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 THE PHNOM PENH CAPITAL CITY (PHASE III) IN THE KINGDOM OF CAMBODIA

March 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

CTI ENGINEERING INTERNATIONAL CO., LTD.
in association with
NIPPON KOEI CO., LTD

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the Preparatory Survey on the Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III) in the Kingdom of Cambodia, and organized a survey team consisting of members from CTI Engineering International Co., Ltd. and Nippon Koei Co., Ltd., headed by Mr. Tsuyoshi MATSUSHITA of CTI Engineering International Co., Ltd., between March 1st 2010 to April 13th, 2010.

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 the 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.

March 2011

Shinya EJIMA
Director General
Global Environmental Department
Japan International Cooperation Agency

SUMMARY

1. Outline of Cambodia

With an area of 181,000 square kilometers, the Kingdom of Cambodia had the population of about 13.4 million in 2008. Gross Domestic Product (GDP) per capita of Cambodia is US$ 775. 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 5% stably since 1999 after Asian Economic Crisis. The Government of Cambodia (hereinafter referred to as "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 of 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. As a result, 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 Phonm 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 "GOJ") to formulate a Master Plan for drainage improvement and flood control in Phnom Penh Capital City and suburbs (hereinafter referred to as "the Master Plan"). In response, the GOJ had dispatched a study team through the Japan International Cooperation Agency (hereinafter referred to as "JICA") to formulate the 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" (hereinafter, referred to as "the Phase 1") from 2001 to 2004, and "The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)" (hereinafter, referred to as "the Phase 2") from 2006 to 2010 were carried out under the Japan's Grant Aid Scheme.

Although drainage conditions in the southwest area, city centre and the northeast areas of the city have greatly improved after then, areas in the southeast area such as the Trabek Basin and its vicinity are still experiencing serious inundation damage in the rainy season. Therefore, "THE PROJECT FOR FLOOD PROTECTION AND DRAINAGE IMPROVEMENT IN THE PHNOM PENH CAPITAL CITY (Phase III)" (hereinafter referred to as "the Project") has been requested in October 2008 by the GOC for

implementation under Japan’s Grand Aid to improve the drainage condition in the remaining southeast areas. Subsequently, request letter from Governor of Phnom Penh Capital City regarding additional works of the Project was submitted in October 2009.

The requested contents from GOC as the Project of Japan’s Grant Aid are summarized in following table.

<table>
<tr><th colspan="2">Item</th><th colspan="2">Content</th></tr>
<tr><td rowspan="2">Construction of Facilities</td><td>Requested in October 2008</td><td>Drainage Improvement in Trabek Area
Trabek North Drainage Area 5.60km
Trabek West Drainage Area 4.00km
Trabek Center Drainage Area 4.36km
Trabek East Drainage Area 1.34km
Trabek South-1 (1) Drainage Area 6.61km
Trabek South-1 (2) Drainage Area 1.20km
Trabek South-2 Drainage Area 2.73km</td><td>Total Length 25.84km</td></tr>
<tr><td rowspan="2">Requested in October 2009</td><td colspan="2">Reconstruction of Big Chamber at R240</td></tr>
<tr><td>Procurement of Equipment</td><td colspan="2">Procurement of High Water Cleaner Equipment</td></tr>
</table>

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

JICA dispatched the Preparatory Survey Team to Cambodia from March 1 to April 13, 2010. 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 January 10 to 15, 2011. Both sides had agreed on the contents and the finalization of the Preparatory Survey Report.

3.1 Outline of the Survey/Design

(1) Drainage Improvement

To confirm and understand actual inundation state in Trabek area, interview surveys to Sangkat chief and residents around frequently inundated roads were carried out. And then, appropriate layout and scale of the drainage network were studied in consideration of results of interview survey. Basic policies and prerequisite conditions for designing of the drainage improvement were set as followings:

- Planning scale of the drainage network was set as 2-year return period of rainfall in consideration of recent rainfall intensity;
- 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;
- Drainage network detail shall be studied and designed on the basis of hydraulic simulation to be able to achieve the above improvement target;
- Retention ponds around the Olympic Stadium will be reclaimed by the GOC due to the

environmental reasons. Retention capacity of those ponds was eliminated from drainage function in the course of simulation; and

- The present condition of the Trabek Pond must be preserved to keep the regulation capacity, and the pond shall never be reclaimed in the future to ensure its function as regulation pond of the Trabek Pumping Station.

(2) Reconstruction of Big Chamber at R240

The Big Chamber at R240 is older than 50years and deteriorated deeply with cracks and bending on slab. It needs to be reconstructed. The chamber shall be reconstructed to keep functions of present chamber and to make maintenance work easier.

Concrete design policies and methodologies of reconstruction of the chamber are as followings:

- New chamber shall be constructed at same site of the present one to keep drainage system around the chamber, to minimize the construction cost and to shorten the construction period;

- Pile foundation was adopted as the foundation of the new chamber to avoid uneven settlement and deformation;

- Design capacity of sediment pit of the new chamber shall be more than 140m^3 which is assumed volume of sediment inflowing to the chamber;

- Countermeasure against floating garbage adopted “Free-Passing Type” ,which is without screen and siphon to keep free flow in the chamber; and

- Accessibility to inside of the chamber is improved for easy-maintenance by increasing the number of manholes.

(3) Procurement of Cleaning Equipment for Drainage Pipes

Drainage and Sewerage Division (DSD) of Phnom Penh Capital City is the responsible organization of operation and management of drainage system. Cleaning equipments for drainage pipe owned by DSD are deteriorated and work efficiency is quite low. Moreover, cleaning workers work in the drainage pipe for hours in spite of dangerousness of accident and disease by poisonous gas and virus. Hence, it is indispensable to procure cleaning equipment of drainage pipe in consideration of those working condition of drainage pipe cleaning. Cleaning equipments will help to improve the work efficiency and to safety of the cleaning workers.

(4) Soft component Plan

Considering the present condition of operation and maintenance work of drainage pipe by DSD, it is necessary to implement technical assistance with soft component to enhance the management capability of DSD on operation and maintenance work of drainage pipe. The soft component (technical assistance) aims to enable the DSD carry out the systematic and scheduled maintenance work introducing the PDCA cycle and to utilize drainage facilities/equipment constructed/procured by Japan's Grant Aid Projects.

3.2 Contents of the Project

Based on the above considerations, the following structures/equipments shall be constructed/procured by the Project as the Japanese assistance.

Project Items		Quantity	Contents, Specification
Drainage Improvement	Ou Russei Area	3,926m	236m Dia. 600mm 680m Dia. 800mm 1,673m Dia. 1,000mm 81m Dia. 1,500mm 78m Dia. 1,800mm 675m Dia. 2,000mm 411m Box Culvert 2m x 2.5m 13m Box Culvert 1m x 1.5m 79m Box Culvert 1m x 1.25m
	Boeng Reang Area	2,433m	811m Dia. 1,000mm 1,077m Dia. 1,200mm 362m Dia. 1,500mm 153m Box Culvert 1m x 1.5m
	Monireth Area	2,047m	657m Dia. 1,000mm (partly two lines) 428m Dia. 1,200mm 952m Dia. 1,500mm
	Tuol Svay Prey Area	2,524m	645m Dia. 800mm 347m Dia. 1,000mm 349m Dia. 1,200mm 746m Dia. 1,500mm 82m Dia. 1,800mm 355m Dia. 2,000mm
	Tuol Sleng Area	2,475m	1,012m Dia. 800mm 489m Dia. 1,000mm 370m Dia. 1,200mm 604m Dia. 1,500mm (two lines)
	Boeng Keng Kang Area	3,045m	1,777m Dia. 1,000mm (partly two lines) 364m Dia. 1,200mm 904m Dia. 1,500mm (two lines)
	Tuol Tumpung North Area	1,147m	54m Dia. 1,000mm 483m Dia. 1,200mm 610m Dia. 1,500mm
	Tuol Tumpung South Area	3,057m	124m Dia. 600mm 708m Dia. 800mm 854m Dia. 1,000mm 602m Dia. 1,200mm 769m Dia. 1,500mm
	Total Length of Drainage Pipes		20,654m
Reconstruction of Sediment Chamber at R240	Sediment Chamber at R240	1	Size: Length approx. 21m x Width 9.4m x Height approx. 4.2m Pile Foundation (400mm x 400mm PC Pile) Storage Capacity of Sediment : 140m^3 or more
Procurement of Drainage equipment for Drainage Pipes	Water jet Machine	2	Gross Vehicle Weight (GVW) : 10,000kg or more Volume of Water Tank : 3m^3 or more Length of Suction Hose : 100m or more
	Sludge Sucker	2	Gross Vehicle Weight (GVW) : 15,000kg or more Volume of Sludge Tank : 4.5m^3 or more Vacuum Pump Type : Blower Type
Technical Assistance by Soft Component	To enable to appropriate management, maintenance and utilization of constructed drainage system and procured equipment in the Project, technical assistance by soft component shall be implemented. The soft component (technical assistance) aims to establish the systematic and scheduled maintenance framework introducing the PDCA cycle.		

4. Implementation Period and Project Cost

Implementation period of the Project is estimated to be 7.5 months for detailed engineering design, and 44 months for construction work including procurement of equipments. The project cost to be borne by the recipient country is estimated to be about US$113,000 (10.3 million Japanese Yen).

5. Project Evaluation

5.1 Adequacy of the Project

Adequacy to execute of the Project has been verified from the following viewpoints.

- Target Scale to be Benefited:
  Beneficially is estimated approximately 230 thousand residences, 50 thousand households, 2,600 shops, 4 large markets, 400 merchandise facilities and 60 public facilities.

- Human Security:
  The Project would contributes 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 the 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 Trabek area will be reduced against 2-year probability rainfall as shown in following table. Furthermore, inundation frequency will also be reduced.

Drainage Area	Inundation Duration (hrs)		
	(1) Present	(2) after Reclamation of Ponds around Olympic Stadium	(3) after Completion of the Project
(1) Ou Russei	1.0	More than 10.0	1.5
(2) Boeng Reang	3.5	3.5	2.0
(3) Monireth	2.0	2.5	1.0
(4) Tuol Svay Prey	3.0	3.0	1.5
(5) Tuol Sleng	2.5	3.0	1.5
(6) Boeng Keng Kang	2.0	2.0	0.8
(7) Tuol Tumpung North	5.0	4.8	1.5
(8) Tuol Tumpung South	6.0	7.0	1.5

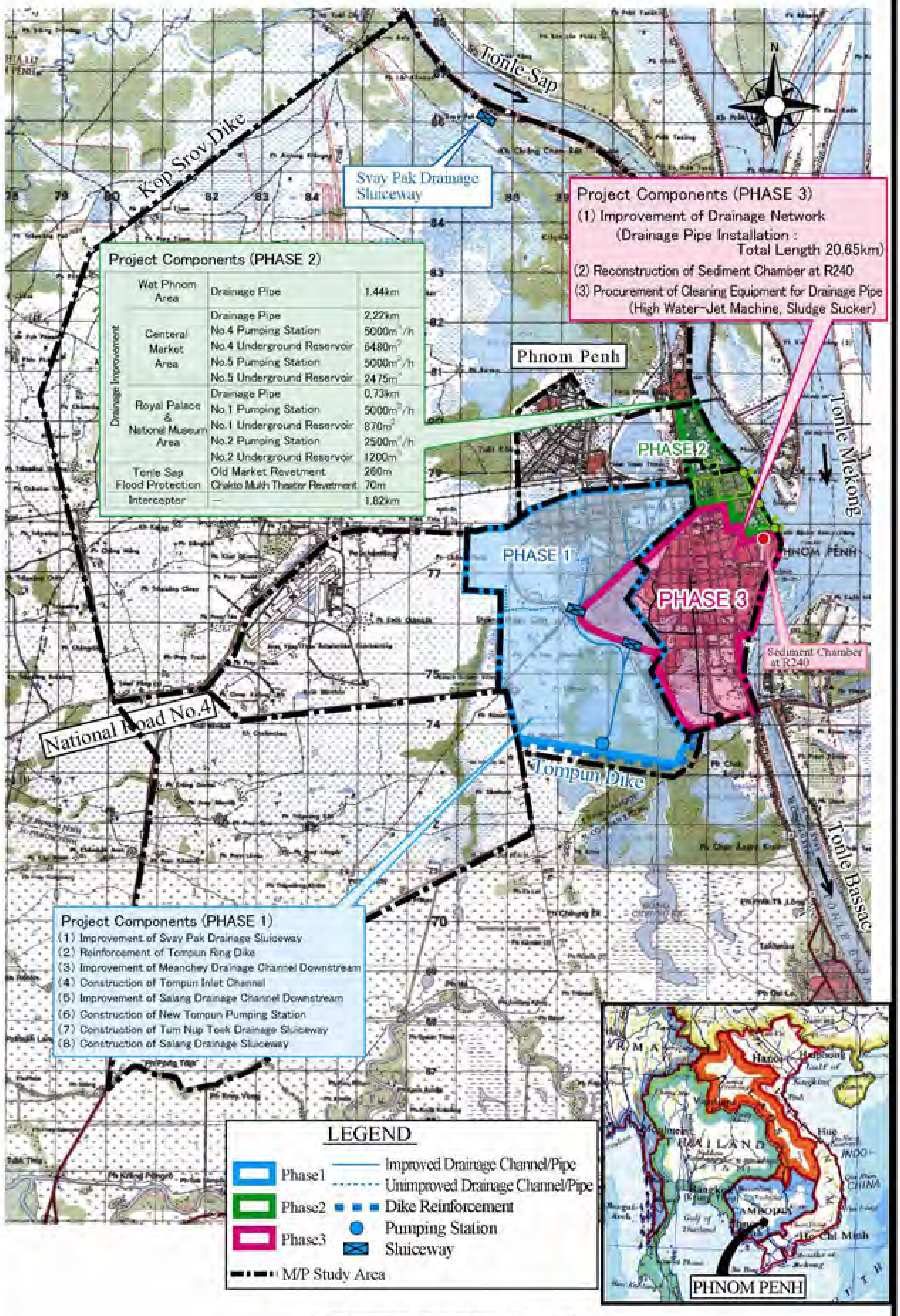
(2) Indirect Effectiveness

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

- Hygienic Effectiveness
  As the indirect effect of the improvement of urban drainage facilities in the Project, the prevention of occurrence and spread of epidemics 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.

