage channels/pipes, are indispensable in order to optimize the drainage function. Most of the garbage dumped to the drainage pipes/channels is plastics accumulated on the road and hence raising public awareness is required.

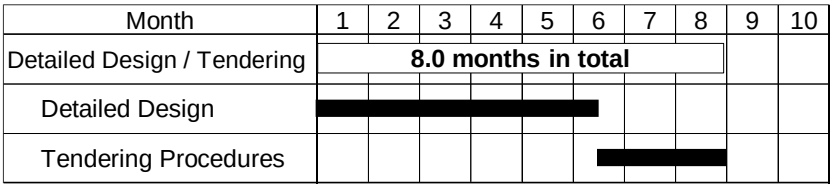
The garbage in Phnom Penh is mostly generated in the markets with which garbage boxes are not fully equipped. In addition, people in Phnom Penh are not conscious of throwing garbage to the garbage boxes. Therefore, installation of garbage boxes and activities for raising public awareness in and around the markets, are proposed in the Project.

Photo R 2.2.5 Sample of Garbage Box

2.2.4.9 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 8 months including engineering design services, preparation of tender documents and tender administration. The total construction period will be 36 months including construction of facilities and procurement of cleaning equipment. Thus, total implementation period of the Project amounts to 44 months. The implementation schedule from the detail design study to completion of the construction works is shown in **Fig. R 2.2.37**.

Detailed Design and Tendering Stage



Construction, Procurement and Soft Component Stage

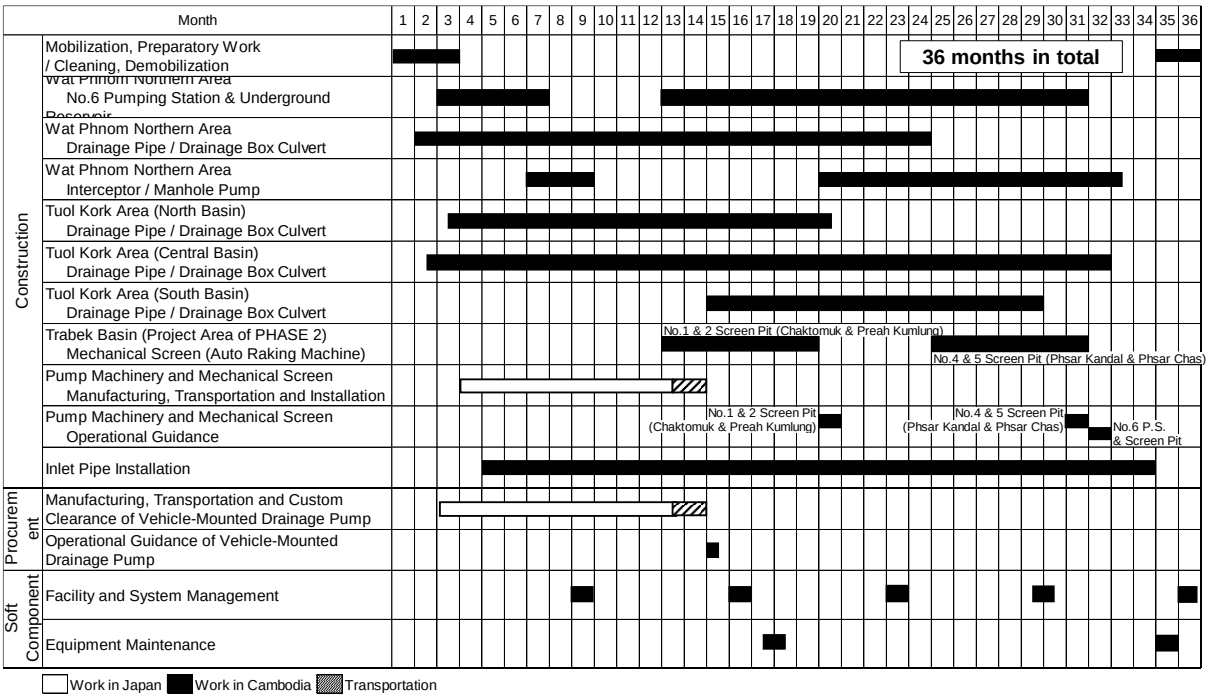


Fig. R 2.2.37 Implementation Schedule

2.3 Obligations of Recipient Country

2.3.1 General Undertakings of Cambodia

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

(1) To secure and clear 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;

(2) To provide following facilities:

- The distributing power line to the site and site office,
- The city water distribution main to the site and site office, and
- The telephone trunk line to the main distribution panel of the site office;

(3) To ensure prompt unloading, tax exemption and Customs clearance of the products at the port/terminal of disembarkation in Cambodia and internal transportation of the Vehicle-mounted Drainage Pump procured under Japan's Grant Aid

(4) 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.

