JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

DEPARTMENT OF PUBLIC WORKS AND TRANSPORT
PHNOM PENH CAPITAL CITY
KINGDOM OF CAMBODIA

THE STUDY ON DRAINAGE AND SEWERAGE IMPROVEMENT PROJECT IN PHNOM PENH METROPOLITAN AREA

FINAL REPORT

VOLUME II
MAIN REPORT

DECEMBER 2016

CTI ENGINEERING INTERNATIONAL CO., LTD.
NIPPON KOEI CO., LTD.
KITAKYUSHU WATER SERVICE CO., LTD.

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COMPOSITION OF FINAL REPORT

VOLUME I: SUMMARY

VOLUME II: MAIN REPORT

VOLUME III: ANNEX

Currency Exchange Rates used in this Report

[Master Plan Stage]

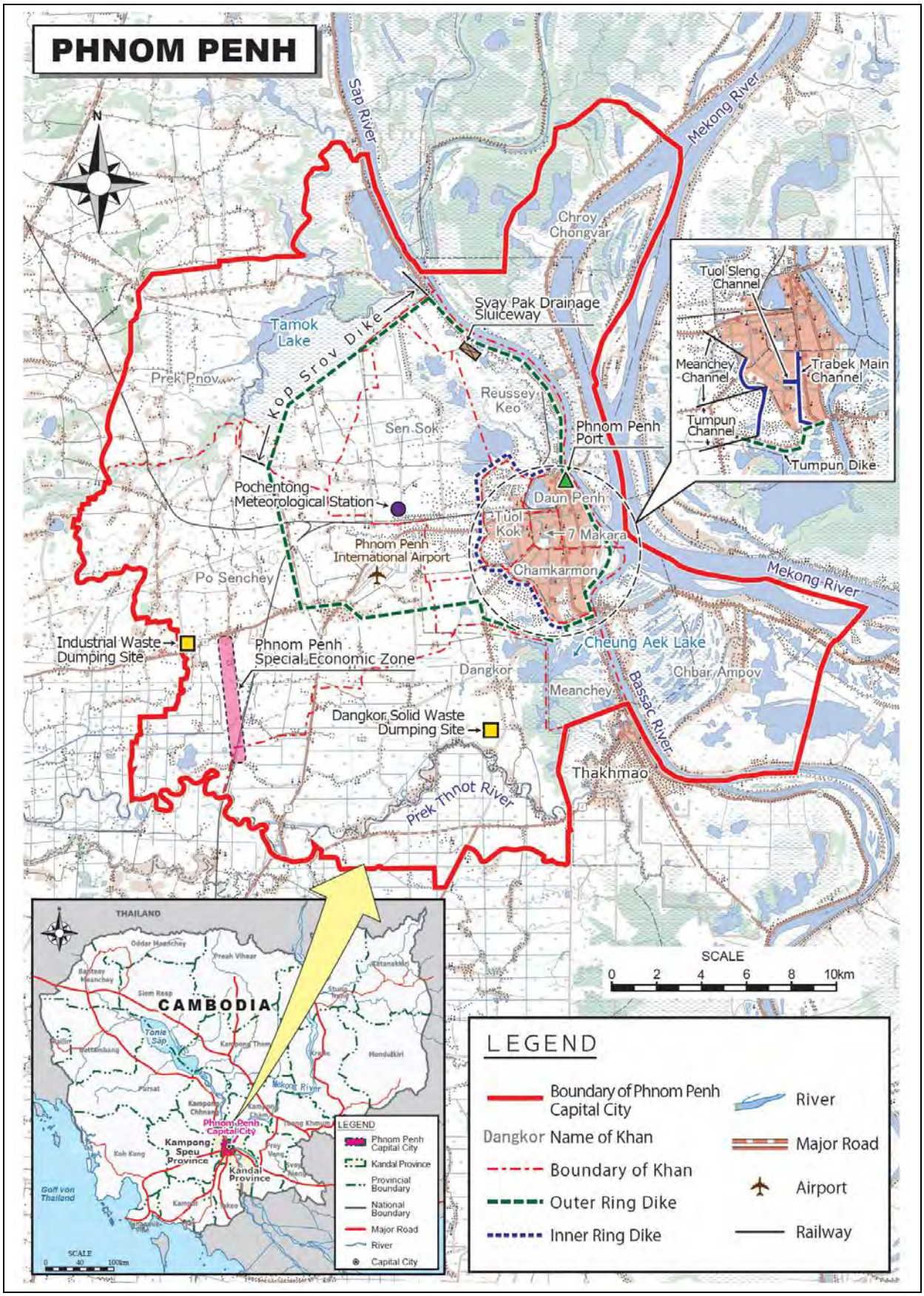
USD	1.00	= Riel	3,988	= JPY	119.64
Riel	1.00	= USD	0.00025	= JPY	0.030
JPY	1.00	= USD	0.0084	= Riel	33.3

(As of 1st April 2015)

[Pre-Feasibility Study Stage]

USD	1.00	= Riel	4,033	= JPY	122.85
Riel	1.00	= USD	0.00025	= JPY	0.030
JPY	1.00	= USD	0.0081	= Riel	33.3

(As of 1st December 2015)



LOCATION MAP

	
Cheung Aek Lake	Discharged Water from Kop Srov Pumping Station
	
Trabek Channel	Tamok Lake
	
Wastewater Treatment Facilities in Dye House	Wastewater Treatment Facilities in Aeon Mall
	
Water Quality Monitoring at Prek Thnot River	Septic Tank (Under Construction)
	
Septage Vacuum Truck	Candidate Site of Cheung Aek STP

PHOTOGRAPHS (1/2)

	
Inundation in Wat Phnom Northern Area	Inundation in Trabek Channel
	
House near Trabek Pumping Station (In inundation)	House near Trabek Pumping Station (No Inundation)
	
Existing Drainage Channel (1/2)	Existing Drainage Channel (2/2)
	
Existing Pumping Station (Kop Srov Pumping Station)	Existing Pumping Station (Tuol Sampeo Pumping Station)
	
Box Culvert in Development Area (Under Construction)	Pipe Cleaning by DSD

PHOTOGRAPHS (2/2)

Outline of Master Plan and Pre-Feasibility Study

Item	Contents
Sewage Management (M/P)	
Target year	2035
Planning strategy	PPCC is subdivided into three areas (Cheung Aek, Tamok and Other areas) and applicability of on-site and off-site treatment for the target year 2035, is evaluated.
Planning frame	Cheung Aek area: Population of 1,093,155 in the planning area of 4,701.9 ha. Tamok area: Population of 481,423 in the planning area of 6,019.2 ha. Other area: Population of 1,292,522 (Total Population of 2,867,100-1,093,155-481,423)
Treatment system	Cheung Aek area: Off-site treatment with combined system is applied. A STP is proposed with capacity of 282,000 m^3/day. Conventional Activated Sludge Process (CASP) is applied for the STP. Tamok area: On-site treatment (Johkasou) is applied. Other area: Installation of septic tank, which is most popular sanitary device in PPCC, is recommended especially in households in which no toilet or pit latrine is equipped.
Legal and institutional set-up	Sewerage and Drainage Advancement Office under the director of DPWT/PPCC is proposed in the M/P, with the approach of "Start small and grow big". After the establishment of the Advancement Office, phased implementation plan for establishing independent sewage implementing body, in parallel with human resource development, is proposed.
Phased implementation schedule	Phased implementation schedule is proposed up to year 2040 to equalize volume of projects implemented in each period, as follows. Cheung Aek area: Phased implementation, consisting of (i) Preparatory Project, (II) Phase 1 Project, (iii) Phase 2 Project and (iv) Phase 3 Project, is proposed. Tamok area: Installation of Johkasou is commenced in Medium-term and ended in 2040, the last year of Long-term period, to equalize number of installation of Johkasou.
Project cost and O&M cost	Project cost: 1,025 million USD Breakdown is as follows. Construction cost in Cheung Aek area : 450.1 million USD Construction cost in Tamok area : 396.2 million USD Administration cost and so on : 178.7 million USD O&M cost: 30.692 million USD/year Breakdown is as follows. Cheung Aek area : 14.895 million USD Tamok area : 15.797 million USD
Financial and economic evaluation	Financial evaluation: Sewerage charge, which is equivalent of 75% of water tariff, will be required in the ultimate stage of implementation of Cheung Aek and Tamok area to cover O&M cost. Economic evaluation: EIRR is estimated at 26.31% in the combination of treatment of Cheung Aek and Tamok area.
Environmental and social considerations	Significant environmental and social impacts such as resettlement are not anticipated because proposed sewerage facilities in the M/P are installed in vacant public land or under public roads. Negative impacts such as traffic interruption, noise, dust and vibration would be unavoidable during the construction stage. However, the impacts could be minimized by introducing counter measures such as setting up diversion road, sprinkling water and selecting low-noise and/or low-vibration type construction equipment as far as practicable.
Sewage Management (Pre-F/S)	
Pre-F/S	Pre-F/S is conducted targeting "Preparatory Project", consisting of construction of a part of STP in Cheung Aek treatment area with capacity of 5,000 m^3/day and sewer pipe of about 1,300 m. Project cost of the Project is estimated at 24.05 million USD and O&M cost is estimated at 0.41 million USD/year.

Item	Contents
Drainage Management (MP)	
Target year	2035
Planning strategy	PPCC is subdivided into 25 catchment areas and structural measures, consisting of drainage channels, pumping stations and regulation ponds, are proposed considering topographical conditions as well as availability of existing drainage facilities.
Planning frame	Planning area in the M/P is 621.73 km^2 in total. Drainage facilities in the M/P are designed with return period of 5 years. Rainfall intensity of 5-year return period is 63.2 mm/ha or 112.3 mm/day.
Proposed drainage facilities	Proposed drainage facilities are construction of (i) Drainage channel of 123 km, (ii) Pumping stations in 6 locations and (iii) Regulation pond in 5 locations.
Legal and institutional set-up	Institutional and implementation framework in drainage management is already established to some extent through implementation of drainage improvement projects such as "The Project for Flood Protection and Drainage Improvement Project in Phnom Penh Capital City (Phase 1, 2 and 3)". However, strengthening of institutional framework is proposed because the present framework is insufficient to smoothly implement a number of drainage projects proposed in the M/P, corresponding to rapid urbanization.
Phased implementation schedule	Based on the EIRR, 25 drainage areas are categorized into 4 groups by priority. Of the 25 drainage areas, improvement works of drainage areas in 1st prioritized group are implemented in the Project for Flood Protection and Drainage Improvement Project in Phnom Penh Capital City (Phase 4). Of the 2nd prioritized group, Pochentong East Drainage Area (No. 9 Drainage Area) is studied in the Pre-F/S. Other drainage areas are implemented after implementation of Pochentong East Drainage Area.
Project cost and O&M cost	Project cost: 662.2 million USD Breakdown is as follows. Construction cost : 506.5 million USD Administration cost and so on: 155.7 million USD O&M cost: 5.501 million USD/year
Financial and economic evaluation	Financial evaluation: Not implemented in the M/P due to the reason that cost for drainage management should be borne by PPCC. Economic evaluation: EIRR is estimated at 12.6%.
Environmental and social considerations	About 900 households are to be resettled in the implementation of the proposed projects in the M/P, so detailed survey in the implementation stage will therefore be required to minimize the resettlement. Negative impacts such as traffic interruption, noise, dust and vibration would be unavoidable during the construction stage. However, the impacts could be minimized by introducing countermeasures such as setting up diversion road, sprinkling water and selecting low-noise and/or low-vibration type construction equipment as far as practicable.
Drainage Management (Pre-F/S)	
Pre-F/S	Pre-F/S is conducted targeting "Pochentong East Drainage Area (No. 9 Drainage Area), consisting of construction of: (i) Box Culvert of 5,220 m, (ii) Inlet channel of 480 m, (iii) Pumping Station of 1 location (Capacity of 40 m^3/s), (iv) Regulation pond of 1 location, as well as (v) Rehabilitation of drainage channel of 2,660 m. Project cost is estimated at 93.01 million USD and O&M cost is estimated at 1.23 million USD/year. EIRR is estimated at 12.7%.

Location Map
Photographs
Outline of Master Plan and Pre-Feasibility Study

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ABBREVIATIONS

1. Organizations/Programs/Projects

ADB	Asian Development Bank
AFD	Agence Française de Développement
CDC	Council for the Development of Cambodia
CDS	City Development Strategy
CIA	Central Intelligence Agency
DPWT	Department of Public Works and Transport
DHBE	Department Hydraulique Bureau d'etude
DHI	Danish Hydraulic Institute
DLMC	Department of Land Management and Cadastral
DLMUPC	Ministry of Land Management, Urban Planning and Construction
DOE	Department of Environment
DOP	Department of Planning
DOWRAM	Department of Water Resources and Meteorology
DSD	Drainage and Sewerage Division
EDC	Electricite du Cambodia
EDCF	Economic Development Cooperation Fund
EU	European Union
FAO	Food and Agriculture Organization
GDCE	General Department of Customs and Excise
GDT	General Department of Taxation
GOJ	Government of Japan
ICHARM	International Centre for Water Hazard and Risk Management
ICP	International Comparison Program
IDA	International Development Association
IMF	International Monetary Fund
IRC	Inter-Ministrial Resettlement Committee
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
JETRO	Japan External Trade Organization
KOICA	Korea International Cooperation Agency
MAFF	Ministry of Agriculture, Forest and Fisheries
MEF	Ministry of Economy and Finance
MIH	Ministry of Industry and Handicrafts
MLMUPC	Ministry of Land Management, Urban Planning and Construction
MOE	Ministry of Environment
MOI	Ministry of Interior
MOP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MRC	Mekong River Commission
MWSS	Metropolitan Waterworks and Sewerage System
NSDP	National Strategic Development Plan
PDOE	Provincial Department of Environment
PFPDI	Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh
PIU	Project Implementation Unit
PISC	Project Implementation Support Consultant
PMU	Project Management Unit
PPCC	Phnom Penh Capital City
PPSEZ	Phnom Penh Special Economic Zone

PPUTMP	Phnom Penh Urban Transport Mater Plan
PPWSA	Phnom Penh Water Supply Authority
RD	Department of Resettlement
RGC	Royal Government of Cambodia
SGC	Service Geographique du Cambodge
SRSWTPU	Siem Reap Sewerage Works Treatment Plant Unit
UN-HABITAT	United Nations Human Settlements Programme
UN-ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
USAID	United States Agency for International Development
WHO	World Health Organization
WMD	Waste Management Division

2. Technical Terms

BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
CASP	Conventional Activated Sludge Process
CCTV	Closed-circuit Television
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CSO	Combined Sewer Overflow
CR	Critically Endangered
DEM	Digital Elevation Model
DO	Dissolved Oxygen
EGM	Earth Gravitational Model
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EN	Endangered
FEIA	Final Environmental Impact Assessment
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
IEIA	Initial Environmental Impact Assessment
LARAP	Land Acquisition and Resettlement Action Plan
MPN	Most Probable Number
MSL	Mean Sea Level
NO_2	Nitrogen Dioxide
OD	Oxidation Ditch
PDOP	Position Dilution of Precision
pH	Potential Hydrogen
PTF	Pre-treated Trickling Filtration
PM	Particulate Matter
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
TF	Trickling Filter
T-N	Total Nitrogen
T-P	Total Phosphorus
TOR	Terms of Reference
TSP	Total Suspended Particles
TSS	Total Suspended Solid
SBR	Sequential Batch Reactor
SEA	Strategic Environmental Assessment
SLSC	Standard Least Square Criterion
SO_2	Sulfur Dioxide
SRTM	Shuttle Radar Topography Mission
VU	Vulnerable

3. Others

B/C	Benefit-Cost ratio
CD	Capacity Development
CSES	Cambodia Socio-Economic Survey
CPIA	Country Policy and Institutional Assessment
DMS	Detail Measurement Survey
DSA	Debt Sustainability Analysis
E/N	Exchange of Notes
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
F.C.	Foreign Currency
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GRM	Grievance Redress Mechanism
HH Income	Household Income
HRD	Human Resource Development
IPP	Independent Power Producer
l/c/d	Liter per capita per day
L.C.	Local Currency
M/P	Master Plan
NPV	Net Present Value
O&M	Operation and Maintenance
OJT	On-the-Job Training
PAP	Project Affected People
PCM	Public Consultation Meeting
PPG	Public and Publicly Guaranteed
PPP	Purchasing Power Parities
Pop.	Population
PV	Present Value
RAP	Resettlement Action Plan
RCS	Replacement Cost Study
R/D	Record of Discussions
SCADA	Supervisory Control And Data Acquisition
SEZ	Special Economic Zone
STP	Sewage Treatment Plant
USD	United States Dollars
WG	Working Group
WTP	Water Treatment Plant

CHAPTER 1 INTRODUCTION

1.1 Background

Since 2008 the administrative area of Phnom Penh Capital City (hereinafter referred to as "PPCC") has been expanding and reached up to 678.46 km^2 in 2011. PPCC's population has been also increasing from about 1.0 million in 1998 to 1.5 million in 2010. The city is often threatened by floods from the Mekong River due to the insufficient safety from the flood dikes.

Urban drainage facilities are not also functioning well. The facilities were constructed from the beginning of 1960's and thus superannuated. Poor maintenance during the civil war in the 1970's has worsened the situation. As a result, the city habitually suffers from inundation by local rainfall, especially, in the rainy season.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), in response to the request from the Royal Government of Cambodia (hereinafter referred to as "RGC"), conducted "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh" in 1999. Based on the Master Plan formulated in that study, the Government of Japan (hereinafter referred to as "GOJ") conducted grant aid projects (Phase I, II and III) for the purpose of strengthening the drainage capacity in the city area and to protect the city from flooding. In spite of these efforts, drainage problems are still generated in areas other than the areas of Phase I, II and III, due to the rapid urbanization and changes in land use.

As for sewage management in PPCC, only human excreta are held on plot in septic tanks. On the other hand, overflow effluent from the septic tanks as well as domestic wastewater, flows directly to the drainage pipes or open channels and runs into the ponds/swamps located in the downstream of the watersheds, in which wastewater is purified by the natural purification function to some extent.

However, the ponds/swamps have been invaded by houses, factories and other activities, and they no longer demonstrate their natural purification functions. Since the amount of wastewater increased due to the population growth and city development, the ponds and swamps have become black and smell terribly. As a result, outbreak of insects and waterborne diseases are anticipated, and the water quality of Mekong River, Sap River and Bassac River, which are the final disposal bodies of wastewater from the city, are also polluted[1].

Taking the above conditions into consideration, revision of the Master Plan on urban drainage improvement as well as consideration of wastewater treatment is necessary. Thus, the RGC requested assistance from the GOJ. In response to the official request, the GOJ decided to conduct the "The Study on Drainage and Sewerage Improvement Project in Phnom Penh Metropolitan Area". Accordingly, JICA, which is the official agency responsible for the implementation of technical cooperation programs of the GOJ, dispatched its Detailed Planning Survey Team to Cambodia from March to April, 2014 and the Record of Discussions (R/D) was finalized in May 2014.

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[1] Annual average of TSS and conductivity increased by more than 25% and 30% based on the monitoring results at 10 monitoring points in PPCC provided by MOE (1999 to 2004 and 2007 to 2013). In addition, TSS of Mekong River became 1.5 times and conductivity of Sap and Bassac River increased by more than 25%. These data indicate progress of contamination in the rivers.

1.2 Study Objectives

The objectives of the Study are:

(1) To formulate the Master Plan of drainage and sewerage improvement in PPCC;

(2) To conduct a Pre-Feasibility Study on priority projects selected in the Master Plan;

(3) To develop planning capacity of drainage and sewerage improvement; and

(4) To transfer relevant skills and technologies to personnel concerned in Cambodia in the course of the Study.

1.3 Study Area

The Study Area covers the entire area of PPCC.

1.4 Working System

In this Study, the Steering Committee is organized to coordinate activities among all the relevant authorities on drainage and sewerage with DPWT/PPCC as the Secretariat. The functions and members of the Steering Committee are summarized in **Table 1.4.1**.

Table 1.4.1 Functions and Members of the Steering Committee

Item	Contents
Functions	• To monitor and supervise the entire Study; • To review and approve the Reports; • To coordinate and harmonize the Study and ensure commitment of the concerned districts and agencies; • To facilitate the necessary endorsement procedures of the Study; and • To arbitrate, if necessary.
Activities	• Confirmation and consultation on the direction and progress of the Study; • Consultation on various concerns arising during the course of the Study; and • Consultation on modification and direction of the activities as necessary.
Committee Members	(1) Governor of PPCC (Chairman) (2) Vice Governor of PPCC (3) Representative of Ministry of Interior (4) Representative of Ministry of Public Works and Transport (5) Representative of Ministry of Economy and Finance (6) Representative of Ministry of Water Resources and Meteorology (7) Representative of Ministry of Environment (8) Director of Department of Public Works and Transport of PPCC (9) Director of Department of Land Management, Urban Planning, Construction and Land Registration of PPCC (10) Director of Department of Water Resources and Meteorology of PPCC (11) Director of Urbanization Division of PPCC (12) Director of Department of Planning of PPCC (13) Director of Department of Environment of PPCC (14) Director of Department of Industry and Handicraft of PPCC (15) Director of Department of Health of PPCC (16) Director of Department of Rural Development of PPCC (17) Director of Department of Social Affairs of PPCC (18) Director of Department of Agriculture, Fishery and Forestry of PPCC (19) Director of Department of Economy and Finance of PPCC (20) Governor of Khans (21) Representative of JICA and (22) JICA expert(s)
Frequency of Reports	At least four times (after preparation of Inception Report, Progress Report 1, Progress Report 2, and Draft Final Report)
Secretariat	DPWT/PPCC

Item	Contents
Venue of Meetings	Government office of PPCC
Cost	To be shared among the participating members.
Roles of the Secretariat	• Preparation of agenda, contacting participants and scheduling • Preparation of meeting materials and management of meetings • Explanation of the Study and preparation of minutes
Roles of the JICA Study Team	• To provide support in the preparation of agenda and handouts. • To provide support in the explanation of the Study and preparation of minutes of meetings.

Source: JICA Study Team

In addition, for smooth implementation of the Study, a Technical Committee was set up under the Steering Committee to manage the detailed progress of the Study. The functions and members of the Technical Committee are summarized in **Table 1.4.2**.

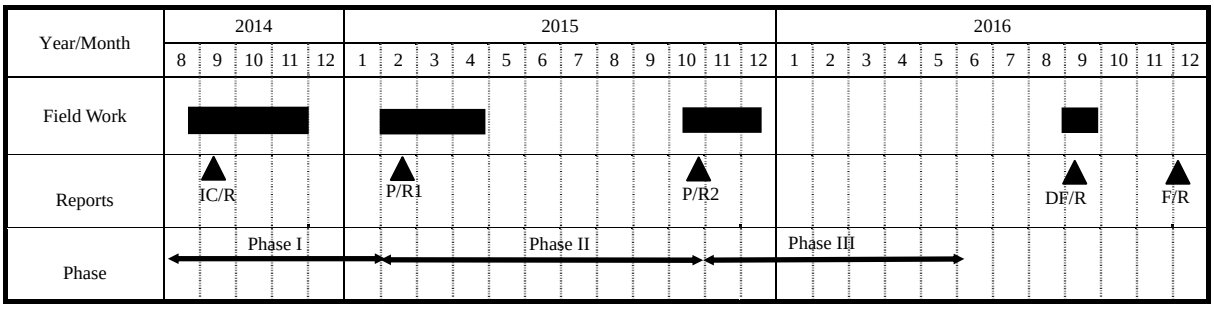
Table 1.4.2 Functions and Members of the Technical Committee

Item	Contents
Functions	• To support the Study Team and provide necessary arrangements, • To examine and analyse the technical aspects of the Reports, • To monitor and evaluate the Study • To coordinate and harmonize the stakeholder of the Study, and ensure involvement of the concerned agencies, and • To perform any other functions that the Steering Committee will request to the Technical Committee for technical assistance
Members	(1) Vice Governor of PPCC (2) Representative/s of Ministry of Public Works and Transport (3) Representative/s of Department of Public Works and Transport of PPCC (4) Representative/s of Department of Land Management, Urban Planning, Construction and Land Registration of PPCC (5) Representative/s of Department of Environment of PPCC (6) Representative/s of Urbanization Division of PPCC (7) Representative/s of Department of Water Resources and Meteorology of PPCC (8) Representative/s of Public Relations and International Cooperation Office of PPCC (9) Representative/s of Waste Management Division of PPCC

Source: JICA Study Team

1.5 Study Schedule

The Study is to be carried out in accordance with the schedule shown in **Fig. 1.5.1**. The study period is about twenty-two (22) months. Various reports are to be submitted periodically as shown in the schedule.



Legend: IC/R: Inception Report; P/R1: Progress Report I; P/R2: Progress Report II;
DF/R: Draft Final Report; F/R: Final Report
Phase I : Collection and analysis of basic information on sewerage and drainage improvement
Phase II : Formulation of Master Plan
Phase III : Pre-Feasibility Study on the priority projects
Source: JICA Study Team

Fig. 1.5.1 Overall Study Schedule

CHAPTER 2 BASIC STUDY

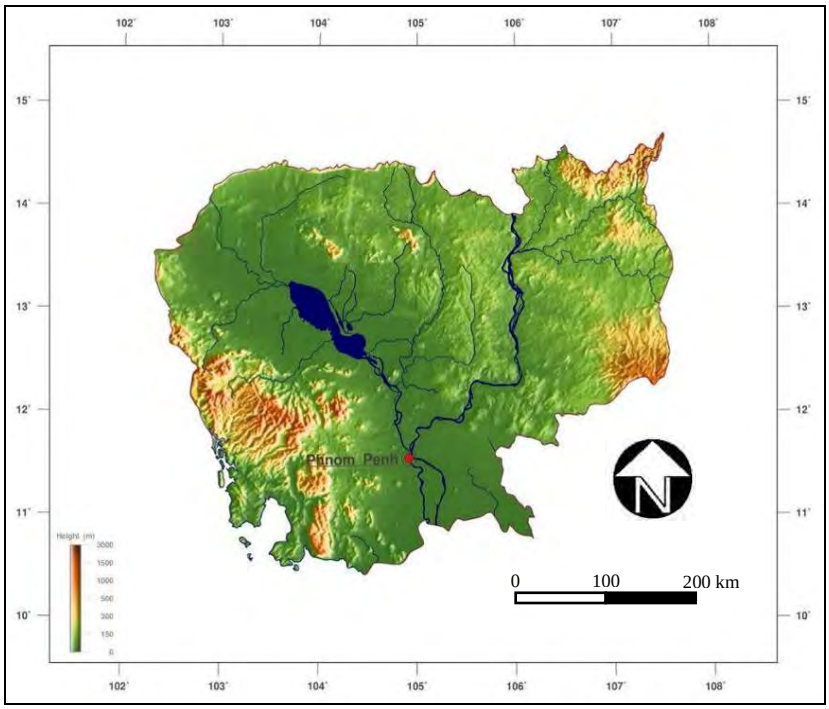
2.1 Natural Condition

2.1.1 Geographical Features

(1) Geographical Features of Cambodia

The Kingdom of Cambodia is located at the southwest of the Indo-China Peninsula (about 10° N to 15° N latitude and about 100° E to 108° E longitude). The land area of Cambodia is about 180,000 km^2, which is about half of Vietnam, one-third of Thailand and half of Japan.

The Kingdom of Cambodia is bordered by Laos on the North, Vietnam on the East, Siamese Bay on the South, and Thailand on the West. The Mondolkiri plateaus continue to Annamite range at the border to Vietnam and Laos, Dangrek Mountains plateau at the north border to Thailand, Cardamom Mountains in the south-west and the Elephant Mountains in the South. Also there is the Crowarnu mountain range at the west of PPCC. Highlands to the north-east and to the east merge into the Central Highlands and Mekong Delta lowlands of Vietnam. About two-thirds of the country is occupied by a central plain of less than 100 m of altitude. The international river Mekong traverses the country from north to south-east, where the low-lying plains extend into Vietnam and reach the South China Sea at the Mekong Delta region. Sap River originates from Sap Lake located at the center of the Kingdom and flows to the Mekong. Regarding the climate, it belongs to the tropical monsoon climate, with the rainy season from May to October and the dry season from November to April. Topographic map of Cambodia is shown in **Fig. 2.1.1**.



Source：Ginkgo Maps, http://www.ginkgomaps.com/en/rl3c_kh_cambodia_map_illdtmcolgw30scut_ja_mres.jpg

Fig. 2.1.1 Topographic Map of Cambodia (Altitude, River, Capital)

(2) Geographical Features of Phnom Penh Capital

Phnom Penh, the capital of Cambodia, is located at about 11°30" North latitude and about 105° East longitude in the center of Southern Cambodia with the administrative area of 678.46 km^2 and population of 1.5 million (Census of 2010). The capital has become the national center of politics,

economic and industrial activities of Cambodia. Geographically, Phnom Penh is located in the relay point of the “Southeast Asian Southern Economic Corridor” that connects Bangkok, Thailand (300 km long), and Ho Chi Minh, Vietnam (700 km long).

Phnom Penh is located in the Cambodian floodplain of the Mekong downstream. Sap River flows from Sap Lake to the Mekong at Phnom Penh, at which the Bassac River splits from the Mekong. These river channels form a “K” shape, giving the area around Phnom Penh its name of "Chaktomuk (which means “four arms”). A vast range of watershed of these four rivers is flooded in the rainy season every year, and the Sap River flows backward into Sap Lake. This area is often included in the Mekong delta, but geographically this area is natural levee and hinterwetlands, so that Mekong delta should begin from the downstream area of the Vietnamese border.

2.1.2 Topographical and Geological Features

(1) Topographical Features

Phnom Penh has grown in alluvial floodplains on the right bank at the junction of Sap River, Bassac River and the Mekong. The center of the capital is surrounded by the natural levee and ring dike, and its suburbs form low wetlands and some places are flooded in the rainy season. There are a lot of big lakes such as Cheung Aek Lake (2,500 ha) at the south of ring dike, Boeng Kok Lake, Poung Peay Lake, Tumpun Lake and Trabek Lake at surroundings of downtown, and there exist many marshes and wetlands. However, they are reclaimed disorderly due to the urbanization in recent years.

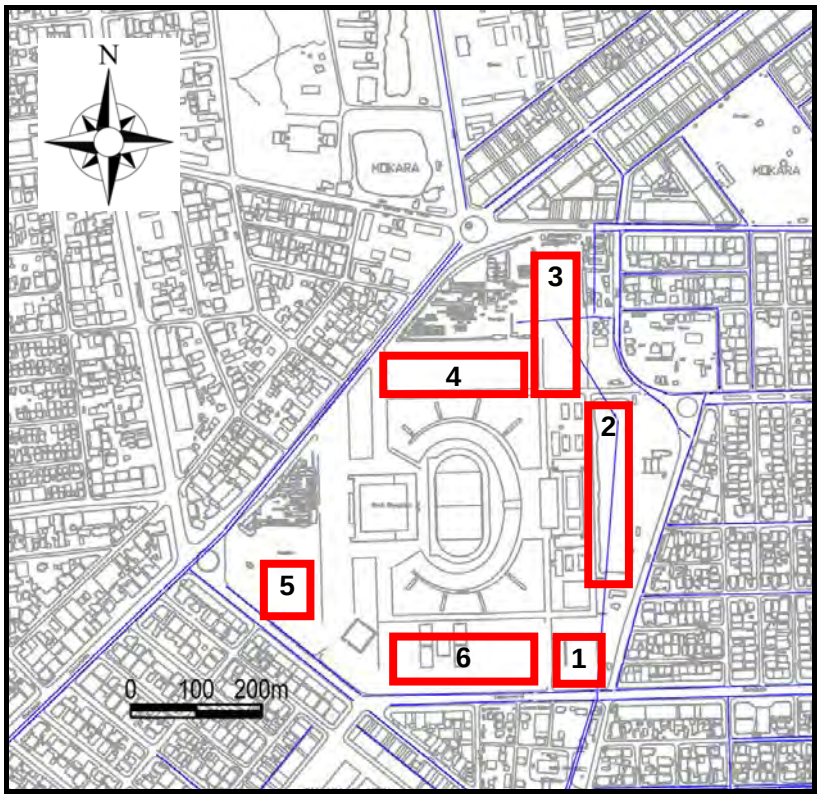
The topographical feature of the PPCC is gently inclined from north to south and from west to east, and almost flat as a whole. The difference of elevation in the region is about 10 m. There is comparatively high land area with elevation of 14 m between the Prey Key Village and the Pochentong Airport. No other area in the capital is higher than this area except around the western capital boundary. On the other hand, there is low land of about 5 to 6 m in elevation at Boeng Poungpeay District and about 4 m at Tumpun area.

Elevation in the study area ranges from 5 to 11 m and water level in the rainy season sometimes reaches more than 10 m, which brings about frequent inundation. Based on the survey work and reviews of the existing survey results, 30% of the capital is lower than 8 m, about 45% is lower than 9 m, and 60% is lower than 10 m in elevation.

The next subsection shows the result of survey on the condition of regulation ponds in PPCC, which was conducted in the Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase 3), JICA, to show the disorderly reclamation of lakes and swamps in PPCC.

(a) Regulation Ponds in and around Olympic Stadium

The Olympic Stadium at upstream of Trabek basin which includes the city center has four regulation ponds in and around the site. The four ponds vary in size because some ponds originated from lowland and others originated from borrow pit. These ponds receive and regulate stormwater from upstream and discharge them to downstream (See **Fig. 2.1.2**).



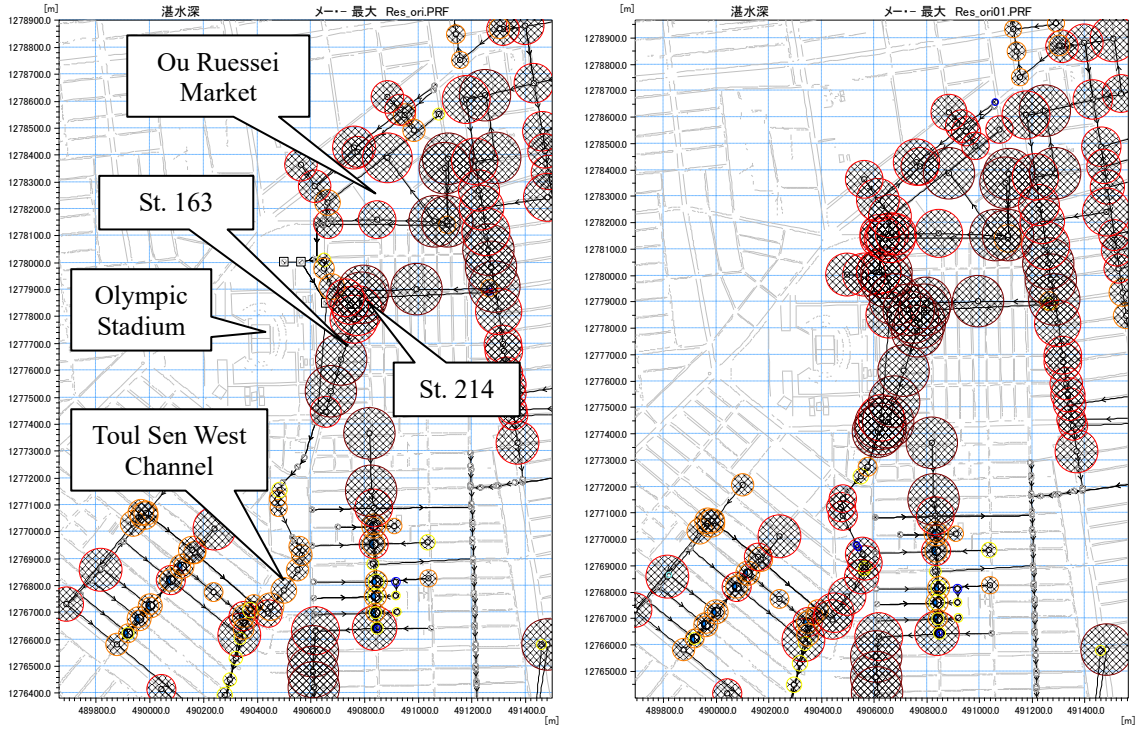
Size of Pond
Pond 1 : 83m×105m
Pond 2 : 55m×270m
Pond 3 : 55m×215m
Pond 4 : 55m×205m
Pond 5 : Unclear
Pond 6 : Unclear

Record of Pond Reclamation
Pond 1 : Reclaimed in 2015
Pond 2 : Reclaimed in 2015
Pond 3 : Reclaimed in 2015
Pond 4 : Reclaimed in 2011
Pond 5 : Reclaimed in 2006
Pond 6 : Reclaimed in 2002

Source: The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase 3), JICA and JICA Study Team

Fig. 2.1.2 Regulation Ponds in and around the Olympic Stadium (2010)

Incremental sewage from the city center due to rapid urbanization, created the offensive odour, outbreak of mosquitoes, and provoked illegal garbage dumping. People living around the ponds complain about deterioration of the environment. Considering the above and the location of ponds in the congested city center, the PPCC decided in 2010 to reclaim the ponds (Pond 1 to Pond 4 in **Fig. 2.1.2**) to create a sound environment and a simulation model was established in the project study in 2010 to roughly analyse inundation under the conditions of with/without regulation pond in and around the Olympic Stadium. The results of simulation are as shown in **Fig. 2.1.3**.



(a) With Ponds (b) Without Ponds

Note: Legend: Yellow (inundation depth: 0 to 25 cm), Orange (inundation depth: 25 to 50 cm), Red (inundation depth: 50 to 100 cm), Brown (inundation depth: more than 100 cm)

Source: The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase 3), JICA

Fig. 2.1.3 Simulation Results of Inundation in and around the Olympic Stadium (Year 2010)

The simulation demonstrates that inundation condition becomes worse, especially in and around Ou Ruessei Market, St. 214, St. 163 next to the Olympic Stadium, Toul Sen West drainage channel, which is located at the south of the Olympic Stadium.

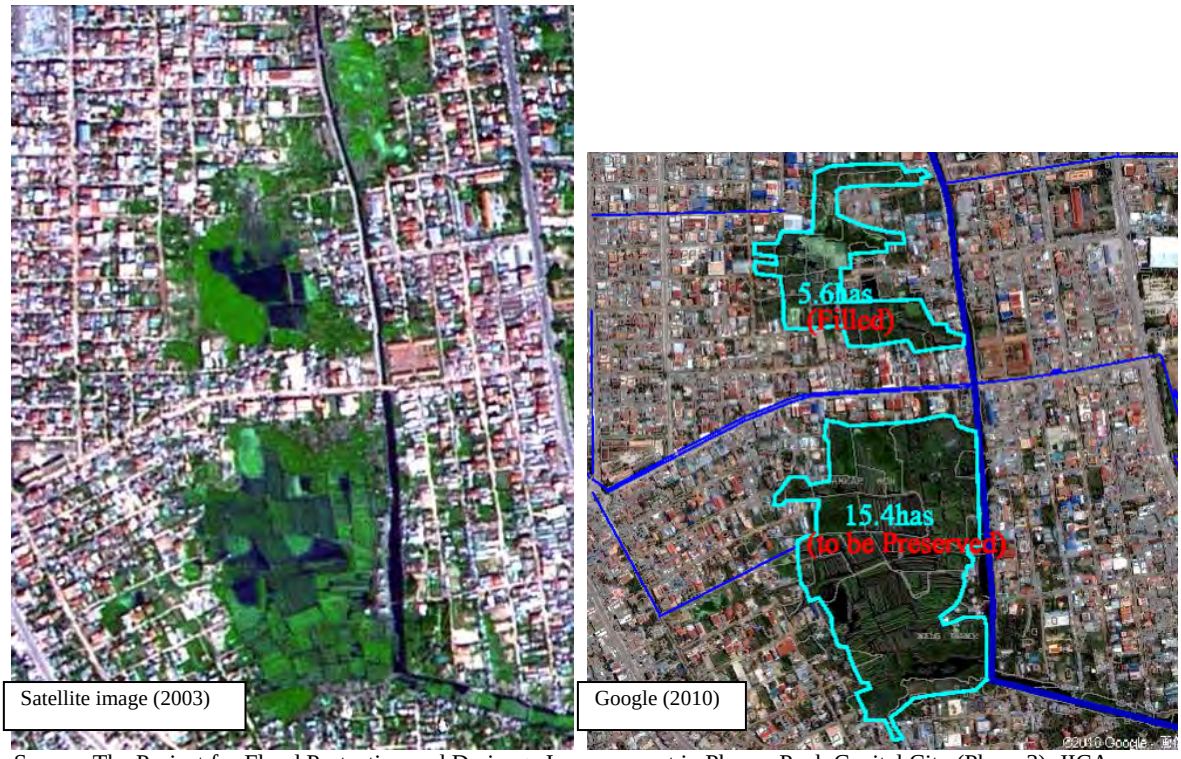
(b) Trabek Regulation Pond

The Trabek regulation pond of PPCC is located at upstream of the Trabek Pumping Station at the downstream end of the Trabek Drainage Channel. Rehabilitated in the ADB's project in 2003, the regulation pond has the function of regulating inflow to the pumping station.

PPCC enacted an ordinance in 2004 to protect the regulation pond from illegal reclamation, and placed markers to identify the boundaries. Additionally, PPCC periodically assigned security guards to enforce the regulation. Unfortunately, the pond was gradually reclaimed by the neighbouring communities during the absence of the guards or in the night time.

Dredging works being implemented by PPCC were discontinued in 2011 due to the massive opposition campaign of the people and the negative articles in the newspapers. Since then, only verbal warnings to the people were given by PPCC to prevent conflict with the surrounding communities.

The site reconnaissance conducted in the JICA Project from March to April, 2010, revealed that (i) housing development was in progress at the northern part of Trabek regulation pond, and the pond has almost disappeared, and (ii) the southern part of Trabek regulation pond was functioning to some extent but gradually lost its volume due to sedimentation of sand and soil, new embankment created by people living around the pond, and new reclamation encroaching the pond. **Fig. 2.1.4** illustrates the transition of Trabek regulation pond.

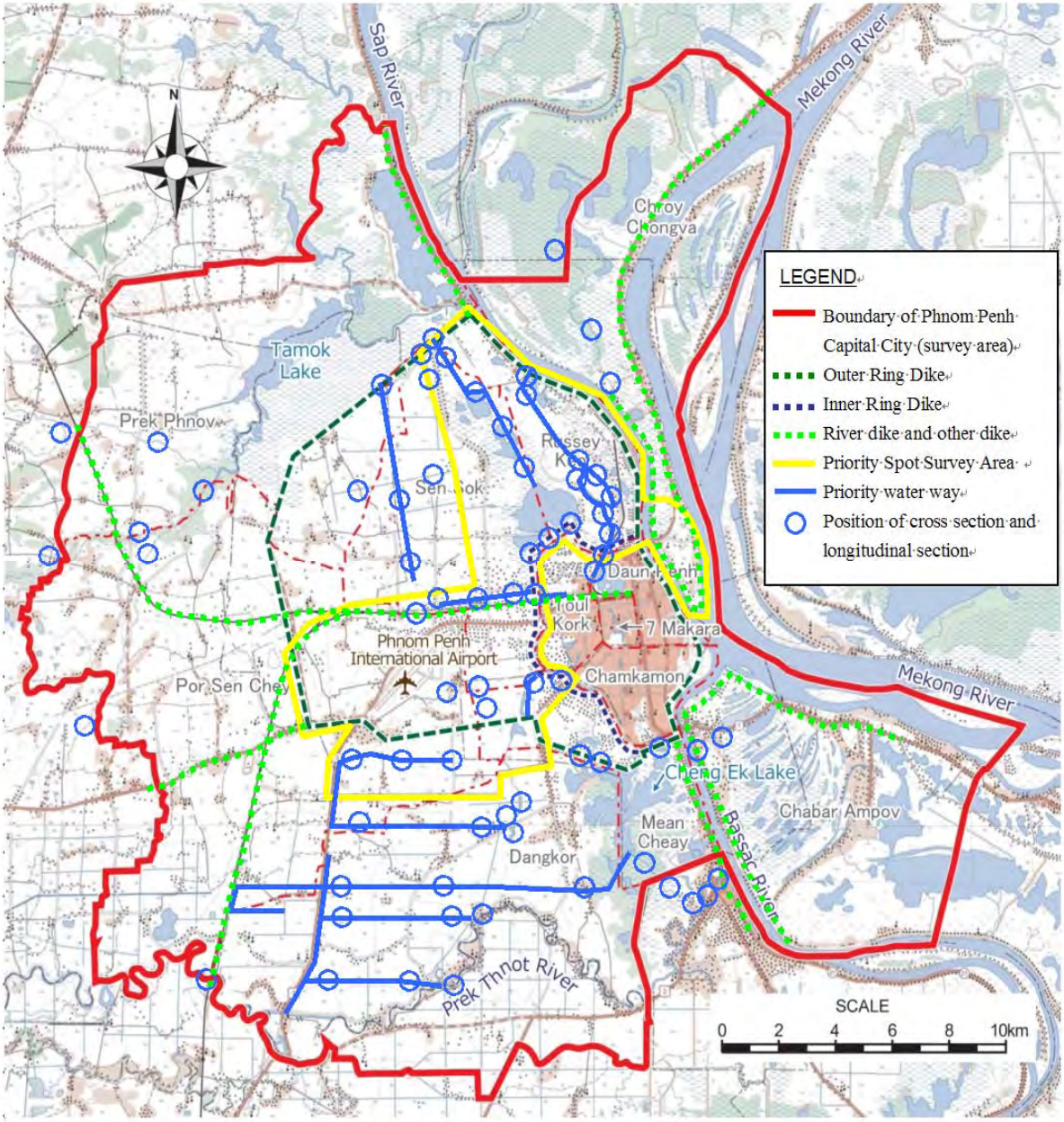


Source: The Project for Flood Protection and Drainage Improvement in Phnom Penh Capital City (Phase 3), JICA

Fig. 2.1.4 Transition of Trabek Regulation Pond (2010)

(2) Outline of Topological Survey Work conducted in the Study

The survey was implemented to provide the data for hydrological analysis, drainage and sewerage planning, establish permanent control points, provide spot height and cross section drawings, develop DEM (Digital Elevation Model) data, in the area as shown in **Fig. 2.1.5**, by establishing control points, conducting control points, spot height and cross section survey in November and December 2014. Reliability was validated by making maximum use of the existing data such as Shuttle Radar Topography Mission, KOICA DEM by the Project of the production of the National Base Map and the Establishment of the Master Plan for the National Spatial Data Infrastructure in Cambodia 2010-2011, considering budgetary and time constraints.



Source: JICA Study Team

Fig. 2.1.5 Local Contract Survey Work, Area and Position

(a) Quantities of Survey Work

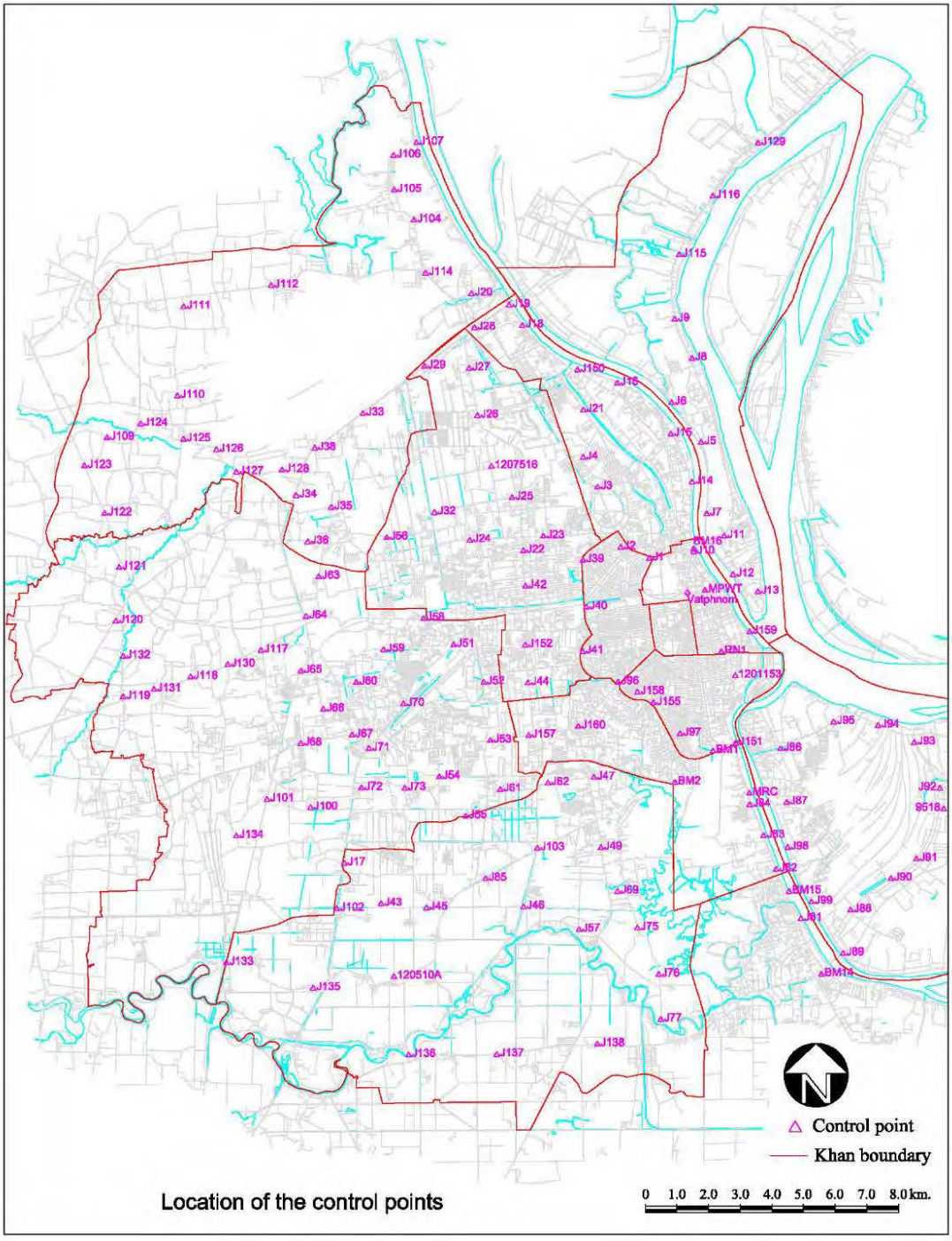
Quantities of the survey works are summarised in **Table 2.1.1** and the location of control points are shown in **Fig. 2.1.6**.

Table 2.1.1 Quantities of Survey Works

Work Item	Quantity	Note
Control Point Establishment	150 places	Concrete Monument
Control Point Levelling Survey	300 km	Direct Levelling
Spot Height Survey	8,500 places	GNSS Rapid Static Survey
Cross and Longitudinal Section Survey	80 places	Total Station Survey
Drainage Pipe/Channel Elevation Survey	20 places	GNSS Rapid Static Survey
Manhole Elevation Survey	60 places	GNSS Rapid Static Survey
Control Point Description, Drawing, Reporting	Lump sum	Topographic map, Cross section

Source: JICA Study Team

Concrete pillars of L 0.2 m× W 0.2m×H 0.5 m were laid underground as the new control points. Vertical control survey was carried out by the direct levelling and the accuracy was confirmed by the multi-observation method, loop closure method and connecting public control points. Spot height survey, drainage pipe/channel elevation survey and manhole elevation survey were carried out by GNSS rapid static survey, then reliability and accuracy was confirmed by ambiguity, PDOP, standard deviation, comparison of multi-observation, verification with publicly-known points and so on. Cross and longitudinal section survey was carried out using total station based on the temporary control points established by the GNSS rapid static survey.



Source: JICA Study Team

Fig. 2.1.6 Location of Control Points

(b) Coordinate System

Cambodia Geodetic Datum was adopted as the coordinate system of this Study and EGM (Earth Gravitation Model) 2008 was adopted for Geoid Model, as shown in **Table 2.1.2**.

Table 2.1.2 Cambodia Geodetic Datum

Coordinate System	Universal Transverse Mercator Zone 48N
Spheroid	GRS80 Semimajor Axis : 6378137m Inverse Flatting : 298.257 222 101
Origin	Central Meridian : just 105 degree East Latitude : just 0 degree (on the equator) False Northing : 0.000 m False Easting : 500,000.000 m Scale factor of origin : 0.9996
Datum Level	Hatien MSL

Source: Ministry of Land Management, Urban Planning and Construction (MLMUPC)

(c) Basic Reference Public Control Points and Summary of Accuracies

Basic reference public control points are enumerated in **Table 2.1.3**.