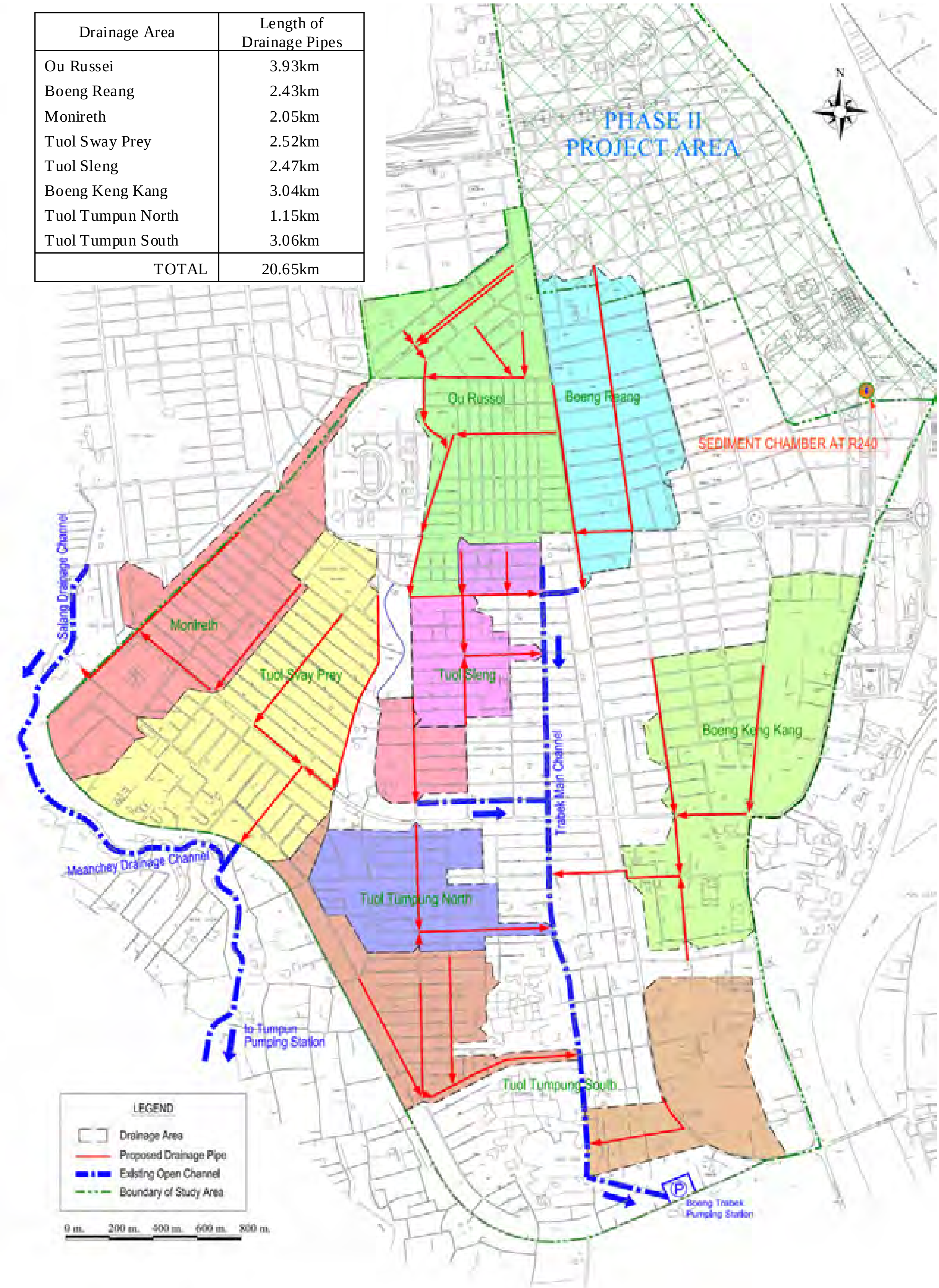
- Drainage Improvement in whole Phnom Penh
  DSD's capacity development of management and maintenance of drainage facilities will contribute the improvement of drainage facilities in not only Trabek area but also whole Phnom Penh Capital City.



LOCATION MAP

Proposed Length of Drainage Pipes

Drainage Area	Length of Drainage Pipes
Ou Russei	3.93km
Boeng Reang	2.43km
Monireth	2.05km
Tuol Sway Prey	2.52km
Tuol Sleng	2.47km
Boeng Keng Kang	3.04km
Tuol Tumpun North	1.15km
Tuol Tumpun South	3.06km
TOTAL	20.65km



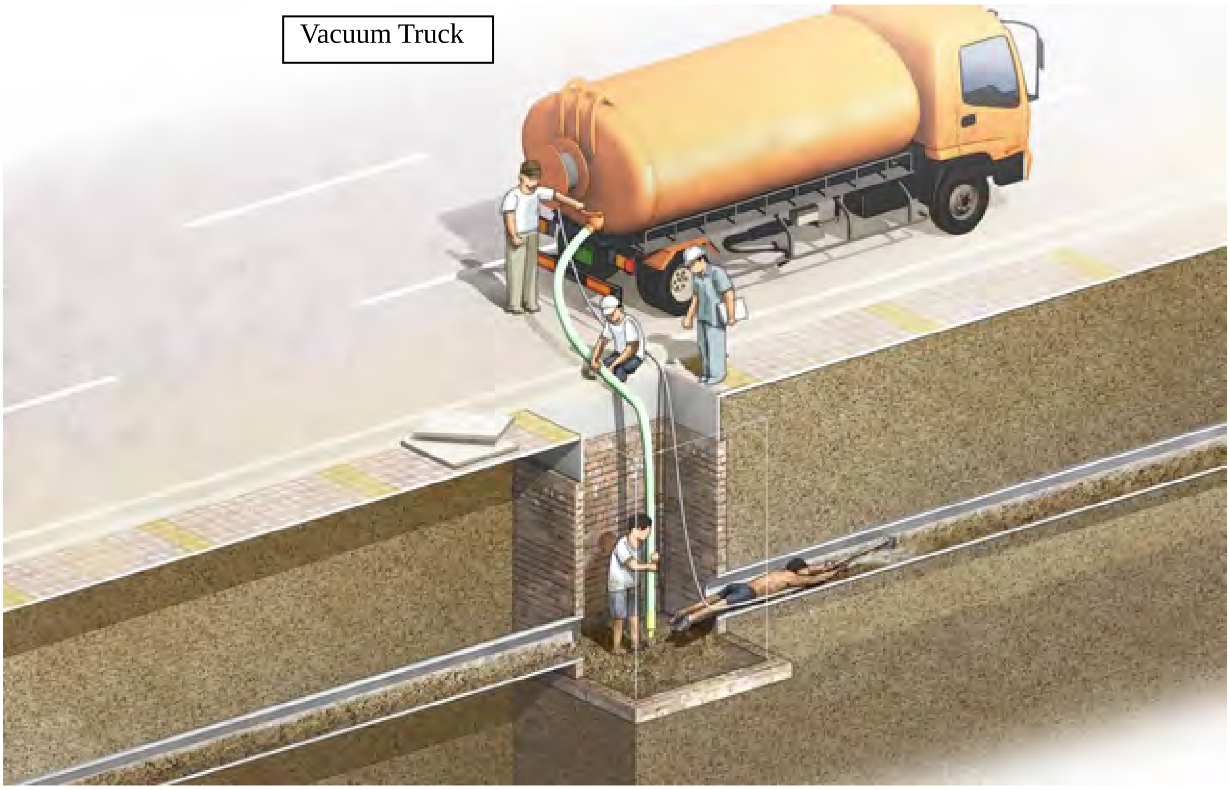
PROJECT AREA

Perspectives – Installation of Drainage System

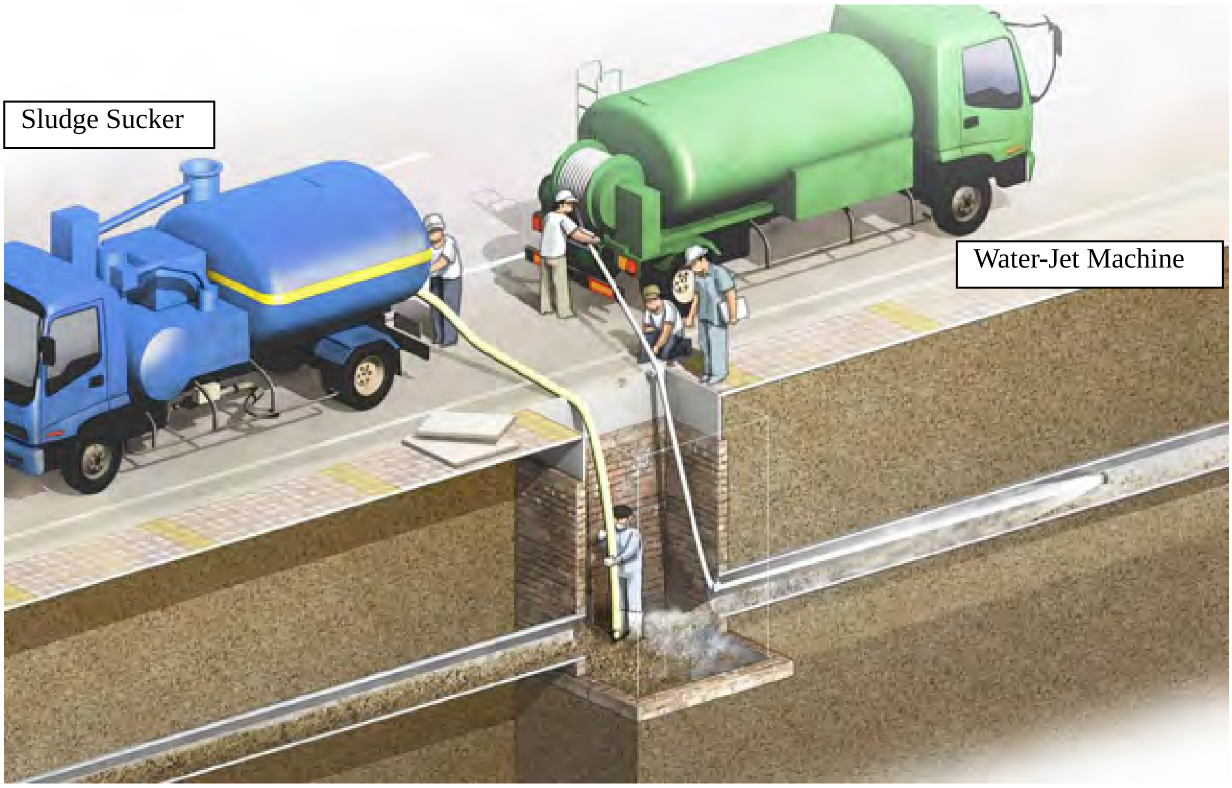
Present Flooding State in Phonm Penh Capital City when Hard Rain Happens

State after Completion of the Project when Hard Rain Happens

Perspectives – Procurement of Cleaning Equipment for Drainage Pipes



Present Cleaning Work State of Drainage Pipes in Phonm Penh Capital City



Cleaning Work State of Drainage Pipes after Procurement of Cleaning Equipment in the Project

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ABBREVIATIONS AND ACRONYMS

1. Organizations

ADB	Asian Development Bank
AFD	Agence Française de Développement
AASHTO	American Association of State Highway and Transportation Officials
BAU	Bureau des Affaires Urbaines (Bureau of Urban Affair)
CDC	Council for the Development of Cambodia
DEF	Department of Economy and Finance
DPWT	Department of Public Works and Transport
DSD	Drainage and Sewerage Division
DOE	Department of Environment
EDC	Electricité du Cambodge
EOJ	Embassy of Japan in Cambodia
JICA	Japan International Cooperation Agency
MPWT	Ministry of Public Works and Transport
MWRM	Ministry of Water Resources and Meteorology
PPCH	Phnom Penh Capital Hall
PMU	Project Management Unit
PPWSA	Phnom Penh Water Supply Authority
UNDP	United Nations Development Programme

2. Others

A/P	Authorization to Pay
ASTM	American Society for Testing and Materials
B/A	Banking Arrangement
BHN	Basic Human Need
BOD	Biochemical Oxygen Demand
CBR	California Bearing Ratio
CTS	Compact Type Transformer Substation
CIF	Cost, Insurance and Freight
GDP	Gross Domestic Product
GNI	Gross National Income
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EGS	Emergency Diesel-Engine Drive Generator Sets
E/N	Exchange of Notes
FOB	Free-on-Board
IEE	Initial Environmental Examination
JIS	Japan Industrial Standards
M/M	Man-Month
NGO	Non-Governmental Organization
NPRS	National Poverty Reduction Strategy
NSDP	National Strategic Development Plan
O&M	Operation and Maintenance
ODA	Official Development Assistance
PRSP	Poverty Reduction Strategy Paper
SEDP	Socio-Economic Development Plan
SPT	Standard Penetration Test
SWL	Surcharge Water Level
UGR	Underground Reservoir

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 at the western side of the confluence of Mekong River and Tonle Sap. It is the political, economic and cultural centre of the country and had the population of about 1.3 million in 2008.

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 of the drainage facilities have stopped functioning well due to old age, as well as insufficient 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 Capital City but the whole country in general.

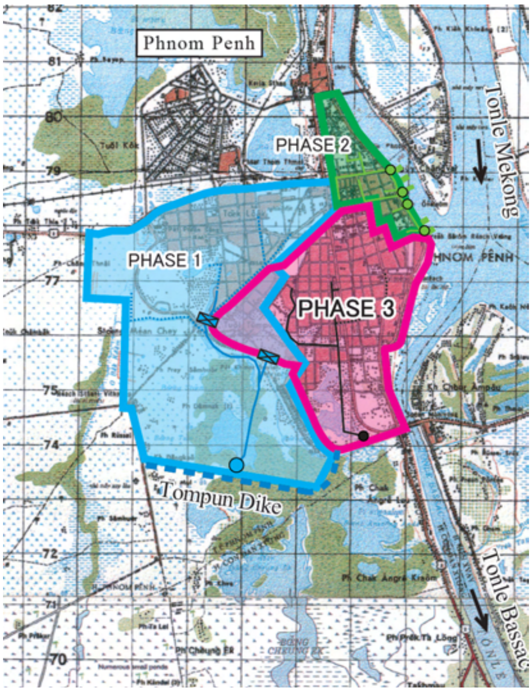


Fig. R 1.1.1 Area of Japan's Grant-Aid Project

To spur development, the Government of Cambodia made a request for technical cooperation from the Government of Japan to formulate a master plan for drainage improvement and flood control in Phnom Penh Capital City and suburbs. In response, the Government of Japan dispatched a study team through the Japan International Cooperation Agency (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, and as a result of a feasibility study, urgently necessary components of the priority projects were selected.

Based on these priority projects, the projects shown in Table R 1.1.1 have been carried out under the Japan's Grant Aid scheme.

Table R 1.1.1 Japan's Grant Aid Projects Implemented in the Past

Project	Project Period	Target Area	Project Components
Phase 1	2001~2004	Southwest area of the city (Tompun Watershed)	Dike Reinforcement, Drainage Channel, Pumping Station, Sluiceway, Bridge, Road
Phase 2	2006~2010	City centre and northeast area of the city (Central Market Area, Royal Palace & National Museum Area, Wat Phnom Basin)	Revetment, Drainage Pipe, Underground Reservoir, Pumping Station

Phase 1: The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh
Phase 2: The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)

Although drainage conditions in the southwest area, city centre and the northeast areas of the city have greatly improved after then, areas in the southeast area such as the Trabek Basin and its vicinity are still experiencing serious inundation damage in the rainy season. Therefore, “THE PROJECT FOR FLOOD PROTECTION AND DRAINAGE IMPROVEMENT IN THE PHNOM PENH CAPITAL CITY (Phase III)” (hereinafter referred to as “the Project”) has been requested by the Cambodian Government for implementation under Japan’s Grand Aid to improve the drainage condition in the remaining southeast areas.

1.2 Contents of the Request

The Government of Cambodia made a request for technical cooperation through the Japan’s Grant Aid scheme for the Project to the Government of Japan on October 10, 2008 to minimize inundation caused by local rainfall and to reduce inundation damage. The request consists of installation of drainage pipes as shown in the table below.