(5) 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;

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

(7) 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.

(8) 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).

2.3.2 Specific Undertakings of Cambodia

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

(1) Internal Transportation of Vehicle-mounted Drainage Pumps

Two (2) units of Vehicle-mounted Drainage Pumps will be procured by the Project for the emergency drainage work. Internal transportation cost of procured equipment from disembarkation port (Sihanoukville port) to Phnom Penh shall be borne by the Cambodian side

(2) Land Acquisition and Temporary House Relocation

The Cambodian side is required to acquire a plot of private land at Tuol Kork area as well as to relocate one house at Tuol Kork area during the construction work.

(3) Periodical Environmental Monitoring

The Cambodian side shall execute the periodical environmental monitoring during construction to check circumstances of negative impacts derived from construction work and implementation state and effectiveness of countermeasures for the negative impacts.

(4) Soft Components (Educational Activities for Waste Disposal)

The Cambodian side shall implement soft components during the project. The contents will be educational activities for waste disposal such as installation of waste bin around local markets in public area and clean-up campaign to protect drainage facilities from malfunction. These costs shall be borne by the Cambodian side.

(5) Application for Electricity

The No.6 Pumping Station constructed by 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 pumping station before the pump installation work. All commissions regarding the application and the installation cost of the wattmeter shall be borne by the Cambodian side.

(6) 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 No.6 Pumping Station. All commissions regarding the application and the installation cost of the water meter shall be borne by the Cambodian side.

(7) Establishment of Monitoring System of Inundation Condition

The Cambodian side is required to establish the inundation monitoring system and to carry out inundation monitoring periodically. Inundation monitoring shall be carried out in some locations in the city area where inundation damages are rather heavy, and some data shall be recorded such as date, time, inundation depth, duration of inundation, rainfall data, and so on in each monitoring point. The sample sheet of inundation monitoring record is as shown in **Table R 2.3.1**.

Table R 2.3.1 Sample Sheet of Inundation Monitoring Record

Location:

Date of Inundation [dd.mm.yy]	Inundation		Duration [h:m]	Max. Depth [cm]	Rain		Daily Rainfall Record (at Khmuouh Weather Station) [mm]
	Start [h:m]	End [h:m]			Start [h:m]	End [h:m]	
03.09.2010	16:30	18:10	1:40	40 cm	16:00	17:00	80 mm

The monitoring locations proposed by the Preparatory Survey Team of JICA are as shown in the following figure.