Table 2.1.3 Basic Reference Public Control Points

No.	Name	Northing	Easting	Elevation	Remarks
1	RN1			10.661	DHBE
2	MPWT			11.314	DHBE
3	Vat Phnom I	1279428.532	491013.536	27.210	SGC
4	MRC			10.527	MRC
5	BM14			7.304	MRC
6	BM16			11.481	MRC
7	1207516	1283423.255	484823.800		DLMC
8	1207517	1284269.793	482803.766		DLMC
9	120510A	1267234.647	481743.812		DLMC
10	BM2			11.194	PFPDI

Source: DHBE : DEPARTMENT HYDROLIQUE BUREAU D'ETUDE
SGC : Service Geographique du Cambodge
MRC : Mekong River Committee
DLMC : Department of Land Management and Cadastral
PFPDI : The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh

General accuracies of direct levelling and general accuracies of GNSS survey are summarized in **Table 2.1.4** and **Table 2.1.5**.

All the vertical accuracies of control points are better than $20\sqrt{s}$ mm and 80% of control points are better than $10\sqrt{s}$ mm. All the horizontal standard deviations of control points are lower than 100 mm and 60% of control points are better than 20 mm. Thus, quality of the control points for the spot height survey is satisfactory.

Table 2.1.4 Distribution of Vertical Accuracies of Control Points

Item	a : Accuracy (mm)			
	$a \geq 20\sqrt{s}$	$20\sqrt{s} > a \geq 10\sqrt{s}$	$10\sqrt{s} > a \geq 5\sqrt{s}$	$5\sqrt{s} > a$
No. of Points	0	24	58	48
Observation Distance (m)	0	35,827	113,510	146,135

s : observation one-way distance in km
Source: JICA Study Team

Table 2.1.5 Distribution of Horizontal Standard Deviations of Control Points

Item	s : Standard Deviation (mm)			
	s ≥ 100	100 > s ≥ 50	50 > s ≥ 20	20 > s
No. of Points	0	1	42	71

Source: JICA Study Team

(d) Reliability of the Observations

Horizontal reliability of GNSS survey was checked by comparing multiple observation of each control point with their average. As shown in **Tables 2.1.6** and **2.1.7**, 96% of the observation is within the error of 20 cm, which indicates high reliability of the data horizontally and vertically.

Table 2.1.6 Distribution of Horizontal Difference with Average of Control Points

Item	Hd : Horizontal difference with average (mm)			
	Hd≥1000	1000>Hd≥200	200>Hd≥50	50>Hd
No. of checking times	6	21	54	708

Source: JICA Study Team

Table 2.1.7 Distribution of Vertical Difference with Level of Control Points

Item	Vd : Vertical difference with direct level (mm)			
	Vd≥1000	1000>Vd≥200	200>Vd≥50	50>Vd
No. of checking times	4	27	164	589

Source: JICA Study Team

Reliabilities of cross section survey data were confirmed by checking back sight observation of total station and GNSS survey. As shown in **Table 2.1.8**, 98% of survey results are within the error of 30 cm and 90% of the results are within the error of 10 cm. Consequently the survey results show high reliability.

Table 2.1.8 Distribution of Back Checking Errors

Classification		e : Error (mm)			
		e>300	300≥e>100	100≥e>50	50≥e
No. of Checking Times	Horizontal	3	4	57	133
	Vertical	0	21	42	134

Source: JICA Study Team

(e) Comparison of Survey Results with Existing Data

Validity of survey results were examined by comparing with existing data of KOICA project "The Production of the National Base Map and the Establishment of the Master Plan for the National Spatial Data Infrastructure in Cambodia (2010-2011)", aiming to formulate the National Base Map and establish the Master Plan for National Spatial Data Infrastructure. As shown in **Table 2.1.9**, it seems that both data have correspondence, although the number of comparable points is not enough.

Table 2.1.9 Comparison between KOICA Data and Survey Results in the Study

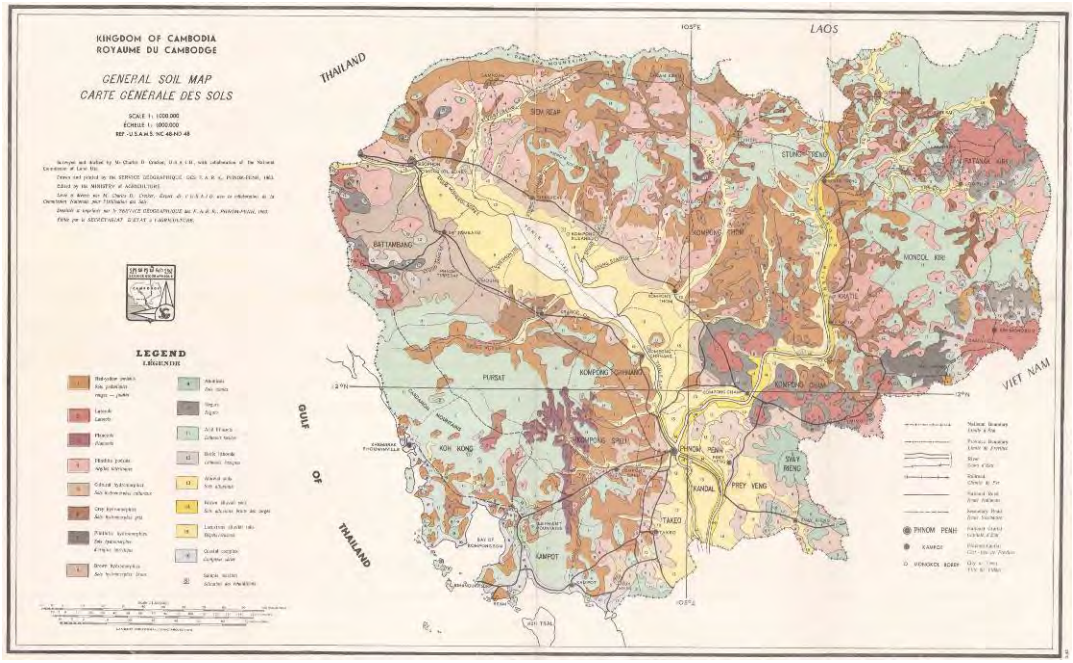
Distance between points	Difference of elevation	-2.25	-2.00	-1.75	-1.50	-1.25	-1.00	-0.75	-0.50	-0.25	0.0	0.25	0.50	0.75	1.00	1.25
0 to 5 m	Point Number										14	10			1	
5 to 10 m											36	31	7	2	1	
10 to 30 m											78	107	41	23	11	3
30 to 99.95 m		31	53	70	125	172	242	312	364	342	434	358	148	128	47	19

Source: JICA Study Team based on data of "The Production of the National Base Map and the Establishment of the Master Plan for the National Spatial Data Infrastructure in Cambodia (2010-2011)"

(3) Geological Features

(a) General Geological Features of Cambodia

Geological features of Cambodia is categorized into comparatively old geological features such as those in early and middle period of Jurassic in northeast area and those in upper Jurassic in southwest area but most of the country is formed by Quaternary sedimentary rock or unconsolidated sedimentary rock and relatively new and soft ground. The capital city of Phnom Penh is formed on these sedimentary rock layers (See **Fig. 2.1.7**).



Source: USAID & National Commission of Land Use

Fig. 2.1.7 Cambodian Geological Map

(b) Geological Features and Soil Condition around Phnom Penh City

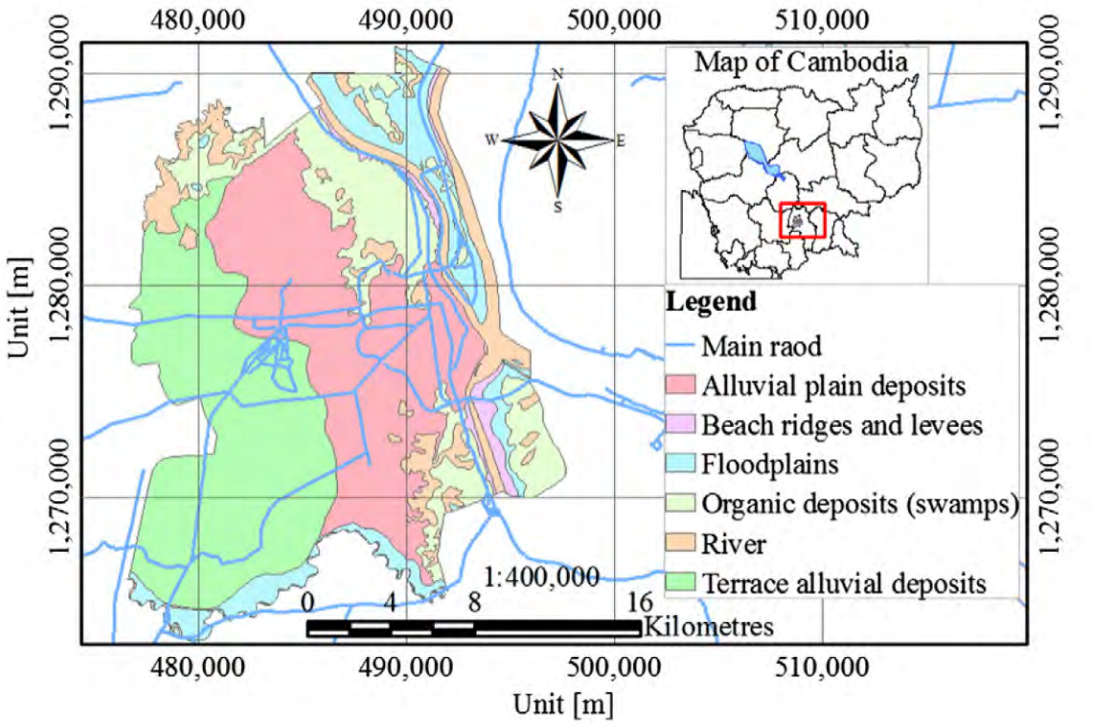
Geological structure of the Mekong Delta region, where the Study Area is situated, had been formed in Precambrian to Holocene ages. Old Alluvium was formed in deltaic shape between the Pliocene and Pleistocene by the Mekong and its tributaries and then Holocene deltaic alluvium was formed. The Holocene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

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

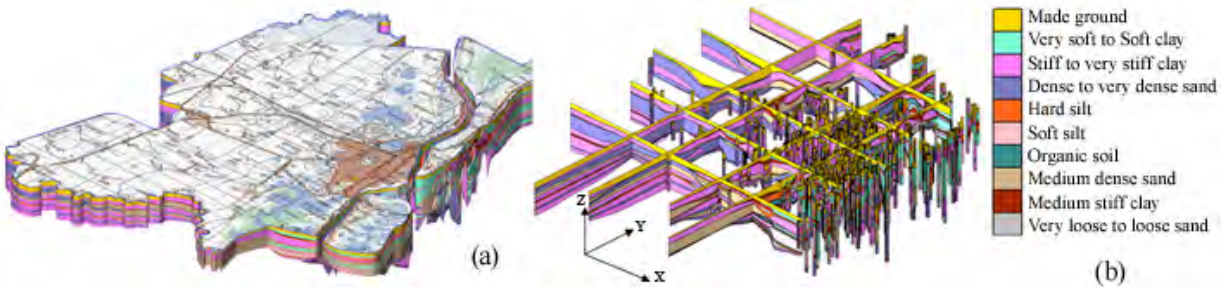
The ground consists mainly of sand up to about 44 m depth in the underground and the gravel appears in some places, according to a boring data of Mekong bridge at Kampong Cham where the low lands spread out in the northeast of Phnom Penh. Near the National Route 6A at about 40 km north of Phnom Penh, hinterwetlands spread out and the clay layer reaches to 24 m depth and N value become high in more than 10 m depth, which indicate the layer was formed in old age, according to the boring data around the area. There is the hill and alluvial fan of Prek Thnot in the west of Phnom Penh plain, and there exists base rock around 30 m as well as clay and sand which includes coarse sand and gravel, according to a deep well survey in the alluvial fan.

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

Soft clay continues up to 27 m in depth, according to the boring data of irrigation project facilities at the Mekong river banks. Deep well data of Svay Rieng Province at left bank of Mekong at southeast of Phnom Penh plain, shows that basic rock is not found up to 130 m depth and all sediments are formed in Quaternary Age. Results of geophysical prospecting show that the structure stretches from north and south and falls down to the east. On the other hand, there is a monadnock named Ba Phnom on the left bank side, which shows that the geographical structure of the base layer is complex (Source: KUBO, 2001, Abstracts, 5thICG.Kubo, 2002, Japan Geography Society summary collection No. 61). Geological maps of Phnom Penh are shown in **Fig. 2.1.8**.



Source: Geological Map of Phnom Penh City (reproduced form JICA and MPWT, 2003)



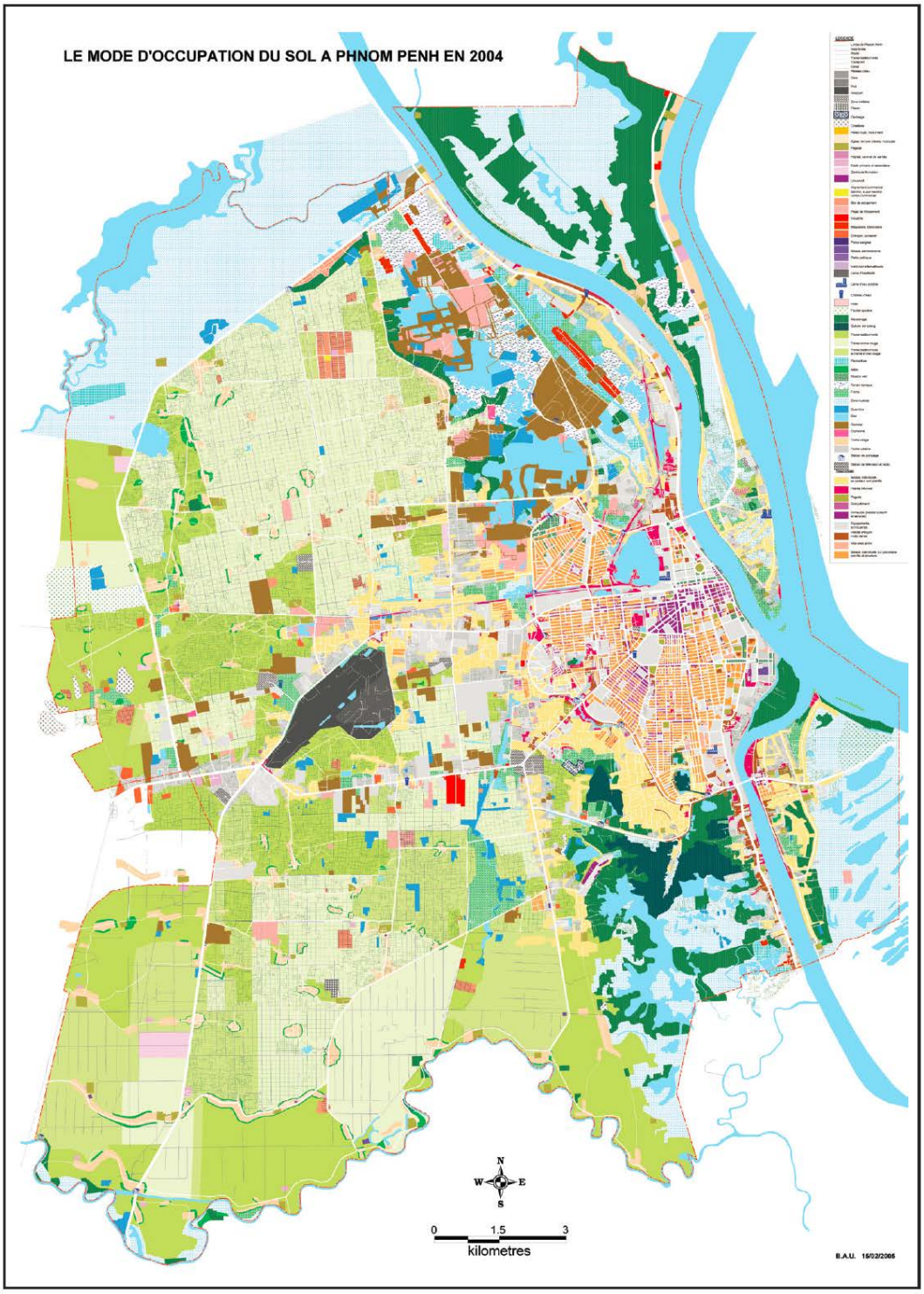
Source: Engineering Geology, 178, and 3D geological modeling and geotechnical characteristics of Phnom Penh sub-soils in Cambodia (58-69(2014)

Fig. 2.1.8 Two-Dimensional and Three-Dimensional Phnom Penh Geological Maps

2.1.3 Land Use

As the urban development Master Plan of PPCC, the "White Book on Development and Planning of Phnom Penh" was issued in October 2007 (hereinafter referred to as "White Book"). In the White Book, the land use plan for the target year 2035[2] (**Fig. 2.1.10**) was formulated based on land use in 2004 (**Fig. 2.1.9**). In comparison with land use in 2004 and 2035, water bodies decrease dramatically, especially in Cheung Aek and Tamok Lake area. The land use plan was approved in the committee for land management and urban planning for the capital, which was established in accordance with a Royal Decree, and finally approved with the issuance of sub-decree dated on 23rd December 2016.

[2] Land-use plan might be abruptly changed due to the lack of appropriate regulation.


LE MODE D'OCCUPATION DU SOL A PHNOM PENH EN 2004
N
W
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S
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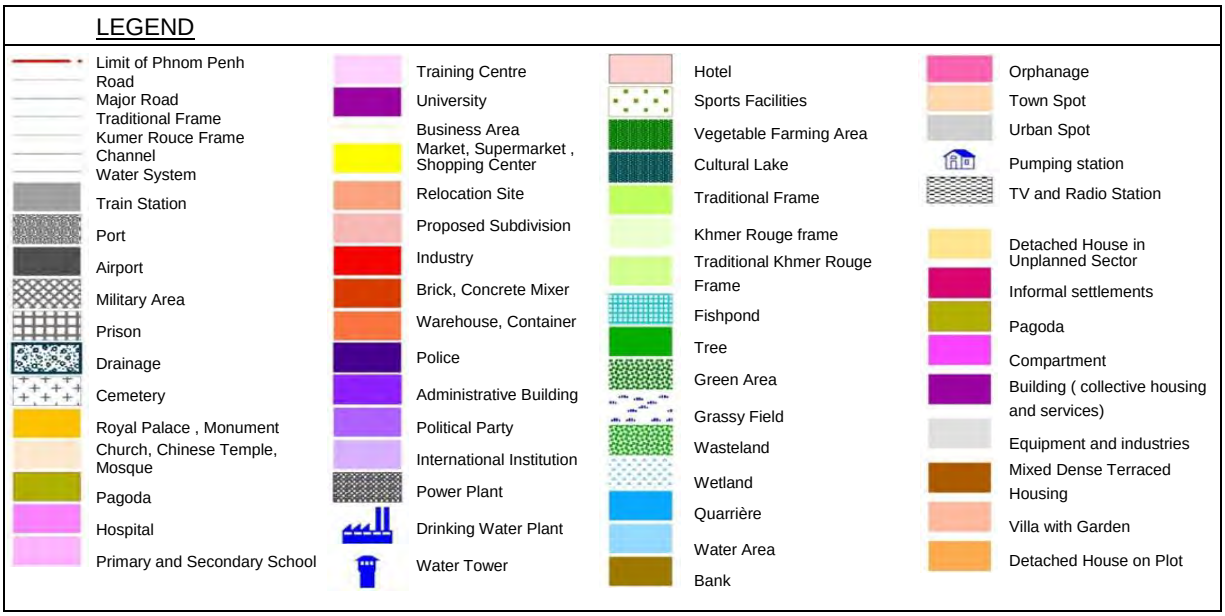
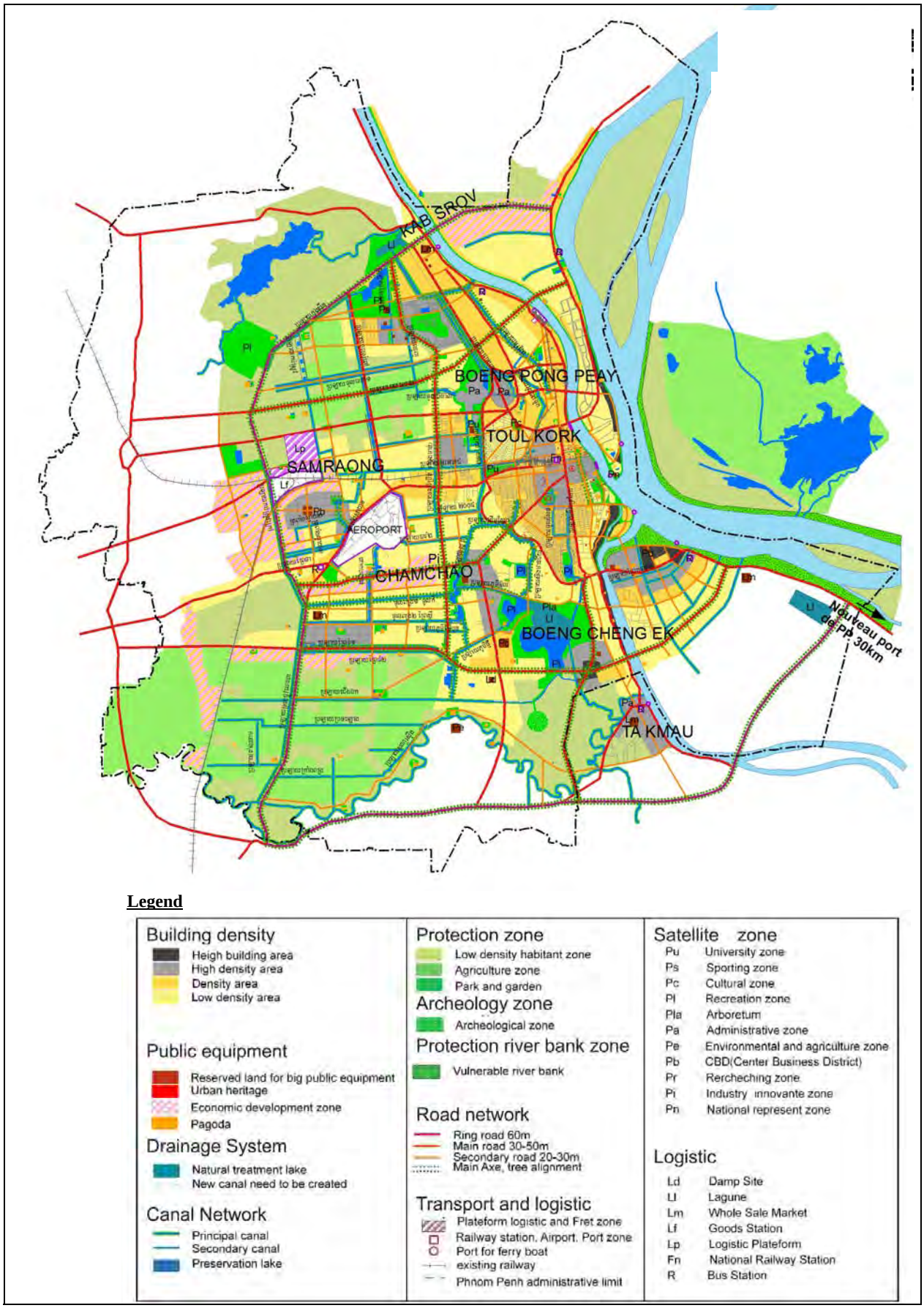
kilometres
B.A.U. 15/02/2005



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

Fig. 2.1.9 Land Use of PPCC in 2004



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

Fig. 2.1.10 Land Use of PPCC in 2035

2.1.4 Meteorology and Hydrology

(1) Climate of Cambodia

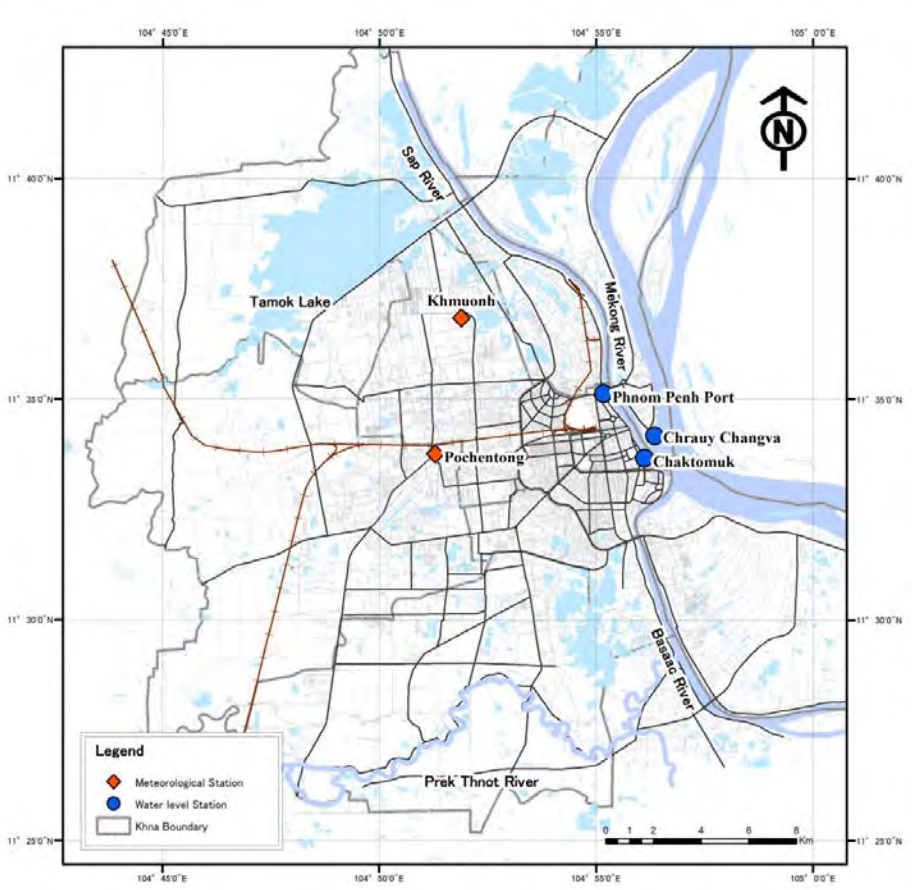
Cambodia is part of a tropical monsoon climate and average total annual rainfall from 1981 to 2013 (33 years) is 1,428.5 mm/year. However, large variation can be seen in annual rainfall from 1,095.4 mm/year (1992) to 2,147.3 mm/year (2000). The dry season is from December to April and 80% or more of the annual precipitation are concentrated in the rainy season (May to November).

Location map of meteorological and water level gauging stations are as shown in **Fig. 2.1.11** and the list of organizations and observed items is shown in **Table 2.1.10**.

Table 2.1.10 List of Organizations and Observed Items

Classification	Station	Items	Duration	Organization	Remarks
Meteorology	Pochentong	Temperature	1985-2013	MOWRAM (Ministry of Water Resources and Meteorology)	Station was changed to Khmuonh from June of 2012
		Humidity	1985-2011		
		Rainfall	1981-2013		
		Evaporation	1981-1996		
		Sunshine	1981-2013		
		Wind	1980-2008		
Hydrology	Phnom Penh Port	Water level	1993-	DOWRAM (Department of Water Resources and Meteorology)	
	Chrauy Changva	Water level	1993-		
	Chaktomuk	Water level	1980-		

Source: JICA Study Team, based on information provided by MOWRAM



Source: JICA Study Team, based on information provided by MOWRAM and DOWRAM

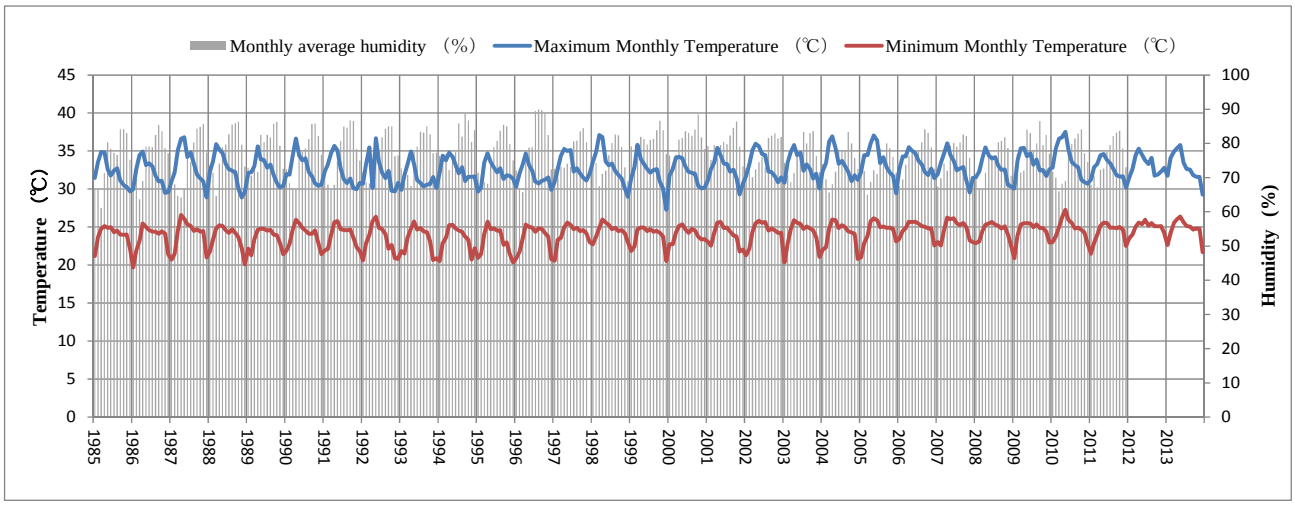
Fig. 2.1.11 Location of Meteorological and Hydrological Observation Sites

(2) Meteorology

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

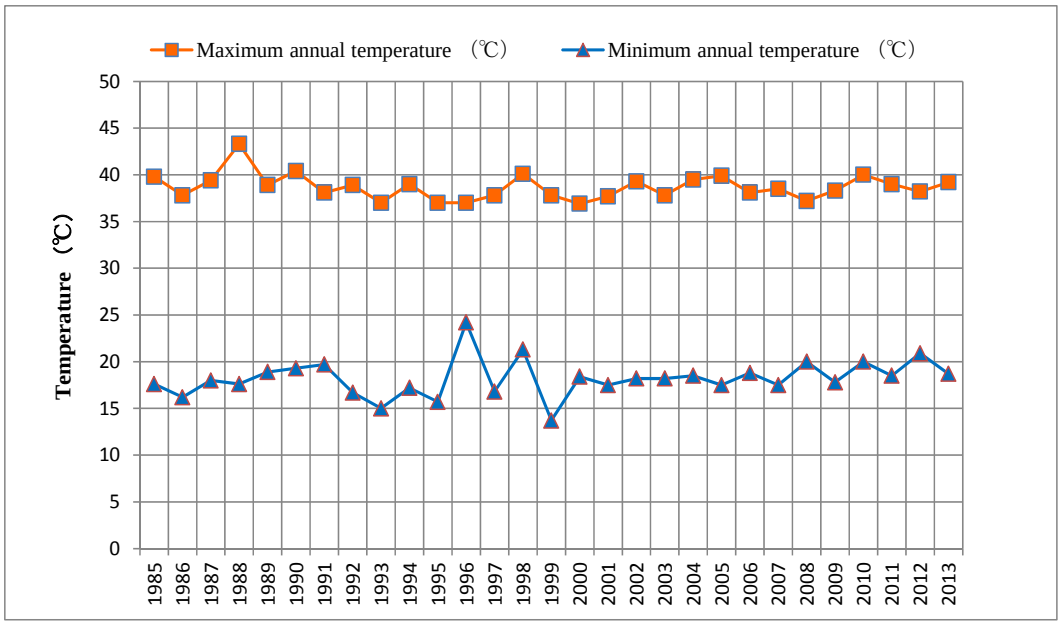
The temperature is as a whole higher in March to May and the difference of maximum and minimum is about 20 degrees Celsius. The annual average of humidity is 77%, ranging from 70% to 80% and secular change is not observed.

Maximum and minimum monthly temperature is shown in **Fig.2.1.12** and annual maximum and minimum temperature is shown in **Fig.2.1.13**.



Source: DOWRAM (Department of Water Resource and Meteorology)

Fig. 2.1.12 Maximum and Minimum Monthly Temperature and Monthly Average Humidity (1985-2013)



Source: DOWRAM (Department of Water Resource and Meteorology)

Fig. 2.1.13 Annual Maximum and Minimum Temperature (1985-2013)

(3) Rainfall

PPCC belongs to the tropical monsoon climate. The annual average rainfall in 2004 to 2013 is 1,487.2 mm/year and large variation can be seen in annual rainfall from 1,170.9 mm/year (2006) to 1,938.7 mm/year (2008).

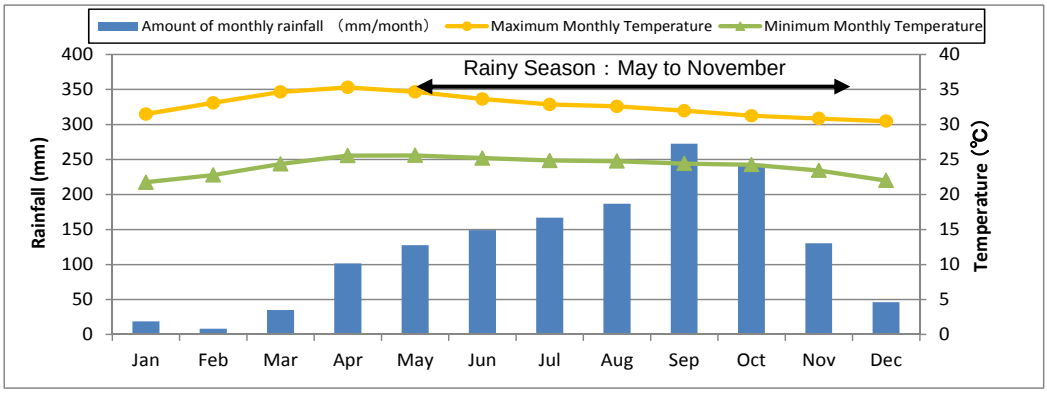
Amount of monthly rainfall is shown in **Table 2.1.11**, and monthly average rainfall is shown in **Fig. 2.1.14.** In addition, the secular change of annual rainfall from 1981 to 2013 (33 years) is shown in **Fig. 2.1.15**.

Table 2.1.11 Amount of Monthly Rainfall (2004–2013)

Unit:mm/month

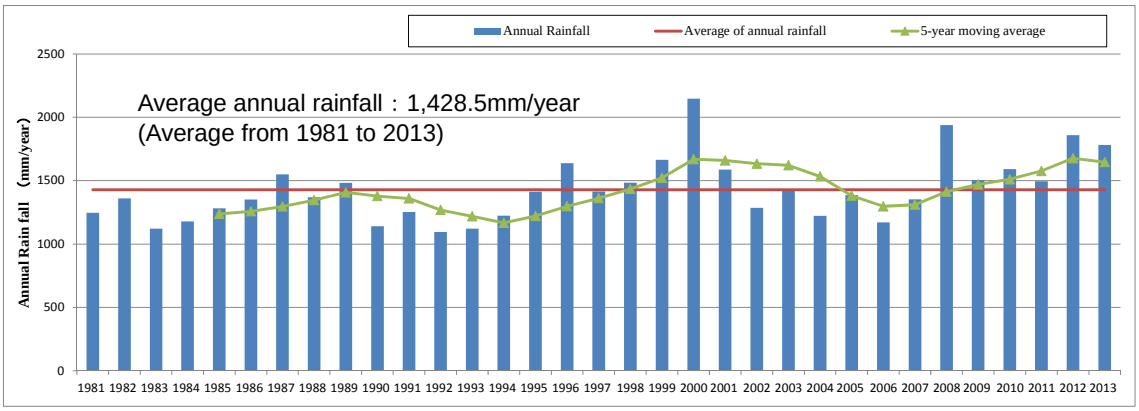
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Season	Dry				Rainy							Dry	
2004	0.4	0.0	0.0	94.8	160.6	164.2	142.7	101.1	237.2	202.1	118.8	0.0	1221.9
2005	0.0	0.0	0.0	73.7	73.5	52.3	125.2	212.1	298.4	375.1	132.7	42.6	1385.6
2006	0.1	42.1	32.8	66.4	84.0	92.0	124.8	274.2	228.2	190.9	12.4	23.0	1170.9
2007	0.0	0.0	32.7	39.9	192.4	258.3	135.7	263.6	155.1	212.1	63.2	0.0	1353.0
2008	74.1	0.6	112.0	83.4	197.3	219.1	169.6	289.6	290.2	259.4	190.7	52.7	1938.7
2009	0.0	14.6	7.1	270.5	241.7	148.6	111.8	267.9	300.2	108.2	33.5	0.0	1504.1
2010	25.4	0.0	35.6	55.9	26.9	254.3	84.1	233.0	324.3	387.1	94.3	69.9	1590.8
2011	0.8	0.0	11.4	130.9	131.4	113.3	227.8	249.7	244.4	311.9	67.0	7.0	1495.6
2012	27.0	41.0	28.8	77.8	185.8	94.3	283.2	177.6	455.8	116.6	350.4	22.0	1860.3
2013	0.0	0.0	2.0	182.2	143.4	350.8	189.8	0.0	139.2	413.8	303.8	56.2	1781.2
Average	**19.0**	**8.1**	**35.0**	**101.8**	**127.7**	**149.1**	**166.8**	**186.7**	**272.4**	**244.0**	**130.2**	**46.3**	**1487.2**

Source: DOWRAM (Department of Water Resources and Meteorology)



Source: DOWRAM (Department of Water Resources and Meteorology)

Fig. 2.1.14 Monthly Average Rainfall (2004-2013)



Source: DOWRAM (Department of Water Resources and Meteorology)

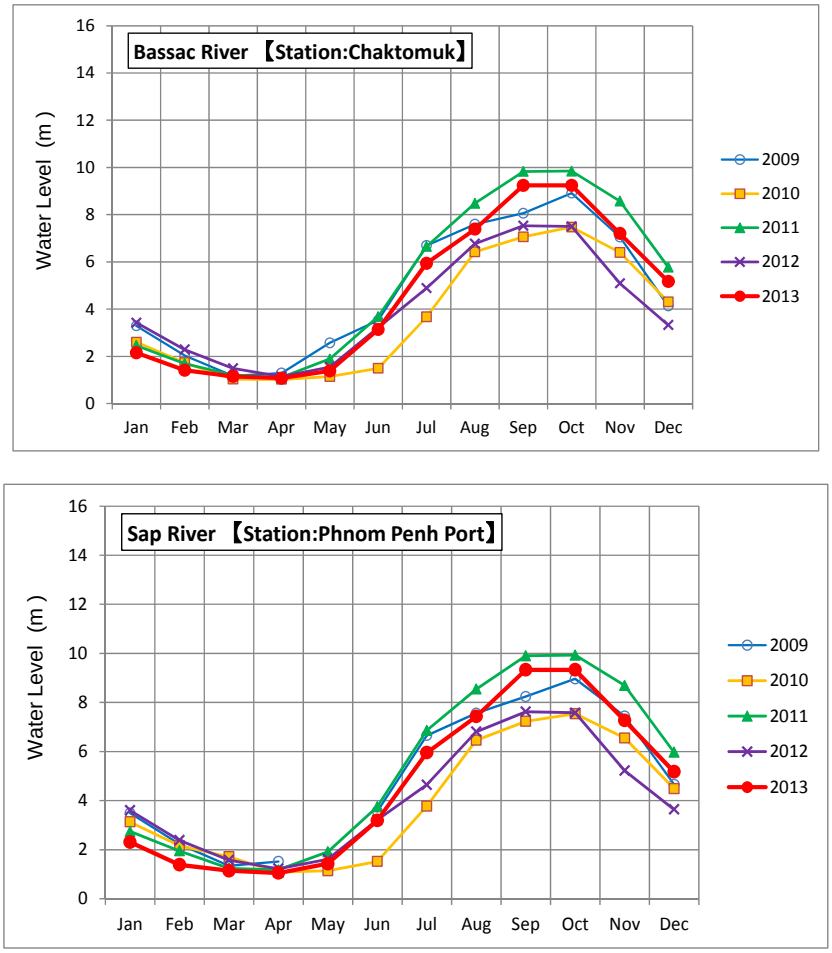
Fig. 2.1.15 Secular Change of Annual Rainfall (1981-2013)

(4) River Water Level

The highest water level of Bassac River and Sap River is generally recorded during August to October. The highest water level of Bassac River is 9.84 m (2011) and lowest level is 7.47 m (2010). On the other hand, water level during March to May is very low (1.2 m). The difference of water level between the dry season and the rainy season is about 6 to 8 m.

According to the interview survey with MOWRAM (Ministry of Water Resources and Meteorology), water level is not observed during the dry season (December to April) because of backwater from the river month of Mekong River. The daily water level fluctuation is about 0.3 m to 0.5 m.

The water level in the last 5 years (2009-2013) is shown in **Fig. 2.1.16**.



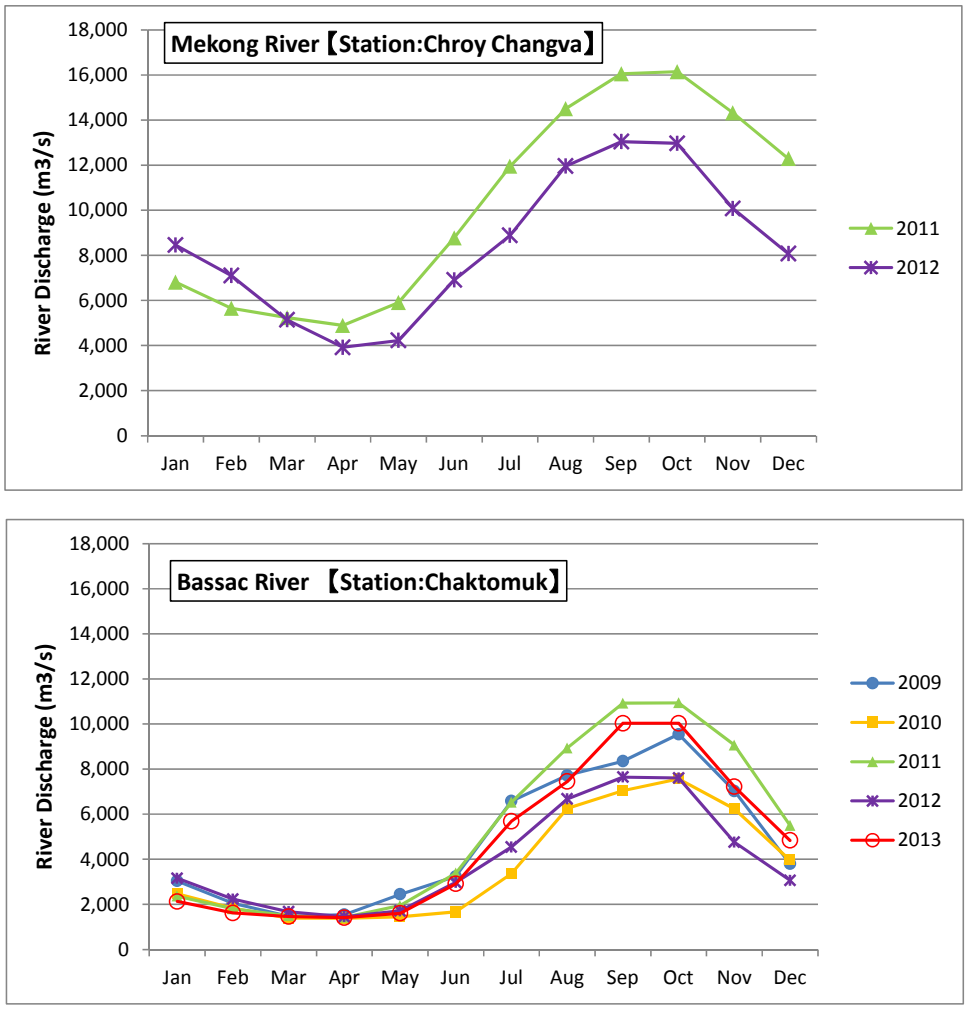
Source: MOWRAM (Ministry of Water Resources and Meteorology)

Fig. 2.1.16 Water Level of Bassac River and Sap River (2009-2013)

(5) River Discharge

According to the interview with MOWRAM, river discharge of the Upper Mekong River is 32,000 m^3/s and maximum river discharges to Sap River and Bassac River are about 8,000 m^3/s and 1,500 m^3/s respectively. Peak discharge of Mekong River is recorded in June to October and the backflow from Mekong River to Sap River occur in this season.

Fig. 2.1.17 presents the estimated discharge of Mekong River and Bassac River using stage-discharge curve (H-Q curve in **Fig. 2.1.18**). Peak river discharge of over 16,000 m^3/s is estimated in August to November.



Source: JICA Study Team

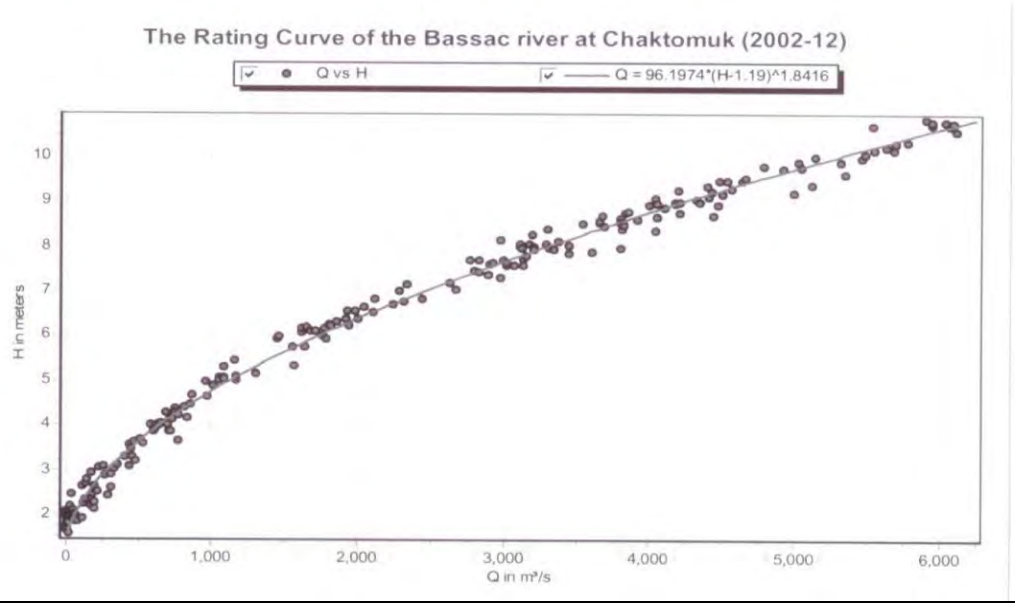
Fig. 2.1.17 Estimated River Discharges of Mekong River and Bassac River

【Bassac River　H-Q Curve】

$$Q = 96.1974*(H-1.19)^{1.8416}$$

where Q = flow discharge, m^3/s

$H_{Chaktomuk}$ = gauge height at Bassac Chaktomuk, m



【Mekong River　H-Q Curve】

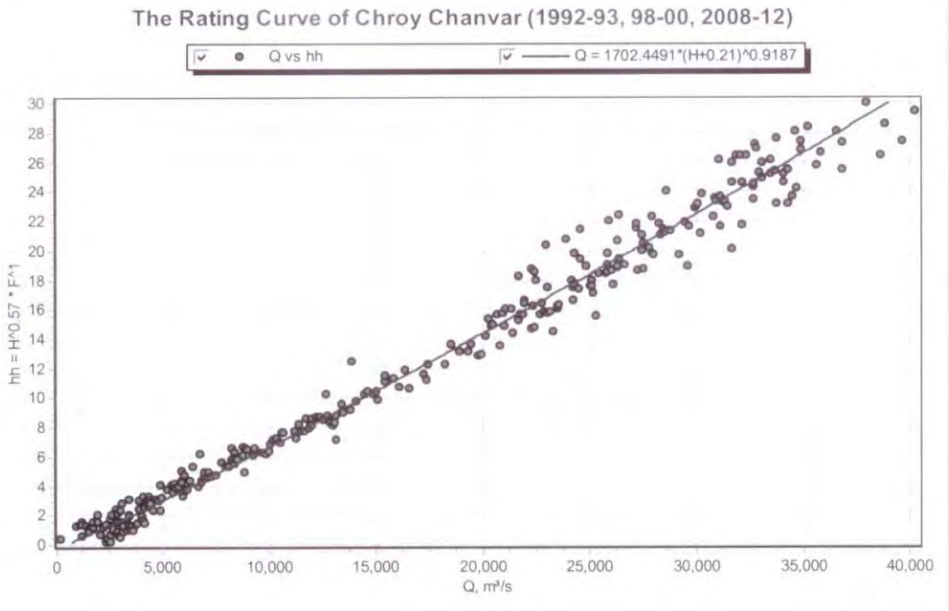
$$Q = 1702.4491*(hh+0.21)^{0.9187}$$

where Q = flow discharge, m^3/s

hh = $H^{0.57}F$

H = reading water levels at Chroy Changvar, m

F = *absolute value of* $[(H_{KgCham} - 0.93) - (H_{Neak\ Leung} - 0.33)]$.



Source: DOWRAM (Department of Water Resources and Meteorology)

Fig. 2.1.18　Stage-Discharge Curve (H-Q Curve)

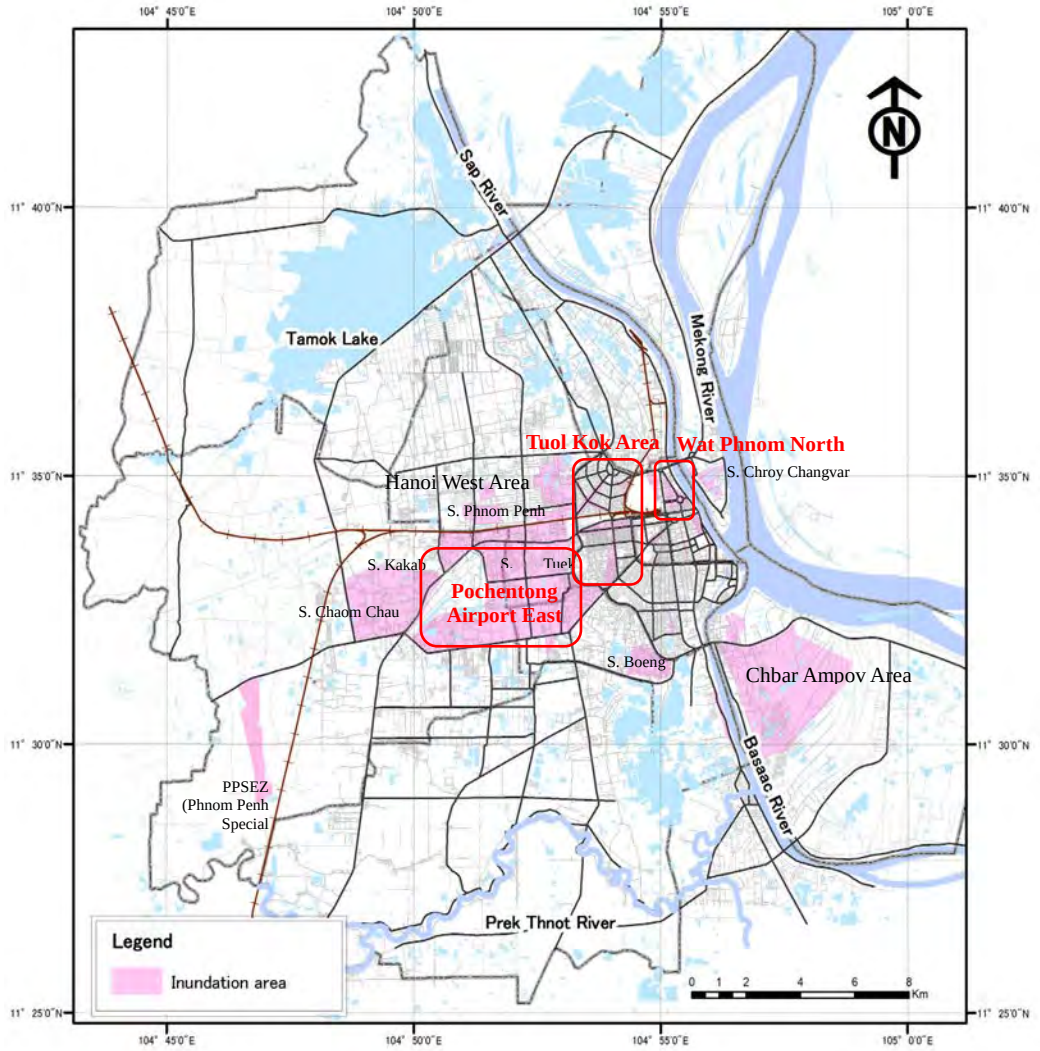
(6) Inundation Area

(a) Inundation Area of Inland Flooding

Fig. 2.1.19 shows the inundation-prone area of inland flooding[3], which was grasped through interview with DPWT staff, DSD staff, public works office of each Khan, and social survey. It is reported that inundation occurs several times in the rainy season every year in these areas.