Table R 1.2.1 Contents of Request from the Government of Cambodia

Drainage Area	Diameter	Length	Drainage Area	Diameter	Length
Trabek North Area (Sub-total : 5.60km)	ϕ 600mm	0.24km	Trabek East Area (Sub-total : 1.34km)	ϕ 1000mm	0.82km
	ϕ 800mm	1.45km		ϕ 1500mm	0.52km
	ϕ 1000mm	2.22km	Trabek South-1(1) Area (Sub-total : 6.61km)	ϕ 600mm	1.81km
	ϕ 1200mm	0.47km		ϕ 700mm	0.26km
	ϕ 1500mm	1.22km		ϕ 800mm	0.92km
Trabek West Area (Sub-total : 4.00km)	ϕ 600mm	1.56km		ϕ 900mm	0.61km
	ϕ 1000mm	0.31km		ϕ 1000mm	0.24km
	ϕ 1200mm	0.26km		ϕ 1200mm	0.86km
	ϕ 1300mm	0.48km		ϕ 1500mm	1.91km
	ϕ 1500mm	0.92km	Trabek South-1(2) Area (Sub-total : 1.20km)	ϕ 1000mm	0.24km
	ϕ 1700mm	0.47km		ϕ 1500mm	0.96km
Trabek Centre Area (Sub-total : 4.36km)	ϕ 600mm	2.06km	Trabek South-2 Area (Sub-total : 2.73km)	ϕ 500mm	0.52km
	ϕ 800mm	0.37km		ϕ 600mm	1.22km
	ϕ 900mm	0.75km		ϕ 700mm	0.36km
	ϕ 1000mm	0.80km		ϕ 800mm	0.31km
	ϕ 1200mm	0.38km		ϕ 900mm	0.32km
Drainage Improvement in Trabek Area : Total Length = **25.84km**					

In October 2009, a supplemental request for technical cooperation on the following works was submitted by the Governor of Phnom Penh Capital City (PPCC) as shown in table below.

Table R 1.2.2 Contents of Additional Request from the Governor of PPCC

Item	Quantity	Remarks
Additional Request from Governor of Phnom Penh Capital City on October 28th, 2009		
Reconstruction of Big Chamber at R240	1 Location	Reconstruction is urgently required.
Procurement of High Water Jet Cleaner Equipment	-	Specifications are not mentioned.

1.3 Natural Condition of the Project Area

1.3.1 Meteorological Phenomena

Meteorological data and water level of the Tonle Sap necessary for planning and designing have been collected. Meteorological data from 2001 to 2009 were collected from the Pochentong Station which is managed by the Ministry of Water Resources and Meteorology (MWRM). The collected items are 1) Rainfall, 2) Humidity, 3) Maximum and Minimum Temperature, and 4) Wind Speed and Direction.

Water level data of the Tonle Sap were collected from Chaktomuk station and Phnom Penh Port station. The periods of collected water level data are from 2001 to 2009. Salient features are as follows:

(1) Rainfall

Average annual rainfall is approximately 1,400mm; however, the range of annual rainfall is wide, i.e., the maximum is 1,934mm (2008) and the minimum is 1,153mm (2004).

On a year round basis, precipitation and rainy days from December to April are around 50 mm/month and 5 days/month respectively, while those from May to November are more than 100 mm/month and 15 days/month, respectively. In general, the monthly maximum of precipitation and rainy days is recorded from August to October.

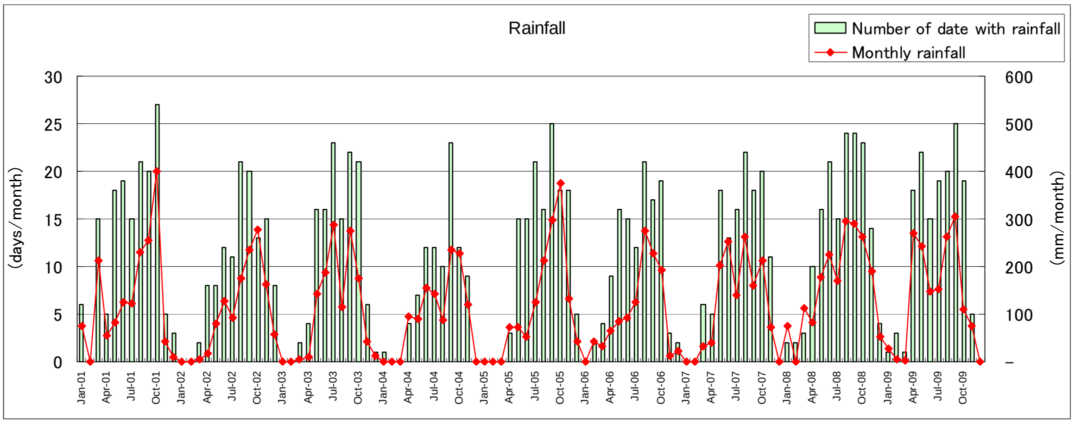


Fig. R 1.3.1 Rainfall Data at Pochentong Station (2001-2009)

(2) Temperature and Humidity

Annual average of monthly maximum temperature is 36 degrees centigrade and monthly minimum temperature is 22 degrees centigrade in the past 9-years. Annual fluctuation range of monthly maximum/minimum temperature was less than 10 degrees centigrade and monthly maximum temperature was always more than 30 degrees centigrade. From March to May, especially, the highest temperature persists. The maximum temperature of 40.0 degrees centigrade was recorded in May 2005, while the minimum temperature of

17.2 degrees centigrade was recorded in December 2001. Monthly average of humidity ranges from 70% to 80% in general.

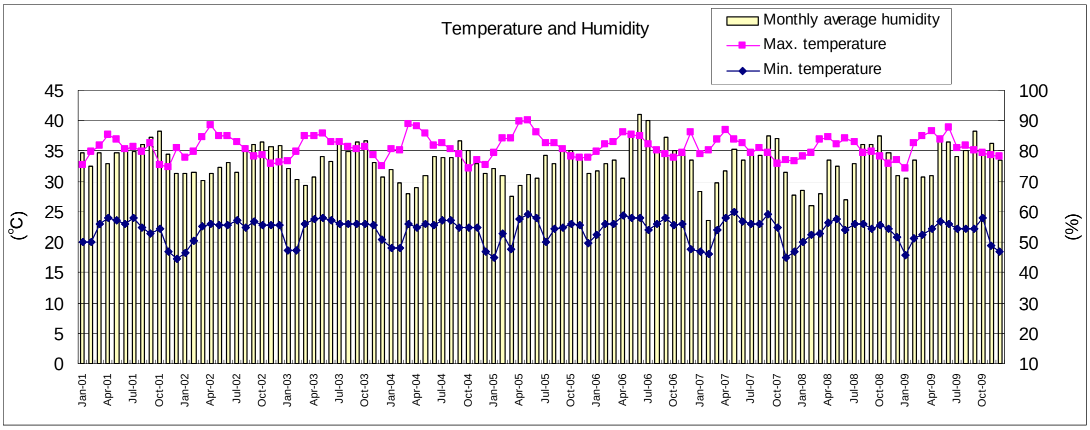
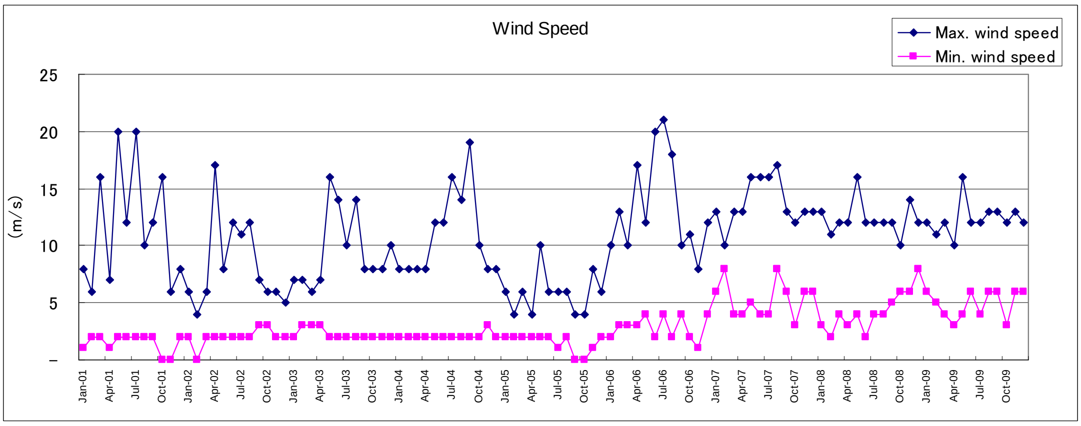


Fig. R 1.3.2 Temperature and Humidity Data at Pochentong Station (2001-2009)

(3) Wind Speed and Wind Direction

The maximum wind speed is 21 m/s recorded in 2006. In general, high wind speed is recorded in the dry season. Wind direction varies with the season: northerly from October to January, south-easterly from February to April, and south-westerly from May to September.



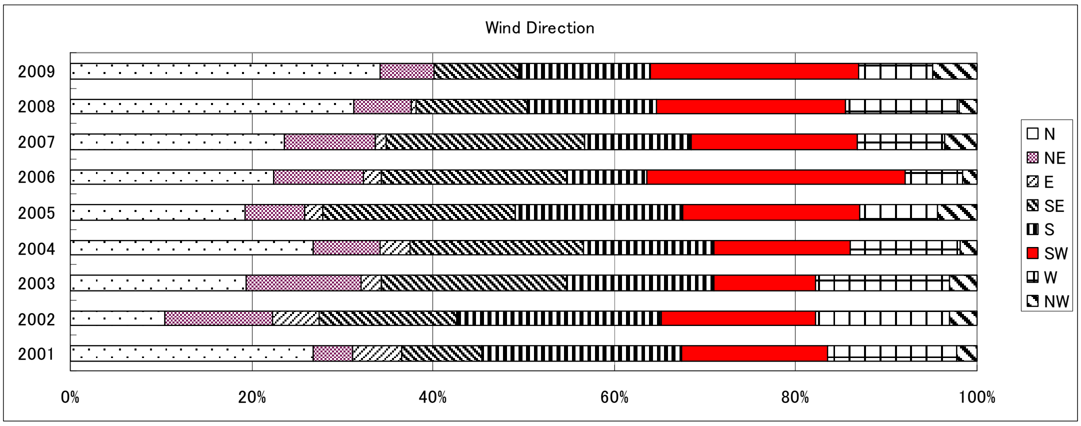


Fig. R 1.3.3 Wind Speed and Wind Direction Data at Pochentong Station (2001-2009)

(4) Water Level of Tonle Sap River

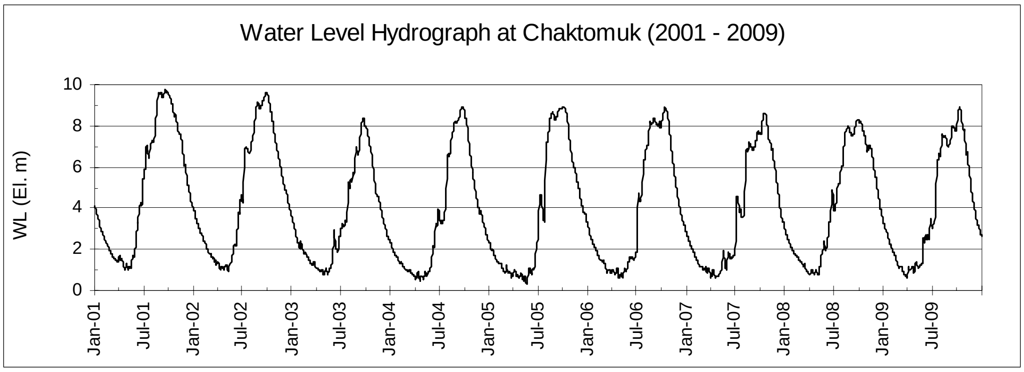
Water level the Tonle Sap River ranges from EL. +9.00 m to EL. +1.00 m, starts rising in May and dropping in October. The highest and lowest water levels in the last 9 years were EL. +9.73 m at Chaktomuk station in September 2001 (EL. +9.78 m at Phnom Penh Port station in September 2002) and EL. +0.33 m at the Chaktomuk station in May 2005 (EL. +0.78 m at the Phnom Penh Port station in April 2006). The highest water level in the record was EL. +10.18 m at Chaktomuk station on 20 September 2000.

Table R 1.3.1 River Water Level around Phnom Penh (2001-2009)

Water Level

Station		2001	2002	2003	2004	2005	2006	2007	2008	2009
Chrui Changvar	Max.	9.69	9.82	8.62	9.29	9.24	9.12	-		
	Min.	0.94	0.91	0.85	0.68	1.04	1.13	-		
Phnom Penh Port	Max.	9.64	9.78	8.50	9.10	9.03	8.98	8.79	8.49	9.03
	Min.	0.94	0.88	0.80	0.55	0.54	0.48	0.70	0.84	1.00
Chaktomuk	Max.	9.73	9.63	8.41	8.95	6.91	8.88	8.62	8.30	8.91
	Min.	1.03	0.94	0.74	0.50	0.33	0.61	0.59	0.76	0.65

Note: Water level observation at Chrui Changvar Station was stopped on March 31, 2007.



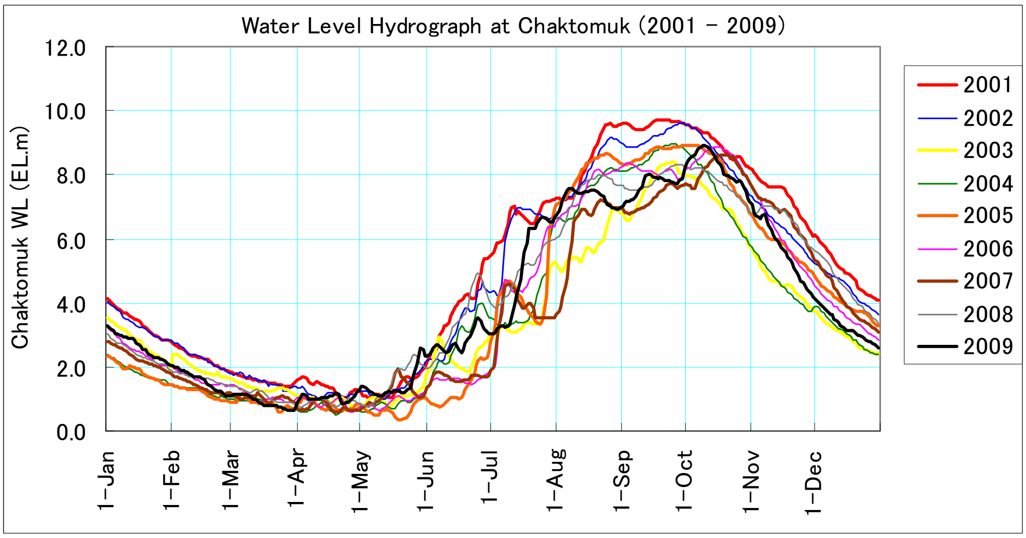
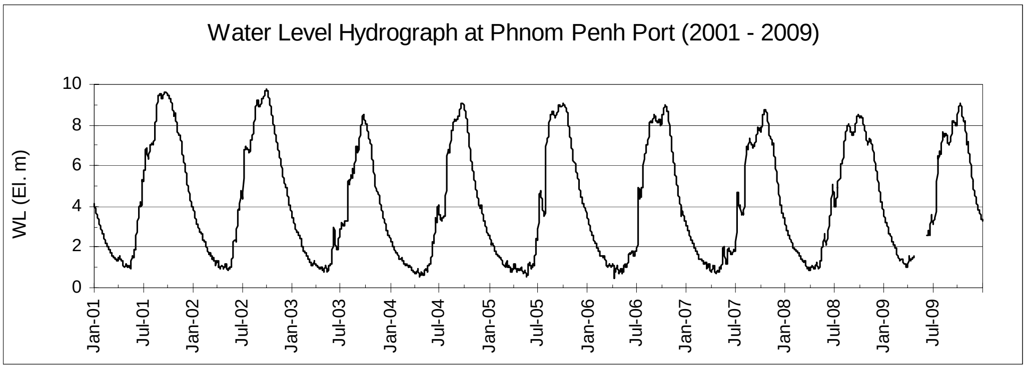


Fig. R 1.3.4 Water Level of Tonle Sap at Chaktomuk Station



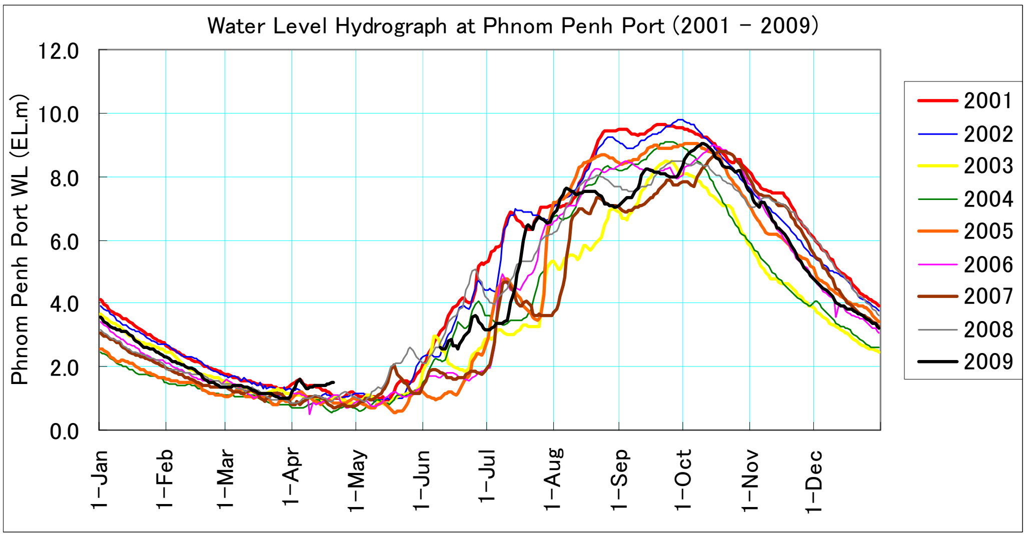


Fig. R 1.3.5 Water Level of Tonle Sap at Phnom Penh Port Station

1.3.2 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 conducted topographic surveys were as follows:

- Longitudinal profile and cross section survey of the roads along the planning drainage pipe lines.
- Plan survey around existing Big Chamber at R240.