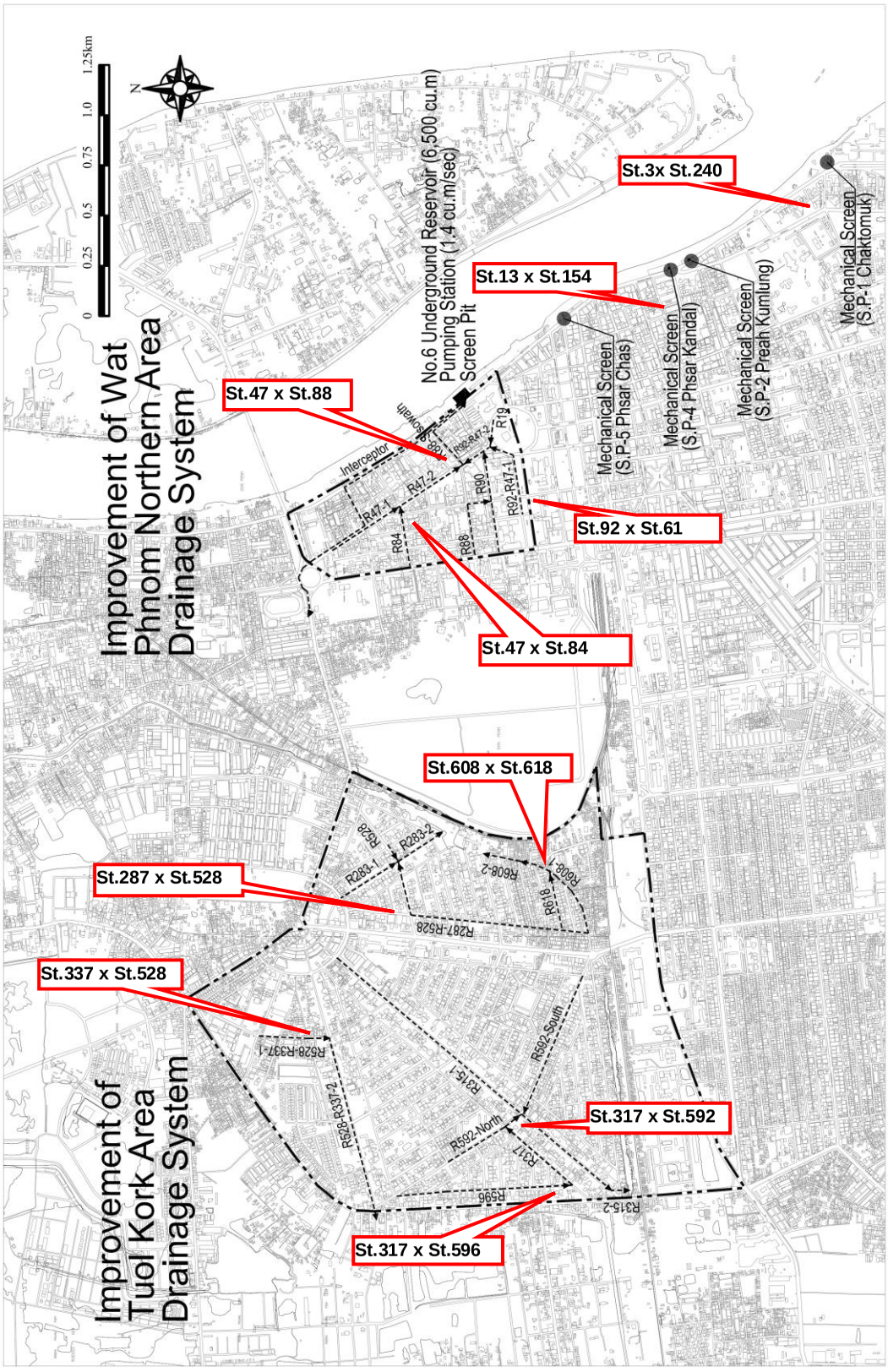


Fig. R 2.3.1 Location of Inundation Monitoring (10 points)

2.4 Project Operation Plan

2.4.1 Organization for Operation and Maintenance

The Drainage and Sewage Division (DSD, refer to **Fig. R 2.4.1**) of the Department Public Works and transport (DPWT) shall be the organization in charge of operation and maintenance works of the facilities to be constructed in the Project such as drainage pipes, underground reservoir, pumping station and mechanical screens as well as the Vehicle-mounted Drainage Pumps to be procured by the Project.

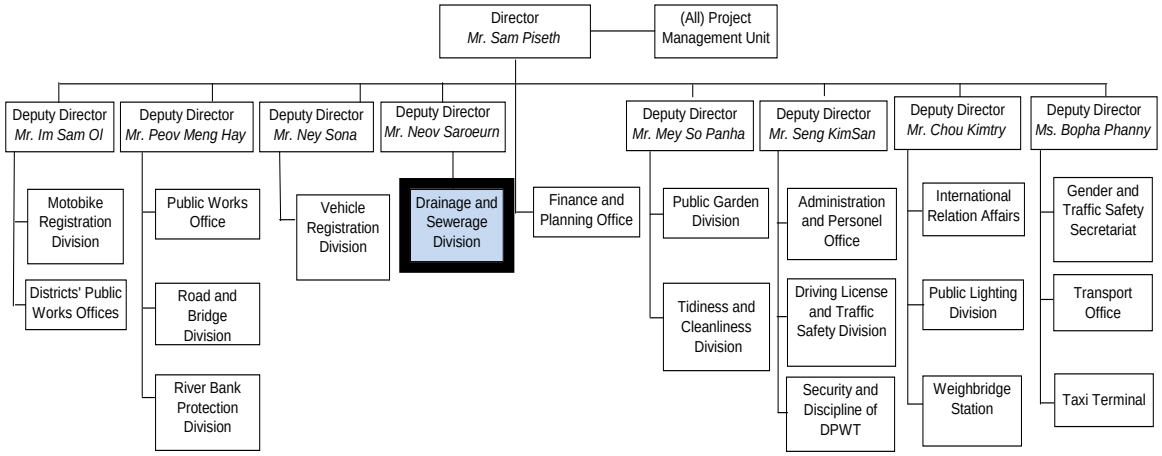


Fig. R 2.4.1 Organizational Chart of DPWT

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	9	-	9
2. Administration and Personnel Office	7	5	12
3. Finance and Planning Office	12	3	15
4. Public Works Office	20	5	25
5. Transport Office	20	6	26
6. Road and Bridge Division	27	38	65
7. Drainage and Sewerage Division	**28**	**171**	**199**
8. Public Lighting Division	9	21	30
9. Public Garden Division	17	282	299
10. Pound Division	8	14	22
11. River Bank Protection Division	25	-	25
12. Districts' Public Works Offices	27	17	44
13. Motorbike Registration Division	47	15	62
14. Vehicle Registration Division	42	3	45
15. Driving License and Traffic Safety Division	3	-	3
Total	301	580	881