In the city center (inside of the inner ring dike), damage of inland flooding has been decreasing in many parts of the area with the upgrading of drainage pipe network and drainage channel, rehabilitation of existing pumping stations and construction of new pumping station. On the other hand, drainage improvement in the area on the northern side of Wat Phnom (eastern half of Sangkat Srah Chak) and most parts of Tuol Kok District have lagged behind other area. Inundation in these areas still occur several times a year in the rainy season

In the newly urbanised area located at Western Phnom Penh, especially in the Pochentong East Area, not enough drainage facilities have been installed, and as a result, inland flooding damage frequently occurs even in short-time duration rainfall in the rainy season.



Note S: Sangkat
Source: JICA Study Team

Fig. 2.1.19 Inland Flooding Area

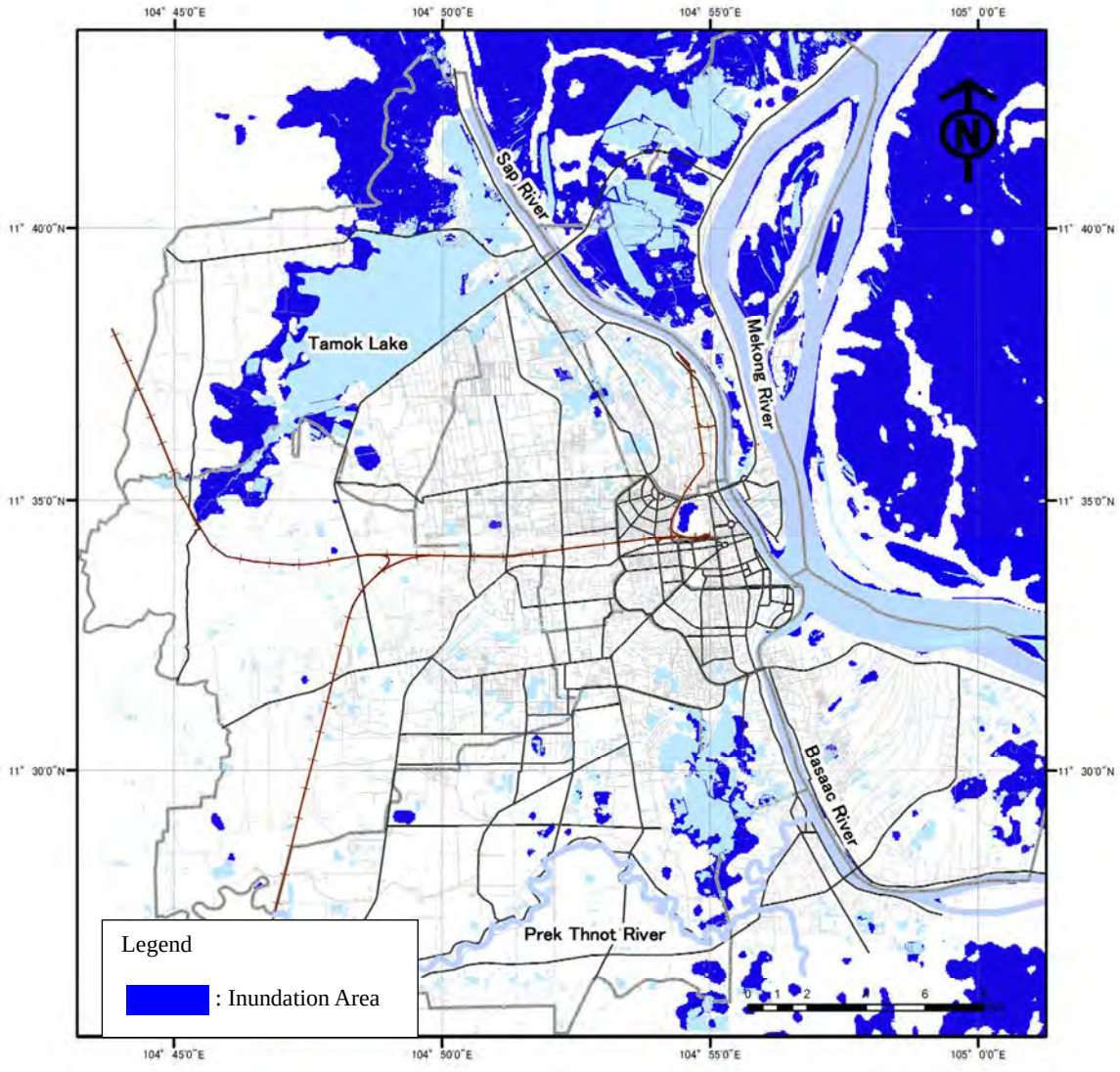
[3] Inland flooding: Inundation in urbanized area due to rainfall exceeds capacity of existing drainage facilities

(b) Inundation Area of Overflow Flooding[4]

During the rainy season in 2011, large-scale flooding occurred around the flat plain from late August to early October due to the large amount of rainfall in the Indochina area. A larger area of flood damage than in normal rainy season was experienced at the area surrounding the Mekong River and the Sap River.

Damage due to this flooding was the largest since the so-called 2000 flood in the Mekong River Basin. The flooding area on the 15th of October 2011 is shown in **Fig. 2.1.20**.

The damage in 2011 was the largest since the 2000 flood, but water level at Chaktomuk did not reach the maximum water level in the 2000 flood (10.18 m) so that no overflow to PPCC occurred. Typical dike crest in PPCC is about +10.8 m (at Chaktomuk), which was obtained by the topographical survey conducted in the Study.



Source: MRC (Mekong River Commission) Secretariat Office in Phnom Penh

Fig. 2.1.20 Flooding Area (15 October 2011)

[4] Overflow flooding: Inundation due to overflow from the river

2.1.5 Runoff and Inundation Analysis for Drainage Improvement Plan

This analysis was conducted to properly formulate the drainage improvement plan, with analysis items and contents in **Table.2.1.12**.

Table 2.1.12 Items and Contents for Hydrological Analysis

Classification	Items	Contents
Rainfall analysis	Data collection of rainfall observed stations	・ Grasp of trend of rainfall from daily and hourly rainfall data
	Evaluation of probability rainfall	・ Evaluation of probable rainfall based on recent rainfall observation data
	Evaluation of rainfall intensity	・ Re-evaluation of rainfall intensity in the previous study
	Set of model hyetograph	・ Set model hyetograph referring to past record of rainfall pattern
	Set design hyetograph	・ Set design rainfall duration and design hyetograph
Run-off and inundation analysis	Run-off analysis	・ Calculation of run-off
	Inundation analysis	・ Evaluation of carrying capacity of channels (Identification of inundated area)
	One-dimensional unsteady flow analysis	・ Planning of pumping capacity

Source: JICA Study Team

(1) Rainfall Analysis

Rainfall intensity was estimated using short-time duration rainfall data observed from 1980 to 1997 at Pochentong Station in the previous JICA study, "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh, 1999". The rainfall intensity estimated in the Master Plan in 1999 is shown in **Fig. 2.1.21**.

Hourly Rainfall (Pochentong meteorological station)

Return Period (year)	Hourly Rainfall (mm/h)	Daily Rainfall (mm/day)
2	44.8	87.8
5	63.2	112.3
10	75.4	128.4

Horner Type[5] was selected as rainfall intensity formula type. Rainfall intensity formula is shown as follows;

$I=2{,}566.07\times(T+25.48)^{-0.93}$ (Design scale of sewer system, 2-year return period)

$I=5{,}009.12\times(T+31.38)^{-0.98}$ (Design scale of infrastructure, 5-year[6] return period)

where, I : Rainfall intensity (mm/hr), T : Rainfall Duration (min)

Source: The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh, JICA, 1999

Fig. 2.1.21 Rainfall Intensity and Probable Rainfall

Review of rainfall intensity and model hyetograph using recent rainfall data is needed because 15 years has passed after the last estimation in 1999.

---

[5] In the Master Plan in 1999, actual rainfall data were analyzed by employing rainfall intensity formulae such as Talbot Type, Sherman Type, Kuno and Ishiguro Type, and Cleveland Type, which are commonly employed in Japan, as well as Horner Type, which is commonly employed in Asian countries such as the Philippines and Taiwan. Thus rainfall intensity was established using Horner Type, which showed minimum error.

[6] Pumping stations, regulation ponds and main channel drains area with approximately more than 1 km^2 of catchment area.

(a) Collection of Observed Rainfall Data

Observed rainfall data was collected from MOWRAM. The rainfall gauging station used to be the Pochentong Station which did observation from 1981, but was moved to Khmuouh where hourly rainfall data was observed by automatic record system from June 2012. The availability of rainfall data is summarised in **Table 2.1.13**.

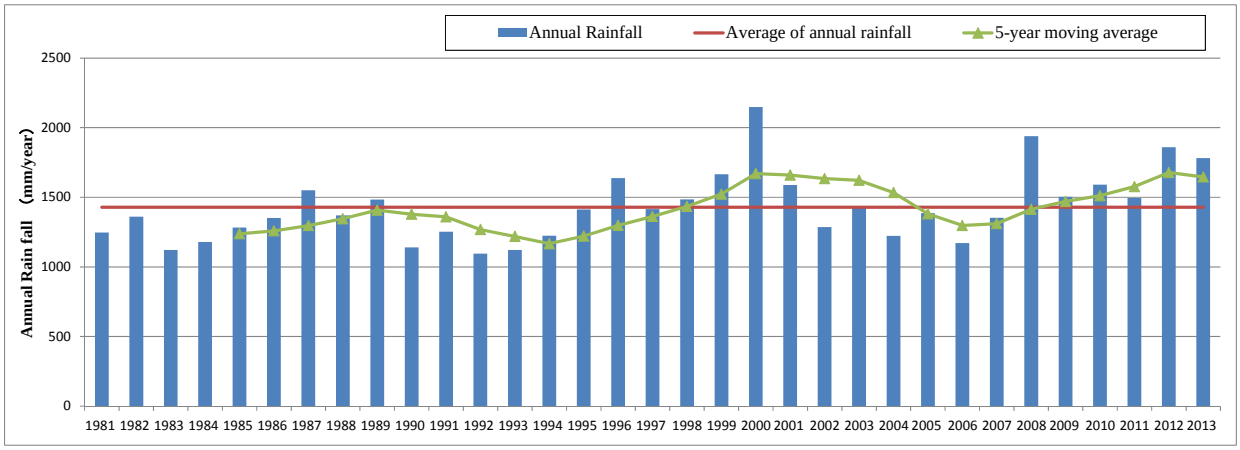
Table 2.1.13 Availability of Daily and Hourly Rainfall Data

	Station Name	Duration	Organization
Daily Rainfall	Pochentong	1981-2011	MOWRAM (Ministry of Water Resources and Meteorology)
	Khmuouh	June 2012	
Hourly Rainfall	Khmuouh	June 2012	

Source: JICA Study Team

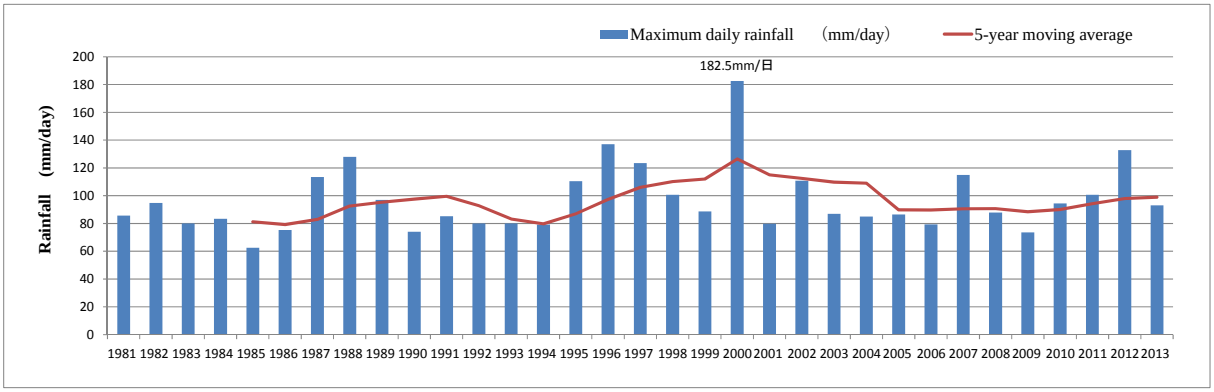
Annual rainfall and maximum daily rainfall (1981 to 2013) are shown in **Fig. 2.1.22** and **Fig. 2.1.23** respectively, and 5-year moving average is estimated to grasp rainfall trend from commencement of observation until recently.

From the result of 5-year moving average (**Fig. 2.1.22** and **Fig. 2.1.23**), annual rainfall seems to be increasing and decreasing sporadically, so that no definite trend can be confirmed.



Source: MOWRAM (Ministry of Water Resources and Meteorology)

Fig. 2.1.22 Annual Rainfall (1981 to 2013)



Source: MOWRAM (Ministry of Water Resources and Meteorology)

Fig. 2.1.23 Maximum Daily Rainfall (1981 to 2013)

(b) Evaluation of Probable Rainfall

As previously stated, hourly rainfall data is not enough in the observation period. A probable rainfall analysis was performed using the daily rainfall data, condition and probability distribution model shown in **Table 2.1.14**.

<< Condition of Probability Rainfall Analysis >>

Used data: Maximum daily rainfall

Data duration: from 1981 to 2013, 33 years

Table 2.1.14 Probability Distribution Model

No.	Probability Distribution Model	
1.	Exp	Exponential Distribution
2.	Gumbel	Gumbel Distribution
3.	SqrtEt	Square-root Exponential Type Maximum Distribution
4.	Gev	Extreme Value Distribution
5.	LP3Rs	Peason Type III Distribution (Real Space)
6.	LogP3	Peason Type III Distribution (Logarithmic Space)
7.	Iwai	Iwai Method
8.	IshiTaka	Ishihara−Takase Method
9.	LN3Q	Log-Normal Distribution (Quantile Method)
10.	LN3PM	Log-Normal Distribution 3 (Slade II)
11.	LN2LM	Log-Normal Distribution 2 (Slade I, L-moment method)
12.	LN2PM	Log-Normal Distribution 2 (Slade I, Product moment method)

Source: Hydrologic Statistics Utility, Japan Institute of Country-ology and Engineering

<< Result of Analysis >>

“Extreme Value Distribution” model was selected from the result of probability rainfall analysis using the probability distribution model shown in **Table 2.1.14**. The reference SLSC value of the selected model is less than 0.04.

Selected model: Extreme Value Distribution

Probable rainfall is shown in **Table 2.1.15** and **Fig. 2.1.24** and maximum daily rainfall data is shown in **Table 2.1.16**.

Table 2.1.15 Probable Rainfall

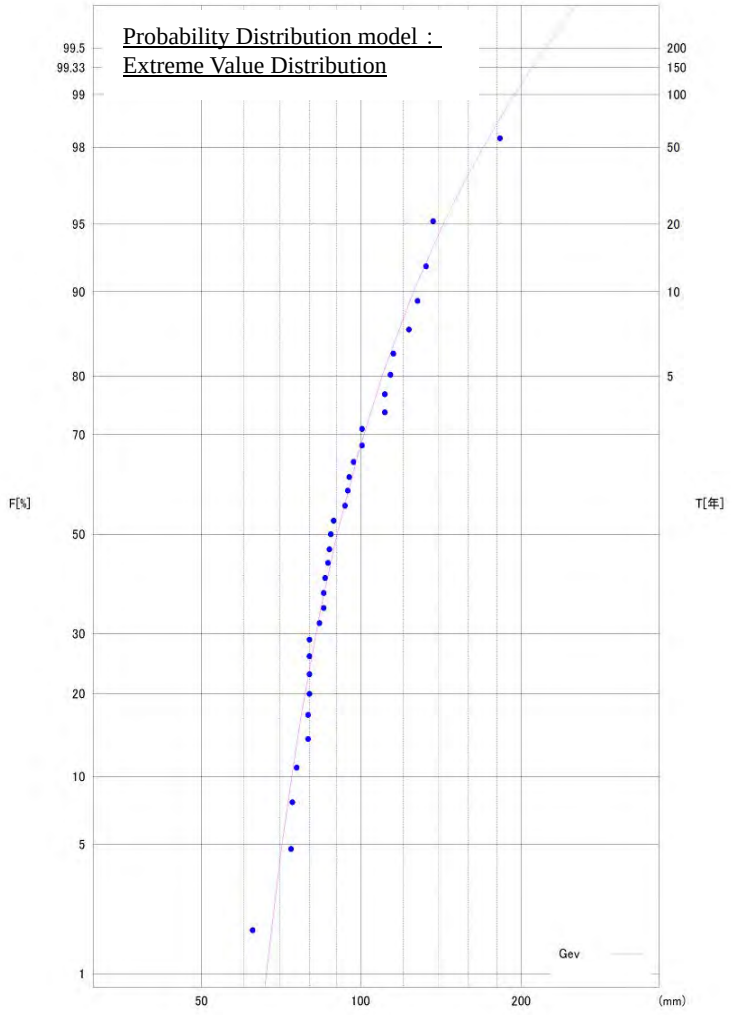
Return Period	Daily Rainfall (mm)		Balance
	(1) Study of 1999 Note1	(2) This Study Note2	(1)-(2)
2	87.8	90.1	+2.3
5	112.3	109.6	-2.7
10	128.4	125.4	-3.0
30	152.9	154.5	+1.6
50	164.0	170.3	+6.3

Note 1: Estimated using observed rainfall data from 1981 to 1997
Note 2: Estimated using observed rainfall data from 1981 to 2013
Source: JICA Study Team

Table 2.1.16 Maximum Daily Rainfall

	day /month /year	Maximum daily rainfall (mm/day)
1	26/Sep/1981	85.7
2	11/Sep/1982	94.8
3	29/Aug/1983	80.0
4	25/Apr/1984	83.3
5	19/Oct/1985	62.5
6	17/Nov/1986	75.4
7	5/Sep/1987	113.5
8	18/Sep/1988	128.0
9	13/Sep/1989	96.9
10	19/May/1990	74.0
11	6/Jun/1991	85.2
12	29/Sep/1992	80.0
13	29/Aug/1993	80.0
14	19/May/1994	79.2
15	8/May/1995	110.5
16	13/Nov/1996	137.0
17	21/Sep/1997	123.4
18	7/Jul/1998	100.6
19	21/Jul/1999	88.7
20	20/Dec/2000	182.5
21	22/Oct/2001	79.8
22	4/Oct/2002	110.8
23	23/Sep/2003	87.0
24	7/May/2004	85.0
25	4/Oct/2005	86.5
26	17/Oct/2006	79.3
27	27/Aug/2007	115.0
28	7/Mar/2008	87.8
29	22/Aug/2009	73.6
30	11/Oct/2010	94.4
31	14/Aug/2011	100.7
32	26/Sep/2012	132.8
33	22/Oct/2013	93.0
	Average	**96.6**
	Maximum	**182.5**
	Minimum	**62.5**

Source: JICA Study Team



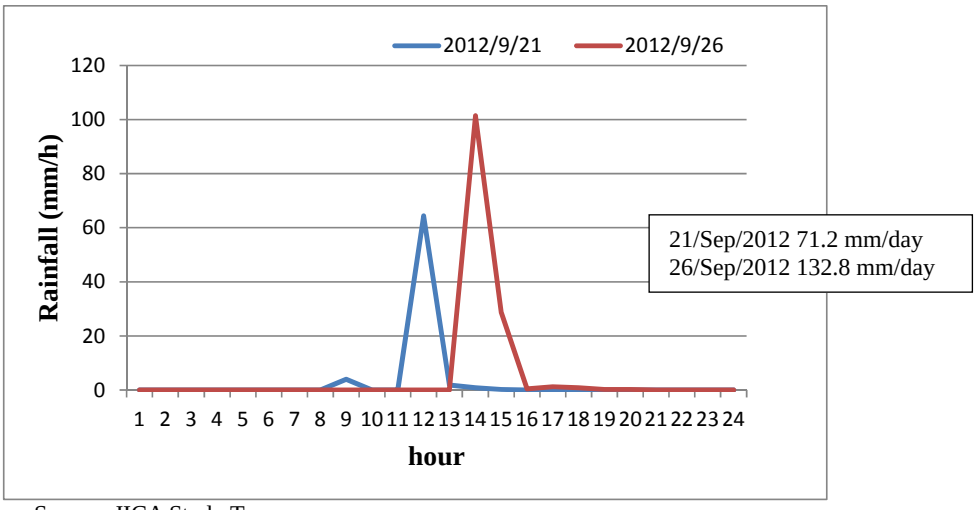
Source: JICA Study Team

Fig. 2.1.24 Result of Probability Rainfall Analysis

(c) Review of Rainfall Intensity

A large difference is not observed from the probability rainfall analysis result compared to the previous study (1999) of 2-year and 5-year return periods for drainage facilities plan. Therefore, rainfall intensity in the previous Master Plan (1999) is employed for the drainage improvement plan in the Study.

As shown in **Fig. 2.1.25**, hourly maximum rainfall of more than 100 mm/hr is at times observed, rainfall intensity formula should be therefore reviewed using updated data, when short-time duration rainfall data is observed and accumulated in the long-term.



Source: JICA Study Team

Fig. 2.1.25 Observed Rainfall Pattern (2012)

2.2 Socioeconomic Situation

The RGC's population in 2008 was 13.4 million according to Census 2008, and it was estimated at 15.5 million in 2014 according to CIA Factbook. The largest ethnic group is the Khmers, which consists of about 90% of total population, and minority groups are the Vietnamese (5%), the Chinese (1%) and Others (4%). Some 96.3% of the population speak the Khmer language, the country's official language, and 96.9% of the population are Buddhists.

PPCC leads Cambodian economy and society as national capital. Social and economic situations of Phnom Penh are as summarized below from the socioeconomic viewpoints, population, industry and others.

2.2.1 Socioeconomic Situation

(1) Gross Domestic Product (GDP)

GDP and related economic statistics data are shown in **Table 2.2.1** to display the national economic development state.

Table 2.2.1 National Accounts of Cambodia

Year	2000	2001	2002	2003	2004	2005	2006
GDP (Billion Riel)	14,083	15,633	16,781	18,536	21,438	25,754	29,849
GDP Growth Rate	5.3%	11.0%	7.3%	10.5%	15.7%	20.1%	15.9%
GDP per capita (USD)	295	319	340	367	417	487	558
GDP per capita Growth Rate	3.2%	8.2%	6.5%	8.0%	13.5%	16.9%	14.6%
GDP (Constant Price)	14,175	15,320	16,232	17,613	19,434	22,009	24,380
GDP (Constant Price) Growth Rate	10.7%	7.4%	6.6%	8.5%	10.3%	13.3%	10.8%

Year	2007	2008	2009	2010	2011	2012	
GDP (Billion Riel)	35,042	41,968	43,057	47,048	52,069	56,617	
GDP Growth Rate	17.4%	19.8%	2.6%	9.3%	10.7%	8.7%	
GDP per capita (USD)	656	760	753	830	911	971	
GDP per capita Growth Rate	17.6%	15.8%	-0.9%	10.2%	9.9%	6.6%	
GDP (Constant Price)	26,870	28,668	28,692	30,406	32,553	34,916	
GDP (Constant Price) Growth Rate	10.2%	6.7%	0.1%	6.0%	7.1%	7.3%	

Note: The top GDP is in current price or market price different from constant price below.
Source: National Institute of Statistics (http://www.nis.gov.kh/nis/NA/NA2012.html)

GDP in current price has grown constantly from 2000 to 2012. Although GDP per capita in USD decreased in 2009 because of the Global Financial Crisis, it grew to USD 971 in 2012. The average annual growth rate from 2000 to 2012 is 10.4% and very high, but recently (after 2009 because of the Global Financial Crisis, particularly in 2012) it seems to show a decreasing trend. The World Bank shows worldwide GDP per capita in current 2013 USD and that of Cambodia is 1,008. GDP per capita in **Table 2.2.1** increased from USD 295 in 2000 to USD 1,008 in 2013 so that the average annual growth rate, 9.9%, is very high. (http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?order=wbapi_data_value_2013+wbapi_data_value+wbapi_data_value-last&sort=asc)

GDP in constant price has grown continuously although the growth rate is lower than that in current price, but that in 2009 is close to zero, barely positive.

On the other hand, the World Bank published the ICP (International Comparison Program) 2011 results in order to make national economy and wellfare comparable controlling the differences in prices. It uses purchasing power parities (PPP) to estimate comparable GDP expenditures. The result of Cambodia, namely, GDP expenditure per capita of Cambodia in USD, is 2,717, 22nd

ranked in Asia and the Pacific consisting of twenty-three countries and economies. (http://siteresources.worldbank.org /ICPEXT/Resources/ICP_2011.html)

(2) Household Income

The National Institute of Statistics, Ministry of Planning, publishes socio-economic research results every year. The household income is shown in **Tables 2.2.2** and **2.2.3**.

The average household income and disposable income in total Cambodia increased from 2009 to 2013 except in 2011. In 2011, self-employment income, in particular, non-agriculture decreased so that the total and disposable incomes decreased.

Table 2.2.2 Household Income Composition, Average per Month in Cambodia

Source of income	Value in thousand Riels				
	2009	2010	2011*	2012*	2013*
Cambodia					
Primary income	727	877	862	984	1,183
Wage and Salary	241	292	340	403	505
Self-employment Income	482	582	520	576	675
Agriculture	162	205	209	229	195
Non Agriculture	250	290	224	249	369
Owner occupied house	70	88	86	98	111
Property income	4	3	2	5	3
Total transfers received	19	24	26	35	53
Total Income	**747**	**901**	**888**	**1,019**	**1,236**
Total transfers paid	11	24	17	5	95
Disposable Income	**736**	**877**	**871**	**1,014**	**1,141**

Note: * Preliminary results
Source: National Institute of Statistics
(http://www.nis.gov.kh/index.php/en/find-statistic/social-statistics/cses/cses-tables.html)

Table 2.2.3 Household Income Composition, Average per Month in Phnom Penh

Source of income	Value in thousand Riels				
	2009	2010	2011*	2012*	2013*
Phnom Penh					
Primary income	1,986	1,940	1,770	1,847	2,478
Wage and Salary	765	910	991	930	1,135
Self-employment Income	1,203	1,023	769	909	1,326
Agriculture	22	20	8	22	11
Non Agriculture	878	650	423	560	935
Owner occupied house			338	327	381
Property income	17	7	10	8	17
Total transfers received	54	47	50	40	38
Total Income	**2,039**	**1,987**	**1,819**	**1,886**	**2,517**
Total transfers paid	24	44	26	17	138
Disposable Income	**2,016**	**1,944**	**1,793**	**1,870**	**2,378**

Note: * Preliminary results
Source: National Institute of Statistics
(http://www.nis.gov.kh/index.php/en/find-statistic/social-statistics/cses/cses-tables.html)

However, the average household total and disposable incomes in Phnom Penh decreased in not only 2011 as those in total Cambodia but also 2010, the previous year. The reason of decrease in 2010 is not clear, but it can be guessed that the reason might be expansion of the Phnom Penh Capital City area in 2010. Perhaps, peripheral low self-employed non-agriculture income households were integrated into Phnom Penh or it may be an omen of the nationwide decrease next year. The decrease in 2011 seems to follow the national trend. Household incomes in Phnom Penh are approximately twice of that in total Cambodia average.

Disposable incomes per capita by quintile group (quintile group is formed by dividing five equal numbers arranging all households from the lowest annual income to the highest and groups 1 to 5 are from the lowest to the highest) in Cambodia and Phnom Penh are shown in **Table 2.2.4**. Poorer stratum income increased more from 2009 to 2013 in total Cambodia and Phnom Penh, and the increase rates of household income in Cambodia are larger than those in Phnom Penh. At least during the period from 2009 to 2013, divides or gaps between the poor and the rich and between Cambodia and Phnom Penh were reduced from the viewpoint of household income.

Table 2.2.4 Disposable Incomes per capita by Quintile Group

Year	Value in thousand Riels					Increase
	2009	2010	2011*	2012*	2013*	'13/'09
Cambodia						
Quintile group						
1	19	28	41	49	47	2.47
2	49	69	89	106	115	2.35
3	88	113	142	165	184	2.10
4	148	180	213	248	277	1.87
5	488	595	506	571	708	1.45
Phnom Penh						
Quintile group						
1	82	85	126	137	137	1.68
2	177	190	217	229	254	1.44
3	271	290	298	324	363	1.34
4	405	438	415	454	531	1.31
5	1,140	1,135	973	1,017	1,471	1.29
PP/Cmbd						
Quintile group						
1	4.32	3.09	3.07	2.83	2.93	
2	3.61	2.76	2.43	2.17	2.21	
3	3.08	2.57	2.10	1.96	1.97	
4	2.74	2.44	1.94	1.83	1.92	
5	2.34	1.91	1.92	1.78	2.08	

Source: National Institute of Statistics
(http://www.nis.gov.kh/index.php/en/find-statistic/social-statistics/cses/cses-tables.html)

Similar inclination is shown in NSDP (National Strategic Development Plan 2014-2018), that is, poverty (which is calculated by the cost of purchasing food equivalent to 2,200 Kilocalories in the lowest 5^{th} quintiles and the allowance for non-food items by definition) headcount in the whole nation is 17.9% and that in Phnom Penh is 15.3%; namely, poverty is less in Phnom Penh than in the nation. NSDP aims to lower poverty headcount in 2018 to 12.9% nationwide and 10.3% in Phnom Penh.

2.2.2 Administrative Divisions of PPCC

PPCC has sequentially expanded jurisdiction area and reorganized districts (Khan) since 2008. Its transition is shown in **Table 2.2.5**. As a result of transition, currently there are 12 districts (Khan) with an area of 678.46 km^2 in PPCC. The area and population in each district is shown in **Table 2.2.6**, and the district map is shown in **Fig. 2.2.1**. There are administrative units called “Sangkat” under District, and minimum administrative unit is “village” under Sangkat.

Table 2.2.5 Transition of Administrative Divisions of PPCC

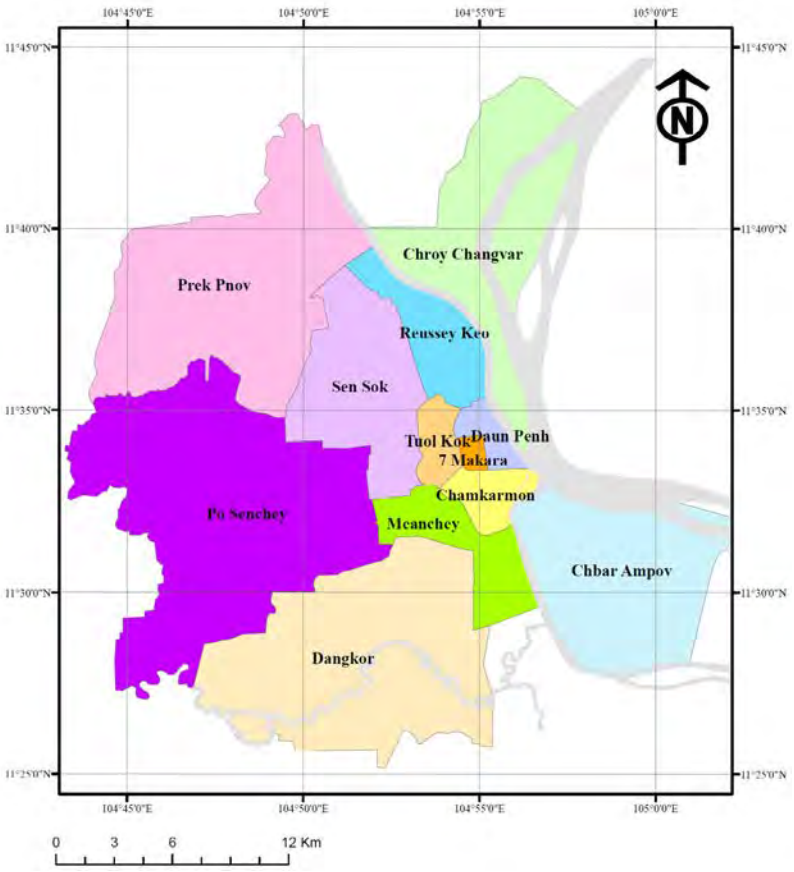
Year	Area of PPCC (km^2)	Number of Districts (Khan)	Transition	Note
2008	376.2	8	・ Russey Keo District is divided into Russey Keo District and Sen Sok District. It became 8 districts from 7 districts.	
2010	678.5	8	・ 20 communes from Kandal Province were integrated into PPCC.	
2011	678.5	9	・ Dangkor District is divided into Dangkor District and Po Senchey District. It became 9 districts from 8 districts.	
2013	678.5	12	・ Meancheay District divided into Meancheay District and Chbar Ampov District. ・ Russey Keo District is divided into Russey Keo District and Chroy Changvar District. ・ Part of Sen Sok District is divided and part of Po Senchey District is divided, and they created Prek Pnov District.	Mentioned in Sub-Decree dated 25 December 2013

Source: JICA Study Team, based on information provided by PPCC

Table 2.2.6 Administrative Division and Population of Districts in PPCC (2008)

District (Khan)	Area (km^2)	Population (person)	Population Density (person/ha)
Chamkarmon	11.1	182,004	164.0
Daun Penh	7.5	126,550	168.7
7 Makara	2.2	91,895	417.7
Tuol Kok	8.2	171,200	208.8
Dangkor	117.8	73,287	6.2
Po Senchey	150.0	159,455	10.6
Meanchey	25.0	194,636	77.9
Chbar Ampov	80.5	133,165	16.5
Reussey Keo	24.9	115,740	46.5
Chroy Changvar	84.0	68,708	8.2
Sen Sok	51.9	137,772	26.5
Prek Pnov	115.4	47,313	4.1
Total	678.5	1,501,725	22.1

Source: JICA Study Team, based on information provided by PPCC



Source: JICA Study Team

Fig. 2.2.1 Administrative Division Map

2.2.3 Population Dynamics in PPCC

(1) Population and Number of Households

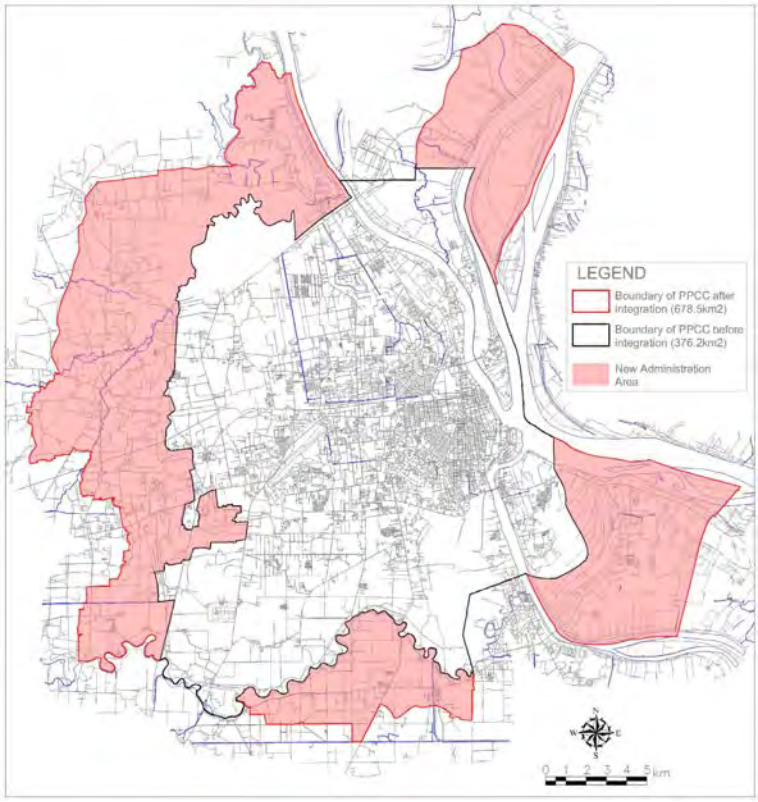
According to the 1998 and 2008 census, the population of PPCC increased to 1,327,615 in 2008 from 999,804 in 1998. Additionally, due to the expansion of the jurisdiction area in 2010, its population became 1,501,725. The population became about 1.5 times of 1998's. Population and the number of households in 1998 and 2008 are shown in **Table 2.2.7**. New Administrative Area in the following **Table 2.2.7** is shown in red hatched area in **Fig. 2.2.2**.

Table 2.2.7 Population and Number of Households

	1998	2008
Population		
Old Administrative Area	999,804	1,327,615
Urban Area	570,155	1,242,992
Rural Area	429,649	84,623
New Administrative Area	-	174,110
Total	999,804	1,501,725
Household		
Old Administrative Area	173,678	260,468
Urban Area	97,296	242,974
Rural Area	76,382	17,494
New Administrative Area	-	34,890
Total	173,678	295,358
Average Number of Persons in Household		
Old Administrative Area	5.76	5.10

	1998	2008
Urban Area	5.86	5.12
Rural Area	5.63	4.84
New Administrative Area	-	4.99
Total	5.76	5.08

Note: Urban Area: (The Sum of Sangkat which satisfies the following 3 conditions. Population Density; More than 200 people/km^2, Proportion of farmers of adult men; Less than 50%, Total Population; More than 2,000)
Source: Overview of Urban Development in Phnom Penh Capital City, 2011



Source: JICA Study Team, based on information provided by PPCC

Fig. 2.2.2 Administrative Area in PPCC (Old/New)

(2) Population Dynamics

According to the 1998 and 2008 census, 395,246 people moved from other provinces to Phnom Penh in 1998, and 515,492 people moved in 2008. Conversely, 80,794 people moved from Phnom Penh to other provinces in 1998, and 83,365 people moved in 2008, as shown in **Table 2.2.8**. The population inflow to Phnom Penh has become excessive; therefore, the population of Phnom Penh has increased explosively. This is due to the influx of the young people (especially young women) with the expansion of sewing factories.

Table 2.2.8 Population Dynamics of Phnom Penh

From	To	Year	Migrants
Phnom Penh	Other Provinces	1998	80,794
		2008	83,365
Other Provinces	Phnom Penh	1998	395,246
		2008	515,492

Source: Overview of Urban Development in Phnom Penh Capital City, 2011

(3) Population Projection

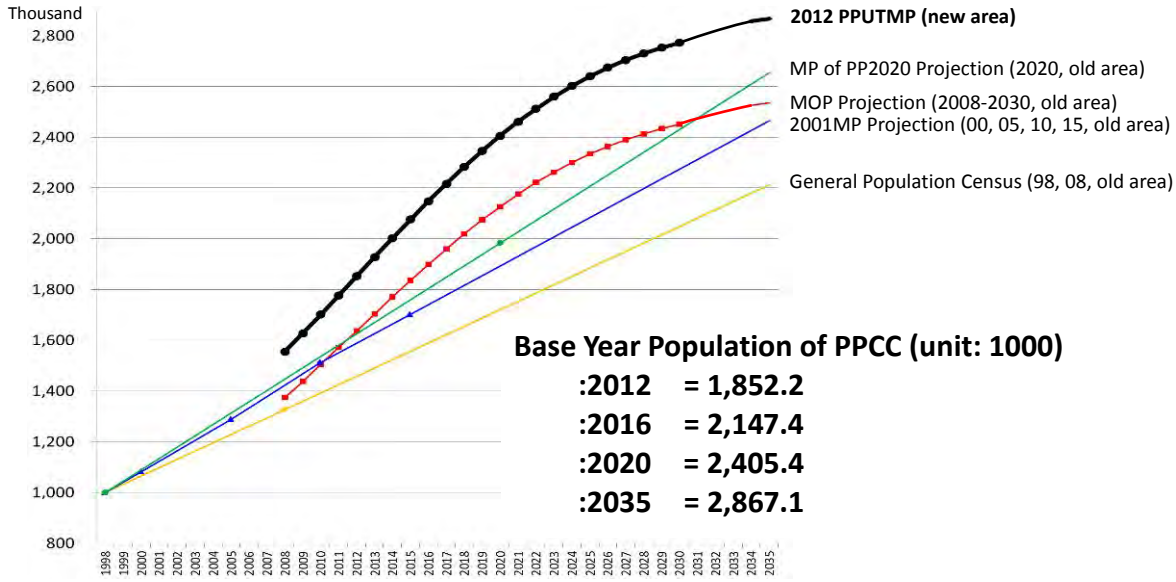
Population up to 2035 has been projected based on the population in base year of 2012, with the reference of census of 1998, 2008, and the population projection of MOP up to 2030, in the

"Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City" implemented by JICA, as shown in **Table 2.2.9** and **Fig. 2.2.3**[7]**.** According to this projection, the population of 2035 will be 2,867,100 people. The population is computed by adding (i) population of "Old Area" in **Fig. 2.2.3** projected by MOP and (ii) population of "New Area" projected by the "Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City". Sewerage and drainage improvement plans for year 2035 will be formulated, using this population projection in this Study.

Table 2.2.9 Population Projection by JICA Project

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

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



Source: JICA, "Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City"

Fig. 2.2.3 Population Projection by the Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City, JICA

[7] "Old Area" in this figure represents the white hatching area, and "New Area" represents the area covering both white and red hatching area, as shown in **Fig. 2.2.2**.

2.2.4 Industries

(1) Industrial Structure of Cambodia

Industrial employees' ratio and GDP ratio are shown in **Table 2.2.10**. It is revealed that agriculture, forestry and fisheries are key industries of the country because about 70% of population is engaged in primary industry and its GDP ratio occupies one-third of the total. However, tertiary industry has grown significantly in recent years. GDP ratio of tertiary industry in 2008 is 41.3%, which is higher than primary industry.

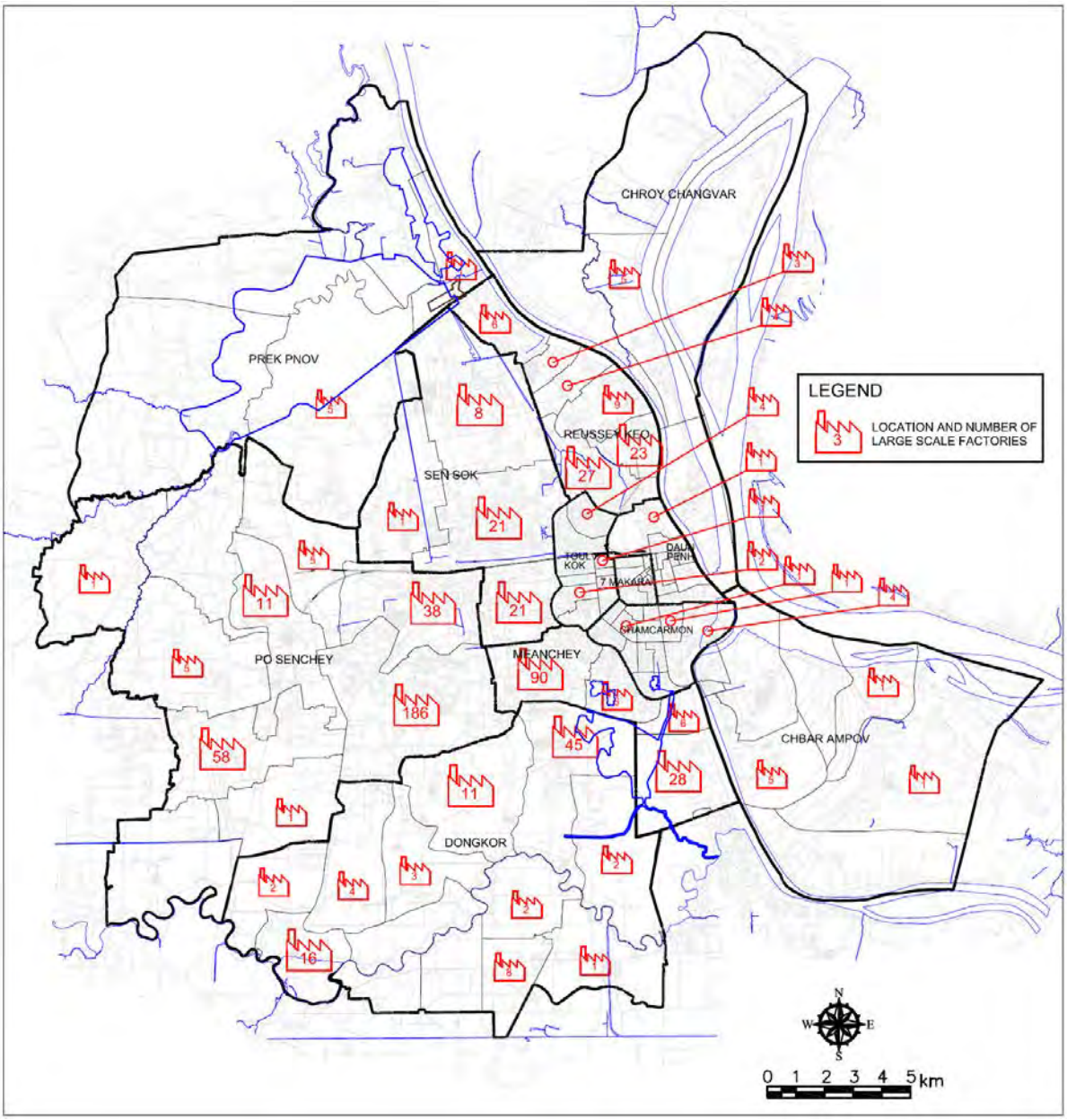
Table 2.2.10 Industrial Employees Ratio and GDP Ratio in Cambodia

Category	Ratio of Employment (%)				Ratio of GDP (%)	
	National		Phnom Penh		National	
	1998	2008	1998	2008	1998	2008
Primary Industry	77.5	72.3	9.9	5.3	44.9	34.9
Secondary Industry	4.3	8.5	22.2	32.5	19.2	23.8
Tertiary Industry	18.2	19.2	67.9	62.2	35.9	41.3

Source: Industrial employees ratio; General Population Census of Cambodia 2008 and 1998
Source: GDP; JETRO Website (2008), and Key Indicators (ADB 2004)

(2) Industries

There are currently 684 large-sized enterprises in PPCC. The factories, whose capital investment is more than 500,000 USD, are classified into large-sized enterprises. Location of large-sized enterprises is shown in **Fig. 2.2.4**. About 470 factories out of the large-sized enterprises are textile factories, and about 50 factories are leather product factories such as shoes and bags.



Source: JICA Study Team based on data of MIH

Fig. 2.2.4 Location Map of Large Sized Enterprises

On the other hand, the factories, whose capital investment is less than 500,000 USD, are classified into small and medium-sized enterprises. Medium and small-sized enterprises are those whose capital investment ranges from 250,000 to 500,000 and less than 250,000 USD, respectively. There are 1,600 small and medium-sized enterprises in PPCC, consisting mainly of sewing factories, foods factories and ironworks factories.

2.2.5 Others

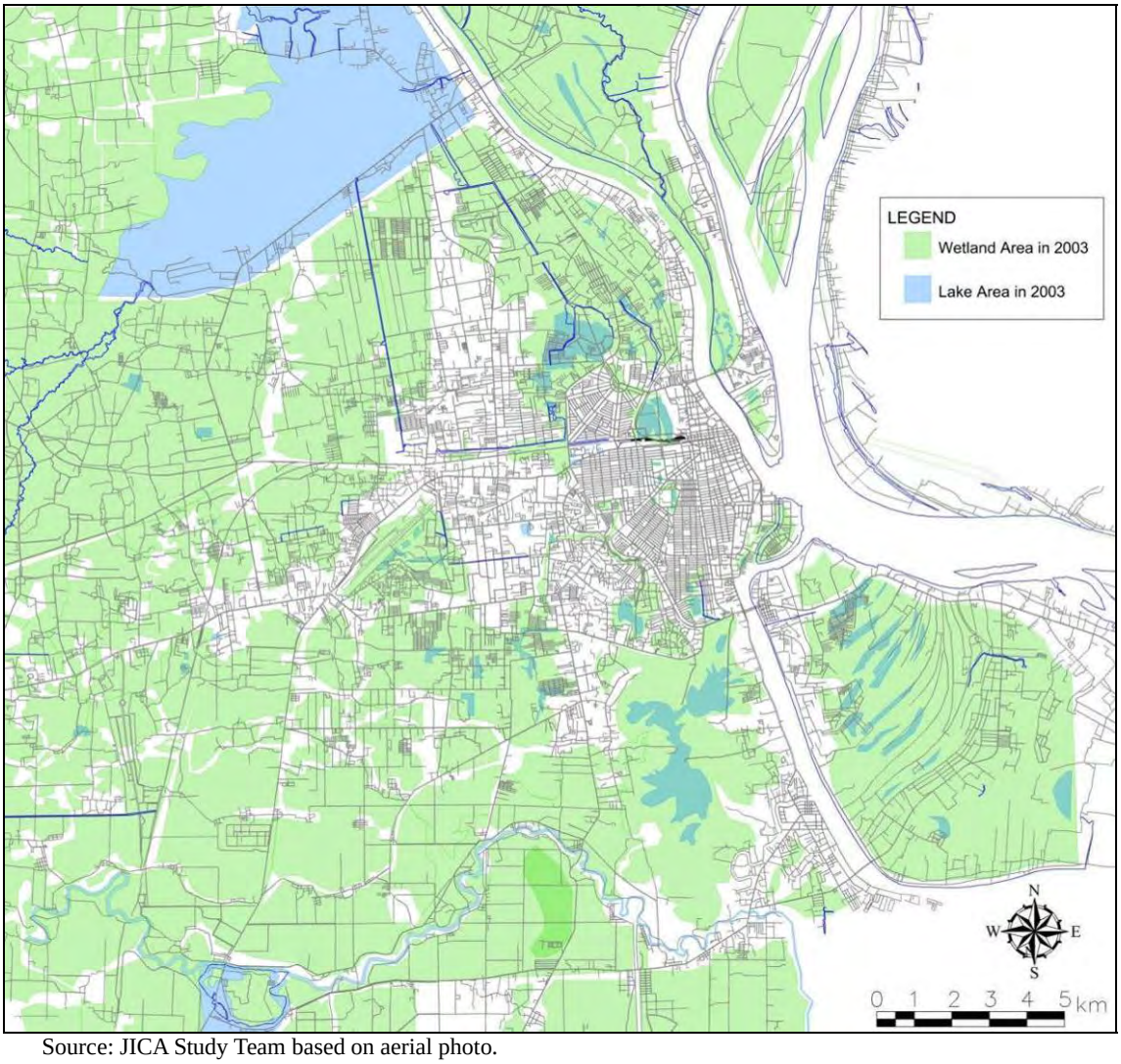
(1) Power Supply

Electrical power in Cambodia is supplied by EDC (Government Enterprise, Electricite du Cambodia), IPP (Independent Power Producer) and imported power from Thailand and Vietnam. Some 60% of total power supply is covered by imported power. Therefore, large-sized hydroelectric power plants and thermal power plants have started operation in order to increase the domestic power generation capacity.

Electricity charges in PPCC is more expensive (0.15-0.20 USD/kWh for domestic and 0.18-0.22 USD/kWh for commerce, industry and government institutions) than that of neighbouring countries, because main current power source is small-sized diesel power generation and imported power.