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 the Topographic Survey

Work Items	Survey Items	Quantities
Road	Longitudinal Profile	26.0 km
	Cross Section	About 520 sections (interval: 50m)
Big Chamber	Plan Survey	10,000 m^2

At Street No. 182 (Road Survey)

At intersection between Monireth Blvd. and Mao Tse Toung Blvd. (Road Survey)

Around Big Chamber South of Royal Palace (Plan Survey)

Source: JICA Study Team

Photo R 1.3.1 Site Conditions during the Topographic Survey

Fig. R 1.3.6 Location of Longitudinal Profile and Cross Section Survey

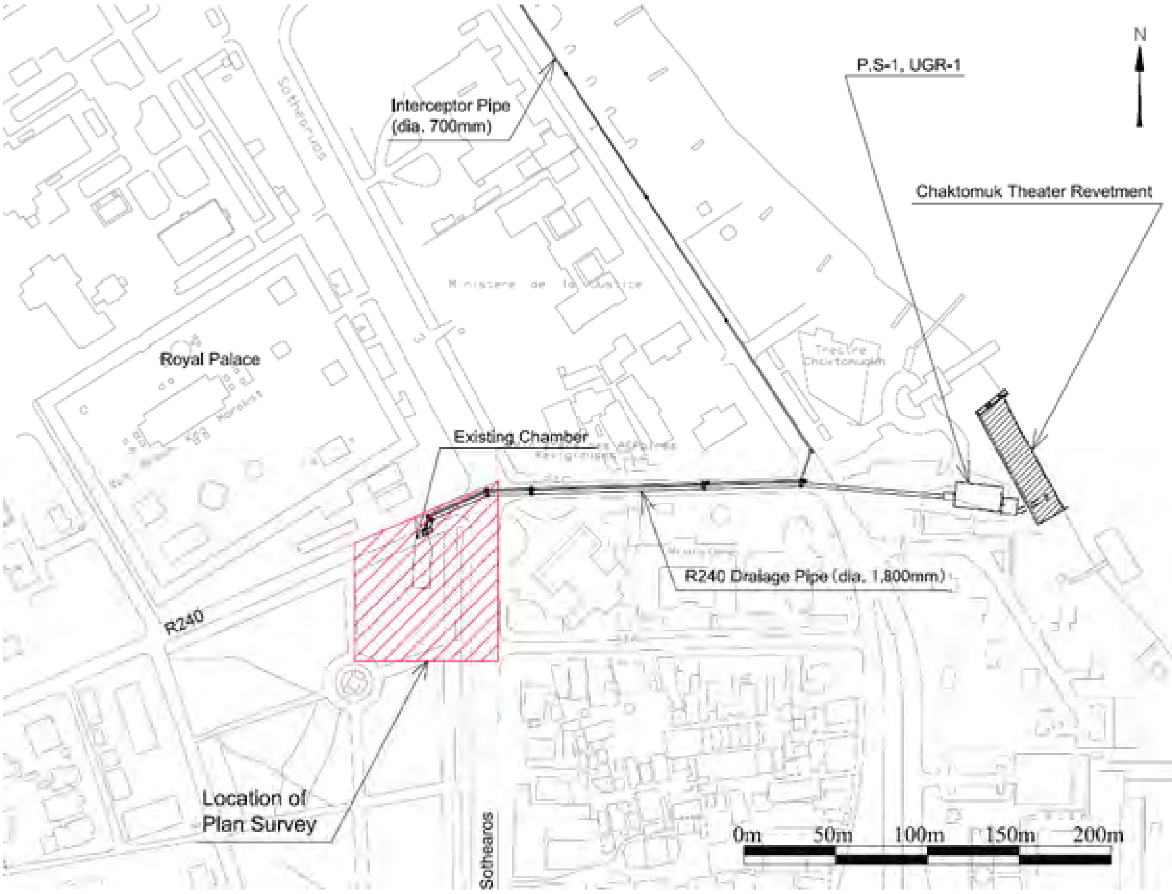


Fig. R 1.3.7　　Location of Plan Survey

1.3.3　　Drainage Network Survey (Manhole Survey)

The manhole survey aimed to achieve the following:

- To ascertain the present condition of existing drainage networks;
- To analyze problems and prepare the improvement plan of drainage system by using the MOUSE simulation model; and,
- To establish a database of drainage facilities that can be used as guide in the operation, maintenance, rehabilitation and/or improvement of the facilities.

Based on the joint reconnaissance of the survey area by the drainage engineer of the JICA Study Team and the surveyor, manholes due for opening and inventory were first identified. The locations of survey manholes were decided by considering the preparation for the MOUSE simulation model and the inundation situation in the survey area. Locations of surveyed manhole are as indicated in Fig. R 1.3.8.

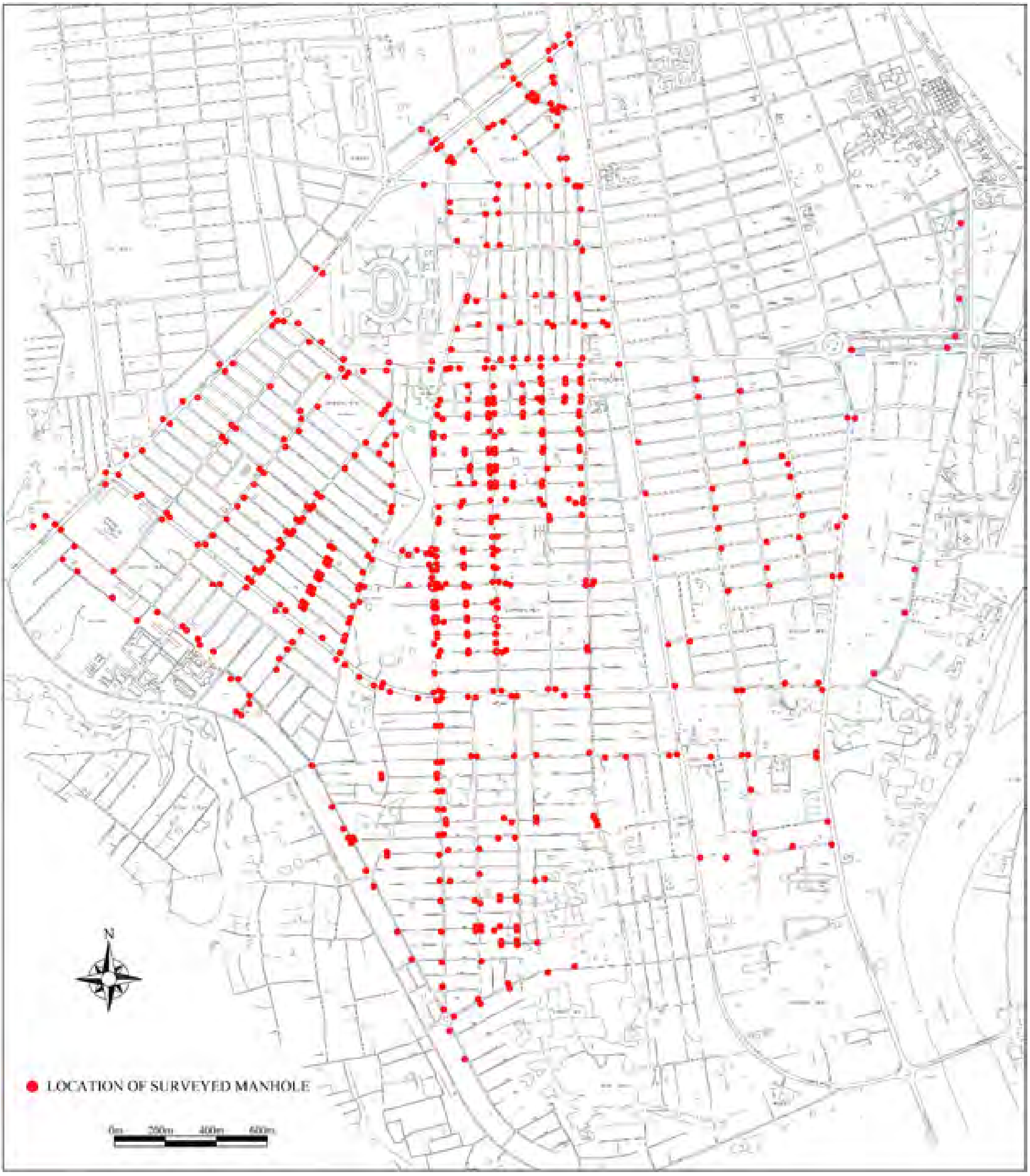


Fig. R 1.3.8 Locations of Surveyed Manhole

The distance between surveyed manholes is normally 20 to 50 meters, preferably at road intersections. The survey of each manhole afterward proceeded by opening the manhole and recording the physical features of the manhole, inlet and outlet pipes. Photos 1 and 2 in Photo R 1.3.2 show a survey team opening the drainage manhole.

Photo 1

Photo 2

Source: JICA Study Team

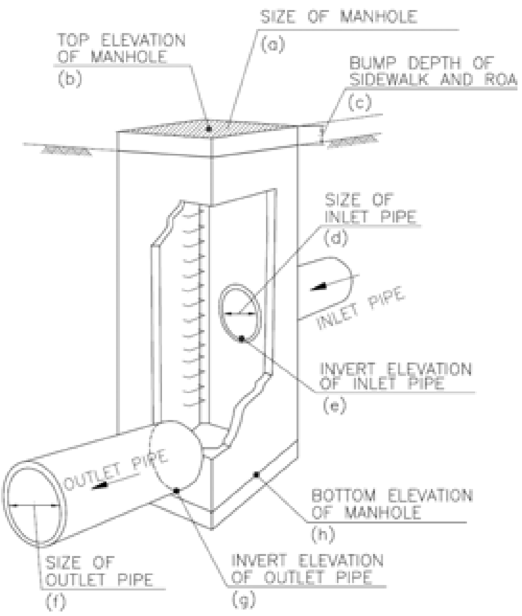
Photo R 1.3.2 Manhole Survey

Surveyed items were as follows (refer to Table R 1.3.3):

Table R 1.3.3 Manhole Survey Items

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

The data gathered from the surveyed manholes were recorded on a data sheet, as illustrated in Fig. R 1.3.10.



Source: JICA Study Team

Fig. R 1.3.9 Surveyed Items

Fig. R 1.3.10 Survey Sheet

1.3.4 Geological Survey

Machine boring and laboratory tests have been conducted to clarify the geological condition of the foundation of the Big Sediment Chamber at R240.

(1) Machine Boring

Machine boring was conducted at one (1) location, as indicated in Fig. R 1.3.11. In the borehole, in-situ tests were also carried out. The test items were as follows:

- Standard Penetration Test (SPT)
- Groundwater level survey
- Sampling of every layer
- Geological columns

The condition during the survey is shown in Photo R 1.3.2.

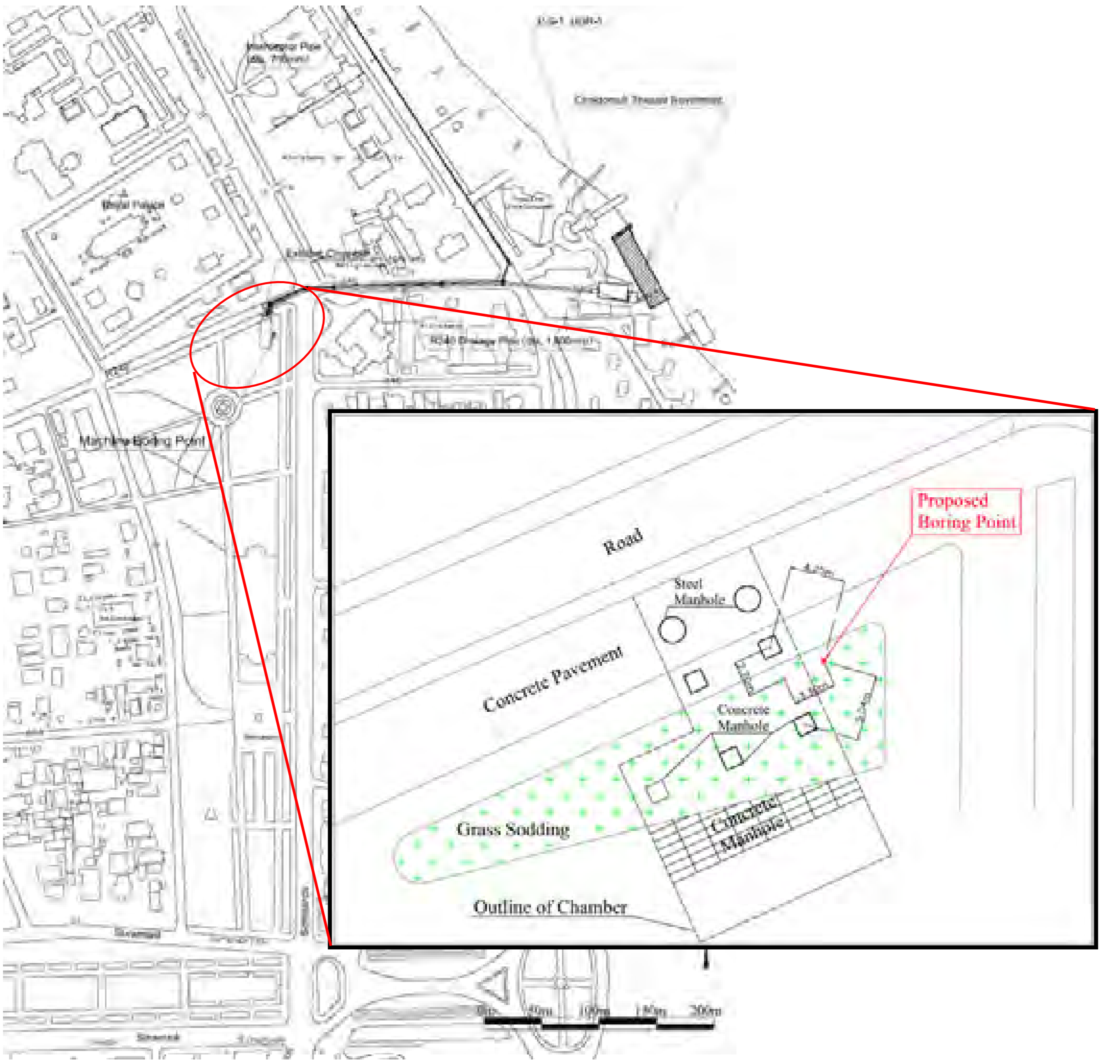


Fig. R 1.3.11 Location of Geological Survey

(At Boring Works)

(Samples taken from Borehole)

Source: JICA Study Team

Photo R 1.3.3 Machine Boring and Layer Samples

(2) Laboratory Test

In the machine boring test, disturbed samples and undisturbed samples were taken from the borehole for the laboratory tests. The implemented test items were as follows:

[For Undisturbed Sample]

- Consolidation test
- Direct shear test
- Unconfined compression test

[For Disturbed Sample]

- Unit weight analysis
- Solid density
- Grain Size
- LL/PL Test
- Moisture Content

(3) Test Results

The summary of laboratory soil test results is shown in Table R 1.3.4. The distribution of N-value in the borehole is shown in Fig. R 1.3.12. As the pattern of soil layer, the borehole has a topsoil layer with the depth of 0~1 m, followed by clayey sand or sandy silt with the depth of up to -28m with a low N-value. Then the borehole encounters the hard layer with N-value of more than 30 with the depth of more than -30m (at the elevation from EL. -20.4 m).