Source: DPWT

DSD has twenty-eight (28) regular personnel in the managing position of DSD. Among them, eight (8) regular staff (Technical Group) have the responsibility for maintenance of drainage facilities and equipment, design of sewage pipes and assistance in sewage pipe construction work, and one (1) regular staff has the responsibility for drainage pipe cleaning works, two (2) regular staff have responsibility for operation and maintenance work of pumping stations.

Among the 171 contracted staff of DSD, 45 contracted staff are belonged to Cleaning and O&M group which is in charge of emergency drainage work and cleaning work of the drainage pipes. 56 contracted staff are working for O&M for pumping stations, and 20 contracted staff are working for O&M for drainage facilities and equipment.

The Cleaning and O&M group (one regular staff and forty-five contracted staff) is working emergency drainage work during the rainy season, and in other period, they work for cleaning of the drainage pipes. O&M of the drainage pipes to be constructed in the Project and Vehicle-mounted Drainage Pumps to be procured in the Project shall be under the responsibility of this Cleaning and O&M group.

The underground reservoir, pump station and mechanical screens to be constructed in the Project shall be under the responsibility of pumping station O&M group (two regular staff and fifty-six contracted staff).

2.4.2 Operation and Maintenance Method

2.4.2.1 Drainage Network (including Drainage Pipe, Box Culvert, Manhole and Interceptor Pipe)

Since drainage pipes are laid underground, it is difficult to predict and detect any trouble and abnormality. On the other hand, if these abnormalities/troubles occurred within the installed drainage pipes, accidents would be caused directly affecting city activities and civil life, such as leakage of sewer, road collapse, etc. Positive promotion of operation and maintenance works of drainage pipes would contribute to reduce accidents, maintain performance of drainage pipes and extend the practical service life of drainage pipes. Taking these effects into account, carrying out operation and maintenance works for the drainage pipes has economic advantages.

DSD is in charge of the maintenance of existing pipes. Total forty-six staff (one regular staff and forty-five contracted staff) works maintenance of existing pipes. The total length will be extended by the implementation of the Project, but it is still manageable for the maintenance work under the current number of the staff.

Adequate operation and maintenance work of drainage pipes shall involve following procedures:

1) Maintenance and inspection;

2) Cleaning and dredging; and

3) Renewal and repair.

(1) Maintenance and Inspection

In the “Guidelines for Optimization of Operation and Maintenance of Sewage Works in Developing Countries (issued by the Infrastructure Development Institute, JAPAN, October 2001)”, the inspection frequency is about once in every five (5) years for pipes in general. According to the record, the inspection frequency in urban area in Japan is once in every three (3) to seven (7) years.

It has been confirmed in the site investigations that the drainage system in many parts are clogged with debris and sediment. It means that there are a lot of sections where maintenance work has not been done for a long time. On the other hand, DSD is implementing pipe cleaning works more than once a year for the main trunk of drainage

system.

It is preferable to execute the inspection work at the frequency of about one in every three (3) to five (5) years for the drainage pipes constructed under the Project.

(a) Inspection Items

Principal inspection items shall be as follows:

[Drainage Pipe, Box Culvert, Interceptor Pipe]

- Flow condition and sediment build-up condition
- Settlement of the ground surface: Cracking in pavement due to differential settlement of the ground, etc.
- Damage situation: Damage, crack, penetration of root of a tree
- Groundwater infiltration condition
- Illegal connection

[Manhole]

- Manhole cover and internal condition

(b) Inspection Method for Drainage Pipe, Box Culvert, Manhole and Interceptor Pipe

In addition to visual inspection inside the manhole with the cover removed, the inspection shall be made by viewing the inside part of pipe through manhole. Most abnormalities can be detected through visual manhole inspection.

(c) Record of Inspection Result

Inspection results shall be recorded in proper recording sheets, which shall be documented for future use in the elaboration of cleaning plans.

(2) Cleaning and Dredging

Sludge deposits in pipes reduce flow capacity. It also causes wastewater, and hydrogen disulphide and organic acids to accelerate corrosion of pipes. Therefore, it is essential to carry out regular inspections and remove deposits when observed.