(2) Reduction of Lakes and Swamps

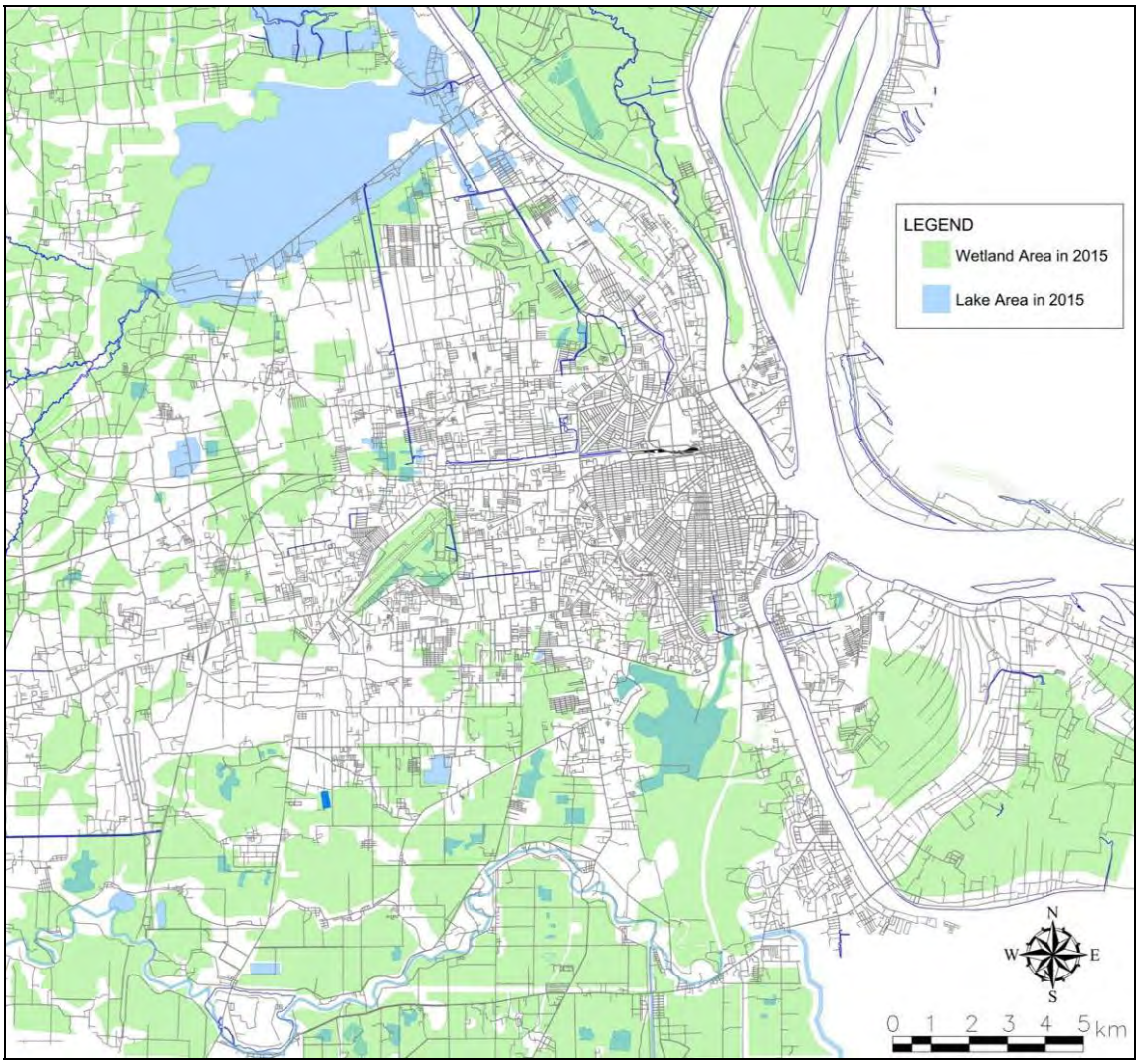
Lakes and swampy areas have drastically decreased due to urbanization and industrialisation in PPCC. As shown in **Figs. 2.2.5** and **2.2.6**, which presents lakes and swampy areas in years 2003 and 2015, the area decreased almost by half and consequently natural purification function decreased. In addition, reclamation of lakes and swampy areas in PPCC are in progress and further decline of natural purification function is anticipated[8].



Source: JICA Study Team based on aerial photo.

Fig. 2.2.5 Area of Lakes and Swamps in Phnom Penh (2003)

[8] Swamps and lakes in PPCC tend to be reclaimed due to the lack of appropriate regulation.



Source: JICA Study Team based on aerial photo.

Fig. 2.2.6 Area of Lakes and Swamps in Phnom Penh (2015)

2.3 National Plans and Relevant Plans

2.3.1 Urban Planning and Development Planning

(1) National Strategic Development Plan (NSDP)

The RGC places top priority on establishing good governance (Fighting Corruption, Legal and Judicial Reforms, Public Administration Reform, Reform of Armed Forces) for national strategy that becomes the foundation of the national development plan. The RGC also set up "Rectangular Strategy", listing the most important issues: "1. Promotion of Agriculture Sector"; "2. Development of Physical Infrastructure"; "3. Private Sector Development and Employment"; and "4. Capacity Building and Human Resources Development".

The RGC announced NSDP 2009-2013 as a development plan based on rectangular strategy in June 2010. In this NSDP 2009-2013, installation and maintenance of sewage/drainage facilities is ranked as priorities in the large cities located along national highway including Phnom Penh. In the latest NSDP 2014-2018, that is also ranked as priorities.

(2) Wastewater Management Plan

At present, MPWT prepares the Wastewater Management Plan, which consists of completed and ongoing plans in wastewater management in major cities of Cambodia. However, this plan is not compiled as documentary records; it is only a list as shown in **Table 2.3.1**.

As shown in **Table 2.3.1**, lots of ADB projects are listed but the projects are implemented focusing on not Phnom Penh but other major cities. Also no project in PPCC is planned in the ADB's mid-term plan up to 2018. On the other hand, ADB plans to implement detailed design and construction of sewage facilities in Poipet, Battambang and Bavet.

Table 2.3.1 Wastewater Management Plans

City	Donor	Capacity (m^3/day)	Status	Completed/To be completed (year)
Poipet town	ADB	3,000	In process of survey	2015
Serei Saophaon Town	ADB	3,000	In process of survey	2015
Battambang Town	EU	2,800	Completed	1994
Battambang Town	ADB	3,000	In process of survey	2015
Sihanouk Ville	ADB	6,000	Completed	2006
Kamport Town	Unknown	6,000	In process of survey (KUNHWA)	2015
Kep Town	Unknown	3,000	In process of survey (DPWT/Kep town)	2015
Phnom Penh	-	30,000	Survey completed (GS Engineering & Construction)	2011
Takhmao Town	-	6,000	In process of survey (KUNHWA)	2015
Bavet Town	ADB	3,000	In process of survey	2015
Kampong Chhnang Town	ADB	3,000	In process of survey	2015
Kampong Thom Town	ADB	3,000	In process of survey	2015
Pursat Town	ADB	3,000	In process of survey	2015
Siem Riap Town	ADB	2,500	Completed	2009
Siem Riap Town	EDCF (Korea)	10,000	In process of construction	-

Note: KUNHWA and GS Engineering & Construction are consultants from South Korea.
Source: MPWT

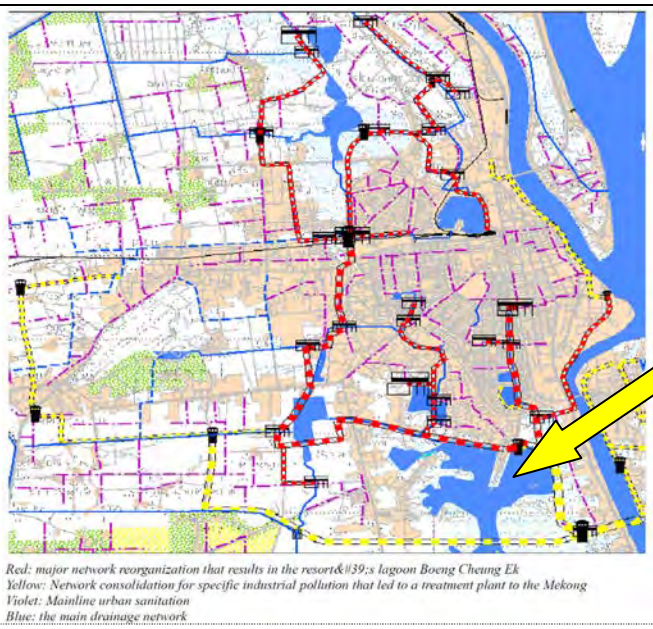
(3) City Development Strategy (CDS)

PPCC formulated CDS for the target year 2015[9] based on NSDP in 2005. In order to develop Phnom Penh and to improve civic life, CDS has listed the following five key visions: (1) Land use and housing; (2) Environment and natural resources; (3) Infrastructure and transportation; (4) Social services; and (5) Economic development. Under these 5 visions, there are goals such as "Prevention of water pollution", "Promotion of sewage treatment" and "Improvement of drainage system". Under the key visions, "Prevention of Water Pollution" and "Promotion of Wastewater Treatment" are listed under Vision (2) and "Drainage Improvement" is listed under Vision (3).

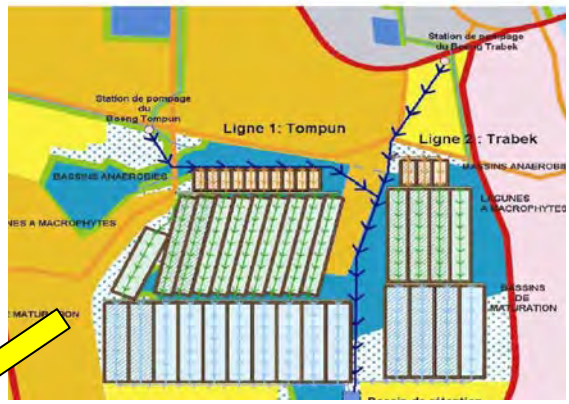
(4) White Book on Development and Planning of Phnom Penh

PPCC with the support of the French government and the City of Paris formulated the White Book for target year 2020 on the basis of CDS in 2007. Then, PPCC revised it by expanding the target year to 2035. It was approved by the committee for land management and urban planning for the capital which was established by the decree and finally approved by the issuance of sub-decree dated 23rd December 2015.

The White Book suggests plans such as "Development of suburbs and expansion of the capital area to prevent the overconcentration of PPCC", "Promotion of public-private partnerships in the housing and land development" and "Establishment of identity as an aesthetic and environmental city". The Book also shows the strategy for development policy of sewage/drainage sector as shown in **Fig. 2.3.1,** suggesting construction of a new sewage treatment plant at Cheung Aek Lake with lagoon system.



Combined pipe network (Red shows main line)[10]



Location of sewage treatment plant (Cheung Aek Lake)

Source: White Book on Development and Planning of Phnom Penh

Fig. 2.3.1 Strategy for Sewage/Drainage Sector in White Book

(5) Large-Scale Development Plan

There are large-scale development[11] plans in PPCC as shown in **Table 2.3.2** and **Fig. 2.3.2**. Design population in this development area is considered in the Population Projection in **Table 2.2.9**.

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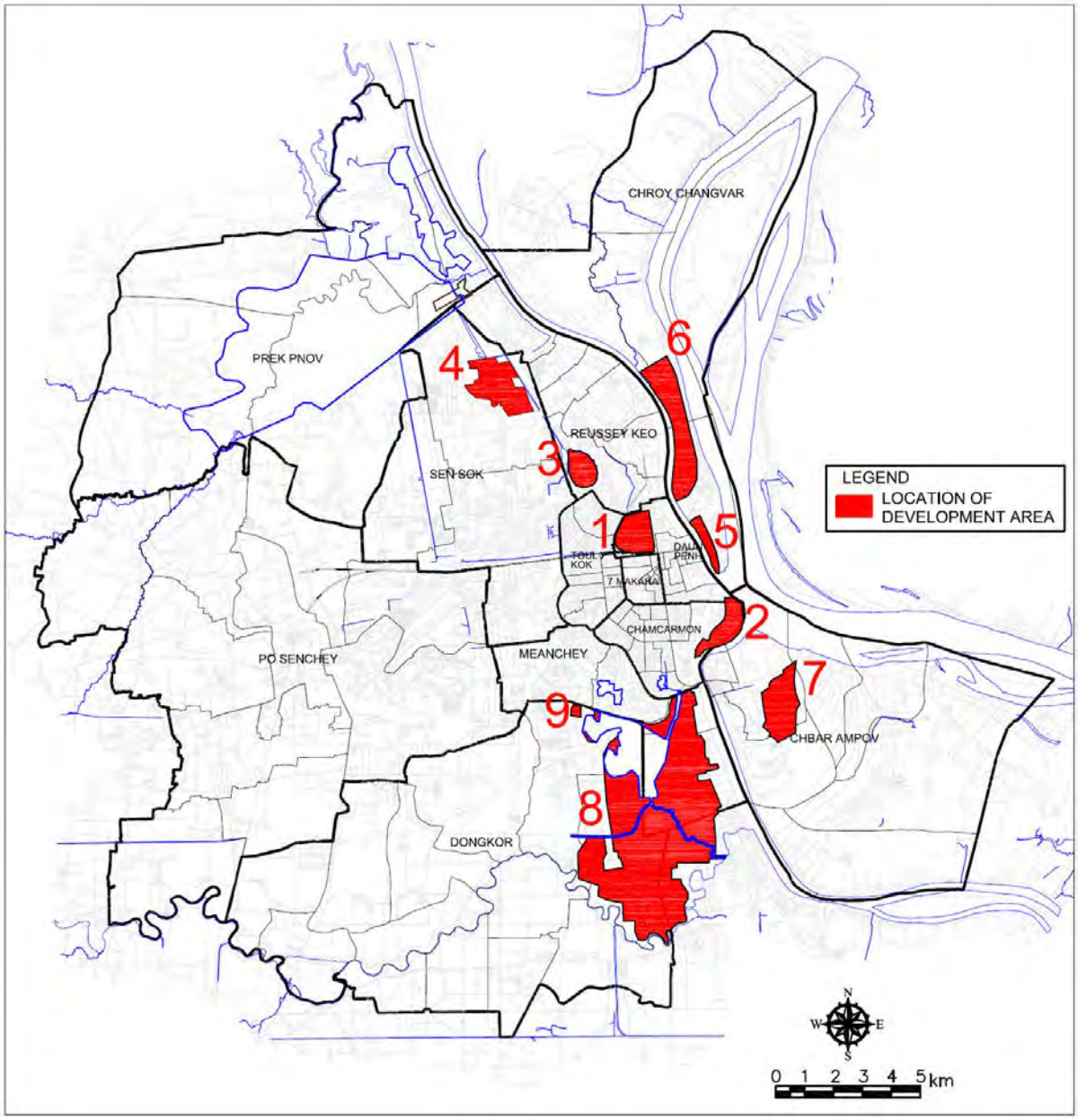
[9] No evaluation is made on the achievement of strategies, although the strategy's target year is 2015.
[10] Land use of this map is updated as shown in **Fig. 2.1.10**.

Table 2.3.2 Outline of Development Area in PPCC

No.	City	Location	Area (ha)	Use(Note 1)	Progress	Project Owner
1	Boueng Kok	Srah Chak in Doun Penh	133	Commercial and Office, Residential (40,000)	Under Construction	Sukaco
2	Diamond City	Tonle Basak in Chamkarmon	80	Commercial and Office, Residential (5,000)	Under Construction	Canadian Bank
3	Camko City	Phnom Penh Thmei in Sen Sok	119	Residential (10,000)	On Sales partially and Under Construction	World City
4	Grand Phnom Penh	Khmuonth in Sen Sok	233	Commercial and Office, Residential (12,000)	On Sales partially and Under Construction	YLP & Ciputra
5	Chroy Changvar	Chroy Changvar	13	Commercial	Under Construction	Sokimex
6	Satellite City	Preaek Lieb, Preaek Ta Sek in Chroy Changvar	380	Commercial and Office, Residential (40,000)	Under Planning	OCIC
7	Pratinum City	Nirouth in Meanchey	140	Residential (8,000)	On Sales partially and Under Construction	Borey Peng Huoth
8	ING City	Chak Angrae Leu, Chak Angrae Kraom in Meanchey. Dangka, Cheung Aek, Preaek Kampis in Dangkor	2,572	Residential (300,000)	Under Planning	ING
9	BTP	Dangkor	10	Residential (1,000)	Under Contract	Borey Peng Houth

Note 1: Figures in parentheses show Design Population
Source: JICA Study Team based on documents provided by PPCC.

[11] Development permit for large-scale development and regulations on sewage and drainage management in the area are discussed in **Subsection 2.6.1(3).**



Source: JICA Study Team based on documents provided by PPCC

Fig. 2.3.2 Location Map of Development Area

2.3.2 Relevant Plan and Project

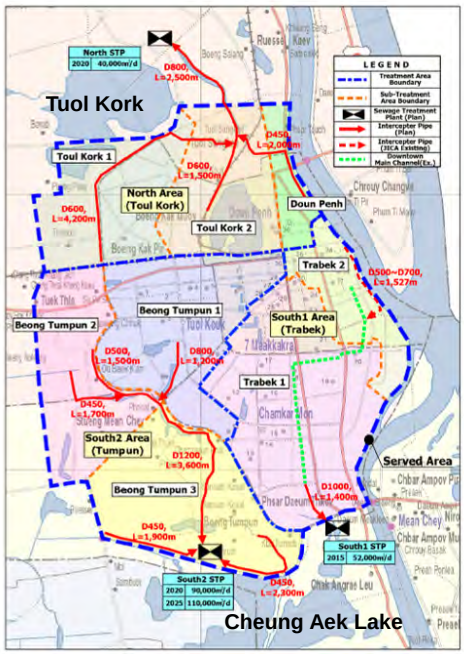
(1) Feasibility Study of Sewage Treatment Plant in Phnom Penh, Kingdom of Cambodia (March 2011, Conducted with Assistance from South Korea)

"Feasibility Study of Sewage Treatment Plant in Phnom Penh, Kingdom of Cambodia", 2011, was conducted with assistance from South Korea in March 2011. An outline of the F/S is shown in **Table 2.3.3**.

However, the administrative area referred in the F/S was the former one (376.93 km^2) instead of the current one (678.46 km^2). In addition, the target area in the F/S only covered the city center and the project cost deemed high. Moreover, PPCC did not require that the new sewage treatment plant could remove T-N and T-P. In other words, there was no need to remove T-N and T-P in the new sewage treatment plant and thus further design was not prepared.

Table 2.3.3 Outline of Feasibility Study

Items	Contents
Target year	Year of 2030
Type of collection	Combined (interceptor)
Number of sewage treatment plant	3 locations - Tuol Kok - Cheung Aek Lake - Downstream end of Tumpun Channel
Interceptor	23.8 km (diameter 450～1,200 mm)
Sewage treatment method	4 Stage-BNR method: advanced treatment method, which can remove T-N and T-P (4 Stage-BNR has reactors consisting of 4 stages of anoxic, anaerobic, anoxic and oxic)
Construction cost	242.6 million USD (Sewage treatment plant: 220.3 million USD and Interceptor: 22.3 million USD



General Plan

:Location of STP

Source: Feasibility Study of Sewage Treatment Plant in Phnom Penh, Kingdom of Cambodia

Relevant projects which have been completed are described in **Section 2.4**.

2.3.3 Water Supply Plan

(1) Current Condition of Water Supply

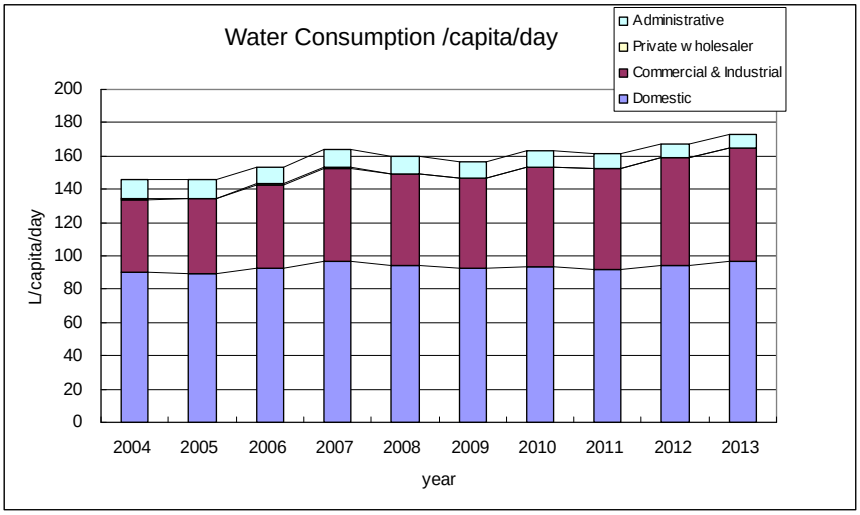
Water Supply in Phnom Penh is operated and maintained by the Phnom Penh Water Supply Authority (PPWSA). Current condition (2004-2013) of water supply by PPWSA is shown in **Table 2.3.4**. It shows that supplied population and water supply amount has increased due to rapid urbanization. Water consumption per capita per day is shown in **Fig. 2.3.3**. The growth rate in annual average is about 2.0%. On the other hand, non-revenue water rate has been stable at 6.0-8.0% in the last 10 years. Ratio of domestic and non-domestic water supply is 6:4.

Table 2.3.4 Water Supply of PPWSA

Item	Unit	2004	2005	2006	2007	2008
Supplied population (Ave.)	Thousand	917.7	1,055.5	1,166.8	1,246.5	1,372.9
Authorized consumption (Ave.)						
(1) Domestic	Thousand m^3/day	83.0	94.5	107.9	121.0	129.6
(2) Commercial/industry	Thousand m^3/day	39.8	47.4	58.5	69.5	75.0
(3) Water distributor	Thousand m^3/day	0.2	0.3	0.6	0.6	0.6
(4) Government office	Thousand m^3/day	10.6	11.7	12.2	12.9	13.7
(5) Total	Thousand m^3/day	133.5	153.9	179.2	204.0	218.9
Ratio of domestic consumption out of total (=(1)/(5))		0.62	0.61	0.60	0.59	0.59
Water consumption per capita per day (Ave.)						
(1) Domestic	L/capita/day	90.4	89.5	92.5	97.1	94.4
(2) Commercial/industry	L/capita/day	43.4	44.9	50.1	55.8	54.6
(3) Water distributor	L/capita/day	0.2	0.3	0.5	0.5	0.4
(4) Government office	L/capita/day	11.6	11.1	10.5	10.3	10.0
(5) Total	L/capita/day	145.5	145.8	153.6	163.7	159.4
Non-revenue water rate (Ave.)	%	14.1	9.2	7.4	6.2	6.2

Item	Unit	2009	2010	2011	2012	2013
Supplied population (Ave.)	Thousand	1,483.2	1,579.6	1,695.1	1,812.6	1,955.7
Authorized consumption (Ave.)						
(1) Domestic	Thousand m^3/day	137.7	148.2	155.9	171.6	189.0
(2) Commercial/industry	Thousand m^3/day	79.8	93.4	102.4	116.3	132.5
(3) Water distributor	Thousand m^3/day	0.4	0.3	0.2	0.2	0.1
(4) Government office	Thousand m^3/day	14.3	16.2	14.9	15.5	17.1
(5) Total	Thousand m^3/day	232.2	258.1	273.3	303.6	338.7
Ratio of domestic consumption out of total (=(1)/(5))		0.59	0.57	0.57	0.57	0.56
Water consumption per capita per day (Ave.)						
(1) Domestic	L/capita/day	92.8	93.8	92.0	94.7	96.6
(2) Commercial/industry	L/capita/day	53.8	59.1	60.4	64.2	67.8
(3) Water distributor	L/capita/day	0.3	0.2	0.1	0.1	0.1
(4) Government office	L/capita/day	9.6	10.3	8.8	8.6	8.7
(5) Total	L/capita/day	156.6	163.4	161.2	167.5	173.2
Non-revenue water rate (Ave.)	%	5.9	5.8	6.7	6.6	7.7

Source: PPWSA

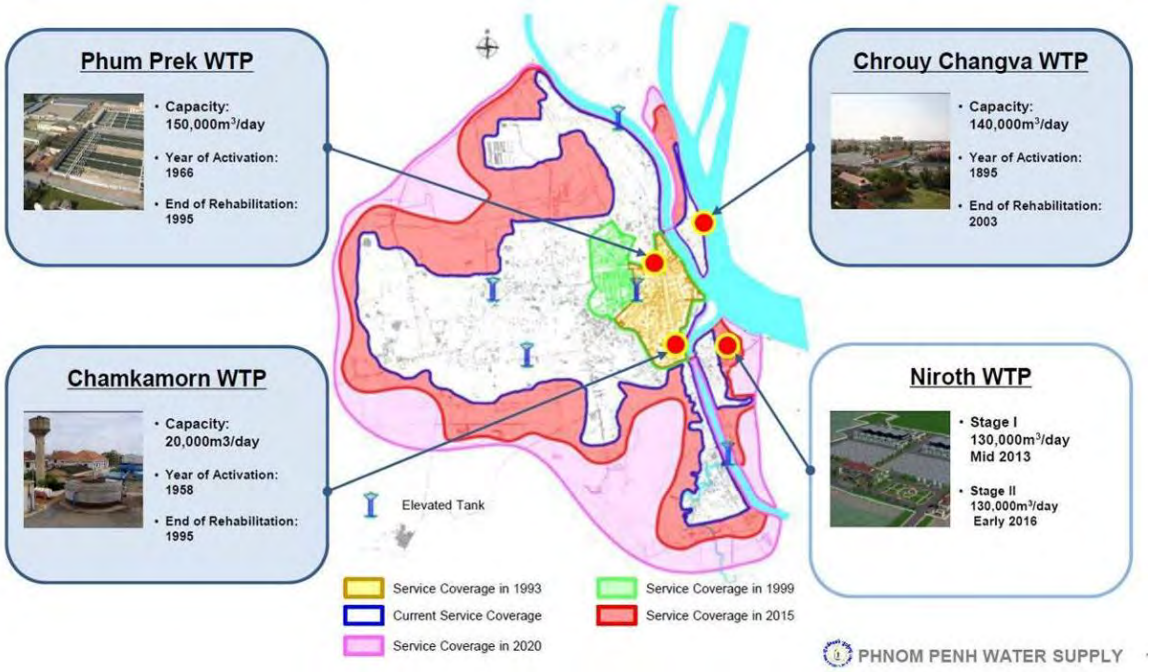


Source: JICA Study Team

Fig. 2.3.3 Water Consumption per Capita per Day

Supply area has expanded from the city center to the outskirts as shown in **Fig. 2.3.4**. In parallel with the expansion, water treatment plants were augmented (Chamkamorn WTP, Chrouy Changva WTP, Puum Prek WTP, and Niroth WTP) with current supply capacity of 440,000 m^3/day.

According to the water supply plan of PPWSA for the target year 2020 (Water Demand Report in Master Plan Update, Feasibility Study and Environmental Impact Assessment, September 2012), water demand will reach 500,000 m^3/day and augmentation of Niroth WTP (2nd phase, supply capacity; 130,000 m^3/day) should be required urgently.



Source: PPWSA

Fig. 2.3.4 Summary of WTP and Supply Area

2.4 Status of Existing Facilities

2.4.1 Assistance from Donors

Table 2.4.1 summarizes the projects related to sewerage and drainage management in PPCC, which are implemented by donors.

Table 2.4.1 Sewerage and Drainage Projects implemented in PPCC with Donor Assistance

Implementation Period	Donor	Project Name	Project Cost	Scheme	Project Brief
1998-2003	ADB	Phnom Penh Water Supply and Drainage Project, Part B (Loan No. 1468-CAM)	12,000 (thousand USD)	Loan	Rehabilitation of Trabek Pumping Station, Trabek Channel and Toul Sleng Channel
2002-2004	JICA	The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase 1)	2,056 (million JPY in E/N)	Grant Aid	Rehabilitation of dike, sluiceway and channel and construction of pumping station and sluiceway, in western and southern area of Phnom Penh
2002-2005	AFD	Project for Capacity Development of Urban Planning Sector in the Municipality of Phnom Penh	Data not available	Technical Cooperation	Formulation of development plan of Phnom Penh, including urban planning, economy, drainage, sewerage, transport, water supply and electricity

Implementation Period	Donor	Project Name	Project Cost	Scheme	Project Brief
2007-2010	JICA	The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase 2)	2,595 (million JPY in E/N)	Grant Aid	Rehabilitation of revetment, construction of pumping stations and reservoirs and drainage pipes, in north-eastern area of Phnom Penh
2008-2010	AFD	Project for Rehabilitation of Central Market	4,200 (thousand USD)	Grant Aid	Rehabilitation of central market including drainage improvement
2012-2015 (on-going)	JICA	The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase 3)	3,700 (million JPY in E/N)	Grant Aid	Rehabilitation of chamber and construction of drainage pipes, in south-eastern area of Phnom Penh, as well as procurement of pipe cleaning equipment

Note: "Municipality of Phnom Penh" and "Phnom Penh Capital City" were the project names used at the time the project was implemented.
Source: JICA Study Team

2.4.2 Sewage Facilities

(1) Current Conditions and Challenges

There is no sewage treatment plant in Phnom Penh. **Table 2.4.2** shows the current condition of sanitary facilities such as septic tanks. According to **Table 2.4.2**, 71.8% of households have toilet facilities and connects to drainage facilities and 19.7% of the households have independent septic tanks.

Table 2.4.2 Current Condition of Sewerage Facilities in PPCC

Total No. of Households	Installation of toilet in household (%)		Type of toilets in household (%)			
	NO	YES	Connecting to drainage facilities[12]	Septic Tank	Pit Latrine	Others
352,702	7.1	92.9	71.8	19.7	1.3	-

Source: Cambodia Inter-Census Population Survey, 2013

According to interviews with WMD, DPWT and private companies, septic tanks in households are desludged by about 30 private companies who have vacuum cars. Larger companies (3 or 4 companies in total) have more than 10 vacuum cars. Other companies have 1-2 vacuum cars. The charge for desludging is about 30-100 USD per session. In PPCC, no licence is required for desludging business. Most of desludged sludge is illegally disposed or carried in Dangkor solid waste disposal site due to the lack of septage disposal site in PPCC.

There is a specification for septic tank in the Sub-Decree on Construction Permit (**Table 2.4.3**). However, there are no standard drawings and no laws and regulations on the maintenance of septic tanks.

Table 2.4.3 Specifications of Septic Tank in Sub-Decree on Construction Permit

Item	Content	
Necessary Capacity	Domestic Households	At least 3 m^3 (per household or per floor in apartment or per 80 m^2)
	Hotels	At least 2 m^3 and 0.5 m^3 per room
Depth	At least 1.5 m	
Others	To install ventilation hole	
	To completely prevent rainwater from intruding into septic tank	

Source: Sub-Decree on Construction Permits

[12] According to DPWT/PPCC, 'Connecting to drainage facilities' means the house which has a septic tank, and it discharges supernatant water from the septic tank and gray water to the drainage pipe.

From the viewpoint of proactive contribution to environmental protection, some industrial factories and commercial facilities install their sewage treatment plant to meet water quality standards or more at their own cost, as shown in **Photo 2.4.1**.

Sewage Treatment in PPSEZ
(Method: Aerated Lagoon, Capacity: Q=4,500 m^3/day)

Sewage Treatment in AEON
(Method: Contact Aeration, Capacity: Q=1,000 m^3/day)

Source: JICA Study Team

Photo 2.4.1 Sewage Treatment Plant in Industrial Factory and Commercial Facilities

(2) Case Study in Other Cities in Cambodia

In Cambodia, sewage treatment plants are, at present, operated in Battambang, Sihanoukville and Siem Reap. The treatment system is summarized in **Table 2.4.4**.

Table 2.4.4 Outline of Sewerage System in Battambang, Sihanoukville and Siem Reap

Item	Battambang	Sihanoukville	Siem Reap
Fund	EU	ADB	ADB/EDCF
Project cost (million USD)	4.00	11.19	44.36
Sewage collection system	Combined	Combined /separate	Combined
Planning population	200,000	100,000	170,000
Population serviced (person)	20,000	7,844	47,260
Serviced area (ha)	300	221.5	1,082
Treatment capacity (m^3/day)	2,800	6,900	8,000
Actual inflow (m^3/day)	Unknown	6,270	17,696
Treatment method	Lagoon	Lagoon	Lagoon
Domestic wastewater generation per person (L/person/day)	120	150	150
BOD generation per person (g/person/day)	Unknown	40	BOD=200 mg/L

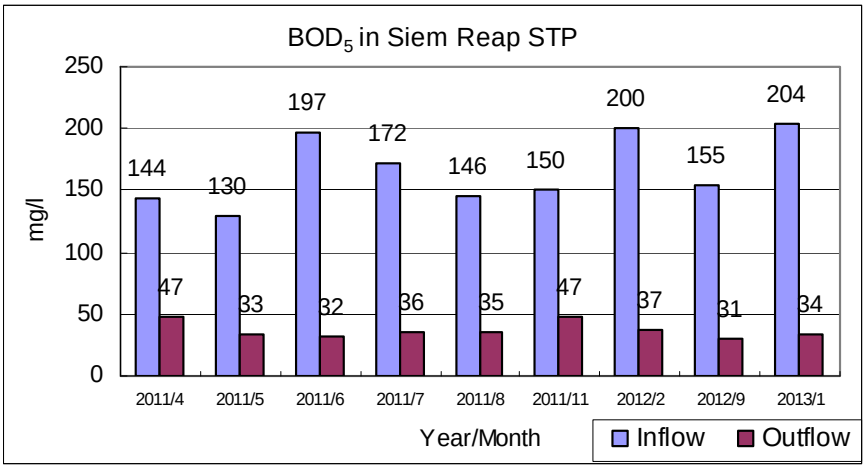
Source: MPWT

Based on the result of interview with MPWT, the current condition and challenges in sewage and drainage management are as summarized below.

- *Battambang;* Water quality of inflow and outflow is not monitored due to shortage of staff. Sewerage fees are collected from the users but budget structure is not independent. It is uncertain that collected sewerage fees are used for only the maintenance of sewerage and drainage system.

- *Sihanoukville;* Cost of O&M of sewerage facilities is covered by collected sewage charges. However, it is necessary to expand the sewerage system to cover the whole city area. In addition, good water quality of sewage treatment plant is not obtained due to aged equipment in the laboratory, as well as the shortage of staff that has enough capacity to analyse and store samples.

- *Siem Reap;* Water quality of Siem Reap STP is shown in **Fig. 2.4.1**. Treated water quality meets the water quality standard. However, the sewerage management entity runs a deficit, as discussed in **Subsection 2.6.3**.



Source: MPWT

Fig. 2.4.1 Water Quality of Sewage Treatment Plant in Siem Reap

2.4.3 Drainage Facilities

Installation of drainage facilities in Cambodia is still in progress, and the areas drainage facilities are installed are limited only in urban areas and suburban villages. The drainage pipes in those areas are in general receiving sewage as well.

Local cities scattered along the Mekong River are small-scale, and these cities are established on the natural levee. Therefore, natural drainage system is functional and thus drainage-related problems are not found even in the areas where drainage facilities are undeveloped. On the other hand, lowland areas rapidly urbanized in large cities such as Phnom Penh, Siem Reap and Sihanoukville, often suffer from inundations due to poor drainage system.

Drainage pipe network and pumping stations in Phnom Penh have been improved but systematic installation of drainage facilities in other cities is not in progress.

(1) Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh (1999)" and Japan's Grant Aid Projects

The Master Plan for drainage improvement and flood control in the Municipality of Phnom Penh, containing eight components, was formulated in "The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh, 1999" (hereinafter referred to as "M/P 1999"). The M/P 1999 proposed projects for the target year 2010 with the total project cost of 261.6 million USD. Economic Internal Rate of Return (EIRR) of the projects in M/P 1999 was calculated at 12.9%.

PPCC has implemented the projects for drainage improvement and flood control on the basis of M/P 1999 where large-scale projects were funded by Japan's Grant Aid, ADB or AFD, and small-scale projects were implemented by their own budget. **Table 2.4.5** summarizes Japan's Grant Aid projects implemented in three phases since 2000, and eight proposed components in the M/P 1999.

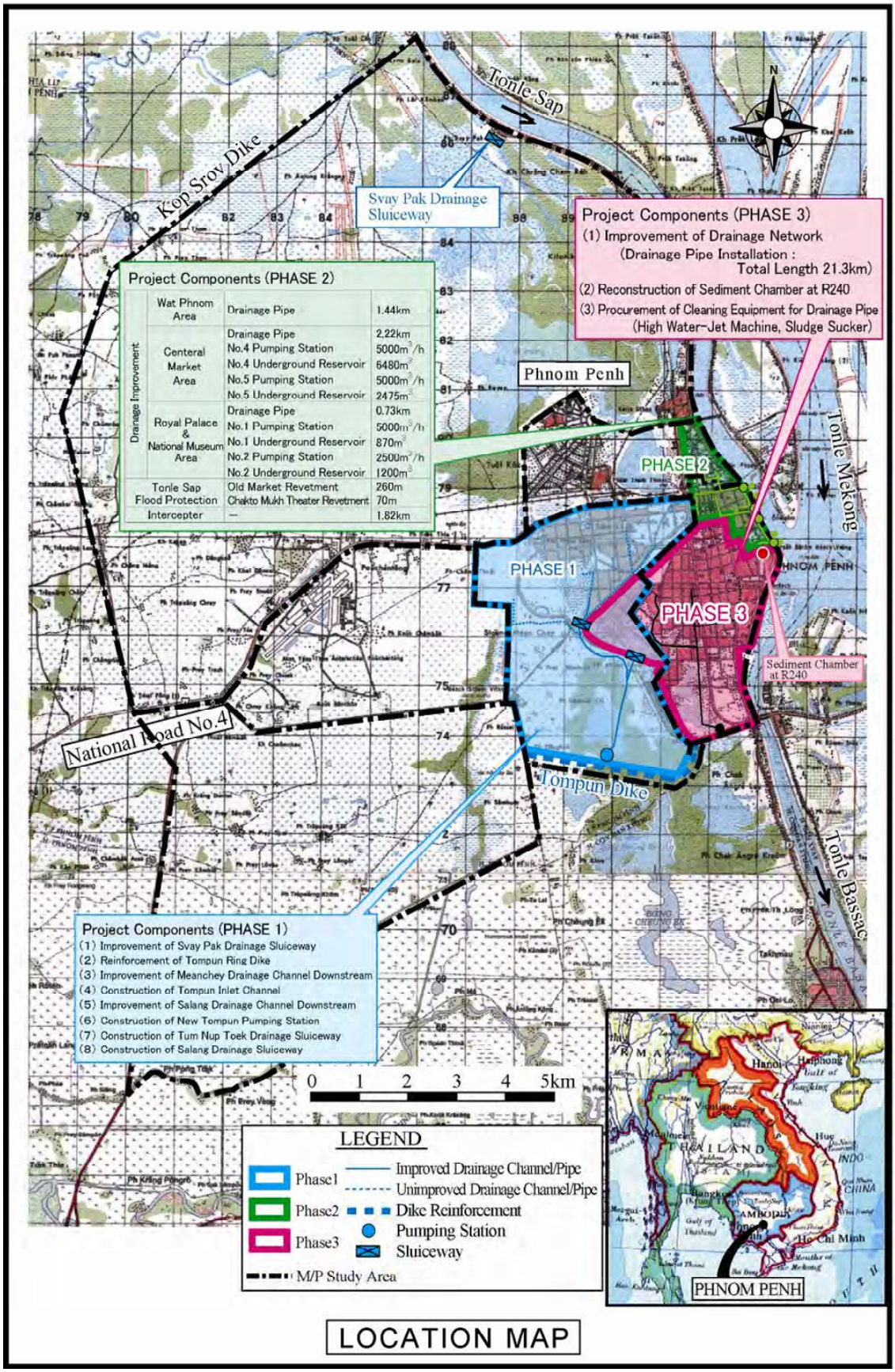
Table 2.4.5 Proposed Components in M/P 1999 and Projects Implemented

Component proposed in M/P 1999		Implemented under Japan's Grant Aid	Implemented with Funds from Other donors
1	Riverfront Protection in Sap Downstream Middle Section	• Rehabilitation and improvement of revetment, only at damaged section and around outlet of pumping station (Phase 2)	-
2	Reinforcement of Kop Srov and Tumpun Dikes	• Reinforcement of Tumpun Dike (Phase 1)	• ADB: Improvement of Kop Srov Dike
3	Tumpun Watershed Drainage Improvement	• Construction of Tumpun Pumping Stations at downstream end, and improvement of drainage channel at downstream part (Phase 1) • Not yet done: upgrading of drainage pipe network in the Tumpun watershed	-
4	Trabek Basin Drainage Improvement	• Construction of underground reservoirs, pumping stations and interceptor pipes (Phase 2) • Upgrading of drainage pipe network in Trabek basin: only main drainage pipes are installed (Phase 2)	• ADB: Construction of Trabek Pumping Station at downstream end and improvement of drainage channel • AFD: Installation of drainage pipes around central market
5	City Core North Area Drainage Improvement	• Installation of drainage ditch around Wat Phnom (Phase 2)	-
6	Pochentong East Basin Drainage Improvement	-	-
7	Northeast and Northwest Areas Drainage Improvement	• Improvement of Svay Pak Drainage Sluiceway (Phase 1)	-
8	Environmental Enhancement	• Renovation of riverfront area along with the improvement of damaged revetment (Phase 2)	-

Source: JICA Study Team

The area where the Grant Aid projects were implemented did not cover whole target area for improvement of the drainage system. It only covered the area where urgent improvement was required. Components proposed in M/P 1999 but not implemented are the "Installation of drainage main and secondary pipes and open channels at upstream of Tumpun basin" and the "Improvement of drainage secondary pipes and drainage improvement at northern part of Wat Phnom".

Boundary of components proposed in the M/P 1999 and locations of grant aid projects are shown in **Fig. 2.4.2**.



Source: Preparatory Survey Report on the Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)

Fig. 2.4.2 Location Map of M/P 1999 Study Areas and Grant Aid Project Areas

(2) Condition of Existing Drainage Facilities

Drainage facilities are constructed by DPWT and local authorities, such as Khan and Sangkat. After construction, the drainage facilities are operated and maintained by DPWT.

DPWT records the total length of drainage pipes by diameter and number of manholes by size since 1994. Cumulative length of drainage pipe and number of manholes constructed in 2006-2013, which were provided by DPWT, are shown in **Table 2.4.6**.

Table 2.4.6 Total Length of Drainage Pipes and Number of Manholes

Drainage Pipes (m)								
Pipe size	2006	2007	2008	2009	2010	2011	2012	2013
Ø200cm								
Ø180cm					301	301	301	301
Ø160cm	85	85	85	85	85	85	85	85
Ø150cm	8,331	9,631	10,847	13,918	17,966	17,966	18,752	19,782
Ø120cm	775	17,820	17,820	17,820	18,187	18,187	18,187	18,187
Ø100cm	42,837	57,962	65,620	81,250	82,110	82,417	84,325	87,876
Ø80cm	26,675	41,712	46,317	50,601	50,939	51,452	51,452	52,125
Ø60cm	124,106	142,125	147,297	157,628	158,068	160,173	160,545	162,049
Ø50cm	51,753	59,873	64,488	64,488	66,237	66,237	66,237	66,237
Ø40cm	13,815	18,942	22,049	22,049	22,105	22,105	22,105	22,105
Ø30cm	33,883	42,902	46,115	46,755	46,755	47,173	47,536	48,412
U-drain					320	320	320	320
Total (m)	302,260	391,052	420,638	454,594	463,073	466,416	469,845	477,479
Length of pipe installed in a year	-	88,792	29,586	33,956	8,479	3,343	3,429	7,634
Manholes								
Size	2006	2007	2008	2009	2010	2011	2012	2013
$Rg_{200x130}$					45	45	61	127
$Rg_{130x130}$	1,993	3,420	3,701	4,510	4,530	4,558	4,617	4,785
$Rg_{110x110}$	1,395	1,669	1,823	2,025	2,025	2,025	2,025	2,052
Rg_{90x90}	5,171	8,080	8,545	9,120	9,142	9,233	9,266	9,354
Rg_{70x70}	6,629	9,103	9,334	16,662	16,682	16,822	16,895	17,104
Total	15,188	22,272	23,403	32,317	32,424	32,683	32,864	33,422
Manholes installed in a year	-	7,084	1,131	8,914	107	259	181	558

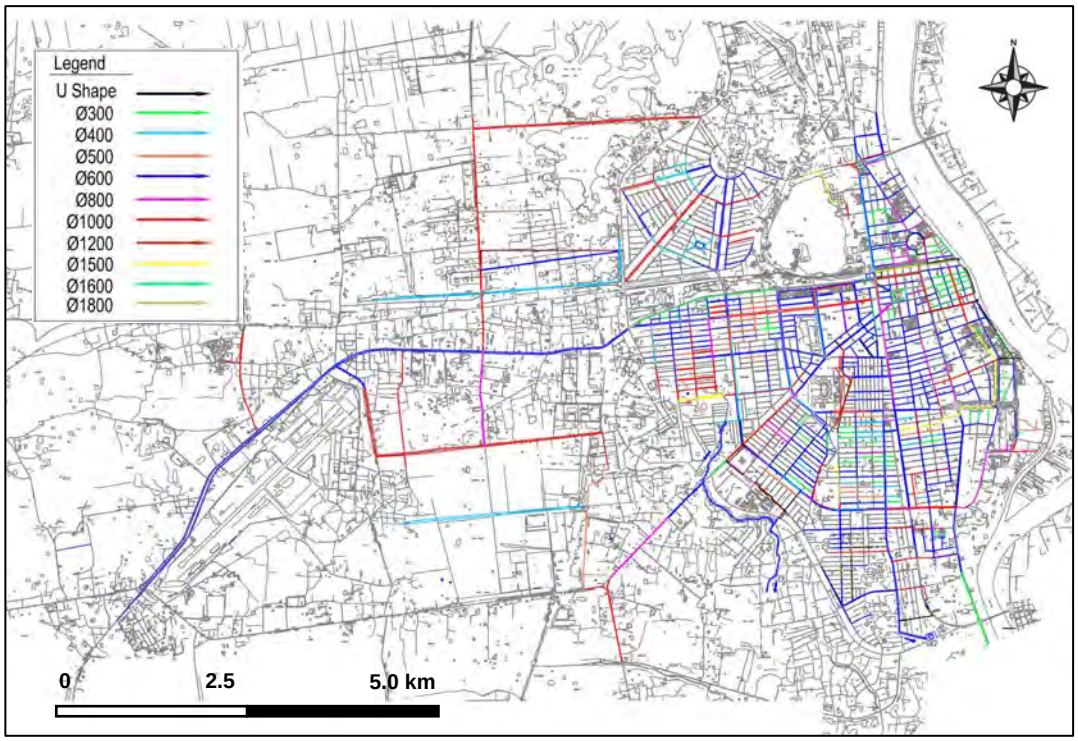
Source: DPWT/PPCC

As shown in **Table 2.4.6**, total length of drainage pipes and number of manholes are gradually increasing. As of the end of 2013, total length of pipes is about 478 kilometers and number of manholes is about 34,000.

As a general rule, DPWT is responsible for operation and maintenance work of drainage main pipe network with diameter of 600 mm or more, local authorities, such as Khan and Sangkat, are responsible for drainage pipe network with diameter smaller than 600 mm. DPWT sometimes carry out repairing work or cleaning work of drainage pipe network according to request by local authorities.

DPWT is in the process of establishing the database[13] of drainage pipes at present. **Fig. 2.4.3** shows the location map derived from the database. However, there are still many drainage pipes in the capital city that have not been recorded in this database yet. Further survey about drainage pipe network is necessary.

[13] The database is established in the soft component of the Japan's Grant Aid Project, "The Project for Flood Protection and Drainage Improvement in the Phnom Penh Capital City (Phase III)".



Source: DPWT/PPCC

Fig. 2.4.3 Drainage Pipe Location Map from Database

Details of open channels and pumping stations managed by DPWT as of September 2014, are shown in **Table 2.4.7** and **Table 2.4.8**. Total length of channel is about 55 kilometres and number of pumping stations is 12.

Table 2.4.7 Total Length of Open Channels Managed by DPWT

No.	Name	Total length (m)	Improved Length (m)	Canal Type
1	Boeng Trabek Upper Canal	2,410	2,410	Reinforced Concrete Canal
2	Boeng Trabek Downstream Canal	850	0	Earth Canal
3	Boeng Tumpun Canal	3,710	3,710	Improved Earth Canal
4	Stoeng Mean Chey Canal	1,900	0	Earth Canal
5	East & West Tuol Sen Canals	1,118	1,118	Improved to Reinforced Concrete Canal
6	Boeng Salang canal	1,260	887	Improved Earth Canal (887m)
7	Canal Baraing (France)	3,700		Earth Canal
8	Canal Lou Pram	1,700		Earth Canal
9	Tuol Poung Ror Canal (South Prey Pring)	7,500		Earth Canal
10	Prey Spoeu Canal	7,000		Earth Canal
11	O Akuch Canal	4,200		Earth Canal
12	598 Canal	1,850		Earth Canal
13	Tuol Sampoeuv Canal (Philippines Canal)	5,000		Earth Canal
14	Kop Srov Canal	4,700		Earth Canal
15	Bak Touk Canal	3,800		Earth Canal
16	O Veng Canal	4,150		Earth Canal
	Total	**54,848**	**8,125**	
	Improved to Reinforced Concrete Canal	**3,528**		
	Improved in Earth Canal	**4,597**		
	Normal Earth Canal	**46,723**		

Source: DPWT/PPCC

DPWT is responsible for operation and maintenance work of drainage channels and carry out periodical patrol. If any problem, such as accumulation of soil sedimentation or overgrowth of vegetation, are found or reported, they carry out necessary countermeasures. Dredged soil and vegetation are disposed in Dangkor solid waste disposal site, which is operated by WMD.

Table 2.4.8 List of Pumping Stations Managed by DPWT

Station Name		Electrical Engine Driven				Diesel Engine Driven				Total Discharge Capacity [m^3/sec.]	Observation (Date of Equipment)
		Nos	Pump type	Power /Unit [kW]	Capacity /Unit [m^3/sec.]	Nos	Pump type	Power /Unit [HP]	Capacity /Unit [m^3/sec.]		
1	Boeng Trabek	8	Horizontal	132	1.0	1 unit of Backup Generator, 1000 KVA				8.0	Operation since 2003 (ADB Loan)
2	Boeng Tumpun	5	Submergible Pump	280	3.0	2 units of Backup Generator, 700 KVA each				15.0	Operation since 2004 (Japan's Grant Aid)
3	Tuol Kork I	2	Vertical shaft	45	0.47	2	Vertical shaft	145	0.69	2.32	Constructed in 1970's
4	Tuol Kork II	1	Vertical shaft	45	0.47	2	Vertical shaft	145	0.69	1.85	Constructed in 1970's
5	Chak Tomuk	2	Pump Gate	45	0.7	1 unit of Backup Generator, 200 KVA				1.4	Operation since 2010 (Japan Grant Aid)
6	Preah Kumlung 1	1	Pump Gate		0.2	-				0.2	Operation since 2004 (Joint Research with Kubota)
7	Preah Kumlung 2	2	Pump Gate	22	0.35	-				0.7	Operation since 2010 (Japan's Grant Aid)
8	Phsar Kandal	2	Pump Gate	45	0.7	1 unit of Backup Generator, 200 KVA				1.4	Operation Since 2010 (Japan's Grant Aid)
9	Phsar Chaas	2	Pump Gate	45	0.7	1 unit of Backup Generator, 200 KVA				1.4	Operation since 2010 (Japan's Grant Aid)
10	Svay Pak Km No.9	4	Submergible Pump	75	0.13	3	Vertical shaft	190	0.38	1.66	Operation since 2006
11	Kop Srov	5	Vertical shaft	400	2.8	-				14.0	Operation since 2010
12	Tuol Sampeo	3	Submergible Pump		0.66	-				1.98	Operation since 2014

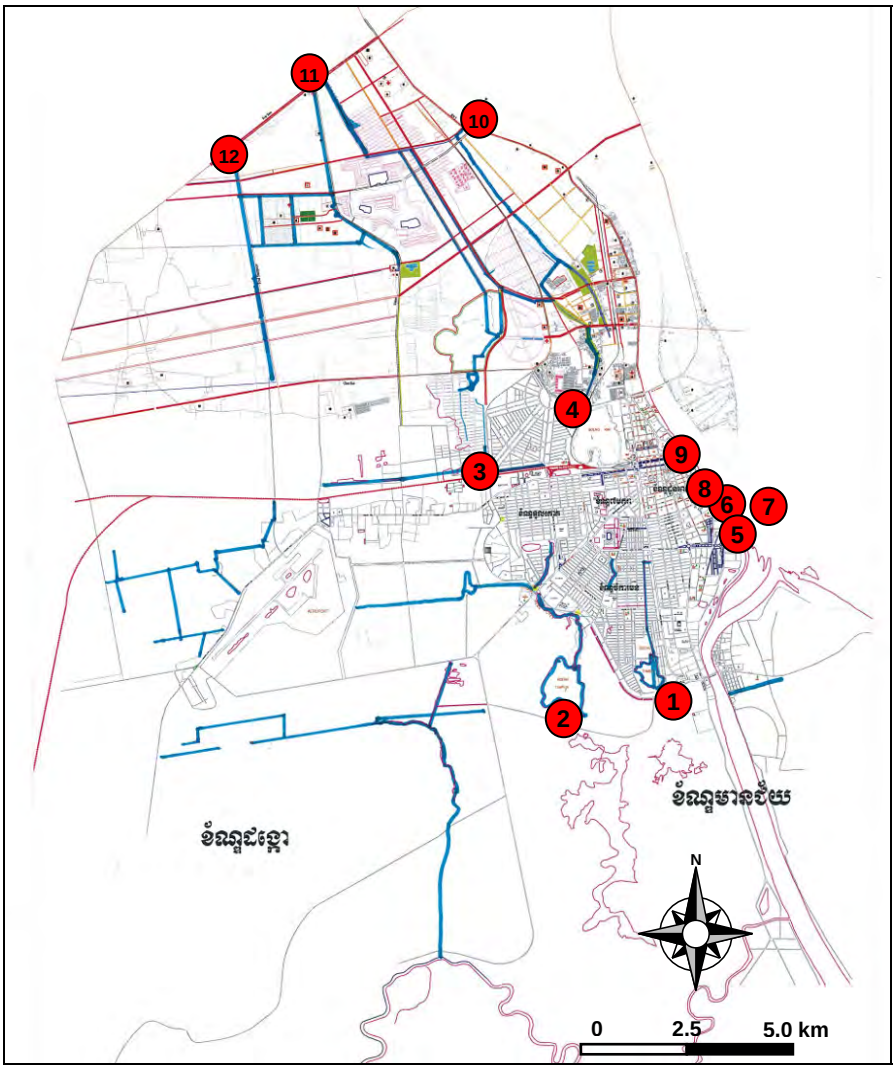
Source: DPWT/PPCC

DPWT is responsible for operation and maintenance work of drainage pumping stations. They carry out daily maintenance only. Repairing work of pump equipment is outsourced.