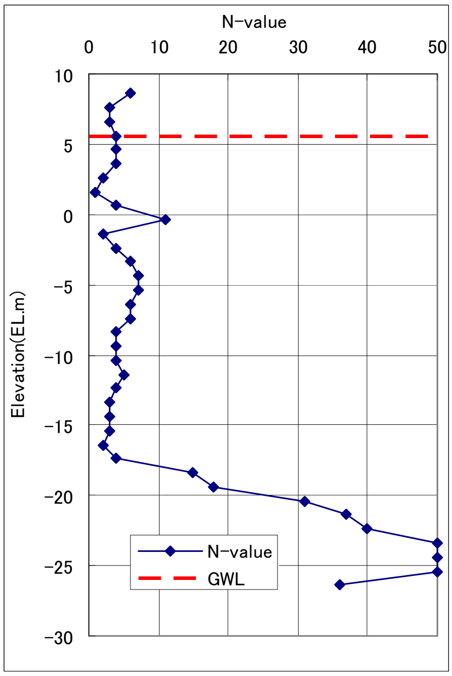


Fig. R 1.3.12
Distribution of N-value of Borehole

Table R 1.3.4 Summary of Laboratory Test Results of Geological Survey

Depth	Type of Soil	Average N-Value	Outline of Laboratory Test Results					
			Unit Weight γ	Direct Shear		Unconfined Compression qu	Consolidation	
				C	ϕ		e_0	Cc
GL-1m	Topsoil (GS)	-	-	-	-	-	-	-
GL-6m	A little fine sandy silt (CL)	4	18.44 18.28	5.3 5.1	8 7	44.2 29.5	0.643 0.660	0.225 0.165
GL-9m	Very clayed fine sand (SL)	2	-	-	-	-	-	-
GL-15m	Some fine sandy silty clay (CL)	7	18.10 17.82	5.5 6.4	8 6	-	-	-
GL-21m	Very silty fine sand (SM)	5	18.21 17.82	0.2 0.8	23 23	-	-	-
GL-24m	Some fine lean silt (ML)	4	-	-	-	-	-	-
GL-28m	Clayed fine sand (SC)	3	17.93 18.21	1.5 1.9	19 18	-	1.273 1.141	0.393 0.345
GL-29m	Clayed fine sand (SC)	15	-	-	-	-	-	-
GL-30m	Some sandy lean clay (CL)	18	-	-	-	-	-	-
GL-33m	Fine sandy fat clay (CH), gravel	36	-	-	-	327 351	-	-
GL-36m	Fine sandy fat clay (CH), gravel	>50	-	-	-	-	-	-

1.3.5 Underground Facilities Survey and Test Excavation

Data collection for underground facilities that will influence the design and construction work was conducted to provide the data from the management authority of each facility. The researched facilities and management authorities are as shown in Table R 1.3.5.

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	PPFOTV
Optical cable	Private	Cambodia Fiber Optic Communication Network (CFOCN)

For the smooth construction work, design work in consideration of location and installation depth of underground facilities based on the results of preparatory excavation prior to pipe installation shall be implemented to avoid and constrain large-scale design changes. Hence, test excavation works at ten (10) significant intersections (refer to Fig. R 1.3.13) were executed to check the actual installation circumstance of underground facilities. Test excavation results and necessary relocation works of underground facilities are summarized in Table R 1.3.6 and Table R 1.3.7.

Table R 1.3.6 Results of Test Excavation (1/2)

Excavated Point		Underground Facility		Treatment in the Project	Relocation Work
No.	Road Crossing	Facility, Diameter	Depth		
1	No.163, MaoTseToung	Electricity ϕ150×2, ϕ100, ϕ30	0.68m	New drainage pipe will not installed here	—
		Water Supply ϕ300	0.77m		
		Telephone ϕ100	0.97m		
		Drainage ϕ600	0.66m		
		Telephone ϕ100	1.06m		
		Water Supply ϕ300	0.68m		
		Optical Cable ϕ98×8	0.58m		
2	No.161, Sihanouk	Electricity for Signal ϕ80	0.30m	no concern	—
		Electricity ϕ150	0.82m	no concern	—
		Water Supply ϕ300	0.60m	no concern	—
		Drainage ϕ1200	0.87m	connected to new drainage pipe	(connect to new drainage pipe)
		Telephone ϕ100×4	1.30m	new drainage pipe is installed under the cable	excavation for lift up
		Water Supply ϕ300	1.33m	relocated	relocation & renewal of pipe
		Drainage ϕ1200	0.95m	connected to new drainage pipe	(connect to new drainage pipe)
		Electricity □250×270	1.07m	new drainage pipe is installed under the cable	excavation for lift up
		Water Supply ϕ300	1.00m	relocated	relocation & renewal of pipe
		Optical Cable ϕ98×8	0.65m	no concern	—
3	No.161, No.182	Drainage ϕ400	0.91m	no concern	—
		Electricity ϕ60	0.56m	no concern	—
		Telephone ϕ20	0.90m	no concern	—
		Drainage ϕ1200	1.25m	connected to new drainage pipe	(connect to new drainage pipe)
		Water Supply ϕ300	0.73m	no concern	—
		Drainage ϕ1200	1.30m	connected to new drainage pipe	(connect to new drainage pipe)
		Electricity ϕ50×2	0.40m	no concern	—
4	No.161, Charles de Gaulle	Optical Cable ϕ98×8	0.63m	new drainage pipe is installed under the cable	excavation for lift up
		Telephone ϕ30	0.71m	new drainage pipe is installed under the cable	excavation for lift up
		Electricity ϕ50	0.30m	no concern	—
		Telephone ϕ80	0.58m	new drainage pipe is installed under the cable	excavation for lift up
		Telephone ϕ60	0.74m	new drainage pipe is installed under the cable	excavation for lift up
		Water Supply ϕ300	1.31m	relocated	relocation & renewal of pipe
		Water Supply ϕ250	1.35m	relocated	relocation & renewal of pipe
		Electricity ϕ50	0.77m	no concern	—
		Drainage ϕ700	1.35m	connected to new drainage pipe	(connect to new drainage pipe)
		Drainage ϕ700	0.88m	connected to new drainage pipe	(connect to new drainage pipe)
		Telephone ϕ100	0.95m	no concern	—
		Water Supply ϕ300	1.15m	relocated	relocation & renewal of pipe
		Drainage ϕ400	1.04m	no concern	—
5	Circular Road, No.488	Water Supply ϕ300	1.33m	no concern	—
		Telephone ϕ150	0.82m	no concern	
		Drainage ϕ1200	0.87m	no concern	
6	No.163 No.454	Telephone ϕ20	0.91m	no concern	—
		Electricity ϕ50	0.63m	no concern	—
		Water Supply ϕ200	0.95m	no concern	—
		Electricity ϕ150	0.97m	no concern	—
		Telephone ϕ100	0.73m	no concern	—
		Drainage ϕ700	1.00m	connected to new drainage pipe	(connect to new drainage pipe)

Table R 1.3.7 Results of Test Excavation (2/2)

Excavated Point		Underground Facility		Treatment in the Project	Relocation Work
No.	Raod Crossing	Facility, Daimeter	Depth		
7	No.183, MaoTseToung	Drainage ϕ 500	1.22m	no concern	–
		Drainage ϕ 500	0.65m	connected to new drainage pipe	(connect to new drainage pipe)
		Drainage ϕ 300	0.57m	connected to new drainage pipe	(connect to new drainage pipe)
		Electricity ϕ 50	0.24m	no concern	–
		Optical Cable ϕ 98×8	0.85m	no concern	–
		Water Supply ϕ 250	0.45m	no concern	–
		Water Supply ϕ 100	0.30m	no concern	–
8	No.193, MaoTseToung	Electricity ϕ 30	0.56m	no concern	–
		Electricity ϕ 40	0.89m	no concern	–
		Water Supply ϕ 150	1.03m	no concern	–
		Drainage ϕ 500	0.92m	connected to new drainage pipe	(connect to new drainage pipe)
		Electricity ϕ 50	0.35m	no concern	–
		Drainage ϕ 600	1.20m	connected to new drainage pipe	(connect to new drainage pipe)
		Electricity ϕ 150	0.74m	no concern	–
		Water Supply ϕ 200	0.73m	no concern	–
		Optical Cable ϕ 98×8	0.57m	no concern	–
		Water Supply ϕ 100	0.63m	no concern	–
9	No.143, No.310	Water Supply ϕ 200	1.41m	no concern	–
		Concrete Plate t=100mm	0.48m	no concern	(set new drainage pipe apart from the plate)
10	Circular Road No.163	Drainage ϕ 250	0.56m	no concern	–
		Drainage ϕ 1000	0.76m	no concern	
		Water Supply ϕ 150	0.66m	no concern	
		Drainage ϕ 1000	0.76m	no concern	

Fig. R 1.3.13 Locations of Test Excavation Site

Installation situations of each underground facility confirmed from the results of hearing survey with management authorities and the test excavation are as described below.

(1) 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 office, which is sometimes seen in the area of Tuol Tumpung and Phsar Daeum Thkov in the southern part of the Study Area.

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. 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.

(2) Water Supply Pipe

Data on the water supply network has been obtained from the Phnom Penh Water Supply Authority (PPWSA). The clean water treated in the purification plant at PPWSA is distributed to the entire city area through the complicated pipe network.

Almost all of the branch distribution pipes in the city area (dia. 90mm to 160mm) are laid at around 1.0m deep beneath the roads. At the busier roads like Street No. 182, Sihanouk Blvd., Mao Tse Toung Blvd., Street No. 163 and Street No. 488, the distribution pipes (dia. 300mm to 250mm) are also laid at around 1.0m deep under these roads.

However, two main distribution pipes related to the Project (dia. 1,000mm to 800mm) have been laid down at approximately 3.0m to 4.0m deep beneath Charles de Gaulle Blvd., Monireth Blvd. and Monivong Blvd. Therefore, 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.

(3) Electric Cable

Data on electric cables has been obtained from the Electricite du Cambodge (EDC). All electric cables laid along the walkway are basically within 1.0m deep from the ground level. Hence, these electric cables are not serious obstructions to the drainage pipe installation work in the Project.

However, the electric cables laid underneath the walkway often run across the branch roads, similar to the existing drainage pipes. If the new drainage pipes will intersect with these electric cables, the alignment and elevation of the new drainage pipes have to be examined carefully.

(4) Telephone Cable

Data on the telephone cables has been obtained from private telephone companies such as Camintel which are under the control of Telecom Cambodia (subsidiary of the Ministry of Communication). The telephone cables laid along the walkway are 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.

(5) Television

The television cables for Cable TV are owned by PPFO TV (a private company). The television cables are laid under walkway 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.

(6) 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 (dia. 100mm) are laid basically under the walkway at a maximum depth of 1.0m. When the cables run across the existing roads, they are also laid within a depth of 1.0m.

However, in cases where the PPCH 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 walkway was adopted. The depth for laying optical cables in the centre of road is estimated to be 4m to 5m, approximately, depending on the span length (width between the manholes).

According to the CFOCN engineer’s commitment, 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, preparatory excavation 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.

1.3.6 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 study areas of the Preparatory Survey on the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase III) through interview survey with the Sangkat chiefs and households in the area of the Trabek Basin and the adjacent areas of Wat Phnom Basin, Central Market, and the Royal Palace and National Museum.

(2) Methods

(a) General

The consultant had sublet the survey to an appropriate survey team in accordance with the Terms of Reference (TOR). The contents of the survey in each survey area are shown in the table below.

Table R 1.3.8 Survey Required in Socio-Environmental Survey Areas

Project Area	Survey Area	Survey to be Done
Phase 2*	Wat Phnom Basin	- Interview with Sangkat Chiefs - Interview with Households
	Central Market Area	
	Royal Palace & National Museum Area	
Phase 3*	Trabek basin & adjacent area	

* Phase 2: The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)
Phase 3: The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)

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

The survey team met with the Sangkat chiefs in the area and asked questions, namely; 1) the inundated road location, length and its inundation level; 2) the roads without drainage system (location and length); and, 3) the desired location to improve the drainage condition in the Sangkat. The number of Sangkats subjected to the interview was 28 in total.

(c) Interview with Households (Interview-2)

Flooding areas were identified based on the results of Interview-1. The total number of respondents of Interview-2 was 429. The survey areas for the household interview are listed in Table R 1.3.8 and were divided into nine (9) sub-areas, as shown in Fig. R 1.3.14.