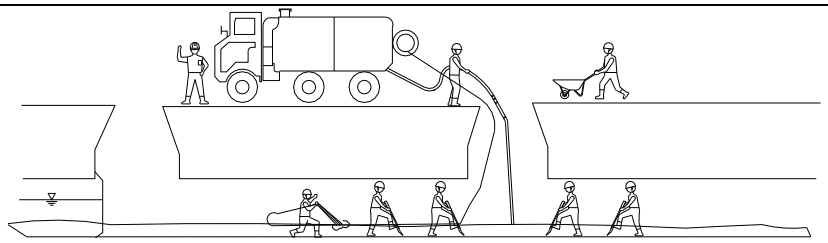
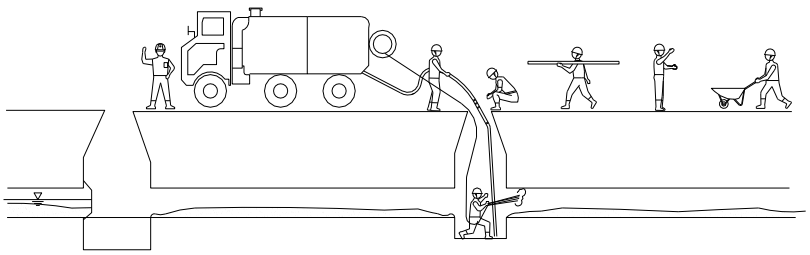
(a) Guidelines for Pipe Cleaning and Desludging

Generally, the clogging ratio required for cleaning, which is calculated by [(clogged sectional area) / (interior cross sectional area) x 100(%)], is approximately 20% for drainage mains and 60% for house connections. Basically, cleaning does not need to be more frequent than the inspections. However, in commercial areas where restaurants and markets are concentrated, there may be the necessity to increase the maintenance frequency due to the excessive deposits that may accumulate rapidly in these areas

(b) Pipe Cleaning and Desludging Method

Currently DSD works for pipe cleaning and desludging by using equipment and manpower. They have cleaning equipment such as high water jet machine, sludge sucker, vacuum track, etc. including four units of high water jet machines and four units of sludge sucker procured in Phase III (refer to **Fig. R 2.4.2**). Basically, it is recommended to continue current cleaning method. But considering cleaning work efficiency and more

safety, it is desirable to work with using equipment procured in Phase III preferentially.

Large size of diameter More than 1200mm		Cleaning and desludging work by manpower using previous vacuum track. The workers go into the drainage pipes and break and remove the sludge and garbage manually using shovels and water jet.
Small size of diameter Less than 1200mm		
		Cleaning and desludging with using high water jet machine and sludge sucker procured in Phase III. It doesn't need workers to go inside of the pipes. In case of deeper pipes, the worker go only into manhole.

Source: JICA Survey Team

Fig. R 2.4.2 Pipe Cleaning Method conducted by DSD (with Equipment)

(3) Renewal and Repair of Drainage Pipes

Deterioration of pipes proceeds at almost the same time and spreads extensively, and renewal and repair of pipe will take a considerable time. Therefore, it is necessary to implement renewal and repair work systematically according to the inspection results of pipe. It will prevent accident caused by deterioration of pipes.

2.4.2.2 Pumping Station, Underground Reservoir and Mechanical Screens

Objective facilities of the Project, namely No.6 Pumping Station, No.6 Underground Reservoir and five units of Mechanical Screens, shall be operated and maintained by DSD of DPWT after the completion of the Project. DSD has an important role to carry out the maintenance of drainage facilities such as drainage pipes and pumping stations in Phnom Penh Capital City.

(1) No.6 Pumping Station (P6)

It is necessary to reside three staff at the new No.6 Pumping Station for its operation and maintenance including operation of mechanical screen. Existing staff at existing pumping stations, which were constructed by Phase II, has basic skills and knowledge to operate and maintain the pumping station. They can transfer the skill and knowledge to other staff through on the job training.

(2) Mechanical Screen

The equipment which will be newly introduced in Phnom Penh, it is necessary to be trained by the supplier at the time of completion of the installation of the equipment. Especially, mechanical screen has never been introduced in Phnom Penh before. At the time of first operation of the mechanical screen, it is necessary to dispatch the technical engineer from the manufacturer in order to conduct the training how to use it, how to maintain it and how to operate it. At the same time of the initial training, it is also necessary to make sure the maintenance service to be received from the agent of the equipment, and establish the proper maintenance mechanism.

(3) No.6 Underground Reservoir (UGR6)

It is preferable to clean once a year as the maintenance of the underground reservoir. Therefore, it doesn't need to reside a staff at the underground reservoir. Only the time of the cleaning, DSD allocate the about ten workers for the cleaning. DSD is able to manage on this matter due to consideration of the exiting number of staff in DSD.