Most serious problem at pumping stations is related to solid waste. Excessive amount of garbage flows down to inlet channel and pumping station, and get stuck on the trash screen and impeller of pump. Staff of the pumping stations spends most of their day doing garbage collection and cleaning of impeller of pump.

No periodical inspection of pump equipment by pump manufacturer or specialist is carried out. Only in case of actualization of problem, pump equipment would be repaired. Generally, Cambodian technicians do not have enough skill to solve mechanical troubles of pump equipment. Technicians of pump manufacturer or specialist are hired and invited from abroad to repair the equipment.

Fig. 2.4.4 shows location of open channels and pumping stations managed by DPWT.



Blue line: location of open channels, Red mark: location of pumping station
(Numbers correspond to **Table 2.4.7**)
Source: DPWT/PPCC, JICA Study Team

Fig. 2.4.4 Location Map of Channels and Pumping Stations Managed by DPWT

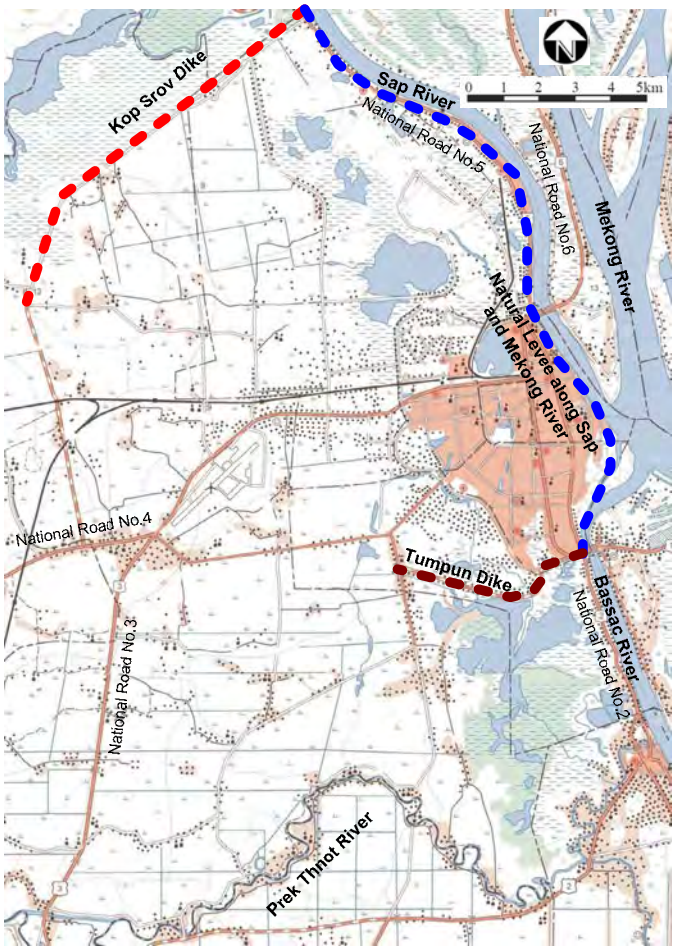
2.4.4 Sludge Management Facilities

The Waste Management Division of PPCC is responsible for septage management but there exists no septage disposal site for septage collected by vacuum trucks.

Therefore, the septage is disposed into the lagoon in Dangkor solid waste disposal site with charge of 10,000 riel per vacuum truck. However, most of septage collected by vacuum car from the households is illegally dumped in the drainage channels or wetlands.

2.4.5 Flood Protection

Urbanized area in Phnom Penh is protected from flooding arising from overflow of Mekong/Sap River by Kop Srov Dike at northern part, Tumpun Dike at southern part and natural levees along the Mekong/Sap River, as shown in **Fig. 2.4.5**.

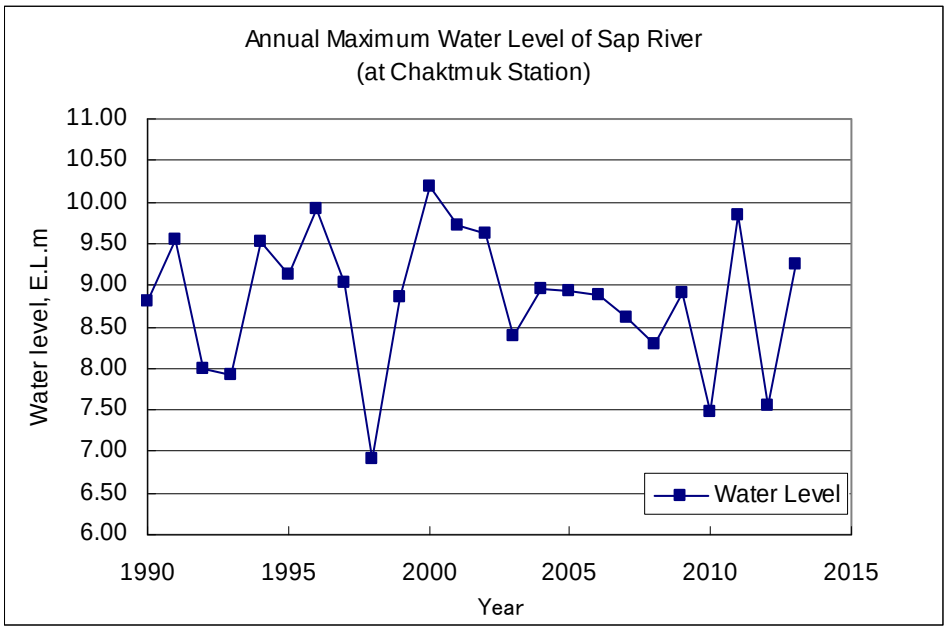


Source: DPWT/PPCC, JICA Study Team

Fig. 2.4.5 Location Map of Dikes in and around PPCC

When the M/P 1999 study was conducted, Kop Srov Dike formed a part of the northwest administrative boundary of the Municipality of Phnom Penh, connecting National Roads of Routes 4 and 5. Due to expansion of the administrative area of Phnom Penh, the role of Kop Srov Dike has changed into a dike to protect the city from flooding as well as a ring road to bypass the city center area. Similarly, there are two roles of Tumpun dike, namely, as a dike and a ring road. The crests of the two dikes are paved by asphalt or cement concrete.

Water level of Sap River has been observed since the 1960's, the maximum water level was recorded in 2000. Annual maximum water level recorded between 1993 and 2013 is shown **Fig. 2.4.6**. It is obvious that there is no record which exceeds the maximum water level recorded in 2000 (E.L. 10.18m).



Source: MOWRAM

Fig. 2.4.6 Variation of Annual Maximum Water Level in Sap River

Overflow from the Mekong/Sap River has never happened since the 1960's. However, historical maximum flooding in 2000 revealed that height of river dike at Kop Srov and Tumpun is not enough, although overflow from the dikes were prevented with effort. Therefore, the project for bank raising of Kop Srov Dike was implemented in 2001 with ADB funds. In addition, the project for reinforcement of Tumpun Dike was implemented from 2002 to 2004 in the Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase 1), funded under Japan's Grant Aid.

Revetment along the Sap River, totalling 330 m, has been improved in Phase 2 of the project mentioned above. In the Chroy Changvar area at the left bank of Sap River, revetment from Chroy Changvar Bridge (Japan Bridge) to the downstream was improved and bank raising along riverfront section was implemented.

Safety level for overflow from Mekong and Sap River has been enhanced by the implementation of above projects, and thus temporary measures such as piling sandbags are satisfactory to cope with the risk of flooding at present.

At the areas recently incorporated into PPCC (i.e.; North part of Kop Srov Dike, west part of Kop Srov Dike (Prek Pnov), southwest area (Dangkor and Po Senchey), Chroy Changvar and Chbar Ampov), there is no provision for backwater of rivers such as Mekong and Sap, except for area surrounded by natural dikes. However, serious damages caused by flooding are not reported because the area is not fully developed or unused.

In and around PPCC, damaged and/or lower dikes, which are vulnerable to flooding, are not found in the topographical survey conducted in this Study.

2.5 Water Quality

2.5.1 Water Quality and Effluent Standard

The Sub-Decree on Water Pollution Control, 1999 was enacted on 6th April 1999, aiming to prevent water pollution in Cambodia. This sub-decree defines "Classification of waste and hazard discharge", "Water Quality Standard", "Effluent Standard", "Responsibility of polluter", "Monitoring", "Discharge Permit", "Inspection" and "Penalty", etc.

Water quality standard in public water areas such as river, lakes, reservoirs and coastal water is set for bio-diversity conservation (**Table 2.5.1**). In addition, twenty-five parameters are set as water quality standard in public water areas for public health protection (**Table 2.5.2**).

Table 2.5.1 Water Quality Standard for Bio-Diversity Conservation

	No	Parameter	Unit	Standard Value
1. River	1	pH	-	6.5 – 8.5
	2	BOD_5	mg/l	1 – 10
	3	Suspended Solid	mg/l	2.4 – 100
	4	Dissolved Oxygen	mg/l	2.0 – 7.5
	5	Coliform	MPN/100ml	< 5,000
2. Lakes and Reservoirs	1	pH	-	6.5 – 8.5
	2	COD_{Mn}	mg/l	1 – 8
	3	Suspended Solid	mg/l	1 – 15
	4	Dissolved Oxygen	mg/l	2.0 – 7.5
	5	Coliform	MPN/100ml	< 1,000
	6	Total Nitrogen	mg/l	1.0 – 0.6
	7	Total Phosphorus	mg/l	0.005 – 0.05
3. Coastal Water	1	pH	-	7.0 – 8.3
	2	COD_{Mn}	mg/l	2 – 8
	3	Suspended Solid	mg/l	2 – 7.5
	4	Coliform	MPN/100ml	< 1,000
	5	Oil Content	mg/l	0
	6	Total Nitrogen	mg/l	0.2 – 1.0
	7	Total Phosphorus	mg/l	0.02 – 0.09

* Some parameters have 'lower limit' and 'upper limit'. As the result of inquiry to MOE about 'lower limit', setting up of the 'lower limit' (excluding pH) is not correct and those should be revised but the schedule of the revision is not fixed.

Source: Sub-Decree on Water Pollution Control, Annex 4: Water Quality Standard in public water areas for bio-diversity conservation.

Table 2.5.2 Water Quality Standard for Public Health Protection

No.	Parameter	Standard Value (µg/l)
1	Carbon tetrachloride	< 12
2	Hexachloro-benzene	< 0.03
3	DDT	< 10
4	Endrin	< 0.01
5	Diedrin	< 0.01
6	Aldrin	< 0.005
7	Isodrin	< 0.005
8	Perchloroethylene	< 10
9	Hexachlorobutadiene	< 0.1
10	Chloroform	< 12
11	1,2 Trichloroethylene	< 10
12	Trichloroethylene	< 10
13	Trichlorobenzene	< 0.4
14	Hexachloroethylene	< 0.05
15	Benzene	< 10
16	Tetrachloroethylene	< 10
17	Cadmium	< 1
18	Total mercury	< 0.5
19	Organic mercury	0
20	Lead	< 10
21	Chromium, valent 6	< 50
22	Arsenic	< 10
23	Selenium	< 10
24	Polychlorobiohenyl	0
25	Cyanide	< 0.005

Source: Sub-decree on Water Pollution Control, Annex 5: Water Quality Standard in public water areas for public health protection.

"Effluent standard for pollution sources discharging wastewater to public water areas or sewer" is defined in this sub-decree (**Table 2.5.3**). "Protected public water area" is set in this standard. All effluent including industries should comply with the standard for "Public water area and sewer" since the protected area is currently not yet specified.

Table 2.5.3 Effluent Standard for Public Water Areas or Sewer

No	Parameter	Unit	Standard	
			Protected Public Water Area	Public Water Area and Sewer
1	Temperature	^{0}C	< 45	< 45
2	pH		6 – 9	5 – 9
3	BOD_5 (5 days at 20℃)	mg/l	< 30	< 80
4	COD_{Cr}	mg/l	< 50	< 100
5	Total Suspended Solids	mg/l	< 60	< 120
6	Total Dissolved Solids	mg/l	< 1,000	< 2,000
7	Grease and Oil	mg/l	< 5.0	< 15
8	Detergents	mg/l	< 5.0	< 15
9	Phenols	mg/l	< 0.1	< 1.2
10	Nitrate (NO_3)	mg/l	< 10	< 20
11	Chlorine (free)	mg/l	< 1.0	< 2.0
12	Chloride (ion)	mg/l	< 500	< 700
13	Sulphate (as SO_4)	mg/l	< 300	< 500
14	Sulphate (as Sulphur)	mg/l	< 0.2	< 1.0
15	Phosphate (PO_4)	mg/l	< 3.0	< 6.0
16	Cyanide (CN)	mg/l	< 0.2	< 1.5
17	Barium (Ba)	mg/l	< 4.0	< 7.0
18	Arsenic (As)	mg/l	< 0.10	< 1.0
19	Tin (Sn)	mg/l	< 2.0	< 8.0
20	Iron (Fe)	mg/l	< 1.0	< 20
21	Boron (B)	mg/l	< 1.0	< 5.0
22	Manganese (Mn)	mg/l	< 1.0	< 5.0
23	Cadmium (Cd)	mg/l	< 0.1	< 0.5
24	Chromium (Cr^{+3})	mg/l	< 0.2	< 1.0
25	Chromium (Cr^{+6})	mg/l	< 0.05	< 0.5
26	Copper (Cu)	mg/l	< 0.2	< 1.0
27	Lead (Pb)	mg/l	< 0.1	< 1.0
28	Mercury (Hg)	mg/l	< 0.002	< 0.05
29	Nickel (Ni)	mg/l	< 0.2	< 1.0
30	Selenium (Se)	mg/l	< 0.05	< 0.5
31	Silver (Ag)	mg/l	< 0.1	< 0.5
32	Zinc (Zn)	mg/l	< 1.0	< 3.0
33	Molybdenum (Mo)	mg/l	< 0.1	< 1.0
34	Ammonia (NH_3)	mg/l	< 5.0	< 7.0
35	DO	mg/l	>2.0	>1.0
36	Polychlorinated Byphenyl	mg/l	<0.003	<0.003
37	Calcium	mg/l	<150	<200
38	Magnesium	mg/l	<150	<200
39	Carbon tetrachloride	mg/l	<3	<3
40	Hexachloro benzene	mg/l	<2	<2
41	DTT (Dithiothreitol)	mg/l	<1.3	<1.3
42	Endrin	mg/l	<0.01	<0.01
43	Dieldrin	mg/l	<0.01	<0.01
44	Aldrin	mg/l	<0.01	<0.01
45	Isodrin	mg/l	<0.01	<0.01
46	Perchloro ethylene	mg/l	<2.4	<2.4
47	Hexachloro butadiene	mg/l	<3	<3
48	Chloroform	mg/l	<1	<1
49	1,2 Dichloro ethylene	mg/l	<2.4	<2.4
50	Trichloro ethylene	mg/l	<1	<1

No	Parameter	Unit	Standard	
			Protected Public Water Area	Public Water Area and Sewer
51	Trichloro benzene	mg/l	<2	<2
52	Hexaxhloro cyclohexene	mg/l	<2	<2

Note: "Protected public water area" is set in this standard. All effluents including those of industries should be subject to the standard of "Public water area and sewer" since the protected area is not yet currently specified.
Source: Sub-Decree on Water Pollution Control, Annex 2: Effluent standard for pollution sources discharging wastewater to public water areas or sewer

2.5.2 Water Quality Monitoring in PPCC

Water quality in and around PPCC is monitored by MOE once a month. According to the data of MOE from January 2010 to December 2013, water quality is monitored at 9 points as shown in **Table 2.5.4** and **Fig. 2.5.1** with the parameters of pH, TSS, BOD, COD, T-N, T-P and Cr^{6+}.

Of the nine points, 5 points (A, B, C, D and E) are monitored to meet "Water Quality Standard at River" and other 4 points (F, G, H and I) are monitored to meet "Effluent Standard for Public Water Area and Sewer". Results of analysis in **Fig. 2.5.2** and **Fig. 2.5.3**, and minimum, maximum and average at each monitoring point in **Table 2.5.5** show the following:

- *TSS;* At river monitoring points (A, B, C, D and E), high TSS ranging from 300 to 600 mg/l were recorded compared with the standard of 100 mg/L especially in the rainy season. At Point (Prek Thnot River), high TSS was observed even in the dry season, because Point C is located close to the outlet of Cheung Aek Lake, receiving the bulk of wastewater from the city center. At the discharged wastewater monitoring points (F, G, H and I), TSS exceeds the standard of 120 mg/L regardless of the seasons.

- *BOD_5, COD;* BOD_5 and COD at Point C (Prek Thnot River) are higher than those at other points of river (A, B, D and E) as with TSS. At Point H (Trabek) and Point I (Tumpun), which are located close to Cheung Aek Lake in the southern part of Phnom Penh, BOD ranges from 100 to 250 mg/L. On the other hand, at Point F (Kop Slov) and Point G (Prek Pnov), which are located at the northern part of Phnom Penh, BOD is less than 50 mg/L, showing water pollution at the southern part of Phnom Penh. As with BOD, COD at Point C, H and I are higher than those of others.

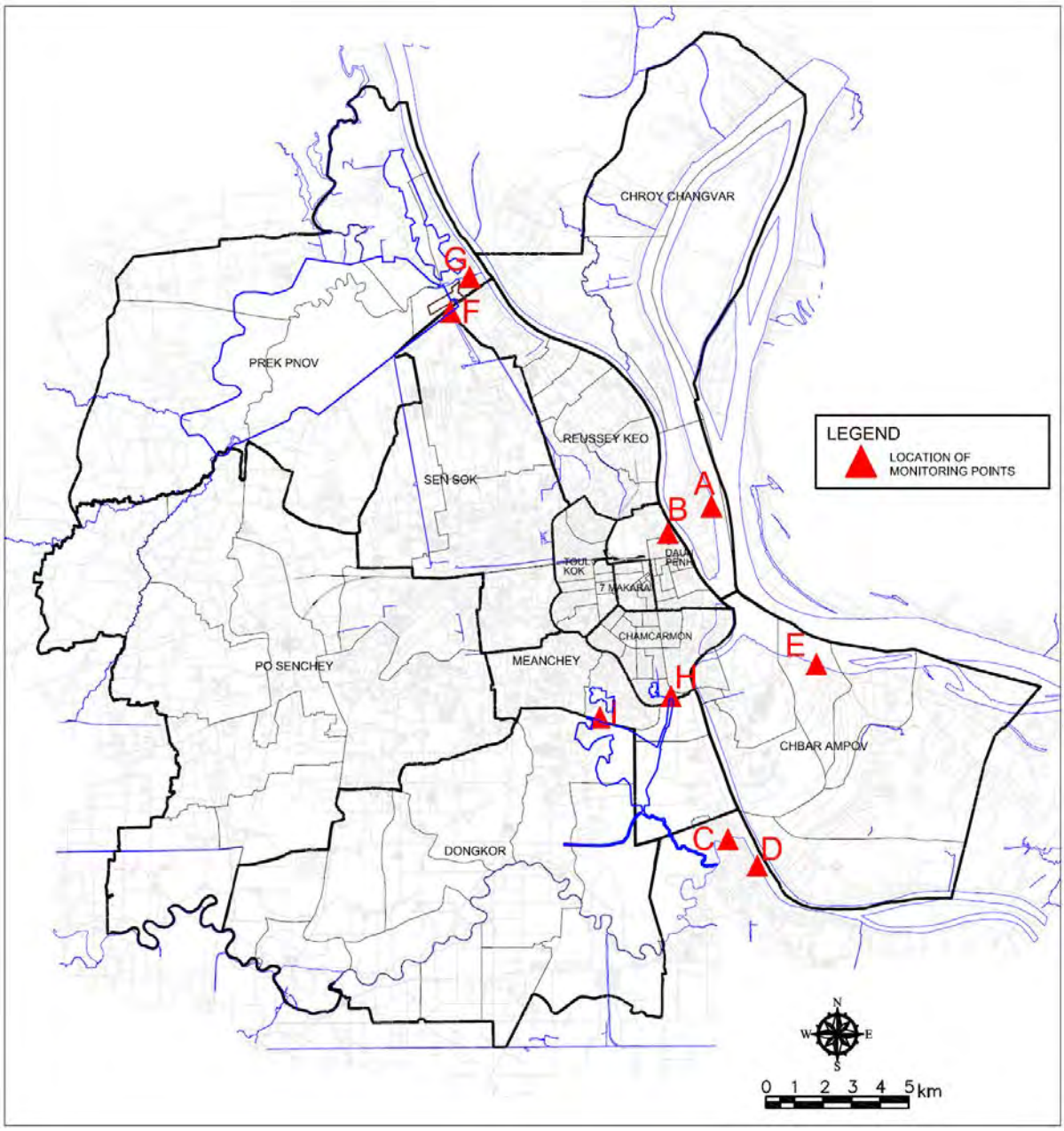
- *T-N, T-P;* At Point C, T-N and T-P are higher than those of other points. However, only T-N in 2013 at Point B was recorded at high concentration with the maximum of 8.1 mg/L. T-P at Points H and I located at Cheung Aek Lake Basin were higher than those at Points F and G. The maximum of T-P at Point H was 6.7 mg/L.

- *Cr^{6+};* Most of the values showed 'Not-detectable' or very low, less than 1.0×10^{-1} mg/L, except for data at Points A, C, D and E in 2010 and at Point B in 2011.

Table 2.5.4 Monitoring Points by MOE and Available Data

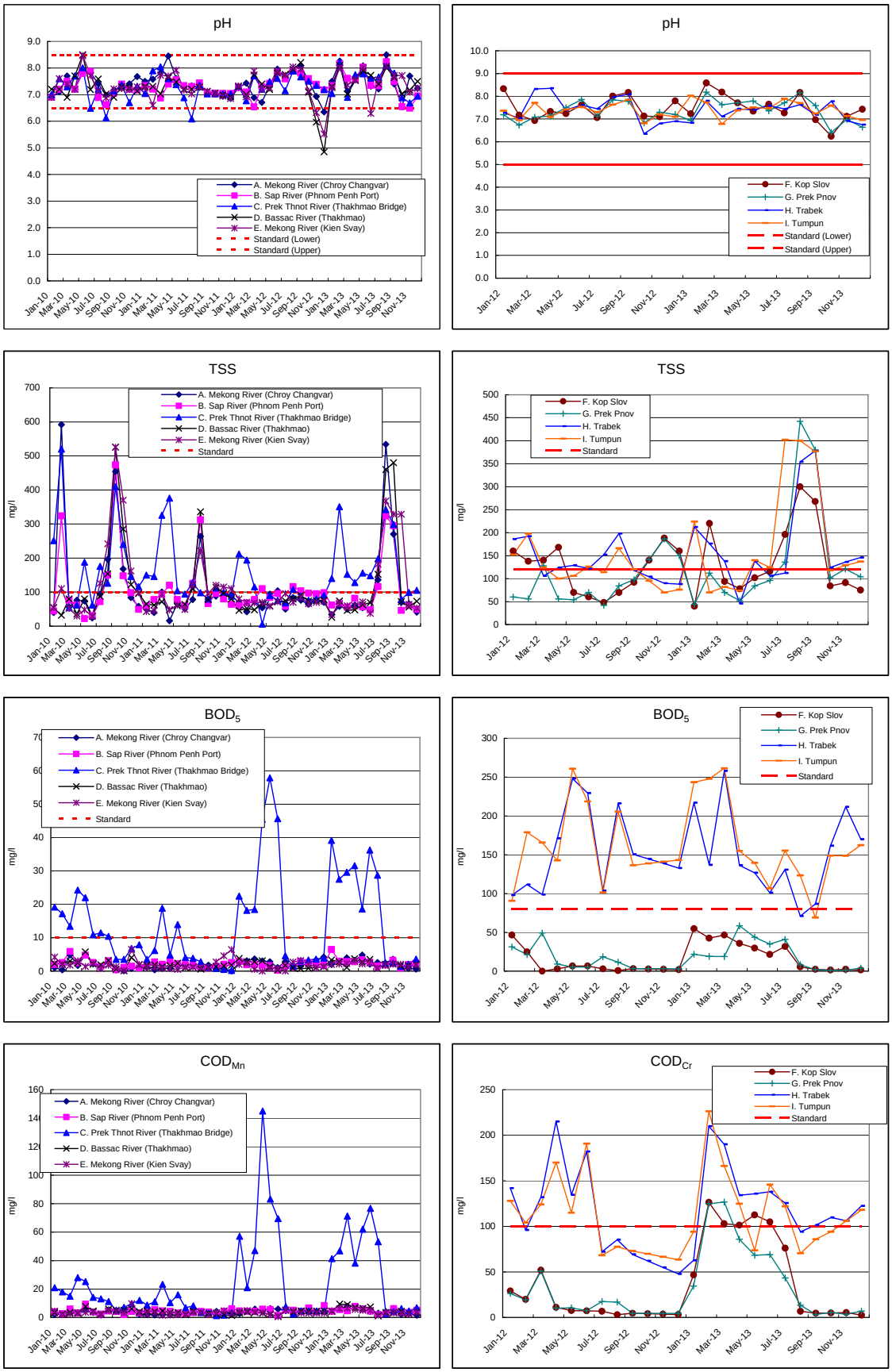
No.	Monitoring Points	Available Data
A	Mekong River (Chroy Changvar)	Data: January 2010 to December 2013
B	Sap River (Phnom Penh Port)	
C	Prek Thnot River (Thakhmao Bridge)	
D	Bassac River (Thakhmao)	
E	Mekong River (Kien Svay)	
F	Kop Slov	Data: January 2012 to December 2013
G	Prek Pnov	
H	Trabek	
I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

Source: MOE, JICA Study Team



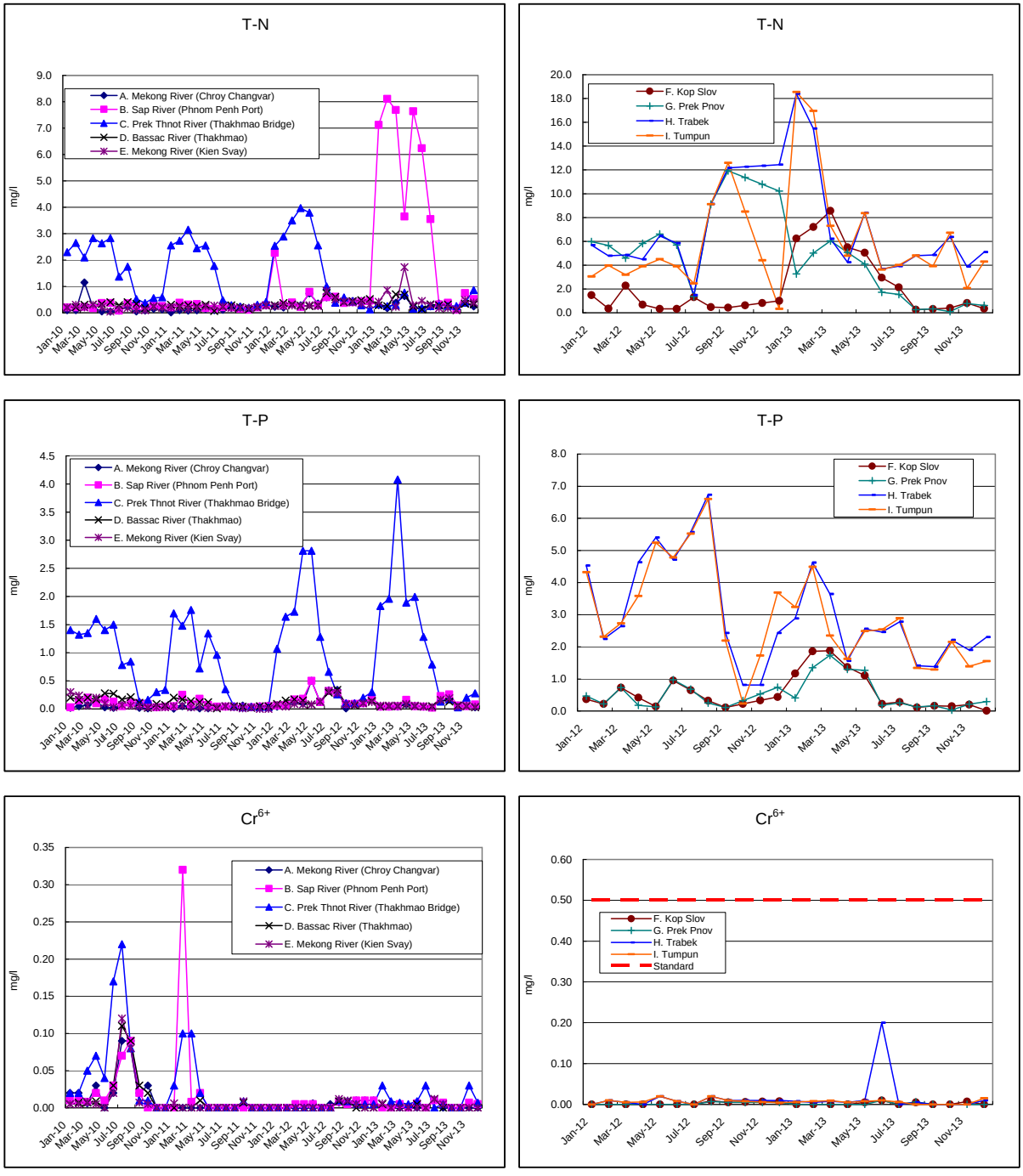
Source: MOE, JICA Study Team

Fig. 2.5.1 Monitoring Points by MOE



Source: MOE, JICA Study Team

Fig. 2.5.2 Analysis Result of Monitoring (1/2)



Source: MOE, JICA Study Team

Fig. 2.5.3 Analysis Result of Monitoring (2/2)

Table 2.5.5 Minimum, Maximum and Average at Monitoring Points

Location		pH (-)	TSS (mg/L)	BOD (mg/L)	COD_{Mn} (mg/L)	COD_{Cr} (mg/L)	T-N (mg/L)	T-P (mg/L)	Cr^{6+} (mg/L)
A. Mekong River (Chroy Changvar)	Min	6.35	16.0	0.1	1.6	-	0.01	0.01	ND
	Max	8.50	592.0	4.9	7.8	-	1.15	0.50	0.090
	Average	7.41	108.5	2.0	4.0	-	0.26	0.08	0.023
B. Sap River (Phnom Penh Port)	Min	6.49	22.0	0.2	1.4	-	0.08	0.02	ND
	Max	8.24	474.0	6.5	9.3	-	8.11	0.50	0.320
	Average	7.32	106.5	2.3	4.5	-	1.23	0.11	0.027
C. Prek Thnot River (Thakhmao Bridge)	Min	6.09	5.8	0.2	1.3	-	0.13	0.03	ND
	Max	8.21	520.0	57.9	145.0	-	3.97	4.08	0.220
	Average	7.30	157.3	13.8	23.8	-	1.33	0.98	0.038
D. Bassac River (Thakhmao)	Min	4.85	26.0	0.1	0.8	-	0.07	0.01	ND
	Max	8.50	526.0	5.8	9.4	-	0.74	0.34	0.110
	Average	7.31	108.3	2.0	4.2	-	0.31	0.12	0.023
E. Mekong River (Kien Svay)	Min	5.52	29.0	0.0	0.6	-	0.04	0.00	ND
	Max	8.47	526.0	6.5	9.7	-	1.73	0.32	0.120
	Average	7.33	114.7	1.9	3.6	-	0.31	0.08	0.019
Standard for A. to E.		6.5-8.5	<100	<10	-	-	-	-	<0.005
F. Kop Slov	Min	6.24	40.0	0.7	-	2.6	0.26	0.01	ND
	Max	8.59	300.0	54.8	-	126.4	8.56	1.88	0.010
	Average	7.49	129.1	16.4	-	35.4	2.08	0.56	0.007
G. Prek Pnov	Min	6.41	42.0	1.0	-	3.4	0.09	0.03	ND
	Max	8.18	442.0	58.4	-	126.7	11.93	1.74	0.010
	Average	7.36	119.5	17.4	-	31.8	4.91	0.53	0.006
H. Trabek	Min	6.35	46.0	70.9	-	47.9	1.48	0.81	ND
	Max	8.35	378.0	258.1	-	215.0	18.40	6.73	0.200
	Average	7.39	153.1	152.1	-	117.7	7.39	3.03	0.021
I. Tumpun	Min	6.78	70.0	68.9	-	63.5	0.32	0.23	ND
	Max	8.02	402.0	261.3	-	226.2	18.55	6.60	0.020
	Average	7.39	155.2	161.9	-	111.6	6.05	2.93	0.009
Standard for F to I.		5.0-9.0	<120	<80	-	<100	-	-	<0.05

ND: Not Detected
Source: MOE, JICA Study Team

In addition, effluent from factories has been monitored by MOE. The number of monitored factories in 2013 was around 60 in Cambodia, 30 of which are in Phnom Penh with six monitoring parameters, pH, TSS, BOD_5, COD_{Cr}, Oil & Grease, NH_3 and in some factories color is monitored.

2.5.3 Water Monitoring and Analysis in the Study

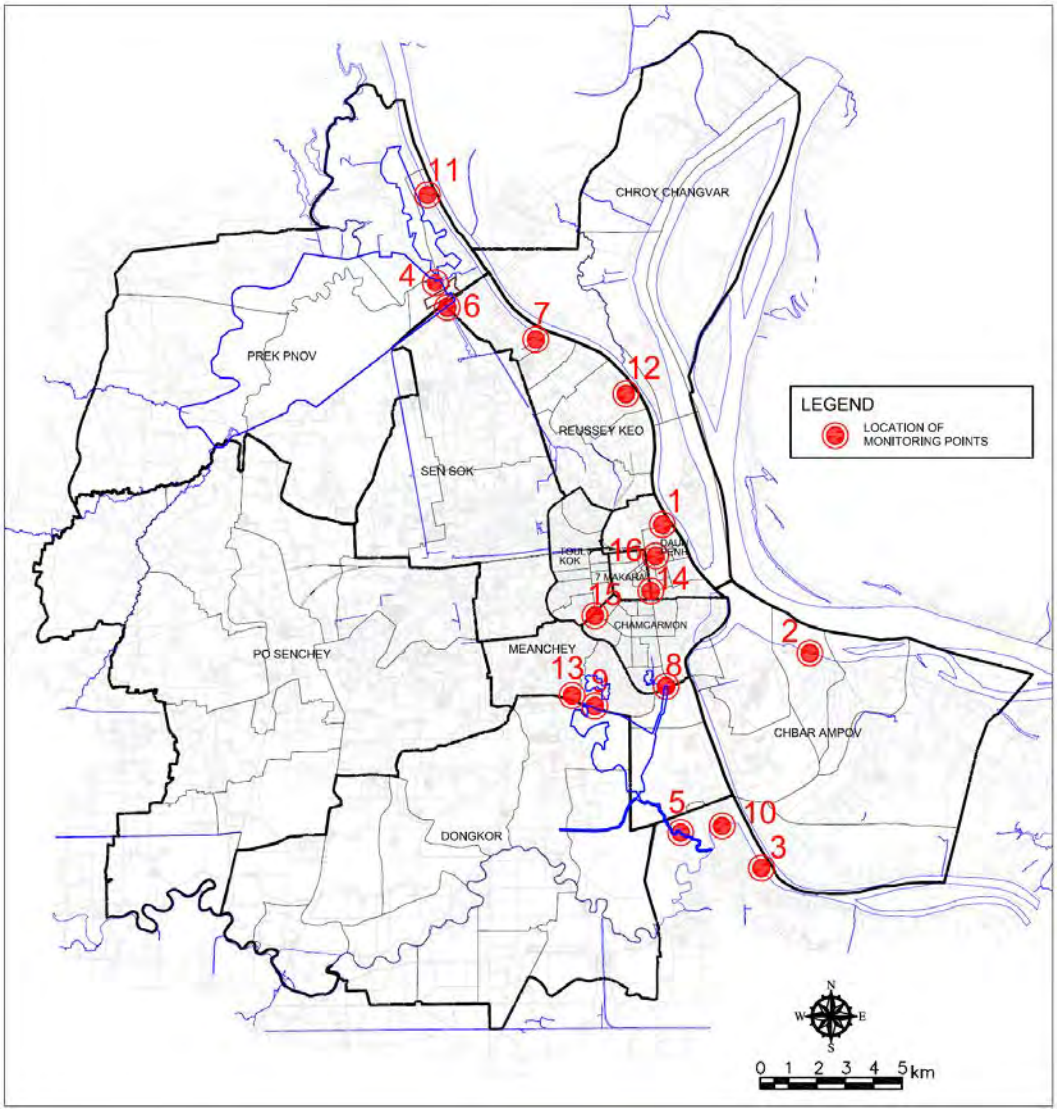
(1) Monitoring Locations and Parameters

Water monitoring and analysis was implemented by JICA Study Team. The survey was independent from MOE's monitoring survey. Locations of monitoring are shown in **Table 2.5.6** and **Fig. 2.5.4**. Sixteen monitoring locations in total include river, lake/swamp, small channel, factory and commercial facilities. Samplings were conducted six times (three times in the dry season (in November and December, 2014 and January 2015) and three times in the rainy season (two times in October and one time in November, 2014)).

Table 2.5.6 Monitoring Points and Parameters in the Study

No	Category	Monitoring Point	Parameters	Remarks
1	River	Sap River (Phnom Penh Port)	pH, DO, BOD_5, COD_{Cr}, COD_{Mn}, TSS, T-N, T-P, Total Coliform (9 parameters)	Surface water is taken from the riverside
2		Mekong River (Kien Svay)		
3		Bassac River (Thakhmao)		
4	Lake/swamp	Tamok Lake (Discharge Point)		Water is taken at discharge point of the lake/swamp
5		Cheung Aek Lake (Discharge Point)		
6	Small Channel	Kop Slov Pumping Station	pH, DO, BOD_5, COD_{Cr}, TSS, T-N, T-P, Total Coliform (8 parameters)	Surface water is taken at the middle of channels. The points of factory and commercial facilities are selected in collaboration with DOE/PPCC.
7		Svay Pak Sluiceway		
8		Trabek Pumping Station		
9		Tumpun Pumping Station		
10		Prek Thnot River (Thakhmao Bridge)		<Treatment Facility>
11	Factory	Men Sarun (Noodle Factory)		Septic Tank
12		SKD (Liquor Factory)		Digestion Tank+Lagoon
13		SL (Garment and Washing)		Activated sludge process+Chemical treatment
14	Commercial Facilities	Phnom Penh Tower (Office Building)		Activated sludge process
15		Intercontinental Hotel		Septic tank+Aeration
16		Central Market		Septic tank

Note: COD_{Mn} is monitored at rivers to compare the COD_{Mn} of lake and swamp where it is regulated.
Source: JICA Study Team



Source: JICA Study Team

Fig. 2.5.4 Location Map for Water Sampling Survey

(2) Survey Result

Monitoring results, six times in total, are shown in **Fig. 2.5.5** to **Fig. 2.5.8**, and minimum, maximum and average at each monitoring point are summarized in **Table 2.5.7.** The findings are summarized below**.**

- *pH:* Most of pH met the standard. At the 2nd monitoring in the rainy season at Mekong River (Point No. 2, monitoring time: 11 o'clock) and 3rd monitoring in the rainy season at SKD (Point No. 12, monitoring time: 8 o'clock), the pH exceeded the standard to a large extent.

- *DO:* At Trabek Pumping Station (Point No. 8) and Tumpun Pumping Station (Point No. 9), receiving wastewater from the Cheung Aek Lake Basin, DOs were extremely low. In particular, at Point No. 8, almost all values were 0.0 mg/L, showing high contamination.

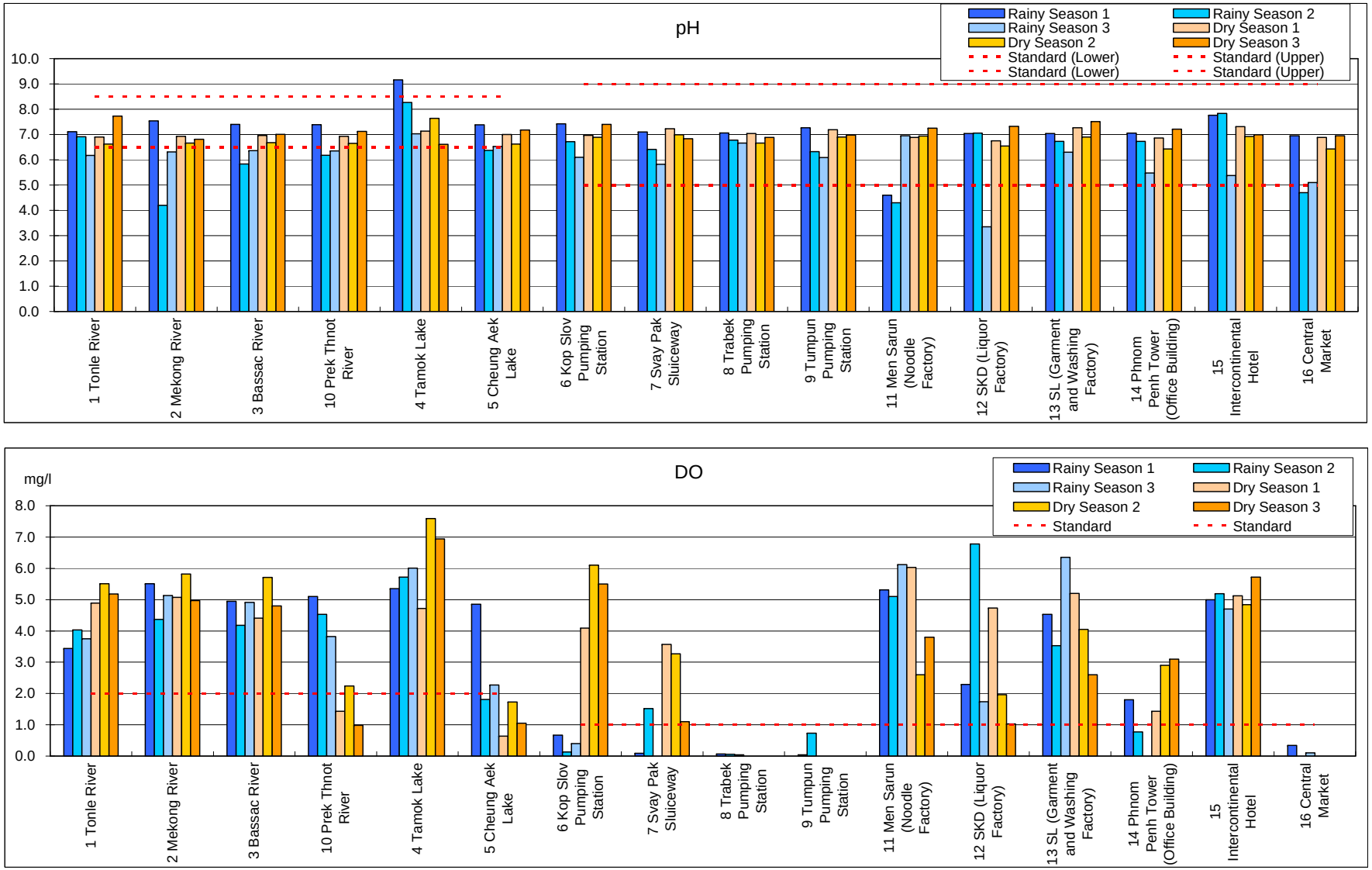
- *TSS:* Maximum TSS was recorded at Trabek Pumping Station (Point No. 8, monitoring time: 11 o'clock) with 740 mg/L in the 2nd monitoring in the dry season, followed by 640 mg/L recorded at Svay Pak Sluiceway (Point No. 7, monitoring time: 11 o'clock) in the 2nd monitoring in the dry season. High TSS at Point No. 7 is due to solids and sand, and is due to wastewater at Point No. 8.

- *BOD_5:* BOD_5 at Trabek Pumping Station (Point No. 8) were as a whole very high and the BOD_5 intensively increases from the end of the rainy season to the dry season. The maximum at the point was 299.9 mg/L recorded in the 2nd monitoring (monitoring time: 11 o'clock) in the dry season. At Tumpun Pumping Station (Point No. 9), similar trend was observed. The maximum at the point was 249.5 mg/L in the 2nd monitoring (monitoring time: 12 o'clock) in the dry season. Among the factories and commercial facilities, only the value at Central Market (Point No. 16) exceeded the effluent standard, with maximum value of 292.5 mg/L (monitoring time: 13 o'clock).

- *COD_{Mn} and* COD_{Cr}*:* COD_{Mn} at Tamok Lake (Point No. 4) and Cheung Aek Lake (Point No. 5) exceeded the standard of 8.0 mg/L, except for the 1st monitoring in the rainy season. The maximum COD_{Cr} was 595.8 mg/L recorded at Men Sarun (Point No. 11) in the 2nd monitoring (monitoring time: 10 o'clock) in the dry season.

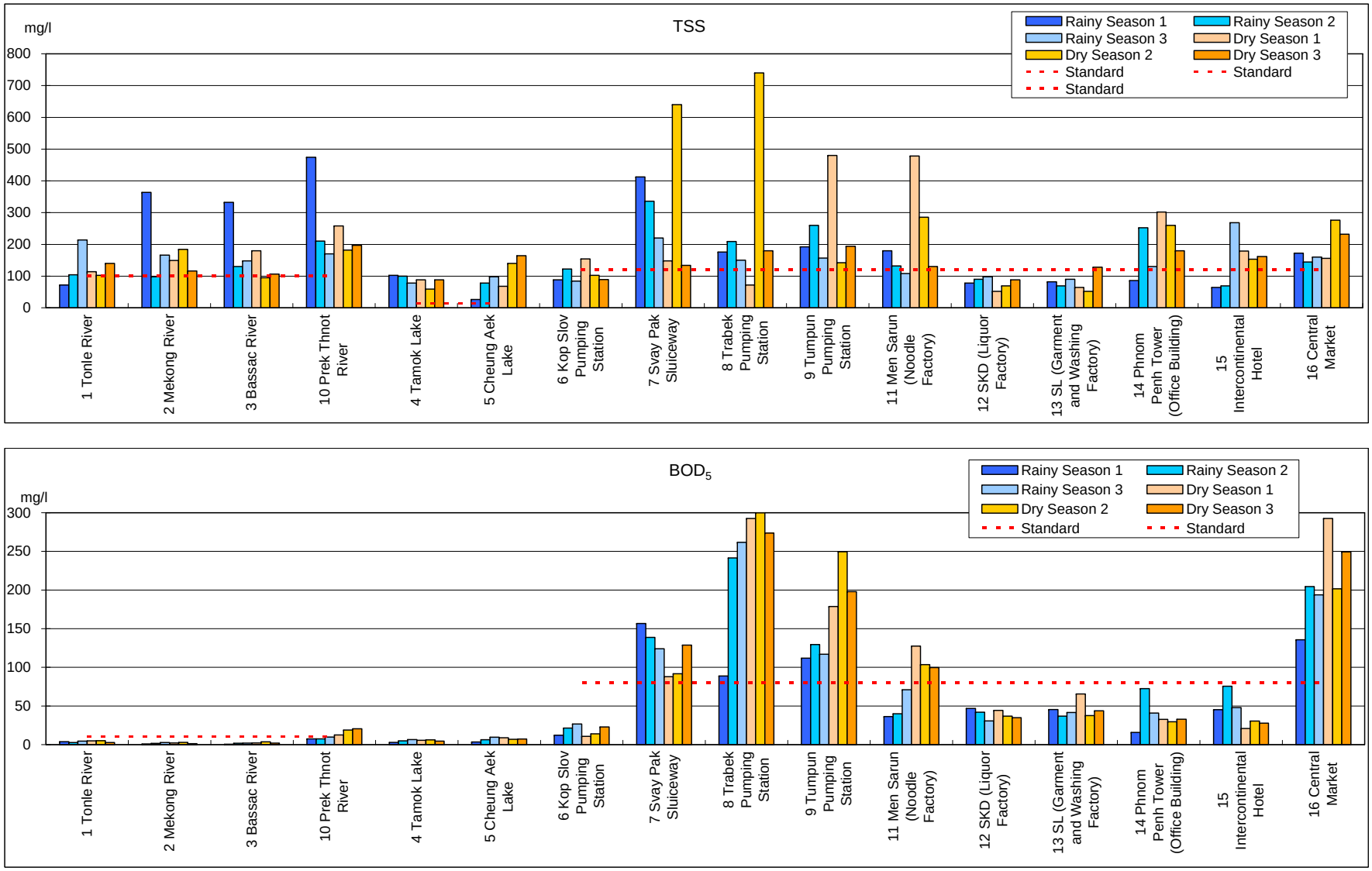
- *T-N and T-P;* The maximum T-N was 26.3 mg/L recorded at Trabek Pumping Station (Point No. 8) in 2nd monitoring (monitoring time: 8 o'clock) in the rainy season, followed by 26.1 mg/L recorded at Intercontinental Hotel (Point No.15) in 2nd monitoring (monitored time: 15 o'clock) in the rainy season. The maximum T-P was 5.81 mg/L recorded (monitoring time: 14 o'clock) at Central Market (Point No. 16) followed by 4.95 mg/L recorded (monitoring time: 12 o'clock) at Tumpun Pumping Station (Point No. 9) and 4.50 mg/L (monitoring time: 11 o'clock) at Trabek Pumping Station (Point No. 8), which were all recorded in the 2nd monitoring in the dry season.

- *Total Coliform;* Most of the values recorded at Sap River (Point No. 1), Mekong River (Point No. 2), Bassac River (Point No. 3) and Prek Thnot River (Point No. 10) exceeded the standard for river (5.0×10^3 MPN/100ml). Similarly, values measured at Tamok Lake (Point No. 4) and Cheung Aek Lake (Point No. 5) also exceeded the standard for lake (1.0×10^3 MPN/100ml).