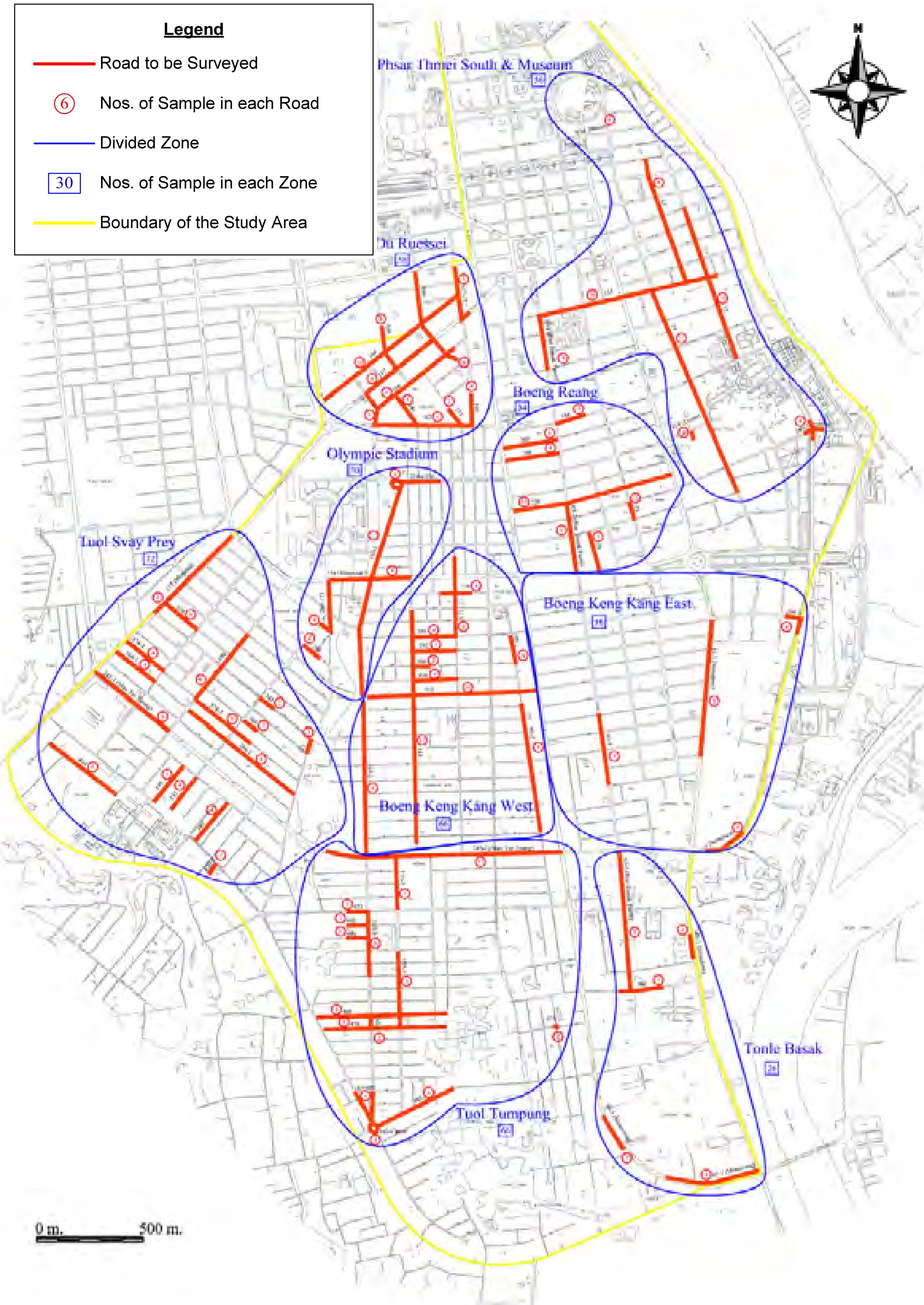


Fig. R 1.3.14 Survey Area for Interview with Households (Interview-2)

The interview items were as follows:

(i) General Questions

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.

Street No. 310, surveyed on 19 Mar. 2010

Street No. 63-1, surveyed on 24 Mar. 2010

Source: JICA Study Team.

Photo R 1.3.4 Interview with Households

(3) Results

(a) Interview with Sangkat Chiefs

The major interview results are as follows and all of the results are shown in Fig. R 1.3.15.

- In Ou Russei, several roads are without drainage systems and the area has some inundation damages.

- In Oulampik, Street No. 163 is without drainage system and this causes the inundation at the upstream area, i.e., Veal Vong.

- Boeng Keng Kang 1 and 2, Tuol Tumpung 2, Tuol Svay Prey 1 & 2, Tumnob Tuek and Tonle Basak have some inundation damages.

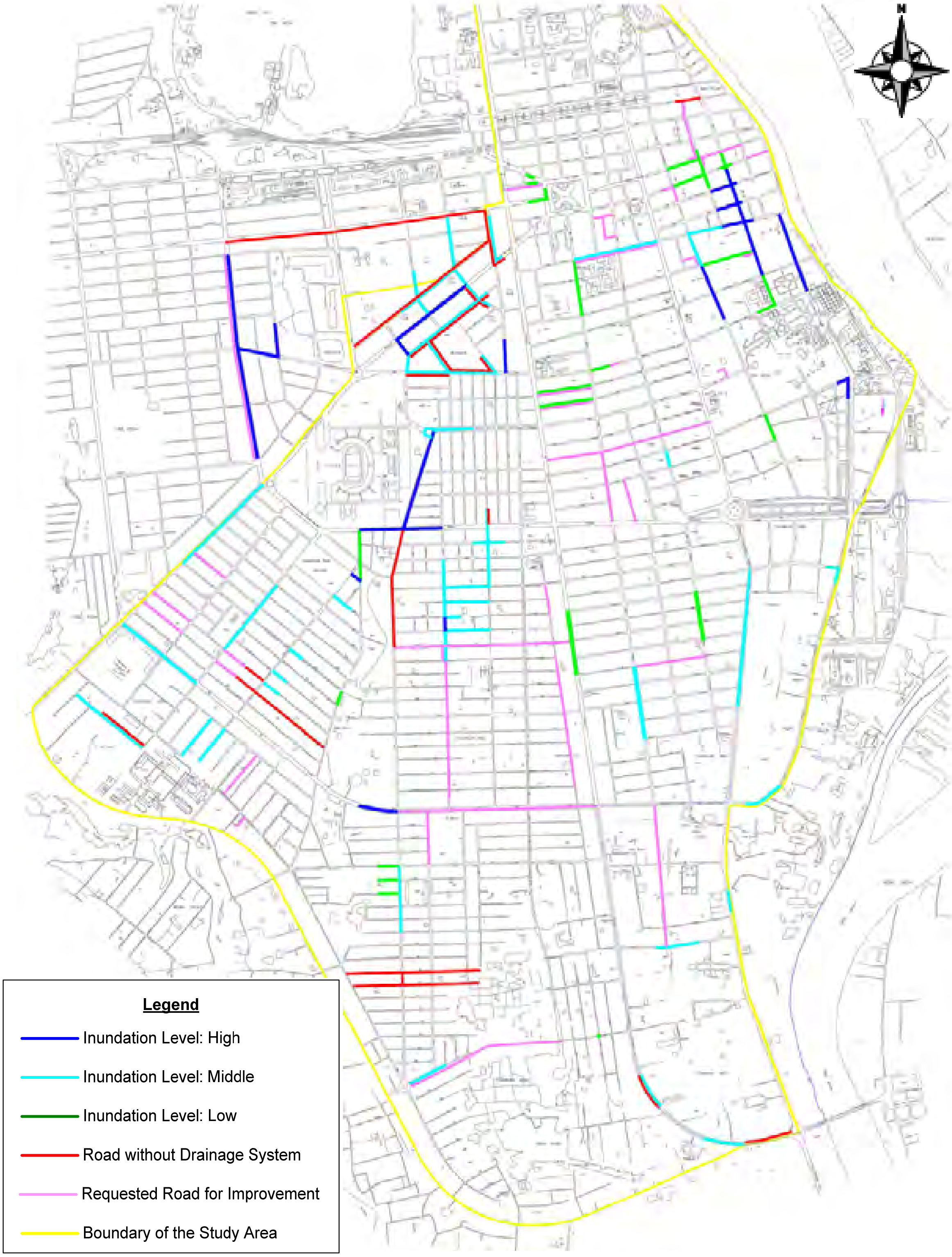


Fig. R 1.3.15 Results of Interview with Sangkat Chiefs (Interview-1)

(b) Interview with Households

(i) General Questions

Survey results for general questions are shown in Table R 1.3.9 to Table R 1.3.13. The number of masters is the largest among the interviewees. Masters' occupations are mostly in tertiary industries. As shown in Table R 1.3.11 and Table R 1.3.12, 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.

Table R 1.3.14 shows that 22 of the interviewees replied that their homesteads in Tuol Tumpung 1, Tumnob Tuek and Boeng Reang were parts of a lake or pond some 30 or 50 years ago, so that generally, the geological condition in such areas is quite poor. Therefore, if the drainage pipe installation is to be carried out in these areas, careful attention is required for the design of measures and construction works due to the poor foundation structure at such locations.

Table R 1.3.9 Number and Type of Interviewees

Type	Housewife	Master	Children	Other House Members	Housekeeper	Others	Total
Number of Respondents	132	187	63	2	13	32	429
Weight (%)	30.8	43.6	14.7	0.5	3.0	7.5	100

Table R 1.3.10 Number of Masters and Employment Type

Type	Primary Industry	Secondary Industry	Tertiary Industry	Pensioner (Retired)	Unemployed	Others	Total
Number of Respondents	1	5	258	29	6	130	429
Weight (%)	0.2	1.2	60.1	6.8	1.4	30.3	100

Table R 1.3.11 Number of Persons Staying in the House

No. of Persons	1	2	3	4	5	6	7	More than 8	Total
Number of Respondents	3	19	44	79	109	53	38	84	429
Weight (%)	0.7	4.4	10.3	18.4	25.4	12.4	8.9	19.6	100

Table R 1.3.12 Number of Dwelling Years at the Place

Period (Year)	Less than 5	5 to 9	10 to 19	20 or more	No Answer	Total
Number of Respondents	115	41	125	147	1	429
Weight (%)	26.8	9.6	29.1	34.3	0.2	100

Table R 1.3.13 Type of Dwelling

Type	Own House	Rental	No Answer	Total
Number of Respondents	316	102	11	429
Weight (%)	73.7	23.8	2.6	100

Table R 1.3.14 Previous Land Use of House Lot

Type	Lake or Pond	Others	No Answer	Total
Number of Respondents	22	57	350	429
Weight (%)	5.1	13.3	81.6	100

(ii) Questions on Inundation Situation

Some 380 respondents corresponding to 89 percent of the total number of interviewees replied that they had experienced flooding in front of their houses. The interviewees who had experienced flooding in front of their houses mentioned that flooding frequently occurs in a year, as shown in Table R 1.3.16.

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 36 percent of the interviewees who experienced flooding mentioned that the duration was longer than 2 or 3 hours.

Table R 1.3.15 Experience of Flooding In Front of House

Answer	Yes	No	Do not know	Total
Number of Respondents	380	46	3	429
Weight (%)	88.6	10.7	0.7	100

Table R 1.3.16 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	3	101	271	3	1	380
Weight (%)	0.3	0.8	26.9	71.3	0.8	0.3	100.4

Table R 1.3.17 Depths of Flood

Type	Up to ankle	Up to shin	Up to knee	Up to thigh	Up to waist	Higher than waist	Total
Number of Respondents	83	182	102	10	3	0	380
Weight (%)	21.8	47.9	26.8	2.6	0.8	0.0	99.9

Table R 1.3.18 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	85	155	115	16	5	1	0	3	380
Weight (%)	22.4	40.8	30.3	4.2	1.3	0.3	0.0	0.8	100.1

From the results of Interview-2, seriously inundated roads were extracted based on the criteria shown in Table R 1.3.19. Fig. R 1.3.16 shows the extracted roads.

Table R 1.3.19 Criteria for Extraction of Seriously Inundated Roads

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.

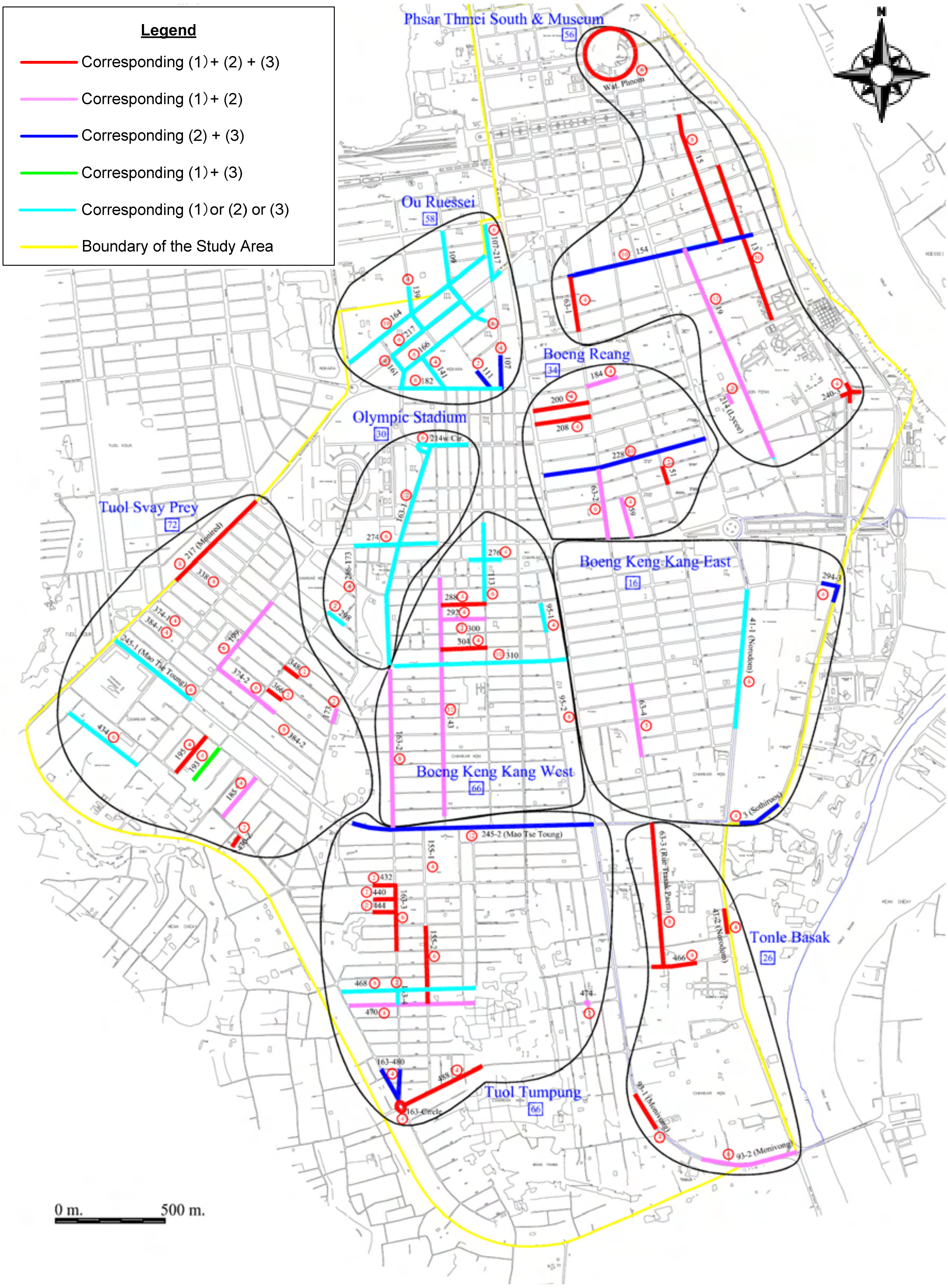


Fig. R 1.3.16 Results of Interview with Households (Interview-2)

(iii) Questions on Sanitary Condition

Some 81 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, food poisoning, diarrhea, typhoid fever and dysentery. Regarding the disposal method of night soil, 32 percent of the interviewees use septic tanks and 64 percent of it flow into the drainage pipes.