2.4.2.3 Vehicle-mounted Drainage Pump

Existing equipment of emergency drainage work that DSD presently have is remarkably in advanced state of aging and the work efficiency is deteriorated. Although DSD staffs have never been trained to operate and maintain the Vehicle-mounted Drainage Pump before, they have maintained it well and used it for the emergency drainage work, and then have accumulated experience on utilizing such old equipment.

It is very possible for DSD to maintain and utilize the Vehicle-mounted Drainage Pump procured by the Project through adequate training for operation and maintenance of the equipment.

The supplier/manufacturer of the Vehicle-mounted Drainage Pump shall carry out initial operation guidance of this equipment to transfer the operation and maintenance techniques to DSD staffs. After service system to receive appropriate maintenance services from the agent of the supplier/manufacturer shall be established and understood by DSD staffs during initial operation guidance.

In addition, in order to transfer the management skill to DSD staff, OJT training shall be conducted in the Project as the soft components. It is preferable to sustainable proper operation and maintenance of the Vehicle-mounted Drainage Pumps.

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 the confidentially.

(2) Cost Borne by Recipient Country

The cost to be borne by the Government of Cambodia is estimated to be about US$418,200 (47.7 million Japanese Yen). Breakdown is presented in the following table.

Table R 2.5.1 Project Cost Borne by Cambodian Government

Item		Cost (US$)	Cost (million Japanese Yen)
1	Land Acquisition and Temporary House Relocation	300,000	34.1
2	Advising Commission for Banking Arrangement (B/A) and Authorization to Pay (A/P), and Payment Commission	76,500	8.7
3	Periodical Environmental Monitoring Cost during the Construction Stage (12 times in total for 36 months)	13,200	1.5
4	Internal Transportation Cost for the Equipment for Drainage Pipe Cleaning Procured by the Project	4,000	0.5
5	Soft Component (Waste Bin: US$200 x 50pcs, Clean-up Campaign: US$2,000 x 5times)	20,000	2.3
6	Application Fee for Electricity at No.6 Pumping Station	4,000	0.5
7	Application Fee for Water Supply at No.6 Pumping Station	500	0.1
TOTAL		418,200	47.7

Exchange Rate: US$1.00 = 113.65 Japanese Yen (as of May 2016)

(3) Cost Estimation Conditions

1. Estimation Timing : May 2016

2. Foreign Exchange Rate : US$1.00 = JPY 113.65 US$: US Dollar
JPY: Japanese Yen

Foreign Exchange Rate applied is the average of Telegraphic Transfer Rate (TTS rate) for three months from February 2016 to April 2016.

3. Construction Period : The implementation schedule of the detailed design, construction and procurement is shown in **Subsection 2.2.4.9**.

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

2.5.2 Operation and Maintenance Cost

The increased amount of annual operation and maintenance cost after the Project is estimated to be US$72,400 in total. This amount is 17% of DSD's annual operation & maintenance cost and 2.9% of the PPCC's annual operation & maintenance cost of drainage facilities in 2014.

Annual operation and maintenance cost of drainage facilities and equipment constructed or procured by the Project is calculated as follows.

(1) Operation and Maintenance Cost of Drainage Pipes

Sludge deposits in drainage pipes reduce flow capacity. It also causes wastewater, and hydrogen disulphide and organic acids to accelerate corrosion of pipes. Therefore, it is essential to carry out regular inspections and remove deposits when observed. In Phnom Penh City, it has been confirmed in the site investigations that many portions of the drainage system are clogged with debris and sediment. Therefore, the frequency of cleaning work should be once in every five (5) years. According to the capital-outlay plan in the DPWT budget, the unit cost of drainage pipe cleaning is US$ 5/m, and unit cost of manhole cleaning is US$50/piece. The annual cleaning cost as the operation and maintenance cost of drainage pipes installed by the Project is approximately **US$15,300**, as estimated below.

[Total O&M Cost] US$5/m x 13,200m + US$50/piece x 209 pieces = US$76,450.-

[Annual O&M Cost] US$76,450/5years = US$15,290/year

(2) Operation and Maintenance Cost of Pumping Station, Underground Reservoir and Mechanical Screens

(a) Operation Cost (Electric Fee) of No.6 Pumping Station and Mechanical Screens (Auto Raking Machine)

The electric fee occupies major portion of operation cost of the newly established pumping station and mechanical screen.

Annual pump operation time is calculated based on record of precipitation and river water level in last four years (from 2011 to 2015), and annual operation cost is calculated based on this annual operation time and annual electric consumption. The annual operation cost of new pumping stations is about US$ 4,500.