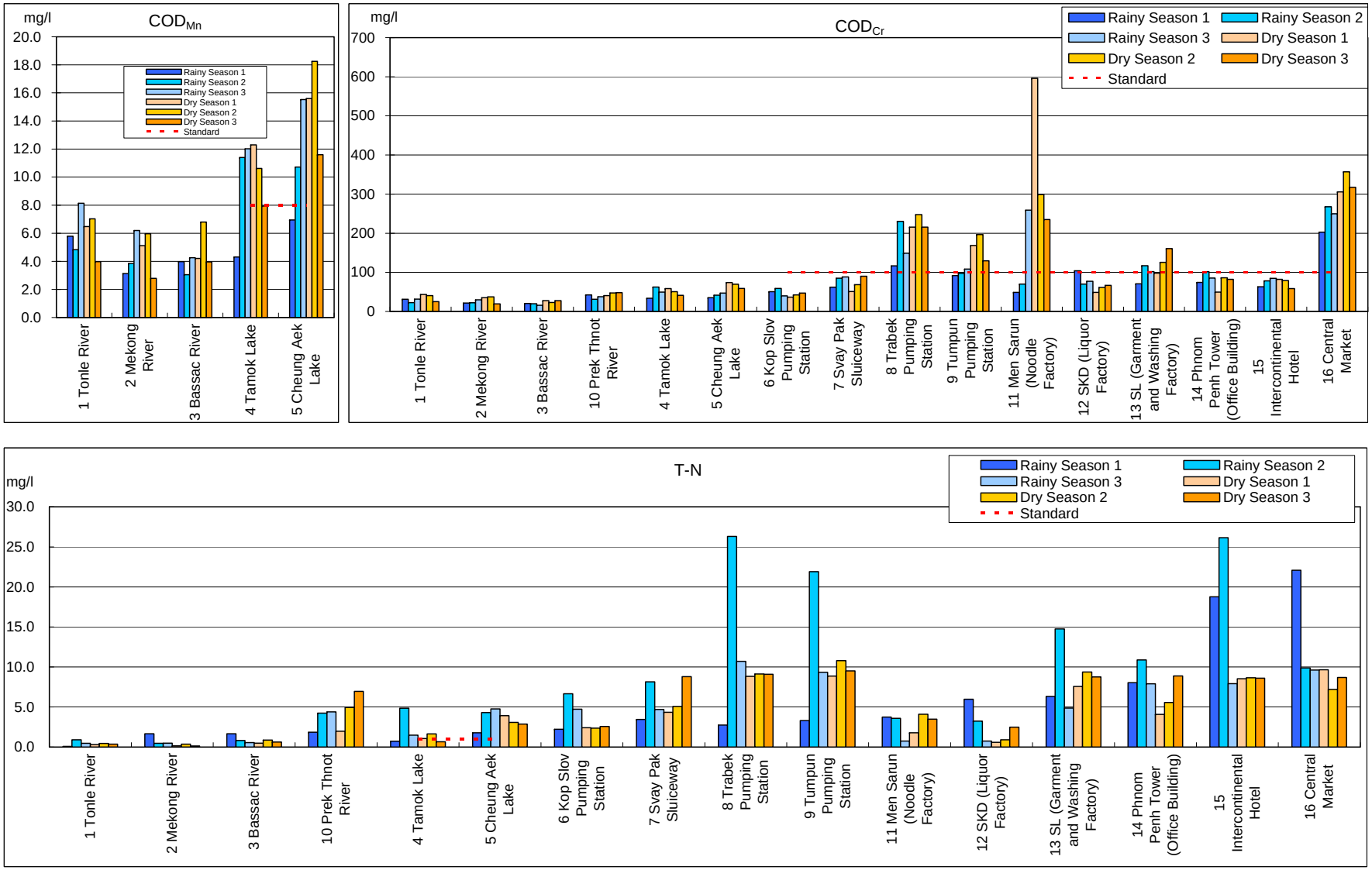
Source: JICA Study Team

Fig. 2.5.5 Survey Result (1/4)



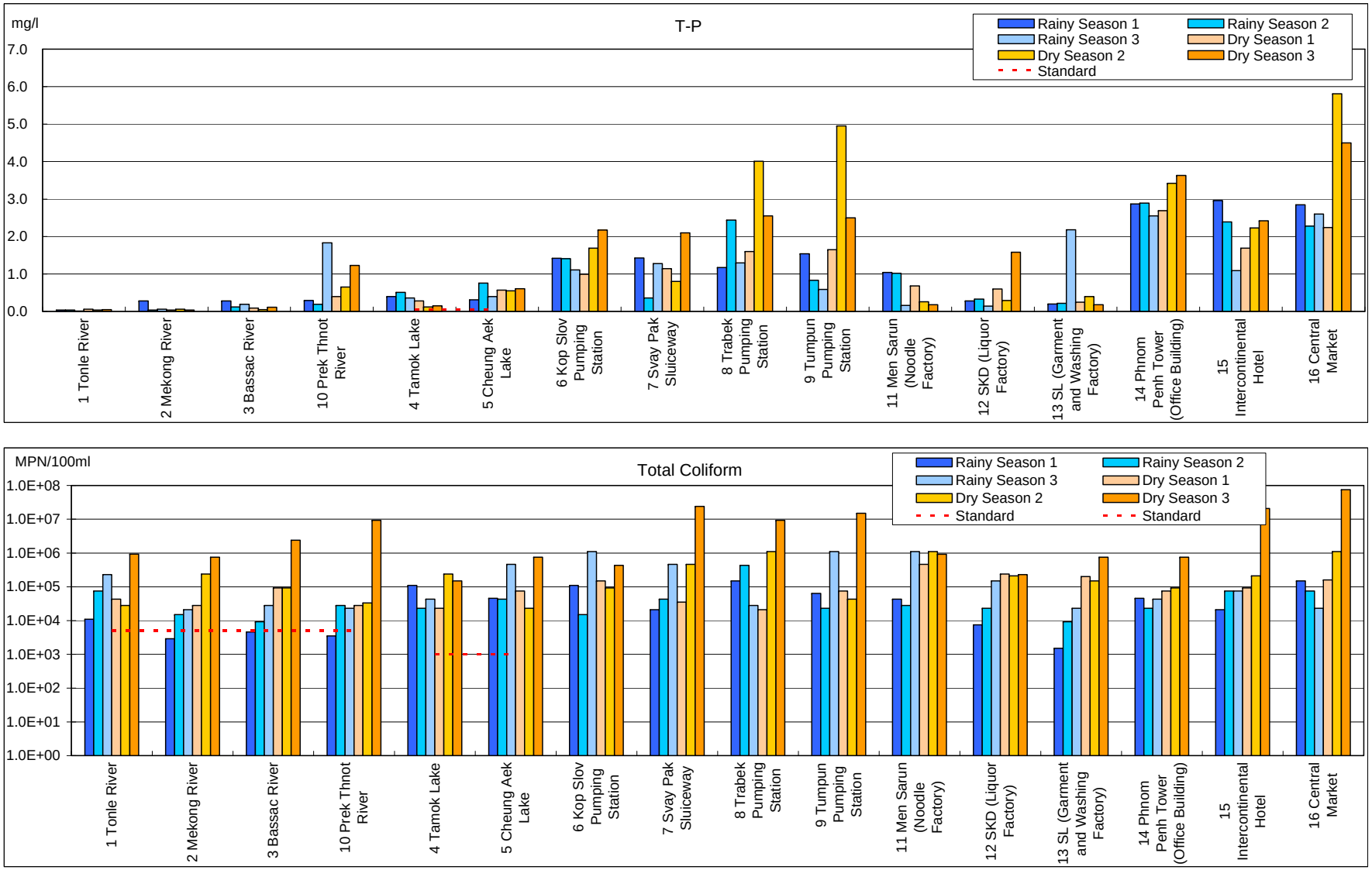
Source: JICA Study Team

Fig. 2.5.6 Survey Result (2/4)



Source: JICA Study Team

Fig. 2.5.7 Survey Result (3/4)



Source: JICA Study Team

Fig. 2.5.8 Survey Result (4/4)

Table 2.5.7 Minimum, Maximum and Average Values at Monitoring Points in the Study

No.	Location		pH (-)	DO (mg/L)	TSS (mg/L)	BOD_5 (mg/L)	COD_{Mn} (mg/L)	COD_{Cr} (mg/L)	T-N (mg/L)	T-P (mg/L)	Total Coliform (MPN/100 ml)
1	Tonle River	Min	6.17	3.44	72.0	2.79	3.98	22.64	0.09	0.01	1.1E+04
		Max	7.73	5.51	214.0	5.18	8.14	43.12	0.91	0.06	9.3E+05
		Average	6.91	4.47	124.3	4.05	6.04	32.40	0.43	0.04	2.2E+05
2	Mekong River	Min	4.20	4.37	98.0	0.90	2.79	19.60	0.13	0.04	2.9E+03
		Max	7.54	5.82	364.0	3.06	6.20	37.50	1.67	0.28	7.5E+05
		Average	6.41	5.15	179.5	2.04	4.51	27.67	0.54	0.09	1.8E+05
3	Bassac River	Min	5.83	4.18	95.0	0.50	3.05	15.68	0.48	0.05	4.6E+03
		Max	7.40	5.71	332.0	3.75	6.80	27.44	1.67	0.28	2.4E+06
		Average	6.71	4.83	165.2	2.06	4.38	22.30	0.84	0.14	4.4E+05
4	Tamok Lake	Min	6.61	4.72	59.0	2.90	4.31	33.80	0.66	0.12	2.3E+04
		Max	9.16	7.59	102.0	6.44	12.29	62.40	4.86	0.51	2.4E+05
		Average	7.64	6.06	85.8	5.17	9.76	49.43	1.74	0.30	9.8E+04
5	Cheung Aek Lake	Min	6.37	0.64	26.0	3.60	6.95	35.27	1.78	0.31	2.3E+04
		Max	7.38	4.85	164.0	9.69	18.24	74.16	4.76	0.76	7.5E+05
		Average	6.85	2.06	95.7	7.13	13.11	54.48	3.45	0.53	2.3E+05
6	Kop Slov Pumping Station	Min	6.10	0.13	84.0	10.80	-	36.84	2.23	0.99	1.5E+04
		Max	7.42	6.10	154.0	26.73	-	59.00	6.65	2.17	1.1E+06
		Average	6.92	2.82	106.5	18.05	-	46.00	3.49	1.47	3.2E+05
7	Svay Pak Sluiceway	Min	5.82	0.00	134.0	88.00	-	50.96	3.44	0.36	2.1E+04
		Max	7.23	3.57	640.0	156.62	-	90.16	8.80	2.10	2.4E+07
		Average	6.73	1.59	315.0	121.35	-	74.21	5.75	1.19	4.2E+06
8	Trabek Pumping Station	Min	6.66	0.00	72.0	89.00	-	116.52	2.74	1.17	2.1E+04
		Max	7.06	0.07	740.0	299.85	-	247.61	26.31	4.01	9.3E+06
		Average	6.85	0.03	254.5	243.05	-	195.71	11.13	2.18	1.8E+06
9	Tumpun Pumping Station	Min	6.09	0.00	142.0	112.00	-	92.18	3.32	0.59	2.3E+04
		Max	7.27	0.73	480.0	249.50	-	196.37	21.90	4.95	1.5E+07
		Average	6.79	0.13	237.5	164.09	-	132.06	10.62	2.01	2.7E+06
10	Prek Thnot River	Min	6.18	0.98	170.0	7.38	-	31.32	1.84	0.19	3.5E+03
		Max	7.39	5.10	474.0	20.69	-	48.12	6.96	1.83	9.3E+06
		Average	6.77	3.02	248.5	12.84	-	41.32	4.06	0.77	1.6E+06
11	Men Sarun (Noodle Factory)	Min	4.30	2.60	108.0	36.40	-	48.80	0.75	0.16	2.8E+04
		Max	7.25	6.12	478.0	127.50	-	595.84	4.10	1.04	1.1E+06
		Average	6.15	4.83	218.8	79.70	-	251.24	2.91	0.56	6.1E+05
12	SKD (Liquor Factory)	Min	3.35	1.03	52.0	30.75	-	48.76	0.59	0.14	7.5E+03
		Max	7.32	6.78	98.0	47.06	-	104.16	5.96	1.58	2.4E+05
		Average	6.34	3.09	79.2	39.34	-	71.36	2.33	0.54	1.4E+05
13	SL (Garment and Washing Factory)	Min	6.30	2.60	52.0	36.95	-	70.68	4.87	0.18	1.5E+03
		Max	7.51	6.35	128.0	65.52	-	160.72	14.75	2.18	7.5E+05
		Average	6.96	4.38	80.8	45.17	-	112.29	8.61	0.57	1.9E+05
14	Phnom Penh Tower (Office Building)	Min	5.48	0.00	86.0	15.70	-	49.60	4.08	2.55	2.3E+04
		Max	7.21	3.10	302.0	72.54	-	101.40	10.88	3.63	7.5E+05
		Average	6.63	1.67	201.7	37.37	-	79.90	7.56	3.01	1.7E+05
15	Intercontinental Hotel	Min	5.38	4.70	64.0	21.06	-	58.82	7.92	1.09	2.1E+04
		Max	7.83	5.72	268.0	75.58	-	84.88	26.14	2.96	2.1E+07
		Average	7.03	5.10	149.2	41.41	-	74.37	13.10	2.13	3.6E+06
16	Central Market	Min	4.70	0.00	144.0	135.62	-	202.80	7.21	2.24	2.3E+04
		Max	6.95	0.34	276.0	292.50	-	356.72	22.08	5.81	7.5E+07
		Average	6.17	0.07	190.0	212.91	-	283.35	11.19	3.38	1.3E+07
Standard for Monitoring Point											
	No. 1 to 3		6.5-8.5	>2.0	<100	<10	-	-	-	-	5.0E+03
	No. 4 to 5		6.5-8.5	>2.0	<15	-	<8	-	<1.0	<0.05	1.0E+03
	No. 6 to 16		5.0-9.0	>2.0	<120	<80	-	<100	-	-	-

Source: JICA Study Team

2.6 Current Status of Organizations and the System

2.6.1 Related Laws and Regulations

Cambodian laws consist of the Constitution, Constitutional Law, Kram (Law), Kret (Royal Decree), Anukuret (Sub-Decree), Prakas (Regulation or Declaration), Sarachor (Circular) and other forms (such as Ordinance of the Mayor, Provincial Governor or Bureau Director). The related laws and regulations are as described below.

(1) Sewage and Sludge Management

No law relating to sewerage and drainage management currently exists. Therefore, a "Wastewater Management Law" is being formulated by MPWT as a new law concerning sewerage and drainage management. Formulation work has been ongoing as of February 2015. Although a draft has been written, the work is still in the stage of gathering ideas from neighbouring countries; therefore, completion of the final is still uncertain. This draft consists of 83 articles in 14 chapters. Currently, assistance from UN-HABITAT and UN-ESCAP is being sought.

With regard to sludge management, the sludge from a Special Economic Zone (SEZ) and from a private treatment plant needs to be treated at a solid waste disposal site (hazardous waste disposal site) owned by a private company. Sludge from septic tanks of general households and from drainage cleaning is supposed to be separated from domestic waste, and then treated and disposed at designated waste disposal site. However, it is actually disposed at a lagoon in the Dangkor solid waste disposal site or other places.

As stated above, no law has been enacted for wastewater management, except for those relevant to the Ministry of Environment. In order to proceed with the establishment of a sewer system, a law concerning the treatment of wastewater and disposal of sludge needs to be established. To address this issue, a sewerage law as the basic law concerning treatment of wastewater and disposal of sludge needs to be established and aligned with other relevant laws; while relevant local government ordinances and decrees need to be formulated. The sewerage law (or ordinance) to be proposed shall include, for example, definition of terms, business plan, structural standards, discharged water quality, installation of drainage utilities, announcement of commission, obligation of sewer connection, installation of specified facilities, monitoring of discharged water quality and effluent utilities, treatment and disposal of sludge, standards for operation and maintenance, setting sewerage fee and method to collect the charges, support scheme such as reduction or exemption of the charges, procedures for respective notifications, and penalty provisions.

In general, regulations for installing facilities to treat wastewater in PPCC are implemented by the Ministry of Land Management, Urban Planning and Construction (MLMUPC) if the treatment facilities are for a building (including ordinary household), or the Ministry of Industry and Handicrafts (MIH) if the facilities are for industrial wastewater treatment and drainage for factory, etc. Treatment and disposal of wastewater and sludge discharged from those facilities are managed by the Ministry of Public Works and Transport (MPWT). Consequently, drainage facilities managed under the MLMUPC or the MIH are controlled by the respective agencies of these Ministries, while treatment and disposal of drainage received at sewage treatment facilities are administered by MPWT (DPWT).

(2) Water Quality

A sub-decree concerning water quality and effluent, "Sub-decree on Water Pollution Control, 1999," was established on April 6, 1999. This sub-decree stipulates such matters as definition of wastewater (liquid waste) and harmful liquid waste, category, environmental water quality standard, effluent standard, polluters' responsibility for draining, monitoring, permits and licenses, inspection and penalties. In terms of standards regarding drainage of sewage, Articles 9 and 11 of

the sub-decree contain provisions on the obligation to connect to the sewer (in Annex 2) and "Effluent standard for pollution sources discharging wastewater to public water areas or sewer".

Although this provision for standards stipulates the standards for "Protected public water areas," "Effluent standards for discharging to public water areas and sewers" is applied to all effluent (including that from a factory), at the discharge point to a public water area because no protected area is currently designated.

The effluent standard specifies a total of 52 parameters to be applied at the discharge point to the public water area. When effluent is discharged into a lake or pond, it is also possible to improve the water quality in the lake or pond.

The "Sub-Decree of Government Regulation (1997)" has a provision which directs factories and plants to install wastewater treatment facilities. Although MOE carries out three-monthly tests of water quality discharged from the wastewater treatment facilities at a factory, it does not sufficiently carry out this function.

Meanwhile, the Cambodian water quality standard specifies items concerning bio-diversity conservation in each river, lakes and reservoirs, and coastal water. There are also water quality standards for public water areas that stipulate altogether 25 parameters that concern public health protection. (See **Subsection 2.5.1** for details of water quality and effluent standards.)

(3) Sewage and Sludge Management in Private Developments

The "Law on Land Management, Urban Planning and Construction (1994)" concerns private development, stipulating provisions related to processes of national or provincial level development planning and land use planning. Local authorities such as PPCC are mandated to formulate a master plan for development planning and a land use plan, which must receive national approval. That is the reason why PPCC is still awaiting a sub-decree for final approval of their urban planning master plan, the "White Book on Development and Planning of Phnom Penh," as previously stated.

Sub-Decree No. 86 "Anukret 86 on Construction Permit (ANK/BK)" concerning building permits was formulated on December 19, 1997. ANK/BK applies to all buildings in the absence of a land use plan or approved master plan. As the conditions for issuance of a building permit, there are provisions concerning sanitary facilities, connection of sewers and land reclamation (Article 2 of the mentioned law), and provisions concerning drinking water supply and connection of sewers and drains (Article 31 of the mentioned law). In the absence of a sewerage system, there are provisions for obligation to install wastewater treatment facilities such as septic tanks and its standards of facilities (as shown in **Table 2.4.3**) (Article 31-3 of the mentioned law). Building permits are issued by the RGC (Council of Ministers). In particular, the buildings in the following list require approval of the National Committee Chairman of the Ministry of Land Management, Urban Planning and Construction (Article 5 of the mentioned law). Residential development with area exceeds 3,000 m^2 require the approval from the Chairman. The member of the National Committee is stipulated in Article 6.2 of the mentioned law.

- Commercial or industrial building whose floor area exceeds 3,000 m^2
- Commercial hotel
- Farmland development not less than 500 ha
- Airport, seaport, railway or carriage storage
- Public or private facility whose floor area exceeds 3,000 m^2 (including such a building whose floor area exceeds 3,000 m^2 after extension)
- Construction in a protected area (environmental, scenic or historical cultural asset)
- Building classified as national heritage
- Building for defence of military facilities

Table 2.6.1 shows laws concerning private investment.

Table 2.6.1 Laws Concerning Private Investment

Name of laws/regulations	Content
Law on Concessions, 2007	• Aims to promote utilization of private fund • Role of CDC in concession • Process of concession agreement • Concession project guideline (Duration, penalty, etc.)
Law on the Amendment to the Law on Investment, 2003	• Revision of the law above • Applied to approved private projects • Definition of approved projects • Procedures for approval of projects
Law on Investment of the Kingdom of Cambodia, 1994	• Law concerning private projects • Role of CDC • Procedures for investment and guarantee • Land ownership and use

Source: Study on Water Improvement in Phnom Penh (March 2012, Ministry of Land, Infrastructure, Transport and Tourism, Japan)

(4) Land Use and Regulations

The "Land Law" regulates land use. The "Land Law" was enacted in 1992 and revised in 2001. This law stipulates rights, form and acquisition of land ownership, and the procedures for land ownership. Although the "Land Law" recognizes legal ownership of land, it does not recognize pre-1980 land ownership rights. However, there are categories of land ownership rights known as ownership rights and a special right to occupy. Depending on the availability of documentary evidence, one may be granted ownership rights or a special right to occupy. Note that land ownership rights are only granted to citizens or organizations having Cambodian nationalities. Incidentally, the 2001 revision of the Land Law clearly listed, in Article 29–31, the conditions for which a special right to occupy is granted.

(5) Environmental and Social Considerations

Details of laws concerning environmental and/or social considerations are mentioned in **Section 2.7**.

(6) Land Expropriation

Details of laws concerning land expropriation are mentioned in **Section 2.7**.

(7) Identification of Issues

As stated in **Subsection 2.3.1** (Urban Plan, Development Plan, and Urban Plan), improvements in sewerage and drainage area are identified as the focus of such materials as NSDP, CDS, and the White Book. However, in the absence of a legal framework concerning establishment of the sewer system, the following are identified as the issues concerning the legal framework.

(a) Absence of Legal Framework concerning Sewerage, Effluent and Sludge Management (Sewerage Law)

The sewerage law governing the sewer system is the bible of smooth implementation of M/P of sewage and drainage improvement. Therefore, establishment of the law is essential.

(b) Absence of Guidelines and Standards for Sewerage Management

Specific guidelines and standards related to the sewer system, based on the sewerage law, are required, to stipulate such matters as subsidiary schemes concerning the sewer system, sewer connection from factory/plant, commercial facility or general household, standards concerning

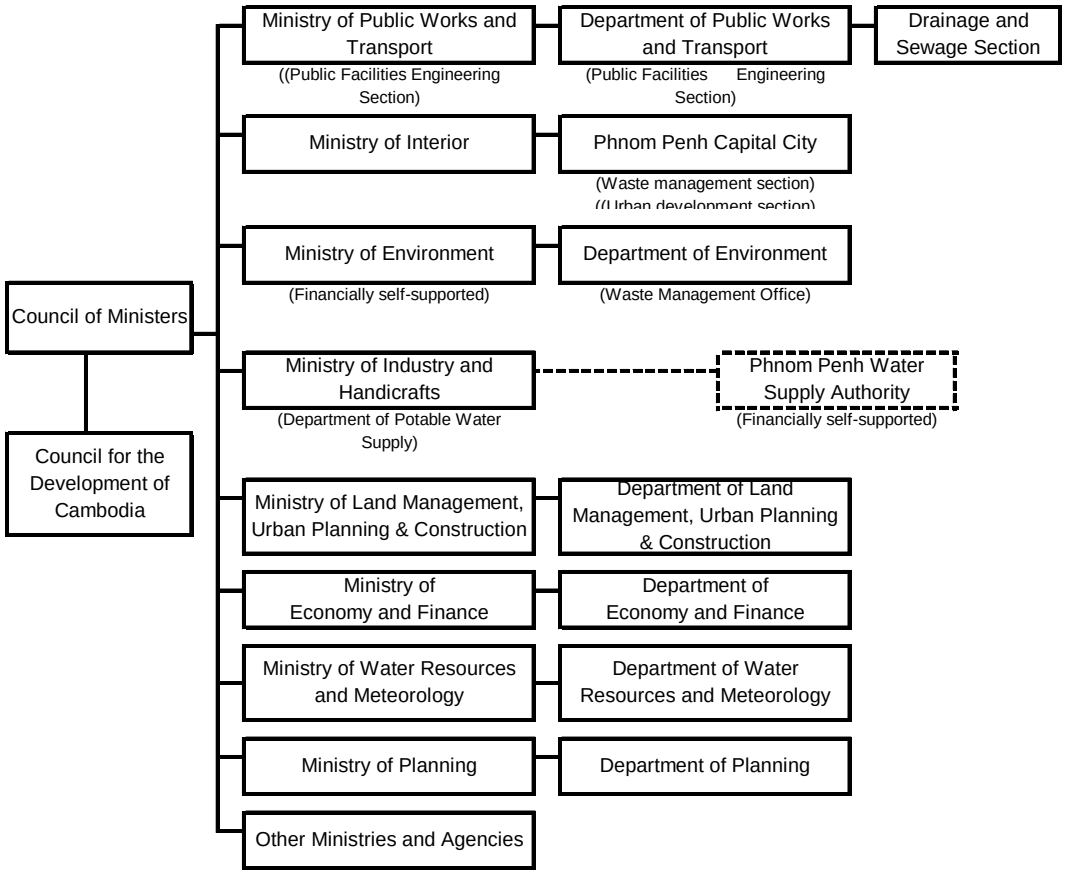
the structure of culvert/pipes and treatment plants, standards for regulating water quality and standards for operation and maintenance.

(c) Establishment of the System to promote the Sewerage Management

In order to smoothly implement this project, which is targeting 2035, firstly, the formulation of sewerage and other relevant laws is required. Also, to promote the sewerage improvement, the following system design will be effective: formulation of short-, medium- and long-term plans, followed by approval from central government and then detailing of a "Five-Year Plan for Sewerage Improvement in Phnom Pen Capital City (provisional name)" to be sustainable until the target year.

2.6.2 Organizations Concerned

This section provides a concise overview of the national organization and describes the organizational structure of the ministries and agencies related to the sewerage, drainage and water supply, especially DPWT/PPCC which are the counterpart agencies for this project, Phnom Penh Water Supply Authority and organizations concerning the environment. **Fig. 2.6.1** shows the relations among the organizations relevant to this Study.



Source: JICA Study Team

Fig. 2.6.1 Relations among the Organizations relevant to this Study

(1) National Overview

The Council of Ministers in Cambodia consists of 25 ministries and two agencies. PPCC is under the jurisdiction of the Ministry of Interior.

(2) Ministry of Public Works and Transport

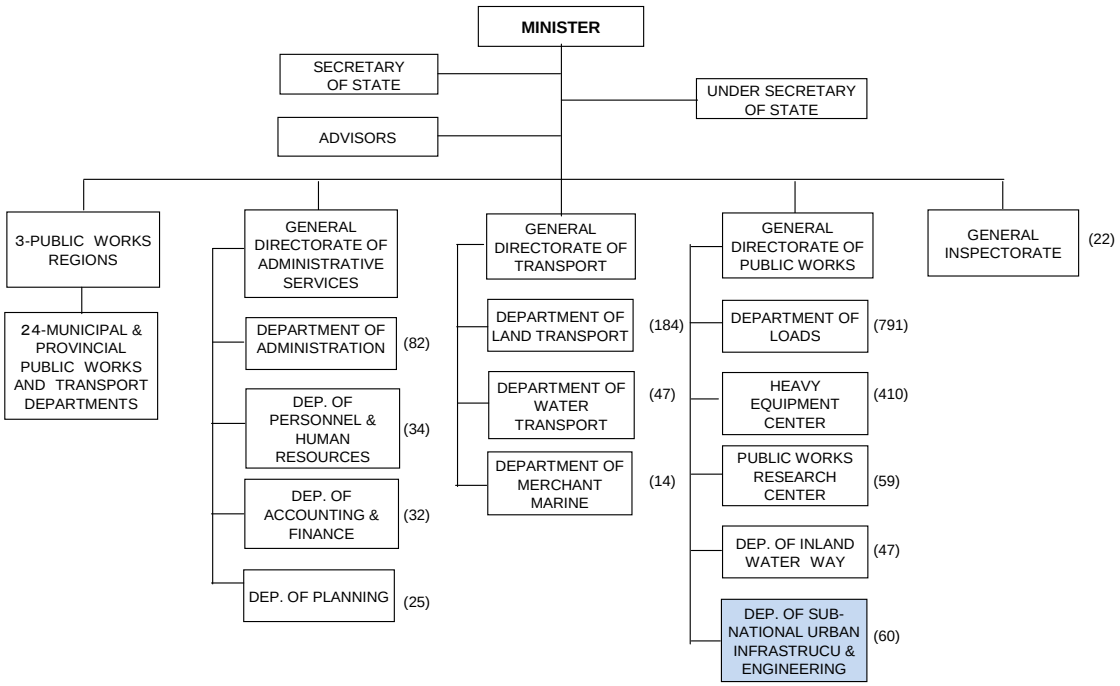
The Ministry of Public Works and Transport (MPWT) governs Cambodia's public works and transport such as roads, ports, transport, urban development, sewerage and drainage. MPWT consists of five departments (General Directorate of Administrative Services, General Directorate of Transport, General Directorate of Public Works, General Inspectorate and public works regions).

MPWT has a plan to create two more departments under the General Directorate of Public Works: one is sewerage and drainage department to promote the establishment and improvement of laws and standards, the other is the department in charge of highways. In addition, alongside organizational development at MPWT, organization at the Department of Public Works and Transport (DPWT) will also be strengthened

When issues arise during establishment of sewerage system, a steering committee will be established by the ministries and agencies concerned for coordination toward solving the issue. The committee will be convened by the Secretariat at the Ministry of Economics and Finance, with members coming from the concerned ministries and agencies.

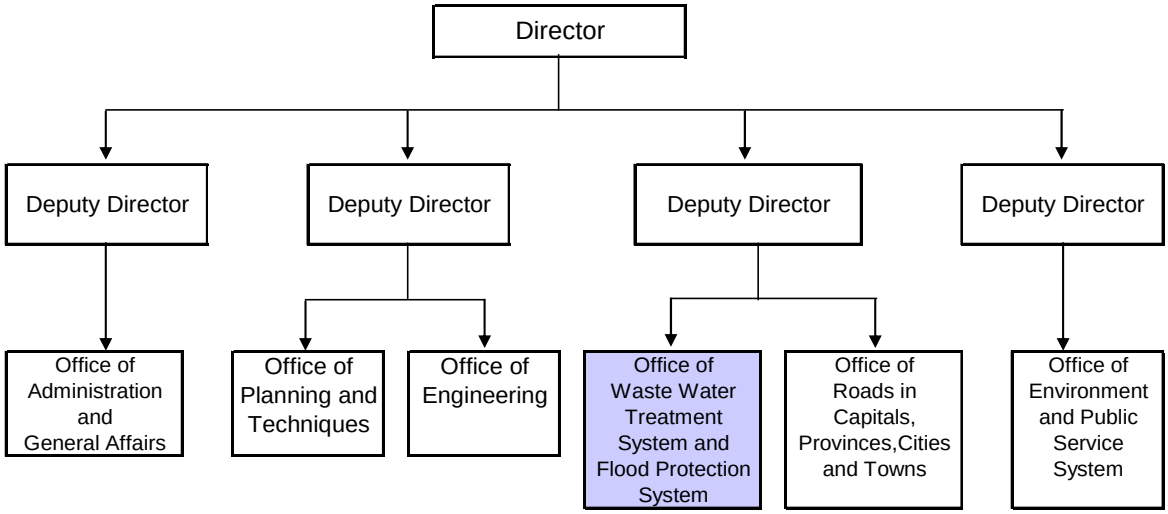
The Office of Wastewater Treatment System and Flood Protection System in the Department of Sub-national Urban Infrastructure and Engineering in DPWT is responsible for laws and standards concerning sewerage and drainage. As of February 2014, MPWT has altogether 3,391 staff members, while the Department of Sub-national Urban Infrastructure and Engineering has 60. **Fig. 2.6.2** shows the organization of the MPWT, while **Fig. 2.6.3** shows the organization of the Department of Sub-national Urban Infrastructure and Engineering.

Incidentally, at present, the sewerage and drainage services in Cambodia are the responsibilities of the General Department of Public Works and Transport of each province or PPCC.



Source: MPWT

Fig. 2.6.2 Organizational Chart of MPWT



Source: MPWT

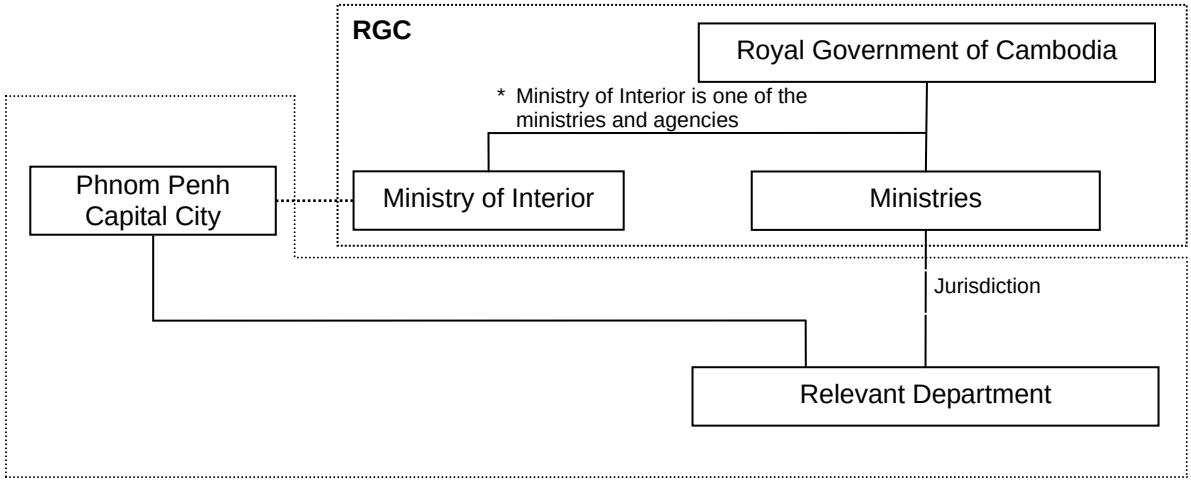
Fig. 2.6.3 Organizational Chart of Department of Sub-National Urban Infrastructure and Engineering

(3) Phnom Penh Capital City

As shown in **Fig. 2.6.5**, PPCC consists of an Administration Division, Planning and Investment Division, Finance Division, Urbanization Division, Human Resource Management Division, Inter-Sectoral Division, Law and Human Right Affair Division, and Waste Management Division. As of December 2010, 268 staff members work there. PPCC operates its services in collaboration with respective ministries and departments under ministries.

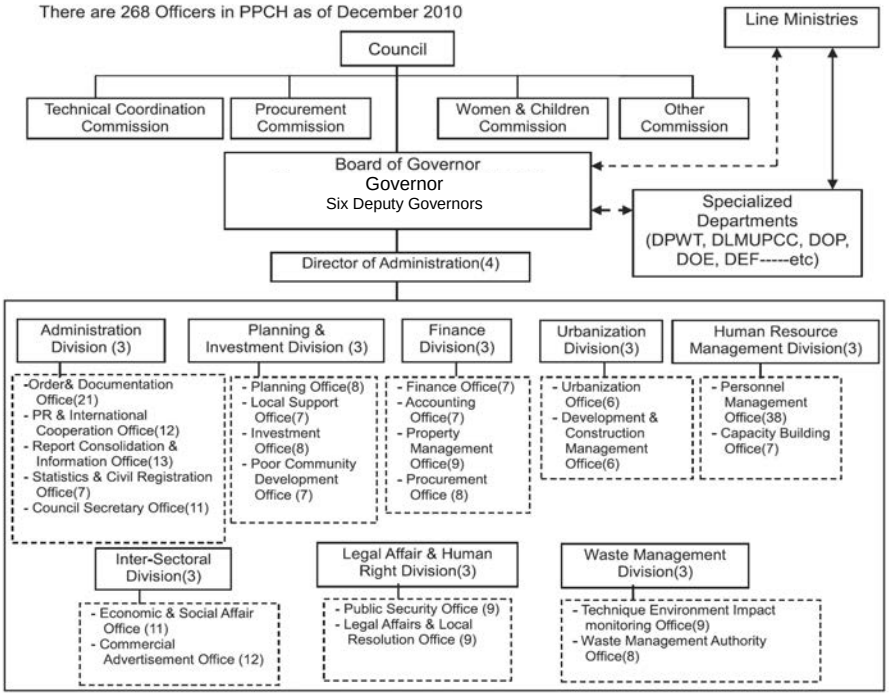
Concerning sewerage services, after approval by the Governor of the Capital City, they will be carried out by the DPWT under direction of and with technical support from MPWT

Fig. 2.6.4 shows the relationship between RGC and PPCC, and **Fig. 2.6.5** shows the Organizational Chart of PPCC, respectively.



Source: JICA Study Team, based on Study on Water Improvement in Phnom Penh (March 2012, Ministry of Land, Infrastructure, Transport and Tourism, Japan)

Fig. 2.6.4 Relationship between RGC and PPCC



Source: Overview of Urban Development in Phnom Penh Capital City, 2011

Fig. 2.6.5 Organizational Chart of PPCC

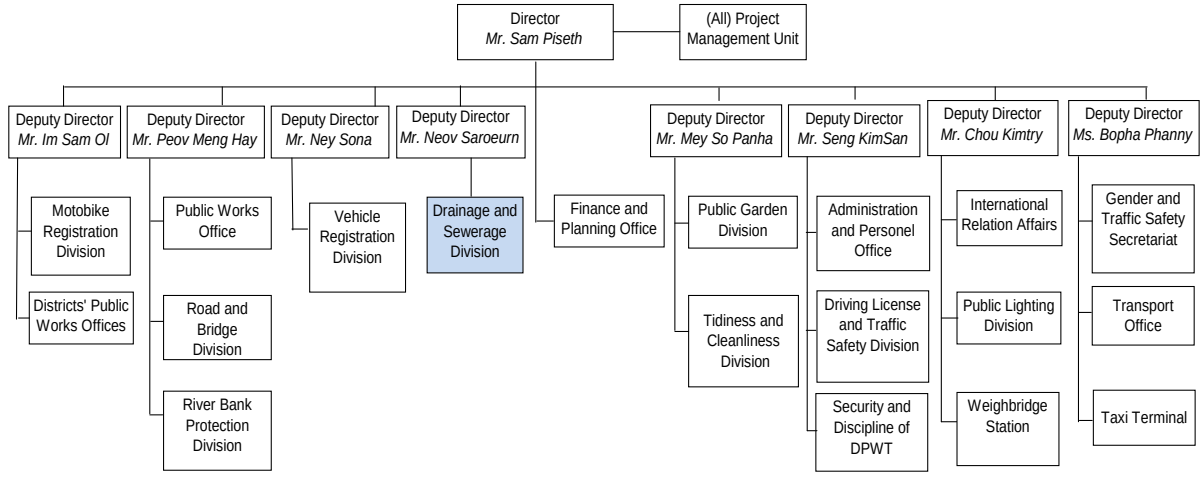
(4) Department of Public Works and Transport

(a) Organizational Structure and Staff Assignment

The Department of Public Works and Transport (DPWT/PPCC) is a branch under MPWT. Under the oversight of PPCC and MPWT, DPWT/PPCC manages public services in Phnom Penh such as roads, ports, transport, urban development, sewerage and drainage, and other services, and is responsible for operation and maintenance of infrastructures. DPWT is one of the counterpart organizations for the Study. Among those divisions/offices in DPWT, the Drainage and Sewerage Division (DSD) is strongly related to the operation and maintenance of sewerage and drainage systems. In addition, when a project is implemented through international cooperation such as this project, the deputy director responsible for International Relation Affairs and the Public Works Office are also involved.

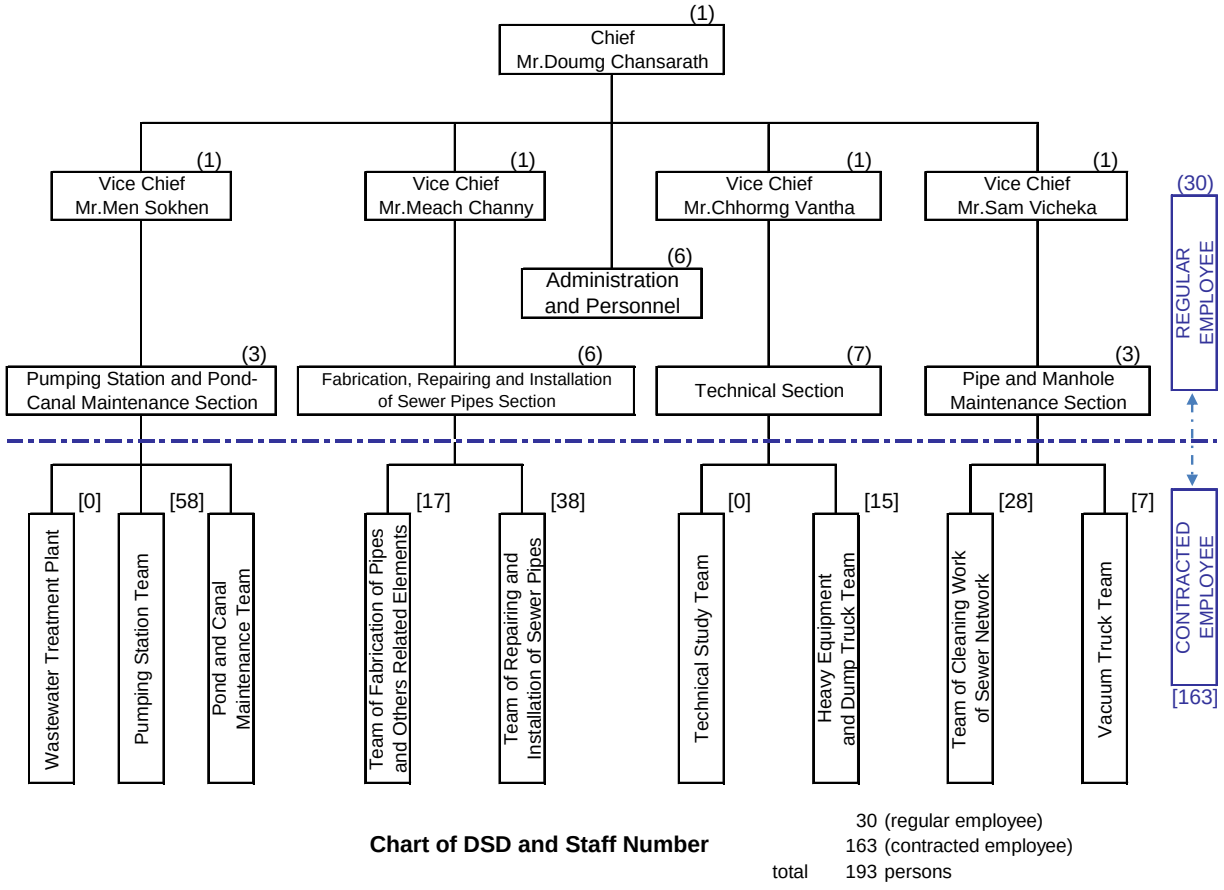
DSD consists of four sections and carries out tasks for operation and management of drainage systems in Phnom Penh. DSD has 30 regular employees, assigned to the management of drainage systems, and the management of cleaning equipment, etc. The Technical Section prepares the improvement plans (budgetary requests) for drainage and sewage treatment systems including such works as repairs of drainage pipes, channels and equipment, operation and management of pumping stations, and reports to DPWT. Field works are implemented by contracted employees in this system. Those contracted employees renew their contract annually. Any change in the quantity of works results in the fluctuation of number of contracted employees.

As shown in **Table 2.6.2**, the number of DPWT staff members is 826 as of end of February 2014, including the 193 staff members at DSD. **Fig. 2.6.6** shows the DPWT organizational structure and **Fig. 2.6.7** shows the DSD organizational structure, respectively.



Source: DPWT/PPCC

Fig. 2.6.6 Organizational Chart of DPWT



Source: DPWT/PPCC

Fig. 2.6.7 Organizational Chart of Drainage and Sewerage Division (DSD)

Table 2.6.2 Number of DPWT Staff Members

No.	Section	Regular Employees					Contracted Employees	Total
		Category 1 (Engineer/Other)		Category 2 (Male/Female)		Sub-Total		
		Engr.	Other	Male	Female			
1	Director Board	5	0	4	1	5	-	5
2	Administration and Personnel Office	-	7	5	2	7	2	9
3	Finance and Planning Office	1	11	9	3	12	1	13

No.	Section	Regular Employees					Contracted Employees	Total
		Category 1 (Engineer/Other)		Category 2 (Male/Female)		Sub-Total		
		Engr.	Other	Male	Female			
4	Public Works Office	19	3	21	1	22	3	25
5	Transport Office	2	18	13	7	20	5	25
6	Road and Bridge Division	6	25	22	9	31	38	69
7	Drainage and Sewerage Division	6	24	19	11	30	163	193
8	Public Lighting Division	-	-	-	-	-	20	20
9	Public Garden Division	4	14	12	6	18	272	290
10	Pound Division	1	7	8	-	8	7	15
11	Flood Control Division	0	1	1	-	1	-	1
12	Solid Waste Management Division	-	-	-	-	-	-	-
13	District Public Works Offices	7	10	14	3	17	-	17
14	Motorbike Registration Division	3	26	23	6	29	14	43
15	Municipal Transport Authority	-	-	-	-	-	-	-
16	Vehicle Registration Division	3	43	25	21	46	12	58
17	Driving License and Traffic Safety Division	7	33	29	11	40	3	43
	Sub Total	64	222	205	81			
	Total		286		286	286	540	826

Note: No. 12 is not shown in the organizational chart. Based on the latest information, staff numbers were reduced to 821, but the section where staff was reduced is unclear.

Source: DPWT/PPCC

(b) Capacity to implement the Service

DPWT/PPCC employs 826 staff members, 64 of which are engineers in regular employment. Out of the 64, the number of engineers working for DSD, who operate and maintain drainage system, is six employees. Although there are drainage pumping stations for flood protection, the absence of sewerage treatment facilities means that they currently lack the capacity for operation and maintenance for sewerage treatment system. Their main works are to clean and to repair the drainage pipes and channels, without maintenance standards, operational manuals or any rules. In order to implement sewerage services including drainage systems, capacity development will be crucial.

(5) Phnom Penh Water Supply Authority

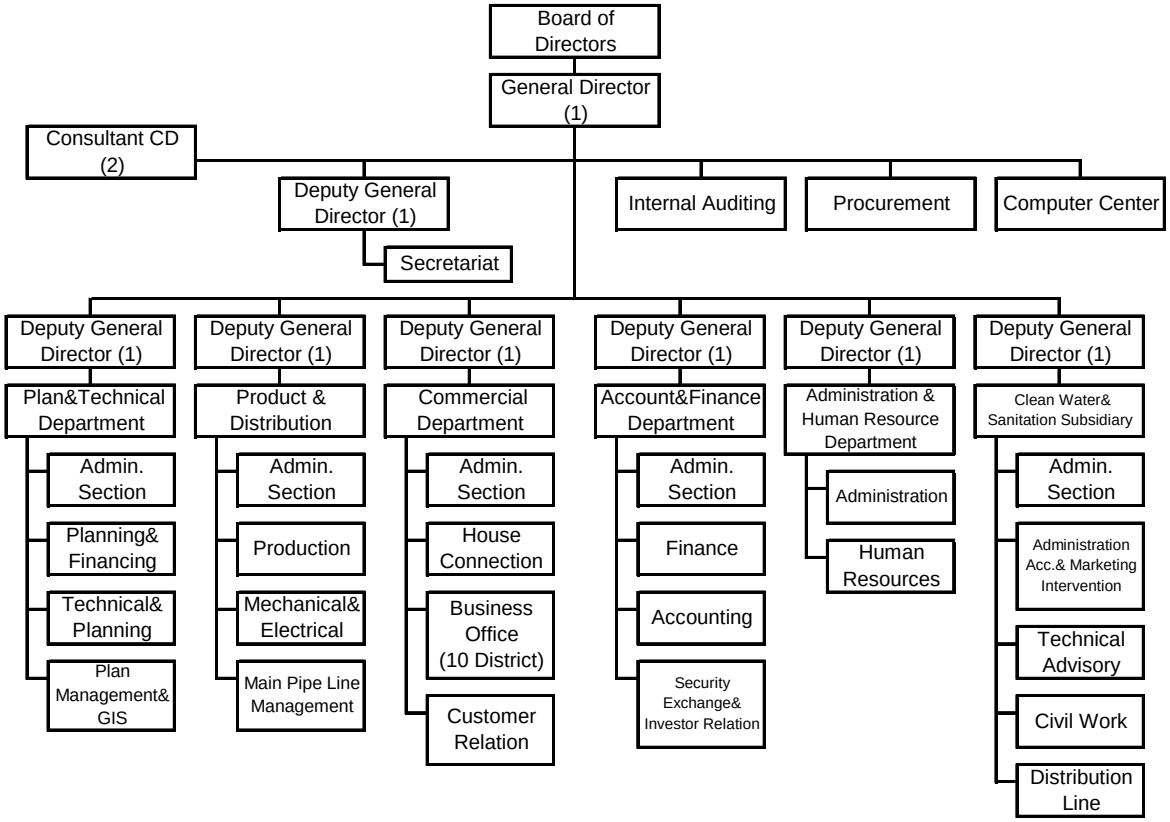
Phnom Penh Water Supply Authority (PPWSA) is the water supply service provider supplying drinking water to Phnom Penh Capital City and surrounding areas (such as a part of Kandal Province). (Refer to **Tables 2.3.4**, **2.6.15** and **2.6.16** for the information on records of work by PPWSA such as amount of water supplied and breakdown of revenue).

PPWSA is independent from all other institutions such as PPCC and MIH, which control the water supply services. However, it needs a license from MIH for decisions on water tariff, water charge price-raising and other similar matters.

The water supply area covered by PPWSA is expanding along with urban expansion. PPWSA has accumulated annual water supply data and owns the basic data which is useful and essential in sewerage planning, improvement planning and implementation of sewerage and drainage service.

Furthermore, PPWSA possesses the know-how to improve collection charge rates and has built an organizational framework for operation and maintenance. PPWSA intends to enhance parts of its organization concerning mapping systems, data management, and water and sanitation services. The service subsidiary is 100% funded by PPWSA, and, as well as carrying out maintenance and operation of water supply and sanitation tasks, also does pipe laying works, construction of sewerage systems and other such works outside Phnom Penh (Siem Riap, Battanbang and Sihanuk Ville), under registration from MEF and MLMUPC based on skilled technique and

experiences obtained in water supply works. **Fig. 2.6.8** shows the organizational structure of PPWAS. They consist of 849 staff members as of December 2014.



Source: PPWSA

Fig. 2.6.8 Organizational Chart of PPWSA

Table 2.6.3 Number of PPWSA Staff Members

Section	Employee	Contractor	Trainees	Total
Secretariat	5	0	0	5
Internal Auditing	5	1	0	6
Procurement	6	1	1	8
Computer Center	16	0	1	17
Sub-total	32	2	2	36
Plan & Technical Department				
Administration Section	3	0	0	3
Planning & Financing	4	1	0	5
Technical & Planning	14	2	0	16
Plan Management & GIS	0	3	0	3
Sub-total	21	6	0	27
Product & Distribution Department				
Administration Section	4	1	0	5
Production	79	4	0	83
Mechanical & Electrical	25	7	0	32
Main Pipe Line Management	90	25	5	120
Sub-total	198	37	5	240
Commercial Department				
Administration Section	30	6	0	36
House Connection	46	5	0	51
Business Office(10 District)	129	12	3	144
Customer Relation	58	13	0	71
Sub-total	263	36	3	302
Account & Finance Department				
Administration Section	1	0	0	1

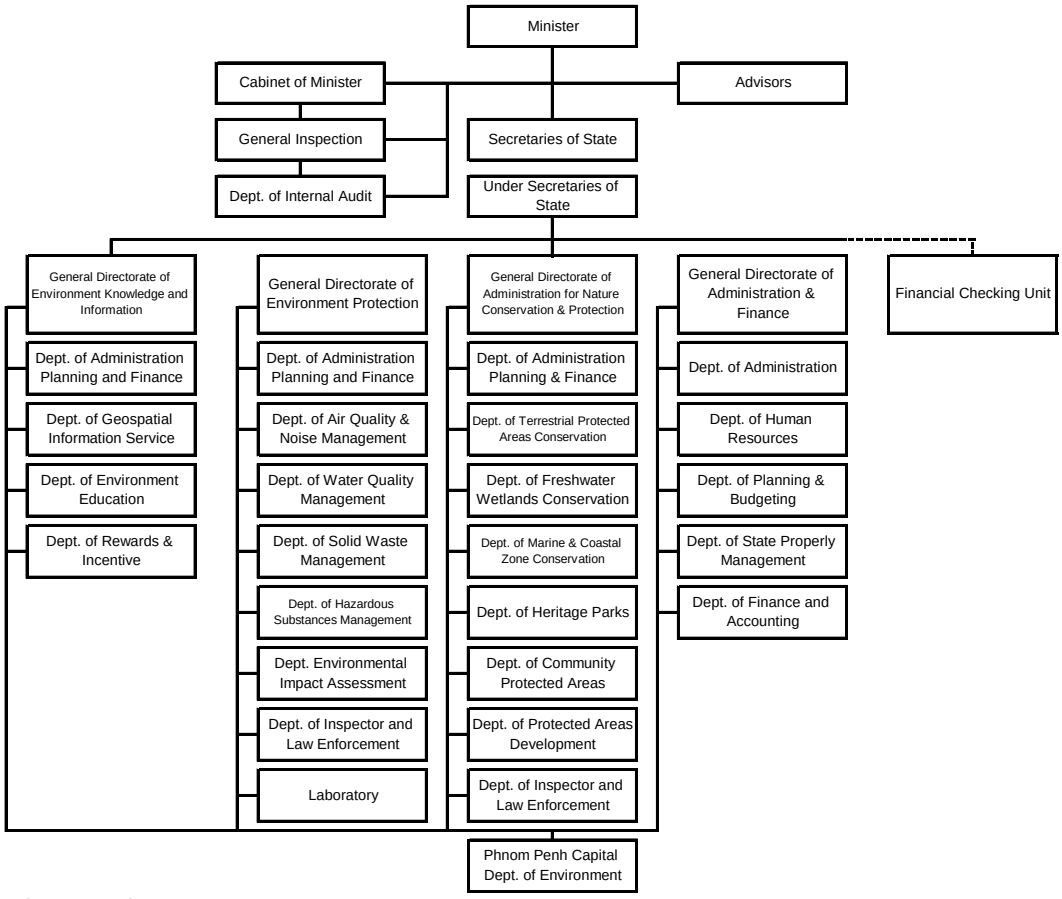
Section	Employee	Contractor	Trainees	Total
Finance	12	0	1	13
Accounting	21	0	1	22
Security Exchange & Investor Relation	3	0	0	3
Sub-total	36	0	2	38
Administration & Human Resource Department				
Administration	56	0	17	73
Human Resources	6	0	2	8
Sub-total	62	0	19	81
Clean Water & Sanitation Subsidiary				
Administration Acc.& Marketing Intervention	10	3	2	15
Technical Advisory & Project Management	7	0	2	9
Civil Work	54	4	26	84
Distribution Line	1	0	0	1
Sub-total	72	7	30	109
Total	684	88	61	833

Board directors and Deputy General Director (16 altogether) are not included in the table.
Source: PPWSA

(6) Environmental Organizations

(a) Ministry of Environment

The Ministry of Environment (MOE) develops legislated rules related to the environment, implements environmental policies, promotes environmental assessments, protects public water areas and natural resources, and carries out water quality testing at public water areas. Its organizational structure is shown in **Fig. 2.6.9.**

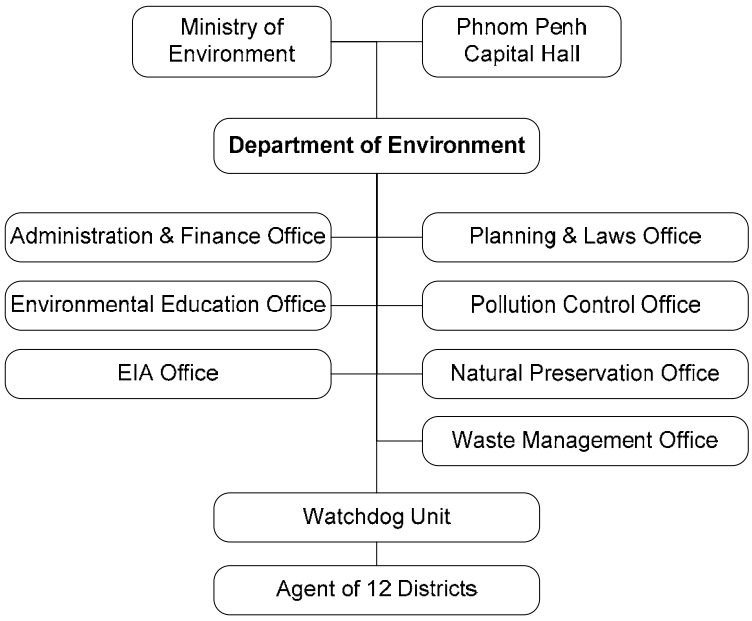


Source: MOE

Fig. 2.6.9 Organizational Chart of MOE

(b) Department of Environment

As the enforcement of Sub-Decree 39 on 1999, all responsibilities for the protection of environment rest with local governments controlled by the Department of Environment (DOE). However, if the project cost exceeds two million USD, approval of Environmental Impact Assessment (EIA) will be under control of the MOE. The DOE has altogether 68 staff members. The Waste Management Office controls matters related to sewerage and drainage, with seven staff members. Its organizational structure is shown in **Fig. 2.6.10** and its staffing details are shown in **Table 2.6.4**.