Table R 1.3.20 Problems after Flood

Answer	Yes	No	No answer	Total
No. of Respondents	348	45	36	429
Weight (%)	81.1	10.5	8.4	100

Table R 1.3.21 Occurrence of Diseases in Family after Flood

Type	Skin Disease	Flu	Food Poisoning	Diarrhea	Typhoid	Dysentery	Total
No. of Respondents	221	285	14	53	38	2	613
Weight (%)	36.1	46.5	2.3	8.6	6.2	0.3	100

Table R 1.3.22 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	2	127	258	10	6	403
Weight (%)	0.5	31.5	64.0	2.5	1.5	100

(iv) Questions on Social Considerations

About 91 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 1.3.23 Opinions on Drainage Improvement Project in front of Houses

Answer	Agree	Disagree	Do not know	Total
No. of Respondents	391	14	24	429
Weight (%)	91.1	3.3	5.6	100

Table R 1.3.24 Opinions on Construction Work for Project in front of Houses

Answer	Agree	Disagree	Do not know	Total
No. of Respondents	355	2	34	391
Weight (%)	90.8	0.5	8.7	100

1.4 Environmental and Social Considerations

(1) Status of Former IEE Prepared in Basic Design Study of Phase 2

The Department of Public Works and Transport (DPWT) of the Phnom Penh Capital Hall (PPCH) prepared the IEE in the course of the Basic Design Study on “the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)” (hereinafter referred to as “the Phase 2”) on 17 February 2006 and submitted it to the Department of Environment (DOE) of the PPCH. The study area of that IEE included the target area of the Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III) (hereinafter referred to as “the Project”). The DOE evaluated the IEE and concluded that there is no need to carry out an EIA because there is no large negative impact caused by projects. The DOE approved the IEE on 8 June 2006.

(2) Explanation to Stakeholders and Interview Survey with Residents

Interview surveys for households located in the Study Area were carried out in March and April 2010. The purpose of the survey was not only to grasp the inundation damage under the present condition but also to increase the stakeholders’ awareness on the Project. The interviewer explained the project’s purpose, contents and possible inconveniences during the construction period, and inquired about the respondents’ willingness to project implementation. According to the survey results, most interviewees (391 in 429 respondents) agreed on the improvement of drainage in front of their houses, 24 respondents said “I don’t know”, and 14 respondents said “No” to project implementation. Thirteen (13) out of the 14 respondents indicated that the reason for answering “No” to project implementation is: “there is no serious flood in front of my house.” As the result, almost all of the interviewees who often have serious flooding agreed on the improvement of drainage even if it requires construction work in front of their houses.

On the other hand, the kick-off meeting was carried out on 09 March 2010. Persons concerned in the Project such as the representatives of PPCH, DPWT and khans (districts) participated in the meeting, and the implementation of the Preparatory Survey for the Project was announced. After the completion of the Draft Final Report, the project contents were explained to the persons concerned in the Project in January 2011.

Before the start of construction work, the contents and detailed schedule shall be explained to the residents and other stakeholders concerned, in public meetings to be held by the PPCH and DPWT in coordination with each khan. The PPCH and DPWT shall prepare the minutes of discussion to document the result of public meetings.

(3) Legal Framework of Environmental and Social Considerations

(a) Law

The related laws and regulations on the environment in Cambodia are as follows:

- Law on Environmental Protection and Natural Resources Management, Dec. 1996, Ministry of Environment (MOE)
- Sub-Decree on Environmental Impact Assessment Process, Aug. 1999, MOE
- Prakas (Declaration) on Guideline for Conducting Environmental Impact Assessment Report, Mar. 2000, MOE
- Sub-Decree on Water Pollution Control, Apr. 1999, MOE
- Sub-Decree on Solid Waste Management, Apr. 1999, MOE
- Sub-Decree on Air Pollution Control and Noise Disturbance, Jul. 2000, MOE
- Prakas (Declaration) No. 1033 on Protected Areas, Jun. 1994, MOE
- Sub-Decree on the Organization and Functions of the Ministry of Environment, 1997
- Declaration on General Guideline for Conducting the EIA or IEIA Report, Sep. 2009, MOE

(b) Projects Subject to Environmental Impact Assessment (EIA)

Projects requiring an Initial Environmental Impact Assessment (IEIA), which is almost equivalent to the IEE, or EIA, are categorized as A: Industry, B: Agriculture, C: Tourism, and D: Infrastructure in the Sub-Decree on Environmental Impact Assessment Process, Aug. 1999. In the said Sub-Decree, drainage system is categorized as Agriculture instead of Infrastructure, and drainage system projects with 5,000 ha or more are required to carry out IEE or EIA.

(c) Procedure for IEE or EIA

The procedure for the IEE or EIA is as follows:

- Responsible and implementing agencies prepare the IEE.
- IEE is submitted to the Provincial Environmental Office (PEO)/Department of Environment (DOE), if the project is at the provincial/urban level.
- PEO/DOE examines the submitted IEE, and in case it is necessary, requests to revise IEE or further detailed study such as EIA.

- PEO/DOE approves the project, if the environmental assessment satisfies its requirements.

(4) Scoping Results of Initial Environmental Examination (IEE) for the Project

(a) Title of the Project

The title of the project shall be "The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)."

(b) Categorization and its Reason

Categorization: Category B

Reason: The project requires the construction of drainage pipe networks in dense urban areas. The construction work in the urban areas will cause temporary negative impacts including noise, vibration and traffic congestion.

(c) Ecology

There are a couple of main drainage channels and the Boeng Trabek Pond which function as a detention pond in the project area. There is neither important fauna in the project area, like migratory birds or important fish species, nor important flora in the pond which is partly covered by water hyacinth.

Terrestrial biodiversity in the project area is limited to scattered trees, both exotic and endemic, alongside the roads and pets fed by city dwellers.

There are no protected natural areas like national parks in the Project Area.

(d) Status of Inundation Damage

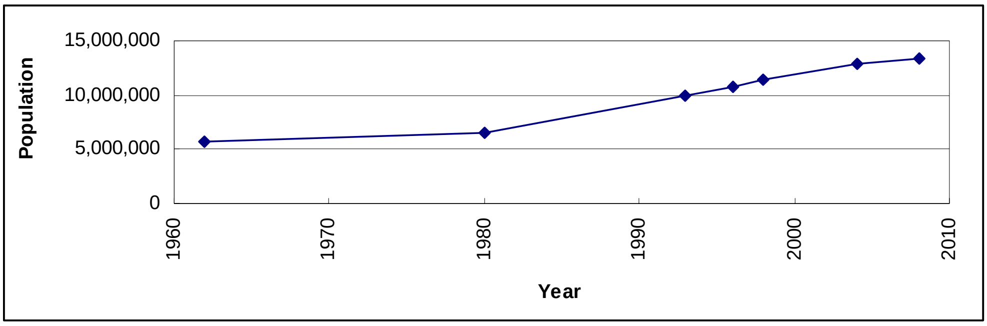
Inundation damage in the Study Area was surveyed with the use of questionnaire in March and April 2010. According to the survey results, most of the people experienced flooding around their homesteads.

(e) Land Use

Land use condition in the project area is a mixture of residential, small to medium scale commercial development areas. The northern part of the project area is more populated than the south. According to the interview survey, several homesteads in the southern part were lowlands reclaimed some 10 to 20 years ago.

(f) Population

The population of Cambodia has been increasing, as shown in Fig. R 1.4.1. According to the Census of 2008, the recent population of the country was approximately 13 million and the recent decadal growth rate works out to 16.66 percent, or an annual exponential growth rate of 1.54 percent.



Source: General Population Census of Cambodia 2008

Fig. R 1.4.1 Population Trend in Cambodia

However, the population of PPCC tends to decrease. Table R 1.4.1 shows the population by Sangkat in the Study Area.

Table R 1.4.1 Population in the Study Area

No.	Districts/Sangkats	Population		Growth Rate
		2004* (1)	2008** (2)	(2)/(1)
01 Chamcar Morn				
1	Tonle Basak	15,300	10,731	0.701
2	Boeng Keng Kang Muoy	14,405	12,440	0.864
3	Boeng Keng Kang Pir	12,055	11,202	0.929
4	Boeng Keng Kang Bei	22,700	22,200	0.978
5	Oulampic	9,799	9,686	0.988
6	Tuol Svay Prey Muoy	13,575	13,621	1.003
7	Tuol Svay Prey Pir	11,589	7,387	0.637
8	Tumnob Tuek	13,720	18,169	1.324
9	Tuol Tumpung Pir	8,594	10,731	1.249
10	Tuol Tumpung Muoy	10,422	12,375	1.187
11	Boeng Trabek	9,452	8,652	0.915
12	Phsar Daeum Thkov	16,258	21,977	1.352
	Sub-Total 01	*157,869*	*159,171*	*1.008*
02 Daun Penh District				
1	Phsar Thmei Muoy	7,447	6,411	0.861
2	Phsar Thmei Pir	7,771	7,387	0.951
3	Phsar Thmei Bei	13,154	10,320	0.785
4	Boeng Reang	7,714	7,210	0.935
5	Phsar Kandal Muoy	11,223	9,427	0.840
6	Phsar Kandal Pir	7,954	7,334	0.922
7	Chaktomuk	12,501	10,312	0.825
8	Chey Chumneah	12,980	12,372	0.953
9	Phsar Chas	8,287	7,023	0.847
10	Srah Chak	34,115	39,491	1.158
11	Watt Phnom	8,767	9,263	1.057
	Sub-Total 02	*131,913*	*126,550*	*0.959*
03 Prampir Makara				
1	Ou Ruessey Muoy	9,120	8,133	0.892
2	Ou Ruessey Pir	10,722	9,518	0.888
3	Ou Ruessey Bei	8,519	7,673	0.901
4	Ou Ruessey Buon	9,123	9,418	1.032
5	Monoroum	12,981	11,227	0.865
6	Veal Vong	21,394	25,489	1.191
7	Boeng Prolit	12,010	10,169	0.847
	Sub-Total 03	*83,869*	*81,627*	*0.973*
Total in the Project Area		373,651	367,348	0.983

Source: * Reclassification of Urban Areas in Cambodia, Nov. 2004
** General Population Census of Cambodia, 2008

The decrease in population appears in the data from 2004 to 2008, which imply that the Study Area is fully used causing the urban sprawl. The population growth rate in the Study Area from 2004 to 2008 is minus 1.7 percent.

The population in the Study Area is a predominantly urban population with various occupations such as government officials, private company staff, shopkeepers, hoteliers, traders, private workers, etc.

(g) Water Quality

1) Water Quality Monitoring

The Office of Air Quality Noise and Vibration in the Ministry of Environment (MOE) carries out water quality monitoring once a month in public water areas around the PPCC. The locations and monitoring periods are shown in Table R 1.4.2. The monitoring was carried out at 10 locations from 1999 to 2008. Since 2008, the number of monitoring locations was only five.

Table R 1.4.2 Water Quality Monitoring in and around PPCC

No.	Location	Station Name	Period
1	Mekong River	Kien Svay	1999 - Date
2	Mekong River	Preaek Ktam	1999 - 2008
3	Mekong River	Chrauy Changva	1999 - Date
4	Tonle Sap River	Phnom Penh Port	1999 - Date
5	Bassac River	Ta khmao	1999 - Date
6	Bassac River	Svay Rloum	1999 - 2008
7	Bassac River	Monivong Bridge	1999 - 2008
8	Preak Thnot River	Stoeung Chrov	1999 - Date
9	PPCC	Boeng Trabek Pumping Station	1999 - 2008
10	PPCC	Boeng Tumpum Pumping Station	1999 - 2008

Source: Office of Water & Soil Quality Management, MOE

2) Water Quality in the Rivers around PPCC

The water quality monitored by the MOE in 2009 in and around the PPCC is shown in Table R 1.4.3. As shown in the table, DOs in February and March at the Stoeung Chrov monitoring point, which is located at the outlet of the wetland to the Preak Thnot River, are smaller than the standard. This fluctuation may be due to seasonal change of water flow discharged from the wetland which is located in the south of Phnom Penh. There may be no critical issue about water quality in the rivers around Phnom Penh at present, since there is no problem with the water quality at the Ta Khmao monitoring point which is located in the downstream from Phnom Penh.

Table R 1.4.3 Water Quality Monitored by MOE (2009)

Item	Unit	Standards	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Phnom Penh Port (Sap River)														
pH	-	6.5 - 8.5	6.73	7.92	7.30	6.98	7.54	7.14	6.95	7.28	-	6.41	-	7.46
BOD	mg/l	1 - 10	2.05	1.30	1.10	1.95	1.20	1.60	2.01	0.37	-	4.55	-	1.20
TDS	mg/l	-	47.5	109.3	105.8	100.1	90.1	78.4	51.5	62.1	-	45.9	-	42.8
DO	mg/l	2.0 - 7.5	4.80	6.10	6.20	6.10	6.40	6.30	5.80	4.90	-	5.90	-	5.70
Stoeung Chrov (Tributary of Prek Thnot River)														
pH	-	6 - 9	6.43	8.04	8.16	7.21	7.49	7.01	6.93	7.30	-	6.48	-	7.46
BOD	mg/l	<30	6.20	6.30	11.20	3.10	4.10	2.10	2.17	1.60	-	11.50	-	12.10
TDS	mg/l	<1000	216.0	404.0	438.0	192.0	136.8	213.0	52.5	64.0	-	49.5	-	50.8
DO	mg/l	>2.0	2.50	0.80	1.50	6.20	5.30	4.70	5.30	5.30	-	6.20	-	3.70
Ta Khmao (Bassac River)														
pH	-	6.5 - 8.5	7.62	6.90	7.64	7.94	7.28	6.90	7.30	6.45	-	6.94	-	7.27
BOD	mg/l	1 - 10	1.60	0.90	2.03	1.40	1.95	1.72	0.70	1.93	-	3.33	-	1.75
TDS	mg/l	-	112.10	46.20	96.40	90.80	77.50	51.60	62.50	50.60	-	47.50	-	49.10
DO	mg/l	2.0 - 7.5	6.70	5.20	6.20	6.20	6.40	5.80	4.80	5.20	-	6.20	-	4.90

Note: pH: potential Hydrogen, BOD: Biochemical Oxygen Demand, TDS: Total Dissolved Solids, DO: Dissolved Oxygen
Source: Office of Water & Soil Quality Management, MOE
Standard: Stoeung Chrov => Allowable limits for pollutant substance discharging to protected public water area
Phnom Penh Port, Ta Khmao => Water Quality Standard in public water areas for biodiversity conservation

(h) Environmental Concerns on Living

1) Deterioration of Drainage System

The drainage facilities in the Study Area 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. 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 PPCC but the whole country in general. Such deteriorated drainage condition is alerted in a tourist guidebook as dangers information.

Tuol Tumpung, inundated on Sep. 2009

Tuol Svay Prey, inundated on Sep. 2009

Source: JICA Study Team.

Photo R 1.4.1 View of Inundation in the Study Area

2) Traffic Congestion

Under the significant economic growth and population growth, the number of traffic has rapidly increased in Cambodia, frequently causing traffic congestion in the Study Area.

Traffic condition in daytime at boulevard

Traffic condition in daytime at street

Source: JICA Study Team.

Photo R 1.4.2 View of Traffic Congestion in the Study Area

(i) Outline of the Project

(i) Proposed Project

The objective of the proposed project is to provide flood protection and drainage improvement works for the Phnom Penh Capital City. Based on the request made by the Government of the Kingdom of Cambodia, the following items are proposed for the Project.

Table R 1.4.4 Items Proposed for the Project

Contents of the Proposed Project	• Improvement of Drainage Network (Drainage Pipe Installation): 20.6km in total • Reconstruction of Sediment Chamber at R240 • Procurement of Cleaning Equipment for Drainage Pipe: 2 units of High Water-Jet Machine and 2 units of Truck-Mounted Sludge Sucker
Beneficiaries	People of PPCC

(ii) Responsible and Implementing Agencies for the Project

The Department of Public Works and Transport (DPWT) of the Phnom Penh Capital Hall (PPCH) is the Implementing Agency to manage the construction works which will be carried out by a construction contractor and supervised by a construction consultant. Following the completion of the Project, the Drainage and Sewage Division (DSD) under the DPWT will be responsible for the operation and maintenance of the facilities constructed by the Project.