Table R 2.5.2 Annual Operation Cost of No.6 Pumping Station and Mechanical Screens

No.6 Pumping Station	Unit	Value	Mechanical Screen	Unit	Value
Drainage Capacity	m^3/s	1.4	Number of Unit	unit	5
Average Electric Power	kW	90	Average Electric Power	kW	1.5
Annual Pump Operation Day	day	82	Annual Operation Day	day	365
Annual Pump Operation Hour	h	280	Daily Average Operation Hour	h	4
Annual Electric Consumption	kWh	27,440	Annual Electric Consumption	kWh	10,950
Unit Electric Fee	US$/kWh	0.18	Unit Electric Fee	US$/kWh	0.18
Annual Operation Cost	US$	4,536	Annual Operation Cost	US$	1,971

Note: Pump shall be operated during the period that river water level is higher than lowest water level of pump operation.
"Unit Electric Fee" is US$ 0.18/kWh, based on EDC rate applied for governmental facilities in 2014.

Five auto raking machine shall be installed as mechanical screen at four existing pumping station, namely Chak Tomuk Pumping Station (P1), Preah Kumlung Pumping Station (P2), Phsar Kandal Pumping Station (P4), and Phsar Chas Pumping Station (P5), and a new pumping station, namely No.6 Pumping Station.

Annual operation cost of mechanical screen is calculated based on the assumption that auto raking machine is operated every day through a year and daily operation time is four hours in average. Annual operation cost of five mechanical screens is about US$2,000.

(b) Maintenance Cost of No.6 Pumping Station and Repairing Cost of Mechanical Screens

Maintenance cost of No.6 pumping station and five mechanical screens consist of maintenance cost of the machinery, electric equipment and the trash removal work etc.

Maintenance cost of pumping station is assumed about US$5,000 based on actual total maintenance cost of existing pumping stations in Phnom Penh in 2014.

Maintenance cost of five mechanical screens is assumed about $4,800, based on the assumption that two workers do maintenance work through a year by monthly salary of US$200.

Repairing cost of mechanical screens shall be secured also. Annual repairing cost of mechanical screens is assumed about US$15,000/year (US$3,000 x 5units). Repairing cost includes material cost of repair parts and repairing service cost.

(c) Maintenance Cost of No.6 Underground Reservoir

No.6 Underground Reservoir shall be constructed under river bank of the Tonle Sap River. Major work of maintenance of underground reservoir shall be the cleaning work of inside of reservoir during the dry season. Cleaning work is basically done with the water jet and the brush by manpower. Cleaning work shall be done every year because sludge, soil, trash and garbage will sediment in reservoir.

The annual maintenance cost of underground reservoir is estimated to be about US$ 4,200, since unit price of cleaning work is assumed as US$ 2.5/m^2 and floor area of reservoir is about 1,700 m^2.

(d) Total Operation and Maintenance Cost of No.6 Pumping Station, No.6 Underground Reservoir and Mechanical Screens

Total operation and maintenance cost of No.6 Pumping Station, No.6 Underground Reservoir and 5units of Mechanical Screens is estimated at about **US$35,500** as shown in the table below.

Table R 2.5.3 Total Annual Operation and Maintenance Cost of No.6 Pumping Station, No.6 Underground Reservoir and Mechanical Screens

Item	Cost [US$]
Annual Operation Cost of Pump (Electricity) (for No.6 Pumping Station)	4,500
Annual Operation Cost of Mechanical Screen (for 5 units)	2,000
Annual Maintenance Cost of No.6 Pumping Station	5,000
Annual Maintenance Cost of Mechanical Screen (for 5 units)	4,800
Annual Repairing Cost of Mechanical Screen (for 5 units)	15,000
Annual Maintenance Cost of No.6 Underground Reservoir	4,200
Total Operation and Maintenance Cost	35,500

This additional amount of annual operation and maintenance cost of No.6 Pumping Station, No.6 Underground Reservoir and 5units of Mechanical Screens is about 2.5% of present total operation and maintenance cost of existing pumping stations in PPCC, which is about US$1,395,000 (5,578million Riel) in 2014.