Source: DOE/PPCC

Fig. 2.6.10 Organizational Chart of DOE

Table 2.6.4 DOE Staffing Details

	Section	No. of Staff (Person)
1	Administration and Finance office	9
2	Waste Management office	7
3	EIA office	8
4	Planning and Laws office	8
5	Environmental Education office	6
6	Pollution Control office	9
7	Natural Preservation office	6
8	Agent of 12 district offices	15
	Total	68

Source: DOE/PPCC

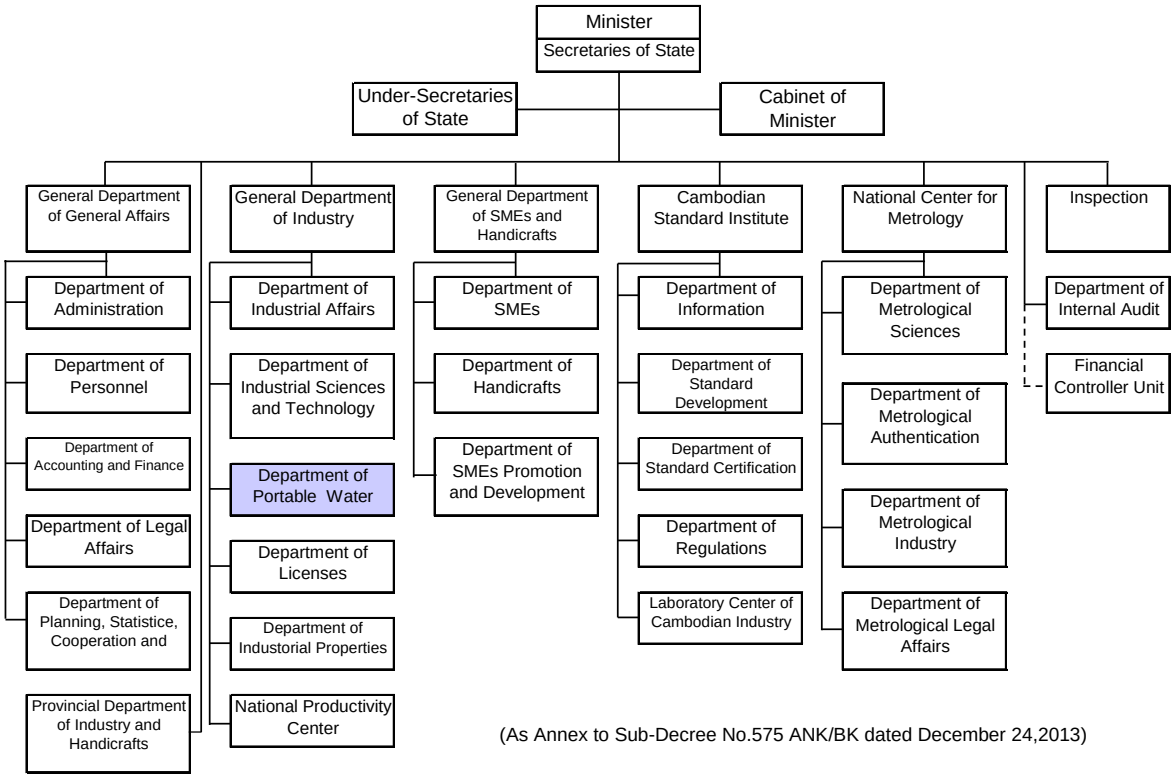
(7) Ministry of Industry and Handicrafts and other Organizations

(a) Ministry of Industry and Handicrafts

The Ministry of Industry and Handicrafts (MIH) has jurisdiction over the water supply services, factories and plants in Cambodia (large as well as medium and small-scale). The Department of Potable Water Supply in MIH controls PPWSA, which is deeply associated with sewerage and drainage services.

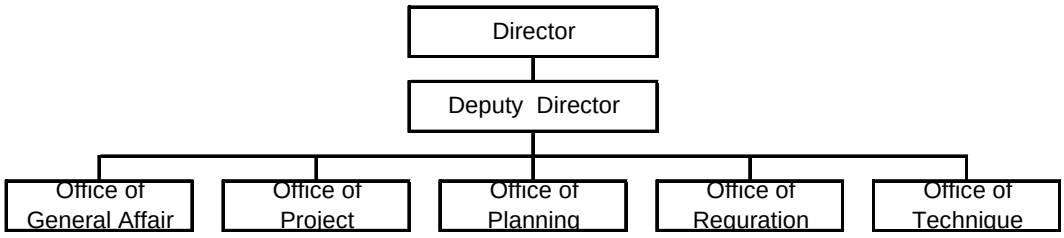
Fig. 2.6.11 shows the MIH organizational structure and **Fig. 2.6.12** shows the organizational structure of the Department of Potable Water Supply.

As part of the management measures, MIH issues the license to each factory. When issuing a license, MIH considers each factory's scale, industry type and other such matters. Then, if a factory is considered to cause a major impact on its surrounding environment, MIH obligates the owner of factory to install a sewage treatment plant (STP) and to conduct an EIA including any impact on the surrounding environment and its mitigation method. MIH also issues Operation Certificate to licensed factories every three years and monitors the operation condition at each factory. In particular, the factories obligated to install STP are supposed to report water quality test results every three months to MIH. Then, MIH checks whether the factory is in compliance with the "Sub-Decree Concerning Prevention of Water Pollution". However, this provision is not sufficiently functioning.



Source: MIH

Fig. 2.6.11 Organizational Chart of MIH

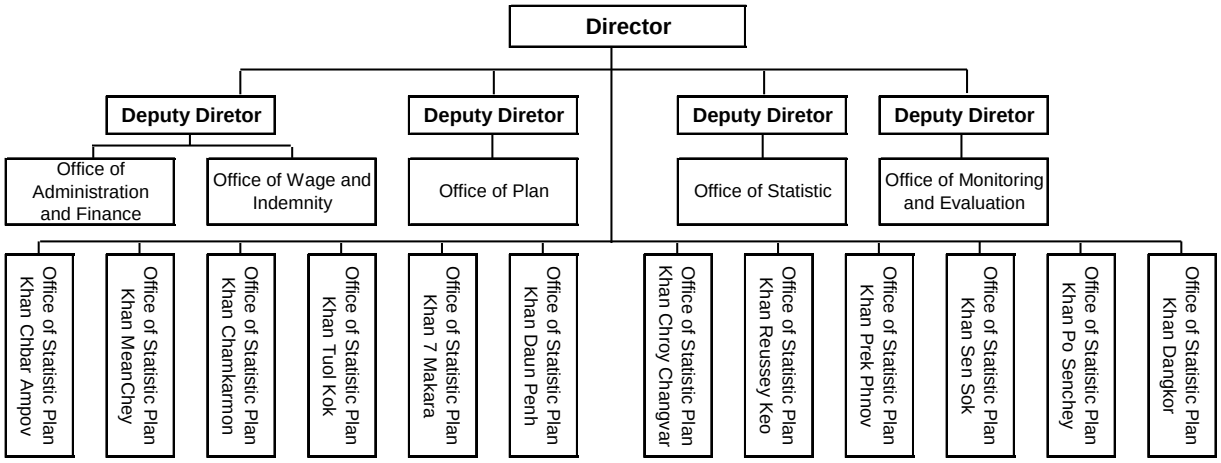


Source: MIH

Fig. 2.6.12 Organizational Chart of the Department of Portable Water Supply

(b) Department of Planning/PPCC

The Department of Planning (DOP)/PPCC gathers statistical data such as demographics and income of Phnom Penh, as well as respective annual reports of directorate of PPCC. Then, DOP/PPCC compiles and evaluates gathered data, and publishes them every three years. The statistical data is essential in planning sewerage and drainage services. **Fig. 2.6.13** shows the organizational structure of the DOP/PPCC.



Source: PPCC

Fig. 2.6.13 Organizational Chart of DOP/PPCC

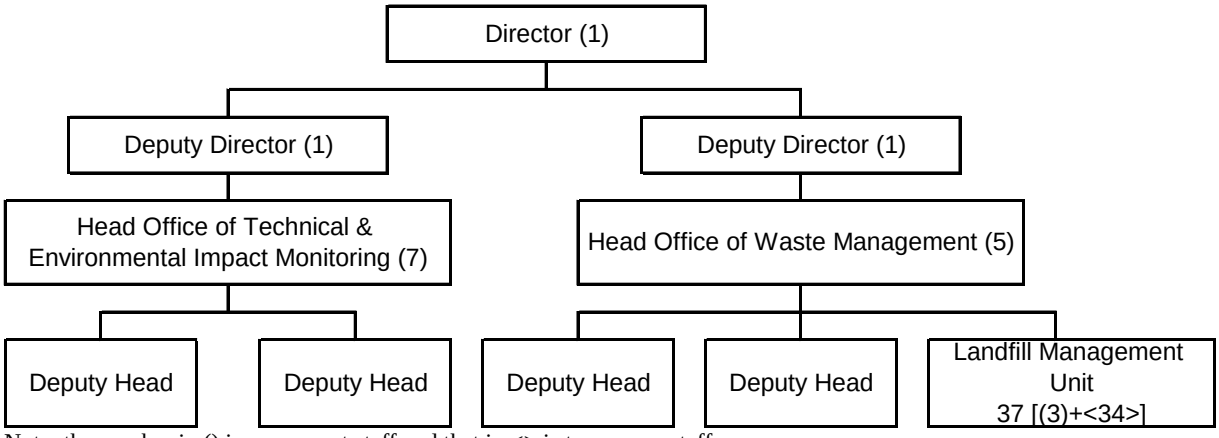
(c) Other related Organizations

Table 2.6.5 shows other related organizations, and organization chart of Waste Management Division (WMD) in PPCC is shown in **Fig. 2.6.14**.

Table 2.6.5 Other Related Organizations

Organization Name	Role
Ministry (Department) of Land Management, Urban Planning, Construction	• Preparation of urban development guidelines • Permission of land development on city, provincial or regional level • Issuance of construction permits and business permits (including septic tanks) • Land registration and valuation • Land tax collection
Ministry (Department) of Water Resource and Meteorology	• Development of water resources • Preparation of regulations concerning water resources • Technical guidance concerning development and improvement of water resources • Observation of river level and meteorological data (precipitation, air temperature, humidity, etc.)
Urbanization Division in PPCC	• Planning and coordination under direction of the Governor (all of which require Governor's approval) • Preparation of Phnom Penh M/P and Northern Development Plan
Waste Management Division (WMD) in PPCC	• Collection of solid waste • Management of solid waste dumping site • Solving issues related to waste management • Formulation of waste management plan • Coordination with organizations concerned
Council for the Development of Cambodia (CDC)	• Administration of approval of private investment in Cambodia, Guidance and Coordination with related institutions (One-Stop Service) • Preparation of Concession Law • Support for training of staff involved in concession projects

Source: JICA Study Team, based on Study on Water Improvement in Phnom Penh (March 2012, Ministry of Land, Infrastructure, Transport and Tourism, Japan)



Note: the number in () is permanent staff and that in <> is temporary staff.
Source: WMD/PPCC

Fig. 2.6.14 Organizational Chart of WMD/PPCC

(8) Identification of Issues

Issues concerning organizations are as described below.

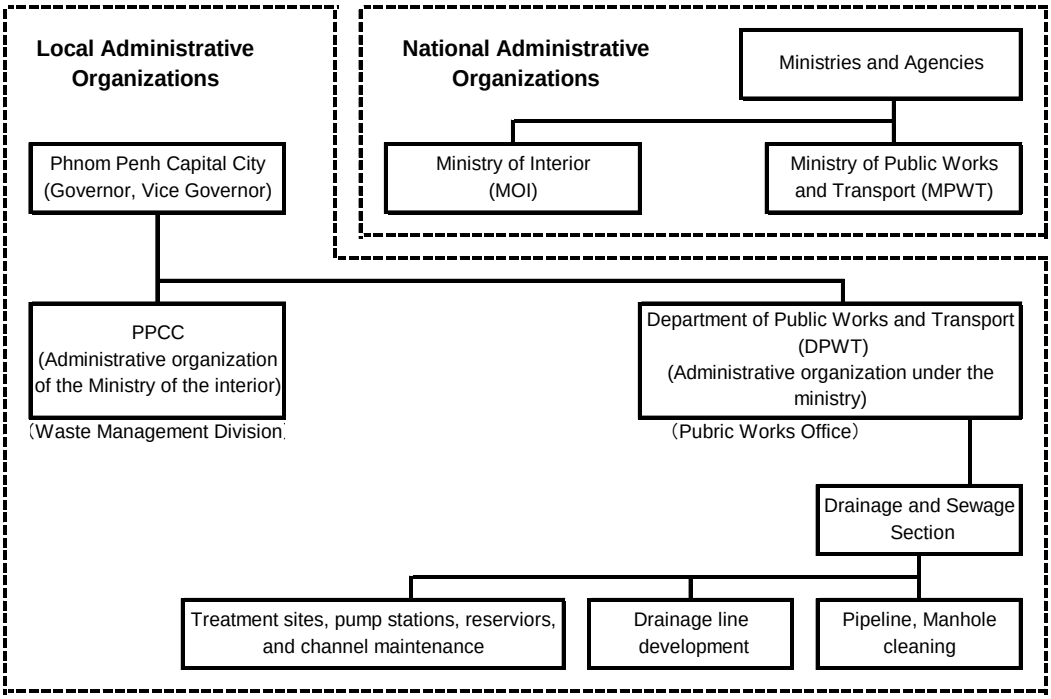
(a) Issues in implementing Sewerage Services

As described in **item (4)**, there exist urgent issues in developing an organizational framework to implement sewerage services as well as developing the human resources and capacity of operation and maintenance. Although there is a section in charge of sewage treatment plants in DSD, no personnel are assigned. To illustrate this status, **Fig. 2.6.15** shows the relations between the posts involved in tasks concerning wastewater and stormwater drainage. The chart shows that DSD is responsible for stormwater drainage services in PPCC, and has three teams to carry out drainage pumping station operation, spot checks and cleaning of channels, repairs and cleaning of drainage channels, and cleaning of manholes. On the other hand, no organization or personnel are in charge of wastewater control. Staff numbers are as shown in No. 7 of **Table 2.6.2** (DSD).

MPWT has a plan to create a department in charge of the laws and standards concerning management of sewerage and drainage services, as well as to create a sewerage and drainage department in DPWT. However, at present, the budget allows only minimal staffing to operate and maintain the aged pipes, channels and pumping stations.

In order to create the M/P and to implement sewerage service smoothly, it is important to clarify the allocation of roles between MPWT and DPWT. For example, MPWT is responsible for the standardization of legislation and standards, and DPWT is responsible for the coordination of concerned authorities and PPCC on specific tasks as well as for guidelines (for design and for management) in accordance with the relevant legislation and standards. DSD is responsible for the various manuals for operation and maintenance at the field level, and supervision, guidance of contracted employees.

Furthermore, regarding staffing, it is necessary to recruit regular employees and contracted employees, to develop human resources for secure technical level and to introduce qualification system alongside the progress of the sewerage service operation.



Source: JICA Study Team

Fig. 2.6.15 Relations between involved Posts

(b) Improvement of Organizational Framework (departments and personnel) for operation

PPCC does not have any engineer for operation and maintenance of sewage treatment plant since there is no sewage treatment plant at present. Although it depends on how future sewage treatment plants are to be operated, for the time being, PPCC needs to organize departments in charge of sewerage planning, sewage connection and sewerage fee collection. Currently there are 193 staff members involved in drainage and sewerage services. Future staffing will need to be an appropriate number for the operation, taking into consideration the operation form (direct operation, contracted operation or another form of operation). Incidentally, PPWSA has 849 staff members for water supply operations.

It is important not only to establish a sewer system but also to operate and maintain septic tanks. Although the Waste Management Division (WMD) should have jurisdiction over the septic tanks, they have not sufficiently managed the septic tanks. Each septic tank should be managed by the house owner. Septage is disposed of by the private company entrusted by the house owner. At present, however, septic tanks have not been managed sufficiently.

Although Anukret 86 on Construction Permit obliges house owner to install septic tanks, there is no rule on the operation and maintenance of them after the installation. In addition, there is no administrative department in charge of it.

(c) Clarification of Allocation of Roles between the Central and Local Organizations

This matter should be discussed with the related parties as the reference of Japanese organization system; MPWT formulates the legal framework and standards, while DPWT develops the technical and construction supervision guidelines, and operation and maintenance manual based on the legislation and standards. For such formulation, it is necessary to consider inviting experts from experienced countries. In addition, there is also an issue of role allocation and staff assignment between regular employees and contracted employees in DPWT.

(d) Necessity to ensure Technical Skill and Personnel for Sewerage Services

Establishing and improving sewerage services require administrative abilities and operation management abilities. Currently, DPWT has staff for maintenance of drainage pipe and channels, but lacks engineers to operate sewerage services. Therefore, it is necessary to have trainings for key-personnel utilizing the Capacity Development Program or overseas training in experienced countries that have good sewerage systems such as Japan. Thereby, technical skill and appropriate personnel are continuously ensured through on-the-job training.

2.6.3 Budget and Financial Situation

(1) State Budget Size

The budget of the Cambodian Government from the viewpoint of revenue is shown in **Table 2.6.6**. The revenues in 2012, 2013 and 2014 are 8,452.0 billion Riels, 8,769.5 billion Riels and 10,517.4 billion Riels, respectively, and increasing year by year. The revenue breakdown shows that tax revenues account for 84.2% in 2014. In the tax revenues, GDCE (General Department of Customs and Excise) revenues are more than half (51.2%=4,533,500÷8,852,481×100). The GDT (General Department of Taxation) revenues follow at 38.7%(=3,429,800÷8,852,481×100). Domestic Capital is only 2.2% of the domestic revenue and much less than the Current Revenue accounting for 97.8%.

Table 2.6.6 Cambodia State Budget Revenue

(Unit: Million Riels)

Item	Actual 2012		Estimate 2013		BL 2014	
	Amount	%	Amount	%	Amount	%
Domestic Revenue	8,452,007	100.00%	8,769,480	100.00%	10,517,449	100.00%
Current	8,201,155	97.03%	8,690,464	99.10%	10,284,449	97.78%
-Tax	6,908,490	81.74%	7,487,915	85.39%	8,852,481	84.17%
GDCE	3,651,948	43.21%	3,566,079	40.66%	4,533,500	43.10%
GDT	2,558,859	30.28%	2,993,585	34.14%	3,429,800	32.61%
Other TR	212,440	2.51%	219,525	2.50%	245,321	2.33%
Province	455,243	5.39%	408,727	4.66%	543,860	5.17%
-Non Tax	1,292,665	15.29%	1,202,548	13.71%	1,431,968	13.62%
Domestic Capital	250,852	2.97%	79,015	0.90%	233,000	2.22%

Note: BL means Budget Law; TR means Taxable Resources.
Source: Ministry of Economy and Finance
(http://www.mef.gov.kh/documents/shares/budget/budget-in-brief-2014.pdf)

Next, the budget expenditures are shown in **Table 2.6.7** and those in 2012, 2013 and 2014 are 12,034.7 billion Riel, 12,056.2 billion Riels and 13,595.6 billion Riels, respectively, showing increase. The profit and loss balance is described soon later, but the breakdown of expenditures shows that current expenditure accounts for approximately 60% and capital expenditure accounts for the remaining 40% in 2014. 54.3% of the current expenditure is non-wage and non-salary, and remaining 45.7% is wage and salary.

Table 2.6.7 Cambodia State Budget Expenditure

(Unit: Million Riels)

	Actual 2012		Estimate 2013		BL 2014	
	Amount	%	Amount	%	Amount	%
Current Expenditure	6,677,327	55.48%	7,173,718	59.50%	8,268,703	60.82%
-Wage and Salary	2,598,189	38.91%	3,079,429	42.93%	3,782,870	45.75%
-Non-wage & Salary	4,079,138	61.09%	4,094,289	57.07%	4,485,833	54.25%
Capital Expenditure	5,357,396	44.52%	4,882,500	40.50%	5,326,924	39.18%
Total	12,034,723	100.00%	12,056,218	100.00%	13,595,627	100.00%

Source: Ministry of Economy and Finance (http://www.mef.gov.kh/documents/shares/budget/budget-in-brief-2014.pdf)

Then, the breakdown of budget expenditures by sector is shown in **Table 2.6.8**. In 2014, social sector expenditure is the biggest, accounting for 36.3% and defence and security sector expenditure is the second accounting for 21.5%. Capital expenditure is 38.4% of the total expenditures and foreign capital expenditure is more than domestic capital expenditure. Concerning the sewerage and drainage expenditures, those related to investments are included in the capital expenditure and the maintenance and management expenditures are included in the economic sector in the table below.

Table 2.6.8 Cambodia State Budget Expenditure by Sector

(Unit: Million Riels)

Item	Actual 2012		Estimate 2013		BL 2014	
	Amount	%	Amount	%	Amount	%
Current Expenditure	6,857,919	55.56%	7,489,296	59.97%	8,720,085	61.55%
General Admin. Sector	1,170,548	17.07%	1,150,824	15.37%	1,121,256	12.86%
Defence & Security Sect.	1,470,920	21.45%	1,655,199	22.10%	1,872,600	21.47%
Social Sector	2,292,866	33.43%	2,733,183	36.49%	3,166,871	36.32%
Economic Sector	525,965	7.67%	615,419	8.22%	701,625	8.05%
Others	1,217,039	17.75%	1,019,093	13.61%	1,407,253	16.14%
Province	450,238	6.57%	444,253	5.93%	589,441	6.76%
Capital Expenditure	5,485,280	44.44%	4,999,907	40.03%	5,447,365	38.45%
Domestic Expenditure	1,525,190	12.36%	1,853,907	14.84%	1,987,365	14.03%
Foreign Expenditure	3,960,090	32.08%	3,146,000	25.19%	3,460,000	24.42%
Total	12,343,199	100.00%	12,489,203	100.00%	14,167,450	100.00%

Source: Ministry of Economy and Finance (http://www.mef.gov.kh/documents/shares/budget/budget-in-brief-2014.pdf)

Revenue and expenditure balance in 2014 is shown in **Table 2.6.9**. The current balance is plus 1,444 billion Riels in the black and overall balance is minus 3,319 billion Riels in the red. Financing for the red account mainly consists of foreign financing.

Table 2.6.9 Cambodia State Financial Operation

(Unit: Million Riels)

Item	Amount	Surplus/Deficit	GDP%
Domestic Revenue	9,945,627		14.68%
Current Revenue	9,712,627		14.34%
Domestic Capital Rev.	233,000		0.34%
Total Expenditure	13,264,703		19.58%
Current Expenditure	8,268,703		12.21%
Capital Expenditure	4,996,000		7.38%
Domestic Investment	1,536,000		2.27%
Foreign Financed Inv.	3,460,000		5.11%
Current Balance		1,443,924	2.13%
Overall Balance		-3,319,076	-4.90%
Financing		3,319,076	4.90%
Net Foreign Financing		3,389,076	5.00%
-Budget Support		260,000	0.38%
-Foreign Financed Project		3,460,000	5.11%
-Amortization		-330,924	-0.49%
Domestic Financing		-70,000	-0.10%
-Govt. Deposit		-80,000	-0.12%
-Budget Support		10,000	0.01%

Source: Ministry of Economy and Finance
(http://www.mef.gov.kh/documents/shares/budget/budget-in-brief-2014.pdf)

(2) Ministry of Public Works and Transport (MPWT)

The budget of MPWT in 2014 is shown in **Table 2.6.10** and **Table 2.6.11**. Revenue is 32 billion Riels and, concerning the central administration and total provincial revenues, provincial total is a little more than the central administration, accounting for 56%. Among the total provinces, Phnom Penh revenue is the most. Although it is less than the 23 other provinces total, it accounts

for 47.8%. The MPWT does not clarify the budget by each sub-sector (such as road). However, it shows expenditures of materials and external services for road and drainage so that operation and maintenance expenditures can be grasped to some extent. Total expenditure is 307 billion Riels and the ministry's budget is a big loss, which seems to be covered by the Ministry of Economy and Finance. In the expenditures, the central administration's expenditure is much more than those of provinces and accounts for 88.7%. Among the provinces, Phnom Penh's is not so much compared with the revenues and accounts for only 21.6%. In the expenditures, capital expenditures are more and account for 80%. However, this Ministry's budget is only the sum of the MPWTs and there are other capital expenditures in foreign currency such as soft loans, which are managed by the MEF. After the coordination with the MEF, the official budget is finalized. Therefore, the MPWT's budget does not show these capital expenditures in foreign currency.

Among the ordinary expenditures other than capital expenditures, staff expenses (salaries and bonuses, etc.) are the most accounting for 58.6%. Material purchase expenses (19.1%), external service expenses (13.6%) and other service expenses (8.4%) such as PR and social expenses follow. Staff expenses include allowances for family and mutual aid such as condolence, baby delivery and disease support. It is noteworthy that items 6013 and 6153 including drainage expenditures are not allocated to Phnom Penh. Therefore, the fund for drainage expenses is not prepared by the MPWT, but by the Phnom Penh Capital government. Staff expenses are allocated to Phnom Penh, that is, the fund goes to DPWT Phnom Penh.

Table 2.6.10 MPWT's Budget in 2014 (Income)

(Unit: Million Riels)

Category of Income			Total	Total of Central Administration	Total of Provinces	Phnom Penh	23 Other Provinces
Total overall income (A+B)			**32,093.0**	**14,113.4**	**17,979.6**	**8,597.0**	**9,382.6**
Country income			**32,093.0**	**14,113.4**	**17,979.6**	**8,597.0**	**9,382.6**
A. Total current income (Gr1+Gr2)			**32,093.0**	**14,113.4**	**17,979.6**	**8,597.0**	**9,382.6**
Gr1: Actual income (Type1+Type2)			**32,093.0**	**14,113.4**	**17,979.6**	**8,597.0**	**9,382.6**
Type2: Non-fiscal income			**32,502.2**	**14,522.6**	**17,979.6**	**8,597.0**	**9,382.6**
72		**Capital of state property**	**6,505.0**	**6,500.0**	**5.0**		**5.0**
720		Concession and land renting	5.0		5.0		5.0
	7205	Land renting	5.0		5.0		5.0
721		Public enterprise	6,500.0	6,500.0			
	7212	Profit from public enterprise	6,500.0	6,500.0			
73		**Sales, rent property and services**	**24,924.6**	**7,472.6**	**17,452.0**	**8,597.0**	**8,855.0**
730		Public enterprise and services	78.0		78.0		78.0
	7308	Other capital income	78.0		78.0		78.0
731		Administrative and service (non-profit)	66.3	50.0	16.3		16.3
	7311	Selling facilities & materials	50.0	50.0	0.0		
	7312	Selling documents, stamps and others	2.4		2.4		2.4
	7313	Goods transportation	13.9		13.9		13.9
732		Administration management income	24,027.4	6,700.0	17,327.4	8,597.0	8,730.4
	7323	Enterprise income	1,505.4	1,200.0	305.4	130.7	174.7
	7324	Examination fee	360.6		360.6		360.6
	7325	Number plate income	22,161.4	5,500.0	16,661.4	8,466.3	8,195.1
733		Renting real estate	752.9	722.6	30.3		30.3
	7331	Renting public enterprise at central administration	636.3	636.3	0.0		
	7332	Renting public enterprise in Municipal-Province	9.6		9.6		9.6
	7334	Renting other real estate (non-furniture)	107.0	86.3	20.7		20.7
74		**Penalties and punishment income**	**1,072.6**	**550.0**	**522.6**		**522.6**
741		Penalties and punishment income	1,072.6	550.0	522.6		522.6

Note: The left column numbers are budget category code numbers based on the government rule.
Source: MPWT

Table 2.6.11 MPWT's Budget in 2014 (Expense)

(Unit: Million Riels)

Category of Income			Total	Total of Central Administration	Total of Provinces	Phnom Penh	23 Other Provinces
Overall expenses (A+B)			**307,198.90**	**272,433.80**	**34,765.10**	**7,498.90**	**27,266.20**
A. Total current expense (Gr1+Gr2)			**62,198.90**	**27,433.80**	**34,765.10**	**7,498.90**	**27,266.20**
Gr.1: Actual expense			**62,198.90**	**27,433.80**	**34,765.10**	**7,498.90**	**27,266.20**
Type1: Means of service			**61,973.50**	**27,283.80**	**34,689.70**	**7,498.90**	**27,190.80**
60		**Purchase**	**11,858.10**	**7,790.40**	**4,067.70**	**429**	**3,638.70**
601		Materials for maintenance	2,902.50	1,564.00	1,338.50	120	1,218.50
	6011	Cleaning and sanitation	62.1	4	58.1	20	38.1
	6012	Building	34	10	24		24
	6013	Road & drainage	13		13		13
	6014	Equipment	98	50	48		48
	6015	Diesel and oil	2,695.40	1,500.00	1,195.40	100	1,095.40
602		Administration	3,954.00	3,392.00	562	129	433
	6021	Office and printing	3,933.00	3,380.00	553	129	424
	6022	Books and documents	21	12	9		9
603		Foods and agro-products	2.3		2.3		2.3
	6031	Foods	2.3		2.3		2.3
604		Clothes and decoration	22	22			
	6041	Uniform	22	22			
605		Small materials, furniture	2,855.30	1,662.40	1,192.90	20	1,172.90
	6051	Technical equipment	1,699.50	1,544.40	155.1	20	135.1
	6052	Furniture	166.9	100	66.9		66.9
	6053	Materials for use	45.3	18	27.3		27.3
	6054	Transport equipment	937.6		937.6		937.6
	6058	Other	6		6		6
606		Energy and water	2,122.00	1,150.00	972	160	812
	6061	Electricity	1,960.70	1,100.00	860.7	140	720.7
	6062	Water	161.3	50	111.3	20	91.3
61		**External services**	**8,463.90**	**1,538.00**	**6,925.90**	**320.4**	**6,605.50**
611		Contract with enterprises	6	5	1		1
612		Renting transportation	156.6	134	22.6		22.6
613		Renting fee (non-furniture)	7		7		7
615		Maintenance and repairs	7,875.30	980	6,895.30	320.4	6,574.90
	6151	Land, forest, beach protection	13		13		13
	6152	Maintenance of building	2,699.20	230	2,469.20	60.4	2,408.80
	6153	Road and sewerage	3,576.50		3,576.50		3,576.50
	6154	Maintenance of other network	456.6	370	86.6	50	36.6
	6156	Maintenance of transport	773.2	300	473.2	70	403.2
	6157	Office supply & ICT	305	70	235	140	95
	6158	Technical materials	51.8	10	41.8		41.8
617		Experiment and service use	419	419			
	6171	Expense for experiment	419	419			
62		**Other external services**	**5,231.80**	**3,808.00**	**1,423.80**	**210.4**	**1,213.40**
622		Public relation communication	2,226.40	1,865.00	361.4	192.4	169
	6221	For national guests	236.6	60	176.6	60	116.6
	6222	For international guests	129.5	80	49.5	40	9.5
	6223	Meeting/Conference	1,701.70	1,600.00	101.7	76	25.7
	6224	Expense for ceremony	68.6	45	23.6	16.4	7.2
		National traditional ceremony	20.1		20.1	16.4	3.7
		King birthday	5.0	5.0			
		Other ceremonies	43.5	40.0	3.5		3.5
	6225	Expense for souvenir	40.0	40.0			
	6226	Expense for expo.	20.0	20.0			
	6227	Public information dissemination	30.0	20.0	10.0		10.0
623		Document purchase	45.0	5.0	40.0	12.0	28.0

Category of Income				Total	Total of Central Administration	Total of Provinces	Phnom Penh	23 Other Provinces
624		Expense for local settlement		1,727.7	810.0	917.7		917.7
	6241	Expense for transportation		115.7	2.0	113.7		113.7
	6242	Expense for mission		218.3	74.0	144.3		144.3
	6243	Expense for accommodation		1,393.7	734.0	659.7		659.7
625		For international settlement		925.0	925.0			
	6251	Expense for transportation		300.0	300.0			
	6252	Expense for mission		150.0	150.0			
	6253	Expense for accommodation		475.0	475.0			
626		Posts & telecommunication		307.7	203.0	104.7	6.0	98.7
	6261	Expense for posts		6.1	5.0	1.1		1.1
	6262	Telecommunication		301.6	198.0	103.6	6.0	97.6
64		**Staff expense**		**36,419.7**	**14,147.4**	**22,272.3**	**6,539.1**	**15,733.2**
641		For top power		901.0	901.0			
	6414	For ministers, state secretaries		395.0	395.0			
	6416	Bonus for advisors		466.0	466.0			
	6418	Bonus for assistants		40.0	40.0			
642		Bonus for permanent staffs		21,861.9	10,693.3	11,168.6	1,695.1	9,473.5
	6421	Basic salaries		18,879.5	9,084.3	9,795.2	1,455.1	8,340.1
	6422	Occupation allowances		2,967.3	1,605.8	1,361.5	240.0	1,121.5
	6423	Overtime		3.0	3.0			
	6426	Regional		11.5		11.5		11.5
	6428	Health affected by heavy work		0.6	0.2	0.4		0.4
643		Gift and other allowances		8,279.2	1,925.0	6,354.2	3,083.1	3,271.1
	6432	Contest allowance		50.0	50.0			
	6433	Gift		8,229.2	1,875.0	6,354.2	3,083.1	3,271.1
644		Incentive allowance for staff		3,839.8	293.0	3,546.8	1,476.5	2,070.3
	6441	Basic salary for contract staff		355.1	145.0	210.1	38.4	171.7
	6443	Salary for temporary staff		3,484.7	148.0	3,336.7	1,438.1	1,898.6
645		Budget for social allocation		1,537.8	335.1	1,202.7	284.4	918.3
	6451	Allowance for family		394.7	129.7	265.0	37.0	228.0
		Child less than 15 years old		162.5	57.0	105.5	13.0	92.5
		Child from 16 to 18 years old		64.8	8.7	56.1	9.0	47.1
		Allowance for dependent		167.4	64.0	103.4	15.0	88.4
	6452	Sick staff and baby delivery		388.8	7.4	381.4	120.0	261.4
	6453	Condolence		98.1	20.0	78.1	12.4	65.7
	6454	Support for retirement		494.4	150.0	344.4	50.0	294.4
	6455	Support of staff leave		68.5	20.0	48.5	10.0	38.5
	6456	Accident at work		89.8	5.0	84.8	55.0	29.8
	6457	Support of officer's orphans		3.5	3.0	0.5		0.5
Type 4: Other Expense				**225.4**	**150.0**	**75.4**		**75.4**
63		**Tax**		**225.4**	**150.0**	**75.4**		**75.4**
631		Stamp		225.4	150.0	75.4		75.4
B. Total capital expense (Gr.1+Gr2)				**245,000.0**	**245,000.0**			
Gr 1: Actual expense (Type1+Type2)				**245,000.0**	**245,000.0**			
Type 2 : Property				**245,000.0**	**245,000.0**			
21		Physical property		245,000.0	245,000.0			

Note: The left column numbers are budget category code numbers based on the government rule.
Source: MPWT

(3) Phnom Penh Capital City Department of Public Works and Transport (DPWT/PPCC)

The budget of DPWT/PPCC is shown in **Table 2.6.12**. It is basically increasing although it fluctuates a little. Its breakdown shows that salaries and indemnities and capital expenditure are the most. In 2013, salaries and indemnities are more than capital expenditure, but from 2008 to 2012 and 2014, capital expenditure exceeded salaries and indemnities on the contrary. 100% of

the salaries and indemnities come from the MPWT, but operational expenditure and small repairs are burdened by the PPCC's budget. However, the budget for operation and maintenance of the national and main roads come from the MPWT.

Table 2.6.12 DPWT's Budget

(Unit: Million Riels)

Items	2008	2009	2010	2011	2012	2013	2014
Salaries and Indemnities	3,581.80	4,053.35	2,393.47	2,442.53	2,658.43	6,082.53	7,524.95
Operational Expenditure & small repair	300.00	397.03	432.55	470.31	558.40	588.40	943.40
Social & cultural (ceremonies, etc.)	161.20	99.50	206.68	229.73	219.84	274.40	246.60
Capital expenditures	3.627.89	5,334.50	4,173.88	9,746.99	10,509.42	4,771.83	9,896.70
Total	7,670.89	9,884.38	7,206.58	12,889.56	13,946.09	11,717.16	18,611.65

Source: DPWT

Next, the expenditures of DSD (Drainage and Sewerage Division) under the DPWT are shown in **Table 2.6.13**. The total amount increased a lot in 2012, 2013 and 2014. The breakdown shows that drainpipe cleaning decreased, but new drainpipe construction increased recently accounting for 62.8% of the total in 2014.

Table 2.6.13 Expenditures of DSD

(Unit: Million Riels)

Item	2009	2010	2011	2012	2013	2014
Drainpipe cleaning	321.48	438.05	732.98	682.03	496.17	390.09
Drainpipe repair	265.91	297.73	162.02	179.02	248.10	222.50
Pumping station repair	253.67	-	-	171.00	262.00	255.95
Drainage ditch & balancing reservoir cleaning	672.17	-	-	265.74	170.00	882.00
Diesel oil for pumping out to the city (kl)	103.9kl	115.7kl	90.5kl	129.4kl	123.6kl	83.9kl
New construction of drainpipe	526.47	373.30	168.00	747.22	2,525.98	2,959.37
Total	2,039.70	1,109.08	1,063.00	2,045.01	3,702.25	4,709.91

Source: DSD

(4) Phnom Penh Capital City (PPCC)

PPCC's drainage related expenditures are shown in **Table 2.6.14**. The total expenditure decreased from 2009 to 2011, but it increased in 2012 and 2013 and decreased again in 2014. In 2014, the breakdown shows that pumping station electricity expenses, pipe & channel cleaning expenses, and pipe repair and new construction expenses are much (one digit) more than others in order. These three-item expenditures include DSD's expenditures in **Table 2.6.13** above. Namely, it seems that pumping stations are managed by the DSD, but most of the expenditures excluding personnel expenditures are covered by the PPCC. Both PPCC and DSD seem to manage pipes and channels. The overall sewerage and drainage expenditures burden from the organizational viewpoint is explained later.

Table 2.6.14 Drainage Related Expenditures of PPCC

(Unit: Million Riels)

Item	2009	2010	2011	2012	2013	2014
Pumping station electricity expenses	3,610	3,690	3,730	3,868	5,264	4,447
Pumping station fuel expenses	585	690	785	647	619	419
Pipe & channel cleaning expenses	3,670	2,960	3,137	3,970	3,866	4,272
Pipe repair and new construction expenses	2,760	3,050	1,980	3,070	2,774	3,181
Pumping building maintenance expenses	560	470	769	975	362	256
Pumping facility maintenance t expenses	440	758	826	649	450	456
Total	11,625	11,618	11,227	13,260	13,335	13,031

Note: These expenses include DSD's expenditures in **Table 2.6.13**.
Source: PPCC

(5) Phnom Penh Water Supply Authority (PPWSA)

PPWSA is a water supply entity in the Phnom Penh Capital City Area. Although it is public, it is financially independent. It is under the control of MIH and MEF, but is a self-sustained public corporation. In April 2012, it was listed in the Cambodia Securities Exchange (CSX). However, the government (MEF) owns 85% share capitals and employee's share is 1% and so the remaining 14% share of capitals are opened (based on PPWSA's 2013 Financial Statement).

Profit and loss of PPWSA is shown in **Table 2.6.15**. At least, it has made profits since 2010 and the profits have been increasing. Profit and loss balance before tax after non-operational profit or loss is added to operational balance and has been in the black, and profits after tax are increasing year by year so that PPWSA is a financially good corporation. The dividend is 414.09 Riels per capital in 2012 and 437.93 Riels in 2013. Income tax rate seems to be 20%, but some expenses cannot be approved as legally accounting expenditure (if 20% as tax rate is multiplied to profit before tax, calculated tax is not equal to the actual tax).

Then balance sheet is shown in **Table 2.6.16**. In the assets, non-current assets, especially property, plant and equipment account for a big share (76.0% in 2013). In equity and liabilities, equity accounts for 63.3% in 2013 and shared capital accounts for 77.9% of equity in 2013. Liabilities account for remaining 36.7% in equity and liabilities in 2013. Non-current liabilities account for 86.0% in liabilities. In non-current liabilities, borrowings account for 65.7%. Non-current and current borrowings came from the following major resources according to the financial statement of 2013:

- AFD (France): 118,308 million Riels in total of two contracts
- MEF (JICA): 999,001 million Riels
- MEF (ADB): 376,646 million Riels
- Total: 1,493,955 million Riels

These borrowings are divided as follows from the viewpoint of short- and long-terms:

- Current (Due within one year): 26,692 million Riels
- Non-current (Due within 1 to 2 years): 27,482 million Riels
- Non-current (Due within 2 to 5 years): 82,445 million Riels
- Non-current (Due after 5 years): 118,336 million Riels
- Total: 254,955 million Riels

Table 2.6.15 Profit and Loss of PPWSA

(Unit: Thousand Riels)

Item Year	2010	2011	2012	2013
Revenues	106,265,913	115,080,331	135,119,518	151,580,207
Sales	105,543,540	113,343,349	122,457,889	136,399,843
Construction fee			6,661,202	7,249,392
Other income	722,373	1,736,982	6,000,427	7,930,972
Expenditures	70,036,453	78,444,113	92,427,831	100,047,277
Depreciation	20,536,261	21,239,491	21,366,678	24,523,863
Electricity	21,223,301	22,809,698	25,489,322	27,406,397
Salaries	17,131,407	18,971,337	20,896,767	19,847,886
Raw materials for water	4,111,934	4,462,250	3,786,880	3,318,097
Raw materials for connections	3,686,038	5,126,863	4,891,092	5,668,838
Repairs & maintenance	3,231,125	2,484,760	3,861,025	4,693,128
Construction expenses			5,976,412	6,649,568
Other expenses	2,804,170	3,131,512	4,486,112	6,649,967
Foreign exchange loss	-2,687,783	218,202	1,673,543	1,289,533
Operating profit	36,229,460	36,636,218	42,691,687	51,532,930
Finance income	6,550,400	9,021,034	6,728,848	8,592,122
Finance costs	4,602,282	5,600,458	6,528,582	12,038,249
Finance income/cost net	1,948,118	3,420,576	200,266	-3,446,127

Item Year	2010	2011	2012	2013
Profit before income tax	38,177,578	40,056,794	42,891,953	48,086,803
Income tax	7,671,226	8,066,887	8,470,992	9,341,274
Profit	30,506,352	31,989,907	34,420,961	38,745,529

Source: PPWSA、"Financial Statement" 2010-2013

Table 2.6.16 Balance Sheet of PPWSA

(Unit: Thousand Riels)

Item Year	2010	2011	2012	2013
Assets	746,097,282	865,250,609	999,681,230	1,098,976,716
Non-current assets	543,086,114	634,122,810	749,637,531	846,438,358
Property, plant & equipment	541,321,047	632,385,744	741,661,049	835,552,690
Intangible assets	996,801	1,033,905	1,282,455	3,292,331
Loan to PWS	768,266	703,161	620,759	578,324
Loans to employees			6,073,268	7,015,013
Current assets	203,011,168	231,127,799	250,043,699	252,538,358
Inventories	20,176,810	28,088,571	59,712,831	35,083,363
Trade and other receivables	44,376,504	40,095,235	28,271,470	29,771,083
Loan to PWS	50,149	62,452	74,742	81,475
Income tax receivable	1,643,818			2,755,704
Short-term investments	129,697,135	151,799,927	148,008,619	174,278,018
Deferred IPO cost		3,620,793		
Cash and cash equivalents	7,066,752	7,460,821	13,976,037	10,568,715
Equity and Liabilities	746,097,282	865,250,609	999,681,230	1,098,976,716
Equity	515,567,573	552,428,481	659,502,757	695,181,630
Share capital	456,000,264	465,028,129	541,227,282	541,227,282
Reserves	29,060,957	55,410,445	83,854,514	115,866,320
Retained earnings	30,506,352	31,989,907	34,420,961	38,088,028
Liabilities	230,529,709	312,822,128	340,178,473	403,795,086
Non-current liabilities	203,512,995	263,714,862	279,402,849	347,243,361
Retirement benefit obligation	20,347,816	24,601,028	26,165,235	28,362,224
Deferred income tax liabilities	15,279,480	16,935,710	18,293,407	24,472,827
Borrowings	129,255,377	182,847,463	192,171,324	228,262,247
Refundable water deposits	21,854,738	24,602,071	27,786,987	31,215,173
Performance guarantee		7192923	7,871,868	
Deferred government & other grants	16,775,584	7,535,667	7,114,028	34,930,890
Current liabilities	27,016,714	49,107,266	60,775,624	56,551,725
Borrowings	8,758,884	15,019,945	14,538,206	26,691,817
Current income tax liabilities		437,665	893,817	
Accrual for IPO fee		3,215,717		
Trade and other payables	18,257,830	30,433,939	45,343,601	29,859,908

Source: PPWSA, "Financial Statement", 2010-2013

Thus, PPWSA has borrowed soft loans through the government, but it seems to be able to pay the interests and repay by own financing.

The PPWSA's tariffs which are the basis of revenues are shown in **Table 2.6.17**. Its structure is that the more water customer use, the much more expensive the charges become. The collection rate is 99.9%. In addition, the tariffs have not been raised since the third revision in 2001. It is impressive that PPWSA has made profits without tariff raise in spite of inflation. Perhaps, it is considered that the revenues increased because customers and water consumption per capita increased. Additionally, according to the interview with the responsible PPWSA persons, the past tariffs were affected by the political situations and the raise was not easily approved and it is still the same at present. However, the tariff regulations and the Water Supply Law (which is old because it was enacted in 1984) are being revised and established in support of JICA and Kitakyushu City. Furthermore, taking PPWSA's responsibility for general shareholders into consideration, it does not seem easy to refuse the tariff raise because of the political reasons in the future. In particular, in 2017, a new treatment facility (capacity: 130,000 m^3 per day in addition to the existing 460,000 m^3 per day) will be operated and the cost recovery will be included in the tariff calculation so that the raise will be expected to be necessary. In 2017, a national election

will be held and it is thought that the raise will be difficult before that. In addition, a new tariff calculation method is being applied now. The present calculation method is for example, if domestic use volume is 10 m^3 per month, the monthly charge is 7 $m^3 \times$ 550 Riels/m^3+(10−7) $m^3 \times$ 770 Riels/m^3＝6,160 Riels. The applied method is 10 $\times$ 770 Riels/m^3＝7,700 Riels. It is insisted that this is not a raise, but it seems a raise substantially (tariffs are not raised for minimum users, that is poor users). This will lead to a 14% increase of the revenues. This tariff calculation method is approved by the PPWSA board, but not yet by the MIH. Tariff change requires the Prime Minister's approval, but does not need the Parliament decision.

Table 2.6.17 PPWSA Tariff

Use	Volume Category (m^3/month)	Fee (Riels/m^3)
Resident	0-7	550
	8-15	770
	16-50	1,010
	>50	1,270
Public (governments)	-	1,030
Commercial/ industrial	<100	950
	101-200	1,150
	201-500	1,350
	>500	1,450

Source: PPWSA

In order to confirm that, actual consumption of customers and average unit price of water consumed are surveyed and shown in **Table 2.6.18.** The data do not seem total annual average, but surveyed for almost two months. It is confirmed that customer numbers (bill numbers) increased annually and the right side columns in the table show that the average consumption per capita and average unit price of water consumed seem increasing although they fluctuate a little annually. Average price of water consumed in 2013 was 6.4 USD/month, which was equivalent to 1.02% of average household income (625 USD/month)[14].

Additionally, 10% of PPWSA tariff revenues are collected in parallel with water supply tariffs as drainage and sewerage facilities operation and maintenance costs and transferred to PPCC. The annual transferred money as well as PPWSA's use charge revenues, are shown in **Table 2.6.19**. Nevertheless, this 10% of water supply use revenue is not applied to every user. In fact, the amount transferred from PPWSA to PPCC in 2013 is divided by the PPWSA sales revenues and the result is approximately 5.8% and less than 10%. This additional 10% of water supply use revenue for drainage was required by the ADB when the ADB lent soft loans for Phnom Penh water supply and drainage project. Thus, the governor accepted it and made the ordinance in 2003. Therefore, this system is applied only to the users within the ADB project areas. Regarding this PPWSA's collection of drainage and sewerage costs instead of PPCC and transfer of the money to PPCC, at first it was asked to from the appropriate PPWSA persons whether PPWSA intends to integrate sewerage treatment business if a sewerage project is implemented in Phnom Penh. The answer was that it could not integrate the water supply and sewerage because water supply is under the MIH and sewerage is under the MPWT. Perhaps, the other reason seems that it is not attractive to integrate profitable water supply business with unprofitable sewerage works. (PPWSA is responsible for share capital holders as listed corporation.) This sewerage use fee collection issue requires more detailed coordination and so it is examined later in financial analysis.

In addition, as a result of the interview with the PPWSA executives, new information was obtained. Namely, 10% of water supply user charge revenues, which were imposed only on the ADB project covered area users, were transferred from the PPWSA to PPCC as sewerage and drainage maintenance costs, but this system was expanded to all the PPWSA Phnom Penh users.

[14] 625USD is obtained by exchange rate of 4,027 Riel, based on GDP statistics in 2013 of 61,327 billion Riels or 15,229 million USD.