(iii) Agency to Set the Principles and Procedures for Environmental Impact Assessment

The Department of Environment (DOE) of PPCH is the agency tasked to set the principles and procedures for IEE or EIA of the Project, because the Project is on the municipality level. The main tasks of the DOE for the Project are as follows:

- Review, evaluation and approval of IEE and/or EIA; and
- Environmental monitoring during the construction and operation stages.

(j) Adverse Environmental and Social Impacts

The possible adverse impacts that might be caused by the proposed project are as shown in Table R 1.4.5 and Table R 1.4.6.

Table R 1.4.5 Possible Adverse Impacts (1/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
I. Human Health & Safe and Natural Environment				
1	Air Pollution, Dust Generation	B	+	Earthworks for pipe installation, road repairing and soil backfilling will generate dust. During the operation, dust level adjacent to the repaired roads especially the dust generation in Boeng Trabek area will decrease.
2	Offensive Odour			There will be no effect by offensive odour during the construction and operation stages.
3	Noise	B		Construction equipment may cause offensive noise.
4	Vibration	B		Construction equipment may cause vibration effects on nearby structures.
5	Accident	B		Potential of accidents during the construction can be considered.
6	Water Pollution			There will be no effect on water quality during the construction and operation stages.
7	Change to Drainage Pattern	B	++	There will be a minor impact to storm water flooding patterns during construction, because some sewer pipes will be cut and/or diverted during new pipe installation.
8	Soil Contamination			There will be no effect on soil contamination during construction and operation stages.
9	Construction Waste and Waste Soil	B		There will be no significant impact on disturbance of hazardous soil during the construction and operation. (Asbestos pipes are not used in the existing pipe network.) Inappropriate management of construction and general wastes can cause waste problems.
10	Soil Erosion and Slope Failure	B	++	New pipe installation can cause soil erosion and slope failure.
11	Vegetation and Tree Removal			There will be no effect on vegetation and of tree removal.
12	Impact on Endangered Species			There will be no effect on endangered species.
13	Loss of Biodiversity			There will be no effect on biodiversity.

Rating
A : Significant Impact Expected
B : Some Impact Expected
C : Extent of impact is unknown
++ : Major Positive Impact
+ : Minor Positive Impact
No Mark : No Impact

Table R 1.4.6 Possible Adverse Impacts (2/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Description
II.	Social Considerations			
1	Involuntary Resettlement			There will be no impact because the construction site is located within the road-right-of-way and public garden. No one lives in such construction area.
2	Effect on Amenity of Tourism-Related Development	B	++	There will be a minor impact since the construction site is close to tourist attraction area. The Project will reduce storm water inundation and will improve environmental condition in the area. It will therefore support the increase of tourism development in PPCC as well as in the whole country.
3	Impact on Road Safety	B		Road safety during the construction is possibly decreased because of the operation of construction equipment.
4	Impact on Road Traffic and Vehicle Movement	B	+	During the construction stage, there will be some disruptions to traffic.
5	Sanitation		+	Reduction of storm water inundation and dust level will reduce the incidence of waterborne and respiratory diseases.
6	Risk of Infectious Diseases such as HIV/AIDS	B		A number of labourers will be employed for the construction. There is a potential of infectious diseases such as HIV/AIDS.
7	Impact on Livelihood/Income	B & +	+	During the construction stage, shops and restaurants etc., alongside the roads where sewer pipe installation is taking place will be temporarily affected due to temporary road closure. Business activities will recover when the construction site moves forward to the next road section. On the other hand, there will be opportunities for local people to be employed in the construction work. During the operation stage, the Project will contribute to increased tourism development and employment potential.
8	Ethnic Minority People			There are no ethnic minority people living in the Study Area.
9	Poverty Incidence			The Project will not cause any poverty incidence in the Study Area.
10	Employment Opportunity	+	+	During the construction stage, there will be opportunities for local people to be employed in the construction work.
11	Social Activity		+	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			There will be no destruction or disturbance of cultural and archaeological heritage.

Rating A : Significant Impact Expected ++ : Major Positive Impact
B : Some Impact Expected + : Minor Positive Impact
C : Extent of impact is unknown No Mark : No Impact

(k) Mitigation Measures

The mitigation measures for the key impacts are shown in Table R 1.4.7 and.

Table R 1.4.8. The measures shall be clearly specified in the technical specifications for construction works.

Table R 1.4.7 Mitigation Measures 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	+	- Dust suppression measure will be used in urban area to minimize dust generation.
3	Noise	B		- Low-noise type equipment such as the Silent Piler and vibratory hammer will be used. - Construction activities in dense residential area will be limited to daytime hours.
4	Vibration	B		- Low-vibration type equipment such as the Silent Piler and vibratory hammer will be used. - Construction activities in dense residential area will be limited to daytime hours.
5	Accident	B		- Safety measures with the construction of fence around the work areas to avoid accidents to third parties. - Safety instructions carried out for every labourer every morning of working day - Safety patrol carried out by DPWT, contractor and consultant once a week
7	Change to Drainage Pattern	B	++	- Temporary inconvenience can be mitigated by using drainage pump or diverted pipes to drain sewage/storm water to the municipal pipeline.
9	Construction Waste and General Waste	B		- Soil materials suitable for backfilling works will be stockpiled temporarily at the designated stockyard. - 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 much as possible.
10	Soil Erosion and Slope Failure	B		- During the installation of pipes, appropriate temporary work such as installation of steel sheet pile and/or trench sheet will be carried out.

Rating A : Significant Impact Expected ++ : Major Positive Impact
B : Some Impact Expected + : Minor Positive Impact
C : Extent of impact is unknown No Mark : No Impact

Table R 1.4.8 Mitigation Measures for the Key Impacts (2/2)

No.	Potential Impacts	Construction Stage	Operation Stage	Mitigation Measures
II. Social Considerations				
2	Effect on Amenity of Tourism-Related Development	B	++	- Carrying out of night works to ensure the commercial activity of the surrounding markets, shops and restaurants.
3	Impact on Road Safety	B		- 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	+	- Security of the present traffic and safety conditions by the setting of detour roads and installation of panel decks. - When construction works are carried out in heavy traffic road, detour route shall be planned clearly. - On the heavy traffic areas such as the junction of major roads, construction work will be carried out at night and, during the daytime, the work site will be covered with steel plates to maintain normal traffic conditions.
6	Risk of Infectious Diseases such as HIV/AIDS	B		- Proper guidance carried out for construction workers to prevent infectious diseases.
7	Impact on Livelihood/Income	B & +	+	- Carrying out of night works to ensure the commercial activity of the surrounding markets, shops and restaurants

Rating A : Significant Impact Expected ++ : Major Positive Impact
B : Some Impact Expected + : Minor Positive Impact
C : Extent of impact is unknown No Mark : No Impact

(l) Monitoring

(i) Monitoring Plan

As shown in the preceding Item (j), Adverse Environmental and Social Impacts, the Project may have some negative impacts during the construction stage. Therefore, mitigation measures shall be carried out and monitored. The environmental monitoring plan is as given in the table below.

Table R 1.4.9 Environmental 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 the construction period with regular monitoring frequency.	Contractor	The activity is reported to the Consultant and DPWT every month. The contractor will prepare the self-monitoring form.
Periodical Monitoring	Monitoring by implementation authority shall be carried out periodically.	DPWT (to be sublet)	**Monitoring shall be carried out once in three months.**

(ii) Monitoring Record

The DPWT shall monitor the key impacts caused by the Project every three month. It may sublet the work because of no equipment and no experience of personnel. Monitoring results shall be recorded, and in case of necessity, the record shall be submitted to JICA.

The monitoring forms for the construction stage are as shown in Table R 1.4.10 and Table R 1.4.11. The Sub-Decree on Air Pollution Control and Noise Disturbance shall be referred for noise.

Table R 1.4.10 Environmental Monitoring Form for Construction Stage (1/2)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards[1]	Remarks
Noise						
Quiet Area[2] (6AM to 6PM)	dB (A)	[ ] ( )	[ ] ( )	45	85	(Location, Date, Method, etc.)
Residential Area[3] (6AM to 6PM)	dB (A)	[ ] ( )	[ ] ( )	60	85	(Location, Date, Method, etc.)
Commercial and service areas and mix (6AM to 6PM)	dB (A)	[ ] ( )	[ ] ( )	70	85	(Location, Date, Method, etc.)
Small industrial factories, intermingling with residential areas (6AM to 6PM)	dB (A)	[ ] ( )	[ ] ( )	75	85	(Location, Date, Method, etc.)

Note: 1) Japanese law for construction works 2) Hospitals, libraries, schools including kindergarten
3) Hotels, administration offices and houses
[ ]: Measured Value under Construction, ( ): Measured Value before Commencement

Table R 1.4.11 Environmental Monitoring Form for Construction Stage (2/2)

Monitoring Item	Monitoring Result during Report Period
Dust Generation	(Monitoring date, site, method and result shall be written)
Vibration	-ditto-
Accident	-ditto-
Change to Drainage Pattern	-ditto-
Soil Erosion and Slope Failure	-ditto-
Construction Waste and General Waste	-ditto-
Effect on Amenity of Tourism-Related Development	-ditto-
Impact on Road Safety	-ditto-
Impact on Road Traffic and Vehicle Movement	-ditto-
Risk of Infectious Diseases such as HIV/AIDS	-ditto-
Impact on Livelihood/Income	-ditto-

(iii) Necessary Cost for Periodical Monitoring

The periodical monitoring by DPWT shall be carried out in every three (3) months. The implementation number of periodical monitoring by DPWT will be, therefore, fourteen (14) times in case that the construction period will be forty-two (42) months. The estimated monitoring cost based on the quotation of DOE submitted in the course of the Preparatory Survey is shown in the table below.

Table R 1.4.12 Estimated Monitoring Cost during Construction Period

Monitoring Item	Unit Cost (US$)	Implementation Times	Necessary Cost (US$)
Dust Generation	100	14	1,400
Noise	150	14	2,100
Vibration	50	14	700
Accident	100	14	1,400
Change to Drainage Pattern	100	14	1,400
Soil Erosion and Slope Failure	50	14	700
Construction Waste and General Waste	100	14	1,400
Effect on Amenity of Tourism-Related Development	50	14	700
Impact on Road Safety	100	14	1,400
Impact on Road Traffic and Vehicle Movement	50	14	700
Risk of Infectious Diseases such as HIV/AIDS	50	14	700
Impact on Livelihood/Income	100	14	1,400
SUB TOTAL			14,000
Reserve Fund			1,400
TOTAL			15,400

(5) Consultation with Recipient Government

(a) Explanation Meeting with Local Residents

In the construction stage of the Phase 2, explanation meetings with local residents were carried out before the start of construction work. Due to the meeting activities, the Phase 2 received no adverse claim from the local residents.

Most of the construction works included in the Project will be executed also 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 Project before the commencement of construction work. These explanation meetings shall be held for each *"Khan"* or *"Sangkat"* concerned. The residents' opinions shall be taken into consideration, and it is necessary to facilitate the understanding and cooperation of the inhabitants on project implementation.

(b) Securing the Environmental Monitoring

The DPWT, the responsible and implementing agency of the Project, shall carry out the environmental monitoring during the construction and operation stages. However, it has no equipment and skill to measure the adverse impacts quantitatively, such as noise level. Therefore, the DPWT has to contract the services of an appropriate institute or firm to do the monitoring work. The DOE is an alternative for the works because it owns equipment for noise and dust measurement and had monitored the construction works of the Phase 2. In this connection, the DPWT is required to secure enough funds for the contracting of environmental monitoring works.

(6) Environmental Checklist

Environmental checklists are shown in Table R 1.4.13 to Table R 1.4.17.

Table R 1.4.13 Environmental Checklist for the Project (1/5)

Category	Environmental Items	Main Check Items	Confirmation of Environmental Considerations
1. Permits and Explan-ations	(1) EIA and Environmental Permits	1) Have EIA reports been officially completed?	1) IEE report was completed in 2006.
		2) Have EIA reports been approved by authorities of the host country's government?	2) IEE report was approved in June 2006.
		3) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	3) IEE report was approved unconditionally.
		4) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	4) No need.
	(2) Explanation to the Public	1) Are 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?	1) Project contents and potential impacts shall be explained to affected people after completion of the Draft Final Report to obtain their understanding and support.
		2) Are proper responses made to comments from the public and regulatory authorities?	2) In the Phase 2, proper responses were made to comments from the public and regulatory authorities. In the Project, the same will be carried out.

Table R 1.4.14 Environmental Checklist for the Project (2/5)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
2. Pollution Measures	(1) Air Quality	1) Do air pollutants such as sulphur oxide (SOx), nitrogen oxide (NOx), 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 be no negative effect of air pollution.
	(2) Water Quality	1) Do effluents or leachates from various facilities such as infrastructure and ancillary facilities comply with the country's effluent standards and ambient water quality standards?	1) The Project will drain floodwaters from the PPCC. The Project will not change water quality.
	(3) Wastes	1) Are wastes from infrastructure and ancillary facilities properly treated and disposed in accordance with the country's standards?	1) The Project will not produce any waste during the operation stage. 2) As countermeasure against waste in the construction stage, soil materials suitable for backfilling works will be stockpiled temporarily at the designated stockyard while soil materials unsuitable for backfilling works will be transported and dumped directly into the designated dumping ground.
	(4) Soil Contamin-ation	1) Are adequate measures taken to prevent contamination of soil and groundwater by the effluents or leachates from the infrastructure and ancillary facilities?	1) There will be no soil contamination effect.
	(5) Noise and Vibration	1) Do noise and vibrations comply with the country's standards?	1) The Project will not make noise and vibration during the operation stage. 2) As countermeasure against noise and vibration in the construction stage, low-vibration and low-noise type equipment such as Silent Piler and light vibratory hammer will be used, and construction activities in dense residential areas will be limited to daytime hours.
	(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) Odour	1) Are there any odour sources? Are adequate odour control measures taken?	1) There will be no offensive odour effect.

Table R 1.4.15 Environmental Checklist for the Project (3/5)

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 a protected area. 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 impact. 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 will be positive changes on the drainage condition in the project area.
	(4) Topography and Geology	1) Is there a possibility that the project will cause large-scale alteration of topographic features and geologic structures in the project site and surrounding areas?	1) There is no possibility that the project will cause large-scale alteration of topographic features and geologic structures in the project site and surrounding areas.

Table R 1.4.16 Environmental Checklist for the Project (4/5)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4. Social Environment	(1) Resettle-ment	1) Is involuntary resettlement caused by 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 particular 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) The project does not require any resettlement. 2) - 3) - 4) - 5) - 6) - 7) -
	(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 condition 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 archaeological, 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 People	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 minorities living in the project area. 2) -

Table R 1.4.17 Environmental Checklist for the Project (5/5)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
5. Others	(1) Impacts during Construct-ion	1) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibration, 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 are considered to reduce impacts during the construction stage. 2) The construction activities will not adversely affect the natural environment. 3) Adequate measures are considered to reduce the impacts. 4) Health and safety education is 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 authority (DPWT) will develop and implement a monitoring program for the environmental items that are considered to have potential impacts. 2) The items, methods and frequencies to be included in the monitoring program are considered to be appropriate. 3) DPWT will establish an adequate monitoring framework including budget. 4) There are some regulatory requirements pertaining to the monitoring report system identified.