(3) Operation and Maintenance Cost of Vehicle-Mounted Drainage Pump (Drainage Pump Vehicle)

DSD has been utilizing a very aged Vehicle-mounted Drainage Pump, which was manufactured in 1987, for emergency drainage work in Phnom Penh. Expenditures, such as fuel and maintenance costs of equipment, are covered under the annual budget of DSD. Two units of drainage vehicles newly procured under the Project will be managed instead of the present aged equipment for emergency drainage work; hence, number of operation staff is assumed as almost the same as the present. When new equipment is procured, work opportunity of emergency drainage work will be increased, and then fuel cost will be increased also. Necessary additional cost for the new drainage equipment is estimated to be about **US$8,800** as shown in the table below (working time: 2month/year, 15day/month)

Table R 2.5.4 Total Annual Operation and Maintenance Cost of Vehicle-Mounted Drainage Pump

Item	Calculation	Cost [US$]
Fuel	US$ 80/day x 2units x 2months x 15days	4,800
Maintenance Parts, Lubricant, etc.	US$ 1,000 x 2units	2,000
Insurance	US$ 1,000 x 2units	2,000
total		8,800

Additional cost to arrange the parking area of new equipment is not necessary because there are enough parking spaces for new equipment at the DSD workshop.

According to the present situation of existing facilities and equipment managed by DSD, the aged equipment has been kept for more than 15 years through the grace and dedicated maintenance services of DSD personnel.

Service life of the cleaning equipment procured by the Project will be guaranteed for 5 years, in general. It is possible to make the service life of equipment longer than the expected economic life by proper management and maintenance work. With proper maintenance as the prerequisite condition, service life of the new equipment procured by the Project is expected to be 10 years.

(4) Operation and Maintenance Cost of Manhole Pump

Manhole pump is installed to pump up sewer water from interceptor to existing drainage pipe at street No.273. Operation and maintenance cost of manhole pump is approximately **US$12,800**, as estimated in the table below.

Table R 2.5.5 Total Annual Operation and Maintenance Cost of Manhole Pump

Manhole Pump	Unit	Value	Manhole Pump	Unit	Value
Pump Diameter	mm	100	Annual Electric Consumption	kWh	64,240
Pump Drainage Capacity	m^3/min.	2.0	(5.5kW×2units×16hr×365day=64,240kWh/year)		
Number of Pump	Unit	2	Unit Electric Fee	US$/kWh	0.18
Electric Power	kW	5.5	Annual Operation (Electric) Cost	US$	11,563
Daily Working Time	h	16	Annual Maintenance Cost	US$	1,200
Annual Working Days	day	365	Total of Annual O&M Cost	US$	12,800

Note) Annual Maintenance Cost is assumed 1% of initial cost.
"Unit Electric Fee" is US$ 0.18/kWh, based on EDC rate applied for governmental facilities in 2014.
US$1 = 4,000Riel

(5) Total Operation and Maintenance Cost

As a result of the studies described in subsections (1)~(4) about operation and maintenance

cost of drainage facilities and equipment, which are constructed and procured by the Project, total annual operation and maintenance cost is calculated as **US$72,400** as shown in the table below.

Table R 2.5.6 Total Annual Operation and Maintenance Cost of the Project

Item for Operation and Maintenance Cost	Cost [US$]
(1) Drainage Pipes	15,300
(2) Pumping Station, Underground Reservoir and Mechanical Screens	35,500
(3) Vehicle-Mounted Drainage Pump	8,800
(4) Manhole Pump	12,800
Total Operation and Maintenance Cost	72,400

The following table compares total increased amount of annual operation and maintenance cost of drainage facilities after the Project implementation with present actual expenditures of DSD and PPCC, and sales revenue of PPWSA as a budget source.

Table R 2.5.7 Comparison Total Annual Operation and Maintenance Cost of the Project

Item	Data Source	Actual Expenditure in 2014	
		[US$]	[million Riel]
DSD's Annual Operation & Maintenance Cost (consist of Drainpipe cleaning, Drainpipe repair, Pumping station repair, Drainage ditch & balancing reservoir cleaning)	DSD	438,000	1,751
PPCC's Annual Operation & Maintenance Cost of Drainage Facilities (consist of Pumping station electricity & fuel expenses, Pumping building & facilities maintenance expenses, Pipe & channel cleaning expenses)	PPCC	2,463,000	9,850
Total Increased Amount of Annual Operation and Maintenance Cost of Drainage Facilities after the Project	JICA Survey Team	72,400	290

Note) US$1 = 4,000Riel

The increased amount of annual operation and maintenance cost after the Project is estimated to be US$72,400 in total. This amount is about 17% of the DSD's annual operation & maintenance cost and 2.9% of the PPCC's annual operation & maintenance cost of drainage facilities in 2014.

Total amount of expenditures of DSD or PPCC (except irregular expenditures) after project implementation is estimated to be still much lower than amount of PPCC's general accounting budget.

Therefore, it can be deemed that budget for operation and maintenance cost for new facilities and equipment is secured.