That is, 10% of PPWSA's sales revenues from Phnom Penh users are collected in addition to the water supply use payments and transferred to PPCC as sewerage and drainage maintenance and management costs. However, water supply users related to garment manufacture contributing to export are exempted from this 10% system. Specifically, water supply users as landowners leasing rooms for garment manufacturers are exempted from this 10% system. Meters measuring total water use are installed to landowners' buildings with manufacturing rooms for garment and the landowners pay depending on the measured use volumes. On the other hand, another meter is installed to each room and the landowners collect water supply use charges from the room lessees. The difference between the landowners' payments to PPWSA and landowners' collected charges is the landowners' profit. If 10% of water supply use payments as sewerage and drainage costs are not imposed, it becomes an incentive for garment manufacture room users and landowners. This system implementation started from early 2015 and so **Table 2.6.19** does not reflect this at all. The exemption share is estimated approximately 4.4% of water supply sales. And it is said that PPWSA gets 9% of the transferred amount as management and maintenance costs on the occasion of transfer from PPWSA to PPCC. Therefore, 95% of water supply sales and actually 91% of that amount, that is, 86% of the water supply sales are transferred to PPCC. Furthermore, concerning **Table 2.6.19**, transferred amount, 7.2 billion Riels, in 2014 is less than 7.3 billion Riels in 2013. Although the water supply revenues increased from 2013 to 2014, it is strange that the transferred amount decreased. According to the interview, the transferred amount is on the budget basis and it was invoiced around October and was more than the actual amount and so it was decreased in 2014. Nevertheless, the explanation such as budget basis amount, etc. is not so understandable because naturally the sewerage and drainage costs should be transferred as soon as they are collected (since they are not PPWSA's use charges). Perhaps, this procedure may be based on the difference between the PPCC's public budget-based system and the PPWSA's corporate-based system.

Table 2.6.18 Unit Price of PPWSA

Year	Categories	Bills	Volume	Amount	Average Tariff Riel/m^3	AVG Days/bill period	Avg/bills/Month		
							in m^3	In Riels	In USD
2008	Domestic	877,992	47,205,750	42,278,978,985	895.63	61	26.44	23,682.38	$ 5.92
	Commercial	133,635	27,438,062	32,354,419,011	1,179.18	61	100.98	119,070.67	$ 29.77
	ADM	4,043	5,010,146	5,160,449,522	1,030.00	61	609.45	627,733.36	$156.93
	Wholesaler	244	212,902	271,703,165	1,276.19	61	429.12	547,641.42	$136.91
	RDE-wholesaler	92	234,638	241,677,488	1,030.00	61	1,254.30	1,291,932.40	$322.98
Total		**1,016,006**	**80,101,498**	**80,307,228,171**	**1,002.57**	**61**	**38.77**	**38,873.15**	**$ 9.72**
2009	Domestic	939,740	50,062,897	44,802,526,709	894.92	60	26.64	23,837.72	$ 5.96
	Commercial	156,813	29,112,547	33,674,258,650	1,156.69	60	92.83	107,370.75	$ 26.84
	ADM	4,206	5,228,883	5,385,749,696	1,030.00	60	621.60	640,246.04	$160.06
	Wholesaler	185	136,862	168,932,300	1,234.33	60	369.90	456,573.78	$114.14
	RDE-wholesaler	67	212,856	219,241,680	1,030.00	60	1,588.48	1,636,131.94	$409.03
Total		**1,101,011**	**84,754,045**	**84,250,709,035**	**994.06**	**60**	**38.49**	**38,260.61**	**$ 9.57**
2010	Domestic	988,255	53,910,877	48,441,019,891	898.54	60	27.28	24,508.36	$ 6.13
	Commercial	182,563	34,081,549	39,400,595,050	1,156.07	60	93.34	107,909.58	$ 26.98
	ADM	4,364	5,912,999	6,090,388,970	1,030.00	60	677.47	697,798.92	$174.45
	Wholesaler	145	103,721	127,716,850	1,231.35	60	357.66	440,402.93	$110.10
	RDE-wholesaler	62	187,068	192,680,040	1,030.00	60	1,508.61	1,553,871.29	$388.47
Total		**1,175,389**	**94,196,214**	**94,252,400,801**	**1,000.60**	**60**	**40.07**	**40,094.13**	**$ 10.02**
2011	Domestic	1,052,543	56,766,995	50,919,550,136	896.99	60	26.97	24,188.82	$ 6.05
	Commercial	201,661	37,370,331	43,140,050,770	1,154.39	60	92.66	106,961.81	$ 26.74
	ADM	4,490	5,438,921	5,602,088,630	1,030.00	60	605.67	623,840.60	$155.96
	Wholesaler	111	62,185	73,173,950	1,176.71	60	280.11	329,612.39	$ 82.40
	RDE-wholesaler	125	127,993	131,832,790	1,030.00	60	511.97	527,331.16	$131.83
Total		**1,258,930**	**99,766,425**	**99,866,696,276**	**1,001.01**	**60**	**39.62**	**39,663.32**	**$ 9.92**
2012	Domestic	1,127,825	62,722,159	56,698,749,731	903.97	61	27.35	24,724.25	$ 6.18
	Commercial	220,489	42,578,594	49,427,480,009	1,160.85	61	94.97	110,248.57	$ 27.56
	ADM	4,692	5,662,859	5,832,744,770	1,030.00	61	593.57	611,373.19	$152.84
	Wholesaler	106	66,270	78,654,900	1,186.89	61	307.47	364,931.49	$ 91.23
	RDE-wholesaler	122	97,929	100,866,870	1,030.00	61	394.77	406,611.95	$101.65
Total		**1,353,234**	**111,127,811**	**112,138,496,280**	**1,009.09**	**61**	**40.39**	**40,754.28**	**$ 10.19**
2013	Domestic	1,206,997	68,911,660	62,849,041,026	912.02	61	28.08	25,608.48	$ 6.40
	Commercial	242,366	48,345,080	56,342,780,210	1,165.43	61	98.10	114,329.42	$ 28.58
	ADM	4,672	6,124,289	6,308,017,670	1,030.00	61	644.68	664,020.50	$166.01
	Wholesaler	91	53,590	63,348,300	1,182.09	61	289.62	342,361.56	$ 85.59
	RDE-wholesaler	120	99,379	102,360,370	1,030.00	61	407.29	419,509.71	$104.88
Total		1,454,246	123,533,998	125,665,547,576	1,017.25	61	41.78	42,498.13	$ 10.62

Source: PPWSA

Table 2.6.19 Drainage and Sewerage Cost Transferred from PPWSA to PPCC

(Unit: Million Riels)

Item	2009	2010	2011	2012	2013	2014
Transferred amount (shown by PPCC)	5,158	5,873	6,253	6,500	7,300	7,200
PPWSA's use charge revenues (sales)	85,869	96,024	102,041	114,157	127,446	137,018
Actual ration to sales	6.01%	6.12%	6.13%	5.69%	5.73%	5.25%

Source: Transferred amount: PPCC, use charge revenues: PPWSA, ratio: JICA Study team

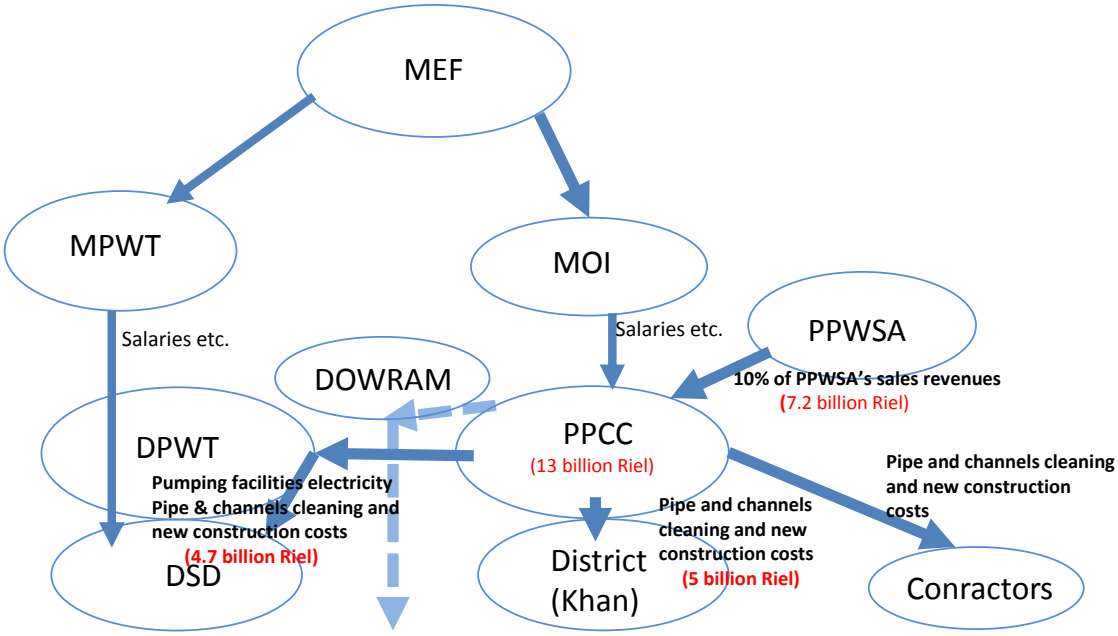
(6) Organizational Burden of Drainage and Sewerage Facilities Cost in Phnom Penh

The budgets of drainage and sewerage related organizations in Phnom Penh were described for each entity above, but it does not show the overview of the whole. Therefore, it is organized here. At first, pumping facilities are managed by the DSD in the DPWT and the budget is shown in the

above **Table 2.6.13**, but it is included in PPCC's budget, that is, **Table 2.6.14**. The total amount of PPCC is much more than DSD's. Consequently, part of the budget came from DSD or DPWT.

On the other hand, DSD's personnel expenses are included in DPWT budget, **Table 2.6.12**. It means that these costs are burdened by the MPWT. In addition, PPCC's drainage and sewerage related expenses are covered by the 10% of PPWSA sales revenues other than PPCC's own budget resource. Amount from the PPWSA is 7,200 million Riels in 2014 and it accounts for approximately 55.3%, more than a half of PPCC total expenditures, 13,031 million Riels. However, if collection of more than 10% of PPWSA sales revenues is not easy based on the discussion above, it is easily imagined that 10% of water supply sales is very insufficient considering the investment and operation and maintenance costs of new sewage treatment facilities because 10% of sales is not enough for even the present drainage facilities maintenance.

The relationship of present drainage and sewerage related cost resource burdening organizations above can be shown in **Fig. 2.6.16**.



Note) Concerning the fund flow in dotted arrow line, the amount is not clarified, but it shows that sewerage and drainage related maintenance and management costs are paid through DOWRAM.
Source: JICA Study Team

Fig. 2.6.16 Drainage and Sewerage Related Cost Resource Fund Flow in Phnom Penh

(7) Two Sewerage Service Entity Examples (for Reference)

There are cases of sewerage service business entities in Cambodia. These business entities are analysed financially for reference. Sewerage works in Preah Sihanouk and Siem Reap can be mentioned as examples for reference. However, the main objective of Preah Sihanouk sewerage project is a countermeasure against pollution caused by commercial and industrial wastewater from the SEZ and Siem Reap case objective is a countermeasure against pollution in lakes and ponds around Angkor Wat caused by tourism development. Therefore, these situations are different from Phnom Penh's. Furthermore, treatment technology of these cases is lagoon and might be different from the plan for Phnom Penh.

Between the two cases, Preah Sihanouk case was earlier and the sewerage treatment project was completed in 2006. Siem Reap sewerage operation began from 2010. The entities of both cases are Sewerage and Wastewater Treatment Plant Units under the control of Province or DPWT. The Sewerage and Wastewater Treatment Plant Unit is called semi-autonomy because if it is a

government organization, the tariff revenues must be included into general account of the government and it cannot become a financially independent sustainable entity. As a matter of course, these units are collecting the user fees.

On the other hand, sewerage business cannot be profitable like PPWSA and so the Sewerage and Wastewater Treatment Plant Unit cannot become a public corporation supporting itself. Thus, it is called semi-(autonomy) organization. At first, profit and loss situation of Sihanouk Sewerage and Wastewater Treatment Plant Unit is shown in **Table 2.6.20**. Profit before tax is attained. However, it seems that income tax is not imposed. Non-operational profit and loss balance shows only foreign exchange profit and loss and it seems that there is no interest payment, which must exist reasonably because the project has borrowings. While soft loan such as ADB's might be used and the operation from the start might be in its grace period, interest must be paid even during the grace period. In the first place, the entity does not seem to have a balance sheet and it is estimated that the financing is shouldered by the provincial government or MEF.

The sewerage tariffs of Sihanouk Sewerage and Wastewater Treatment Plant Unit are shown in **Table 2.6.21** and the system is combined sewerage and does not relate to water supply so that the tariff is based on the building size.

Table 2.6.20 Profit and Loss of Sihanouk Sewerage and Wastewater Treatment Plant Unit

(Unit: Riels)

No.	Description	Chart of Account	2011	2012	2013	Increase Rate ('13/'11)
I	**Operating Income**		218,093,500	233,656,500	246,523,000	13.0%
	Service(income from monthly service/fee)	706	199,672,500	210,922,500	222,560,000	11.5%
	Service (income from drainage cleaning service)	7061	4,320,000	4,600,000	8,160,000	88.9%
	Profit from other subordinate activities	798	14,101,000	18,134,000	15,803,000	12.1%
II	**Operating Expenses**		190,660,035	181,973,460	203,809,808	6.9%
	Materials and sanitation	6011	1,182,000	994,000	1,498,000	26.7%
	Materials for building maintenance	6012	1,037,700	476,800		-100.0%
	Materials for equipment	6014	260,000	1,824,500	1,968,300	657.0%
	Fuel and Diesel	6015	34,793,750	40,514,950	43,760,250	25.8%
	Office equipment and printing	6021	9,248,200	11,963,800	10,747,100	16.2%
	Uniform	6041	3,816,000	5,169,600	5,456,800	43.0%
	Materials and equipment	6051	987,000	800,000	1,010,000	2.3%
	Furniture	6052		-	-	
	Materials for using	6053	973,000	986,500	5,806,000	496.7%
	Materials and equipment for transportation	6054		-		
	Electricity	6061	3,272,620	3,476,800	4,459,160	36.3%
	Water	6062		-		
	Renting transportation	612		-		
	Maintenance and repairs of Buildings	6152	5,274,855	985,020	1,918,800	-63.6%
	Maintenance of other networks	6154	29,365,200	10,943,400	10,780,400	-63.3%
	Maintenance and repairs of transportation	6156	3,926,900	4,956,000	4,840,000	23.3%
	Maintenance and repairs of Office equipment	6157	1,987,700	1,478,900	633,450	-68.1%
	Accounting expense and legal service	61700		-		
	Dissemination and Advertising	62300		-		
	Reception for National Guests	6221	641,000	1,997,500	8,506,400	1,227.1%
	Reception for International Guests	6222	676,500	-		
	Meeting/Workshops/Conferences	6223		-		
	Telecommunication expense	6262	832,100	655,500	709,048	-14.8%
	Banking service	627		-	55,680	
	Transportation expense	6241	168,000	28,000	28,000	-83.3%
	Mission expense	6242	432,000	176,000	467,000	8.1%
	Accommodation expense	6243	2,490,000	930,000	1,695,000	-31.9%
	Tax stamp	631	927,000	777,000	777,000	-16.2%
	Interests and remuneration	641	4,800,000	4,800,000	4,800,000	0.0%

No.	Description	Chart of Account	2011	2012	2013	Increase Rate ('13/'11)
	Other remuneration	6438	3,968,510	4,189,190	4,293,420	8.2%
	Basic salary for temporary staff	6443	79,600,000	83,850,000	89,600,000	12.6%
III	**Operating Results**		27,433,465	51,683,040	42,713,192	55.7%
IV	**Financial Income**	76	1,652,318		60,658	-96.3%
	Income of money exchange (profit)	766	1,652,318	-	60,658	-96.3%
V	**Financial Expense**	66		1,876,204		
	Loss of money exchange	666		1,876,204		
VI	**Financial Results (IV-V)**		1,652,318	-1,876,204	60,658	-96.3%
VII	**Special Income**					
VIII	**Special Expense**					
IX	**Special Financial Results (VII-VIII)**					
X	**Results before Tax (III+VI+IX)**		29,085,783	49,806,836	42,773,850	47.1%
XI	**Profit Tax**					
XII	**Net Profit of this Fiscal Year (X-XI)**		29,085,783	49,806,836	42,773,850	47.1%

Source: MPWT

Table 2.6.21 Tariffs of Sihanouk Sewerage and Wastewater Treatment Plant Unit

No.	Customer	Price (Riel)	
		Connection Service	Monthly Service
I. Private Residences			
1	Residence measuring smaller than 70 m^2 (Type1)	40,000	3,500
2	Residence measuring between 70 m^2-300 m^2 (Type2)	80,000	6,500
3	Residence measuring from 300 m^2 and up (Type3)	160,000	12,500
II. Hotels			
1	Hotel, between 1-10 rooms (Type1)	200,000	33,500
2	Hotel, between 11-20 rooms (Type2)	300,000	66,500
3	Hotel, between 21-40 rooms (Type3)	400,000	135,000
4	Hotel, from 41 rooms and up (Type4)	600,000	210,000
III. Guest Houses			
1	Guest house, between 1-7 rooms (Type1)	80,000	13,500
2	Guest house, between 8-15 rooms (Type2)	180,000	21,000
3	Guest house, from 16 rooms and up (Type3)	234,000	33,000
IV. Restaurants			
1	Restaurant, between 41-100 chairs (Type2)	120,000	16,500
2	Restaurant, between 41-100 chairs (Type2)	240,000	39,000
3	Restaurant, from 101 chairs and up (Type3)	320,000	145,000
Others			
1	Warehouse/Parking	200,000	25,500
2	Service station/Garage	200,000	44,500
3	Nightclub/Karaoke	200,000	25,500
4	Government building	160,000	22,000
5	Monastery and other Cathedral	80,000	11,500
6	School	40,000	2,500
7	Hospitals/Clinics	200,000	41,000
8	Large Industry	Contract	Contract
9	Medium Industry	-	-
10	Small Industry	600,000	26,000
11	Car wash place	200,000	34,500
12	Bank	160,000	13,500
13	Small business place	100,000	17,000
14	Market	2,000,000	130,000
15	Public toilets	100,000	14,000
V. Pumping Service and Cleaning of Reservoir			
1	Reservoir type -1 (for resident)	Pumping 1 truck	120,000
2	Reservoir type-2 (type1&2 for Hotel Restaurant Guesthouse and public building)	Pumping 1 truck	200,000
3	Reservoir type3 (type3&4 for Hotel Restaurant Guesthouse)	Pumping 1 truck	400,000

No.	Customer	Price (Riel)	
		Connection Service	Monthly Service
4	Reservoir not connect to network (for resident outside service system	Pumping 1 truck	250,000

Source: MPWT

Next, profit and loss of Siem Reap Sewerage and Wastewater Treatment Plant Unit is shown in **Table 2.6.22**. It shows a loss in 2012 and 2013 and the loss is increasing. The loss is subsidized by the Government of Siem Reap. In addition, it is said that the DPWT burdens pumping electricity expenses in the expenditures. Additionally, operation and maintenance budget in 2015 is shown in **Table 2.6.23** for reference.

According to the interview with an official of MPWT, these treatment plant unit entities have a problem of securing customers and/or collection of user fees. Since the payment system is different from the others like Phnom Penh drainage cost recovery in which 10% of PPWSA sales is transferred automatically, it seems difficult to collect tariffs by themselves without water supply system. The reason why water supply entities do not collect sewerage user fees or user fees are based on floor areas instead of water supply use is that water supply coverage in both cases is only approximately 30% and most users are using underground water. Thus, water supply use volumes cannot be used for sewerage fees. In Preah Sihanouk case, actual connections are 1,800 accounting for 60% of the 3,000 total planned connections. SEZ is not included. Other factories, housing development and hotels are the object of sewerage. In order to include the remaining 40%, it is necessary to make an agreement with each user to enforce payment, but poor households cannot pay and the revenues from them are not so much. Therefore, they are not targeted.

The domestic users, namely, housing, are zoned A, B and C. A is a high-income class and B is a medium-income class. This C is the poor and so the user fees are set for A and B.

Condominium fees are set based on the room numbers like hotels. The treatment method is a lagoon system with natural gravity flowing down (no electricity) so that the cost is low. At present, seashore resort hotels cannot be connected to the sewer pipes without pumping up. However, Siem Reap Provincial Government is trying to regulate wastewater of the sea resort hotels and so the hotels want to connect to the sewer. Thus, the sewerage entity is examining whether sewerage use charge revenues can cover the pumping up electricity costs. 60% of the contracted users pay the fees (it is possible to stop the business if they do not pay). Big users' fee revenues are main revenues as it is shown that one brewery company payment accounts for 60% of the total revenues.

In Siem Reap, the connection rate is less than 50% and the main targets are hotels and big businesses.

Table 2.6.22 Profit and Loss of Siem Reap Sewerage and Wastewater Treatment Plant Unit

(Unit: Riels)

Description	Description		
	Code	2012	2013
I. Operating Income			
Service income	7300	228,251,300	247,612,000
Income networking services	7311	1,107,000	287,000
Total Income		229,358,300	247,899,000
I. Operating Expenses			
Materials and Sanitation	6011	2,195,400	1,567,500
Materials and maintenance of drainage	6013		1,400,000
Fuel and Diesel	6015	37,442,700	29,333,200
Office equipment and printing	6021	13,785,100	28,348,300
Uniform	6041	4,291,200	5,720,000
Electricity for at Night Market store	6061	664,600	874,000
Electricity for pumping at waste water	6061	124,691,700	109,947,800

Description	Description		
	Code	2012	2013
Clean water	6062	160,500	276,900
	Sub-total	183,231,200	177,467,700
Maintenance- repairing building	6152		1,636,000
Maintenance-repairing drainage	6153	80,637,400	25,507,100
Maintenance-repairing transportation	6156	1,954,800	3,196,800
Repairing Office equipment	6157	2,835,800	2,436,000
Repairing Technical materials	6158	6,220,000	765,000
	Sub-total	91,648,000	33,540,900
Reception for National Guests	6221	6,371,200	7,446,500
Promotions	6227		3,000,000
Expenses on press and documents	6230	67,500	810,000
Mission expenses	6242	3,023,000	315,000
Desk phone expense	6262	1,302,700	929,600
	Sub-total	10,764,400	12,501,100
Tax on transportation	6310	625,000	1,463,500
	Sub-total	625,000	1,463,500
Support for civil servants	6437	21,650,000	32,400,000
Support for staff	6440		120,000,000
Support for financial monitoring officer	6441		4,800,000
Discount 2% of income	6444		3,727,800
	Sub-total	21,650,000	160,927,800
Total Expenditure		307,918,600	385,901,000
Profit or Loss		-78,560,300	-138,002,000

Source: MPWT

Table 2.6.23 Operation and Maintenance Budget of Siem Reap Sewerage and Wastewater Treatment Plant Unit in 2015

(Unit: USD)

Item Components	Maintenance/ Repair	Staff/ Labor	Energy/ Fuel	Total
Stormwater Drainage	75,000	7,200	2,700	84,900
Sanitary Sewer	90,000	13,260	4,000	107,260
Pumping Station	22,738	6,900	11,243	40,881
STP	34,763	4,500	1,000	40,263
Total	222,501	31,860	18,943	273,304

Source: MPWT

The sewerage tariffs of Siam Reap Sewerage and Wastewater Treatment Plant Unit are shown in **Table 2.6.24** and more expensive than those of Sihanouk although category sizes are a little different. The structure is similar.

Table 2.6.24 Tariffs of Siem Reap Sewerage and Wastewater Treatment Plant Unit

(Unit: Riels)

Customer	Connection Service	Monthly Service
Private Residences		
Residence measuring smaller than 70 m^2	82,000	4,000
Residence measuring between 70 m^2 and 300 m^2	123,000	13,000
Residence measuring from 300 m^2 and up	205,000	35,000
Hotels		
Hotel, between 1-20 rooms	164,000	110,000
Hotel, between 21-40 rooms	246,000	123,000
Hotel, between 41-60 rooms	287,000	186,000
Hotel, between 61-100 rooms	410,000	522,000
Hotel, from 101 rooms and up	902,000	1,260,000
Guest Houses		
Guest House, between 1-7 rooms	82,000	30,000
Guest House, between 8-15 rooms	164,000	58,000

Customer	Connection Service	Monthly Service
Guest House, from 16 rooms and up	287,000	145,000
Restaurant		
Restaurant, 1-40 chairs	164,000	37,000
Restaurant, 41-100 chairs	205,000	46,000
Restaurant, from 101 chairs and up	246,000	187,000
Others		
Store/Parking	205,000	41,000
Service station	164,000	73,000
Nightclub/Karaoke	205,000	42,000
Government building	164,000	44,000
Monastery and other Cathedral	82,000	22,000
School	41,000	41,000
Hospitals/Clinics	205,000	62,000
Factory	287,000	68,000
Car wash place	205,000	57,000
Bank	205,000	90,000
Small business place	164,000	69,000
Supermarket	144,000	25,000
Central market	287,000	473,000
Old market	746,000	174,000
Public toilets	41,000	9,000
Pumping service and cleaning reservoir		
Reservoir type -1 (for resident)	Pumping 1 truck	120,000
Reservoir type-2 (type 1 & 2 for Hotel Restaurant Guesthouse and public building)	Pumping 1 truck	200,000
Reservoir type 3 (type 3 & 4 for Hotel Restaurant Guesthouse)	Pumping 1 truck	400,000
Reservoir not connect to network (for resident outside service system	Pumping 1 truck	250,000

Source: MPWT

(8) Materials and Equipment Procurement (Financing) Abilities

Regarding materials and equipment procurement abilities from the viewpoint of financing related to drainage and sewerage in Phnom Penh Capital City, DSD belonging to DPWT allocated approximately 3 billion Riels for new drainpipe construction in 2014 as shown in **Table 2.6.13** and **Fig. 2.6.16**. On the other hand, **Table 2.6.14** shows drainage related costs of PPCC including DSD's and pipe repair, and new construction expenses in 2014 were approximately 3.2 billion Riels. Pipe and channel cleaning expenses were approximately 4.3 billion Riels in the same year and pumping station electricity expenses were similar amount annually. Therefore, the upper limit of materials and equipment procurement abilities in normal budget seem approximately 3.2 billion Riels. Assuming USD1 is equal to 3,988 Riels, the limit is approximately USD 800,000 or 96 million yen. However, if this limit amount is used for new equipment procurement, pipe repair and new construction will not be paid and so usable amount may be much less, actually. Considering the government itself does not have enough budget, grants or loan from the international organization or foreign donors are relied on for more than that limit amount of materials and equipment procurement. The existing sewerage projects in Siem Reap and Sihanoukville, were implemented with soft loan from the international organizations such as ADB so that this drainage and sewerage project in Phnom Penh Capital City may be supported by such soft loans. In this case, there will be a possibility that the user fee revenues of sewerage entity cannot cover the investment costs that is seen in the existing two sewerage entities above. Or before that there may be issues such as loss in operational account or tariff revenue collection difficulty. Specific results are shown in **Section 4.7**.

(9) Financial Issues

The financial issue at first is that DPWT or PPCC does not have sufficient budgets and the government does not have budget surplus either as described in **Item (8)** above. Therefore, the fund for implementation of this drainage and sewerage Master Plan must be grants or soft loan from the donors. Furthermore, if the entity uses revenues, it is preferable that the entity is independent or semi-independent and the account is separated from the government general account. Nevertheless, in that case, it is considered that there are three issues as follows:

(a) Separation of drainage and sewerage costs
(b) Securing users
(c) Possibility of difficult management with tariff setting
(d) Measures to collect tariff revenues

Each issue is explained as follows:

(a) Separation of Drainage and Sewerage costs

This Master Plan project objects are both of drainage and sewerage, but main objectives of those are different for each. Drainage objective is prevention of flood and water immersion and sewerage objective is prevention or decrease of water pollution. However, in this plan, sewerage may be combined with drainage and so drained water and wastewater will be mixed so that it may be an issue to separate investment and operational costs for each. Namely, drainage is for prevention of flood and water immersion so that it is a sort of disaster prevention and the government must implement it for public safety. On the other hand, sewerage should be implemented to prevent or decrease water pollution caused by wastewater from houses, shops, offices, etc. after using water supplied and managed by an independent entity collecting tariff revenues from the users. However, if it is a combined sewer system, both are merged so that the costs are divided roughly based on the water volumes generally. While it can be separated roughly, it may be an issue whether just sewerage is feasible or that total project is implemented by an entity, but investment and operation costs can be divided and burdened by sewerage entity and the government in charge of drainage. Of course, if both are merged and the tariffs can be set high enough to manage politically and spacially, there will be no problem, but it is difficult to set the tariffs as high as water supply tariffs so that there will be no such possibility.

Namely, the first issue is how much the government can burden the drainage as public or how much the sewerage burden can be reduced and the government can burden as public drainage work in order that sewerage management can be feasible with suitable tariffs.

(b) Securing Users

Since Sewerage and Wastewater Treatment Plant Units in Preah Sihanouk and Siem Reap have issues to secure their users, it is important that the causes should be analysed and the analysis results should be used in Phnom Penh wastewater countermeasures. If the sewerage use fees are collected independently from the water use fees, securing the users (contract making) is difficult and enforcement of domestic user payment is difficult (although operation of commercial and industrial users can be stopped).

(c) Possibility of Difficult Management with Tariff Setting

Even if sewerage investment and operation cost burden is reduced to some extent and the public (government) absorbs the costs, the sewerage entity cannot expect tariff revenues like those of water supply so that there is a possibility that independent sewerage management may be difficult. Since the existing sewerage managements in Preah Sihanouk and Siem Reap have difficulty, there is a possibility that it is difficult to get a profit in operation and in case of financing by loan, financial loss may be added so that the difficulty increases. In such a case, it

may be an issue whether there is a way to make the sewerage management feasible. It can be considered that sewerage is integrated into PPWSA's water supply, which is profitable enough, but PPWSA may refuse it mainly because the supervisory ministries are different as described above and water supply and sewerage accounts should be divided. In addition, it can be imagined easily that listed PPWSA cannot integrate even unprofitable sewerage taking responsibility for shareholders into consideration. At most, it is possible that the government can contribute the dividends of PPWSA to sewerage, but they seem insufficient to finance the sewerage project.

It may be necessary to reduce sewerage investment share from the total drainage and sewerage investment and in addition, the government undertakes soft loan for sewerage, namely, shoulders repayment and/or interest payments. It is an issue whether or not the government can undertake it.

(d) Measures to Collect Tariff Revenues

Regarding sewerage tariff revenue collection, if the sewerage entity tries to collect tariff revenues by itself, there may be an issue that collection rate will be low as the existing sewerage entities in Preah Sihanouk and Siem Reap are experiencing. Therefore, they aim at commercial facilities such as hotels and restaurants rather than residences to raise the collection rate. However, there are a lot of residences in Phnom Penh and the situation is different from those of Preah Sihanouk where a lot of industrial companies exist and Siem Reap where impacts of wastewater (from touring facilities) on touring resources are important so that it seems essential to collect appropriate tariff revenues from domestic users in Phnom Penh.

Furthermore, 10% of PPWSA's tariff revenues are collected by PPWSA as drainage and sewerage tariffs at present and the revenues go to PPCC directly as shown in **Fig. 2.6.16** above and are used for drainage costs. If the new sewerage management entity is established, there will be a possibility that PPWSA's collection of drainage costs continues, but 10% of the water supply tariff revenues are not sufficient to cover the present total drainage related costs and will not seem able to cover the additional sewage treatment costs. In addition, if the sewerage tariffs exceed 10% of water supply tariff revenues, PPWSA is not required to respond to users' complaints about high sewerage tariffs so that there is a high possibility that PPWSA does not want to continue the collection for drainage. Nevertheless, it is very convenient to collect sewerage tariffs with water supply tariffs and high collection rate is expected, too.

In that case, there seem to be two issues as follows:

(i) Regulation to collect sewerage tariffs with water supply tariffs and stop water supply when the tariffs are not paid

Even if water supply and sewerage entities are different, supplied water after its use is discharged as wastewater and so water supply and sewerage can seem to be unified. Thus, if users refuse or delay to pay the combined user fee because water supply user fees added with sewerage tariffs become expensive, it will be an issue whether regulations to stop water supply are feasible or not. If this is established, there is a possibility to raise the sewerage tariff revenue collection rate.

(ii) Combined tariff collection system with water supply and burden of sewerage entity

Even if sewerage tariffs are collected with water supply tariffs, more than 10% of water supply tariff revenues as sewerage tariffs will be PPWSA's burden. Intrinsically, the sewerage entity has to collect its tariffs, but combined collection system requires the sewerage entity's joint operation of collection so that PPWSA's collection cost may decrease. It may be merits for both of them, but the sewerage entity needs to establish its systems for complaint and accident handling.

Therefore, it is necessary to coordinate with PPWSA for establishing a user fee collection system jointly. It seems that PPWSA obtains 9% of the total sewerage and drainage cost charges as a commission at present, but its suitability should be coordinated through actual cost survey.

2.7 Environmental and Social Consideration

This study is aiming to establish a Master Plan for the Sewerage and Drainage system in Penh Capital City. The project area might be limited within the polder in Phnom Penh Capital City adequately installing the drainage facilities to reduce inundation and also Sewerage Treatment Plant to improve water quality at surrounding area. The environmental feature is homogeneously equal as in the city area. Adequate consideration to the social impact is expected.

2.7.1 Legislation related to Environmental Consideration

In Cambodia, the Law on Environmental Protection and Natural Resource Management, 1996 (Kram/NS-PKM-1296/36, 1996, 24 Dec.) provides general policy on environmental protection as the principal environmental law. Based on the law, the Government of Cambodia (GOC) should manage the environment deliberately under a periodical National and Regional Management Plan which is supposed to be prepared and revised every 5 years. The requirement of the Environmental Assessment at the project is also included in the law. Private and public project should refer to the law in conducting the required study depending on the scale and location (**Table 2.7.1**).

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

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

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

Table 2.7.1 Legislation related to Environmental Assessment and Protection

No.	Legislation	Description
1	Preah Reach Kram/NS-PKM-1296/36, 1996, Law on Environmental Protection and Natural Resource Management (18 November 1996)	As the principal law on environmental protection, the law provides for a national environment policy, national and regional environment plans, assessment of impact on the environment of projects and activities, management of natural resources, monitoring, data collection and inspection, and participation of the public in relation to the environment. It also prescribes penalties for offences defined in this law. Regarding environmental assessment, the requirement of environmental impact assessment on every private and public project is prescribed in Article 6 and public participation is described in the Chapter VII about the information provision to the public and dissemination by the government.
2	No. 72 ANRK.BK, 1999, Anukret (Sub-decree) on Environmental Impact Assessment (EIA) Process (11 August	This Sub-decree provides the detailed guidelines for implementation of the IEIA/EIA Process. The projects which require environmental assessment are listed in the Annex. The sub-decree consists of

No.	Legislation	Description
	1999)	Institutional Responsibilities, EIA required projects, Procedures of EIA Process, Conditions for Approving Project(s) and Penalties. Its Annex requires the conduct of IEIA/EIA on the following activities under the Project: (i) waste processing, burning activities, all sizes; (ii) wastewater treatment plants, all sizes; and (iii) drainage systems, >5,000 ha. The Sub-decree has no stipulations on environmental assessment requirements for flood protection dykes, riverbank protection and local roads.
3	No. 376 BRK.BST, 2009 Prakas(Declaration) on General Guideline for conducting IEIA1/EIA Reports, 2009	Declaration on General Guideline for Preparing Initial Environmental Impact Assessment (IEIA) and EIA Reports was issued by the Ministry of Environment (MOE) in 2009. The declaration also provides the timeframe and required documents for submission at the approval process in IEIA and EIA. Annex-1 specifies the basic contents of IEIA/EIA Reports: (i) introduction; (ii) legal framework; (iii) project description; (iv) description of the existing environment; (v) public participation; (vi) assessment of, and mitigation measures for significant environmental impacts; (vii) environmental management plan; (viii) cost-benefit analysis; and (ix) conclusion and recommendation. The format for the environmental checklist is provided in Anex-2.
4	No.27 ANRK/BK/1999, Anukret(Sub-decree) on Water Pollution Control, 1999(April 6, 1999)	This Sub-decree regulates activities that cause pollution in public water areas in order to sustain good water quality so that the protection of human health and the conservation of biodiversity are ensured. This consists of 39 articles in 8 chapters with 5 annexes regarding general definition, permission, monitoring, inspection and penalties. Annexes 2, 4 and 5 provide the industrial effluent standards, including effluent from wastewater stabilization ponds, water quality standards for public waters for the purpose of biodiversity conservation, and water quality standards for public waters and health, respectively.
5	No.36 ANRK.BK. in 1999, Anukret (Sub-decree) on Solid Waste Management, 1999	This Sub-decree regulates solid waste management to ensure the protection of human health and the conservation of biodiversity. This consists of 32 articles in 6 chapters with Annex regarding general definition, house waste and hazardous waste management and those monitoring, inspection and penalty for offence. Responsibility of the Ministry and province on house waste management and also responsibility of owner of the hazardous waste including storage and transport which should be strictly handled separately from house waste are provided.
6	No. 42 in 2000, Anukret (Sub-Decree) on the Control of Air Pollution and Noise Disturbance, 2000 (July 10, 2000)	This Sub-decree provides for the management, prevention and control of air and noise pollution, detailing in the Annexes the threshold values for emissions, outlaying the procedures and legal requirements to limit and provide for the pollutants. Following standards are included and those are: Annex 1, Ambient Air Quality Standard; Annex II, Maximum Allowable Concentration of Hazardous Substance in Ambient Air; Annex III, Maximum Allowable Standard of Pollution Substance for Immovable Sources in Ambient Air; Annex 4, Gas Emission Standard of Mobile Source; Annex 5, Maximum Standard of Noise Emission Level Allowable for Vehicles on Public Roads; Annex 6, Maximum Standard of Noise Level Allowable in the Public and Residential Areas (dB(A)); Annex 7, Noise Control Standard at Workshop, Factory and Industry; and Annex 8, Standard of Sulfur, Lead, Benzene, and Hydrocarbon Permitted in Fuel and Coal.
7	No. 745 MEF/MOE 2000, Prakas (Joint Declaration) between MOE and MEF on Determination of Service Fee for EIA reviewing and Monitoring (20th October 2000)	This declaration provides the fee for the environmental services. The fees are determined depending on the categories. The categories are Industrial, Agriculture, Tourism, and Infrastructure. In case of Wastewater Treatment Plants 2,000,000 Riel is charged for all sizes of project.
8	No. 07 NS/RKM/2008, Protected Areas Law (Royal Decree No. NS/RKM/2008/007)	This Law provides for the management, conservation and development of natural protected areas to ensure the conservation of biodiversity and guarantee the use of natural resources in a sustainable manner consisting of 11 Chapters divided into 66 articles The Law classifies natural protected areas into eight categories as follows: 1) National Parks; 2) Wildlife Sanctuaries; 3) Protected

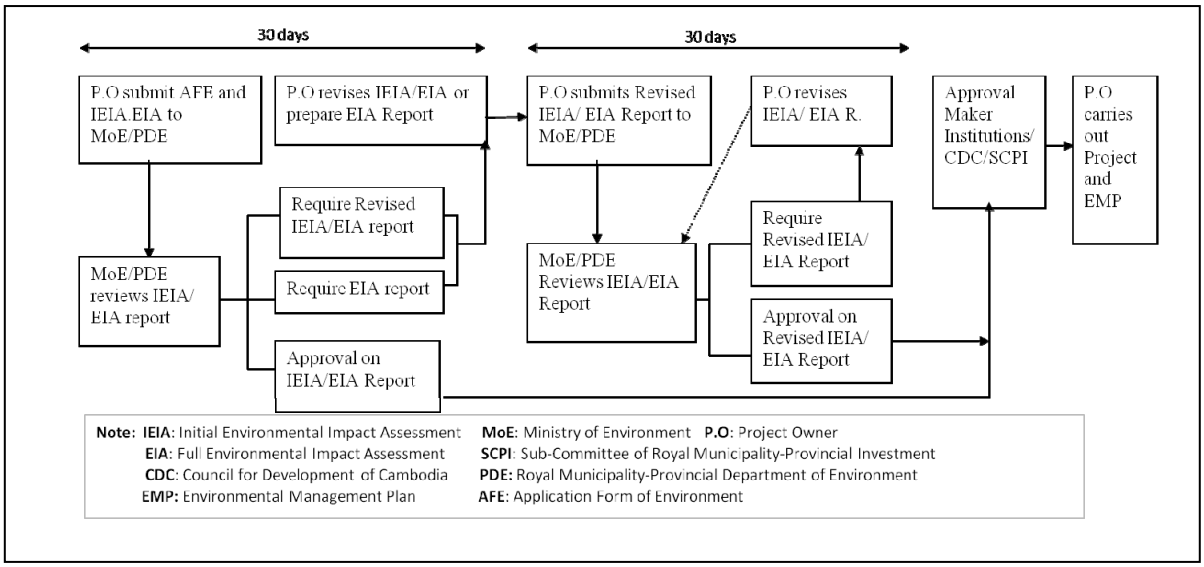
No.	Legislation	Description
		Landscapes; 4) Multi-Use Areas; 5) Ramsar Sites; 6) Biosphere Reserves; 7) Natural Heritage Sites; and 8) Marine Parks. Each natural protected area shall be divided into four management zoning systems: 1) Core zone; 2) Conservation zone; 3) Sustainable use zone; and 4) Community zone. The Law recognizes the power of the Ministry of Environment to manage natural protected areas developing a National Protected Area Strategic Management Plan.
9	No. 1033, 1994, Prakas (Declaration) on Protected Areas, 1994	This "Prakas" (Declaration) of the Ministry of the Environment prohibits a series of acts in natural protected areas in the sense of Royal Decree of 1 November, 1993 on the Protection of Natural Areas. Prohibited activities include construction of sawmills, hunting, placing of traps, fishing of mammals, amphibians, reptiles and aquatic animals for specified purposes, deforestation for land use, water pollution and other forms of pollution of the environment, etc. Research and experimenting requires approval of the Secretariat of the Environment. The Nature Conservation Department of the Secretariat shall implement this Declaration.
10	No. 230 in 2005, Prakas (Declaration) on the Delegation of Power of Decision-Making on Project Development to the Provincial Department of Environment, 2005	Declaration on the Delegation of Power of Decision-Making on Project Development to the Provincial Department of Environment (PDOE), 2005, provides for the PDOE to be the reviewing and approving authority of IEIA/EIA reports of projects costing below USD 2 Million.

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

2.7.2 EIA Process in Cambodia

(1) EIA Process in the Country

As shown in the flowchart below (**Fig. 2.7.1**), the project owner firstly submits the Environment Application Form together with his report to the competent authority, which means, the Ministry of Environment (MOE) or the Provincial Department of Environment (DOE). In case of the project, which exceeds 2 million USD of project cost, the application form with report is reviewed by MOE. After the authority has reviewed the report, it may require the project owner to revise the report or implement further study as the Environmental Impact Assessment (EIA). Should the environmental study fulfill the requirement of the authority, the report is approved by Capital City or DOE in provinces and forwarded to the Council for Development/Sub-Committee of Royal Municipality, Provincial Department of Environment for the approval of project implementation.



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

Fig. 2.7.1 Flowchart of the IEIA/EIA Process for National Level Projects

(2) Organization to Handle Environmental Matters

The Ministry of Environment (MOE) is the authority on environmental assessment in the country. Within the MOE, the Department of the Environmental Impact Assessment Review is in charge of the process. The organizational chart of MOE is shown in **Fig. 2.6.9**.

Under the supervision of MOE, the Department of Environment (DOE) as one of the specialized departments in Phnom Penh Capital City (PPCC), is in charge of the environmental assessment process on the municipal/provincial level. The organizational structure is slightly different among the provinces and the structure in Phnom Penh City is shown in **Fig. 2.6.10**.

Based on the "Declaration on the Decentralization for Environmental Municipal/Provincial Department and the Declaration on the Power of the Delegation to the Decision-Making on Project Development for Environmental Municipal/Provincial Department 2005", projects of less than 2,000,000 USD of capital investment is under the responsibility of the Municipal/Provincial authority and the project of 2,000,000 USD or more is under the responsibility of the MOE. The department has approximately 70 staff members and 8 of them are assigned in the EIA office for the EIA-related works.

(3) Gap between Cambodian Legislation and International Standards

There is no large gap between the Cambodian Government's environmental framework and the JICA guidelines in terms of contents and monitoring items. However, in terms of timeframe, the Cambodian legislation allows special cases to be exempted by the government as described in Article 2 of the Sub-Decree. Some priority cases recognized by the government are allowed to be processed without following the established procedure. Also, SEA application is not clearly described in the Cambodian legislation, although principal ideas such as contents and timing of the environmental study are covered to meet the JICA guidelines. In the present study, relevant organizations are encouraged to implement environmental and social considerations at the early stage, through the explanation of the SEA. (Gap analysis is described in detail in **Appendix 1**).

As an information disclosure, public participation is described in the sub-decree to be involved at the EIA process as an objective of Article-1 of the sub-decree (No. 72 ANRK.BK Phnom Penh, August 11, 1999). However, the detail procedures such as number of participants in the meeting is neither particularly provided in any Sub-Decree nor the guideline. In the Annex 1 in the declaration on general guidelines for EIA (No. 376 BRK.BST. 2009) defines public participation

to involve all concerned stakeholders such as ministries/institutions, local authorities, departments, project owners, consulting companies, representative of affected people and non-government organizations (NGOs). The report to be prepared shall include an introduction, conduct of public consultation dissemination for the authorities and local communities about development projects, commentaries from relevant ministries, institutions, departments and local authorities, commentaries from relevant NGOs and local people, and conclusion on the results of the public consultation.

(4) Legislation and Procedures for Environmental Study on Sewerage and Drainage Project Development

As described in the former section, the Environmental Assessment required projects are prescribed in the Annex in the sub-decree, No. 72 ANRK.BK, 1999. The present study aims to develop physical countermeasure for the sewerage and drainage issues in Phnom Penh Capital City. According to the Sub-decree, the expected activities within the current project may be related to (i) waste processing, burning activities, all sizes; (ii) wastewater treatment plants, all sizes; and (iii) drainage systems, ≧5,000 ha in the Annex.

2.7.3 Legislation and Legal Procedures for Resettlement and Land Acquisition for Development

(1) Legislation on Resettlement and Land Acquisition

There is no major change of legislation related to resettlement and land acquisition after the preparatory survey in 2014. The resettlement process in the country follow different legislations depending on the land status, private land or public land. The legal framework for resettlement and land acquisition is summarized in **Table 2.7.2**.

Table 2.7.2 Legislations related to Resettlement and Land Acquisition

No.	Legislation	Description
1	NS/RKM/0801/14, 2001, Land Law (August 30, 2001)	The law provides the distribution and management of land in Cambodia as well as protect property rights. This basic land legislation covers 8 Titles: (I) Private and Public Ownership; (II) Acquisition of Ownership; (III) The Regime of Private Ownership; (IV) Forms of Ownership; (V) Immovable Property used as Surety; (VI) Cadastre; (VII) Penalty Provisions; and (VIII) Final Provisions. Besides ownership of public property, private ownership such as individual and collective private ownership, are defined.
2	No. 224 in 1996 Ministry of Economy and Finance, Prakas (Declaration) on Collection of Tax on Unused Land (1996)	The declaration defines taxable unused land not falling under the following characteristics: 1) Land with construction located in a residential area in which the owner uses as his principal place of residence for 183 days or more. 2) Land possessed and rented with construction that generates a monthly income of more than 80% of one-twelfth of the land value. 3) Land of legitimate economic activities as determined by the state with the monthly revenue from such activities of more than 80% of one-twelfth of the land value in a tax collection year. 4) Land which belongs to the state and leased to a legal entity or physical person. 5) Land under an investment contract, the performance of which has not been started due to force majeure or unavoidable causes.
3	No. 118 in 2005, Anukret (Sub-Decree) on State Land Management (2005)	The Sub-decree provides the framework for state land management with 11 chapters and 33 articles in total. The sub-decree provides legal definition of state land and the differences between public and private state lands, processes of state land identification and mapping, and the roles of corresponding responsible actors, processes to classify/reclassify the land, procedures to maintain/update the State Land Map and Database as well as the access rights to the database, Trustee's mandate

No.	Legislation	Description
		and administration of the land.
4	Royal Decree NS/RKT/0806/339, 2006, on Provisional Guidelines and Principles Regarding the Reclassification of State Public Properties and of Public Entities (8 August 2006)	The Royal Decree determines the principles and transitional provisions involving the transfer of public properties of the state and legal public entities. The Royal Decree requires that state public land may only be reclassified if certain conditions are met, principally that the land no longer serves the public interest, has lost its originally intended function, or is no longer used directly by the public.
5	Anukret (Sub-Decree) No. 129/ANK.BK, 2006 on Rules and Procedures for Reclassification of State Public Properties and Public Entities (2006)	This sub-decree was signed by the Prime Minister which states that any reclassification of state public land must comply with the Royal Decree (2006).
6	No. NS/RKM/0210/003, Expropriation Law (February 26, 2010)	This Law defines the principles, mechanisms, compensation and procedures for expropriation relating to construction, rehabilitation and expansion of public physical infrastructure in Cambodia. The Law stipulates that only the state may expropriate property for the public benefit or state interest. The Law also requires an expropriation committee to be managed by a representative of the Ministry of Economy and Finance, with representatives from other government bodies. The Expropriation Committee shall prepare an "expropriation project proposal" subjected to be reviewed and approved by the Royal Government. The amount of compensation is determined based on the market price or replacement cost as of the date of the issuance of the declaration on the expropriation project provided in the Article 22. The market price or the replacement cost is supposed to be determined by an independent committee or agent appointed by the Expropriation Committee.
7	Circular (Letter) No. 02 S.R 2007, related to illegal occupation of state land (February 22, 2007)	Supplementing the Land Law (2001), this circular provides the policy/ principle for dealing with illegal occupants in the state land. In principle, people occupying state land illegally have no right to ask for compensation, but possibly guilty as stated in the Land Law 2001(6.2). However, in case of poor families who have no land, etc., Royal Government (RGC) support to provide land with appropriate dimension so that they can exploit it for their living, or building a house under the condition in Item 7 of the Circular.
8	Circular (Letter) No. 03 S.R 2010, Circular on Settlement of illegal construction on state land in cities and urban areas	The circular aims to provide solution to illegal constructions in state land. The works are supposed to be done through Capital/Provincial State Land Management Committees with the state land working groups in the municipalities, districts/khans. The provided work steps are: 1) Collecting data and information about the specific location of the illegal construction. 2) Identifying, mapping and classifying the location of the illegal construction. 3) Conducting census of the household and population living in the location of illegal construction. 4) Providing solutions such as resettlement, on-site development, and other realistic policy options. 5) Coordinated consultation to define the policy measure. 6) The physical infrastructures and basic services must be prepared in advance. 7) Participation by the relevant development stakeholders.
9	Sechkdey Prakas (Declaration) No. 06 BRK 1999 on the Measure of Eliminating Anarchical land Encroachment	This provides the required measures to be taken by the government against anarchical land encroachment: 1) No provision of private right on state land. 2) Prohibition of issuance of application form for land possession. 3) Investigation of illegal land encroachment by the authorities. 4) Responsibility of the local government. 5) Cooperation of the National Police, Royal Armed Forces and Military Region. 6) Ban on illegal encroachment activities.

No.	Legislation	Description
		7) Investigation by the ministries. 8) ROW for the National Road and Railway. 9) Role of the Ministry of Interior in collaboration with the Ministry of Public Works and Transport, the Ministry of LMUPC, the Ministry of National Defence and the Ministry of Economy and Finance. 10) Immediate action for the National Road and Railway by authorities. 11) The Provincial/Municipal Land Dispute Settlement Commission throughout the country shall investigate the implementation of the measure.
10	Circular (Letter) No. 06 S.R 2015 on Procedure to Implement Resettlement of Development Projects	This will ensure the action required by the implementation agencies in: A. Project Feasibility Study Stage; and B. Resettlement Plan Implementation Stage and Post Resettlement Plan Implementation Stage. In principle, the circular states completion of resettlement work before commencing the civil works on any development project. This also requires all Ministries/Institutions to prepare an initial resettlement plan at the feasibility study stage.

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

(2) Land Tenure in Cambodia

Land Law (2001) NS/RKM/0801/14, August 30, 2001, provides land possession in the country including private and public immovable properties. The law replaced the previous land law in 1993 taking recognition of officially denying land ownership prior to 1979. The land in the country is defined as private and state properties, i.e., private land and state land. Private property in the country is allowed individual ownership and collective ownership, exclusively for Cambodian citizens and entities defined in the law. Ownership and Extraordinary Acquisitive Possession are legally recognized as land title for private land. State land is divided into state private land and state public land as described later.

Under the land law (2001), Sub-Decree No. 118: State Land Management (2005) provides the principles, procedures, mechanisms and mapping of state land; registration and classification of state land, creation and maintenance of a State Land Database, allocation and management of state land and reclassification of state land (Article 1). The sub-decree defines land in the country as state land and private land. State land is classified in two; State Public Land and State Private Land. State Public Land is designated for public purpose and State Private Land is used for concession lease such as Social Land Concessions and Economic Land Concessions.

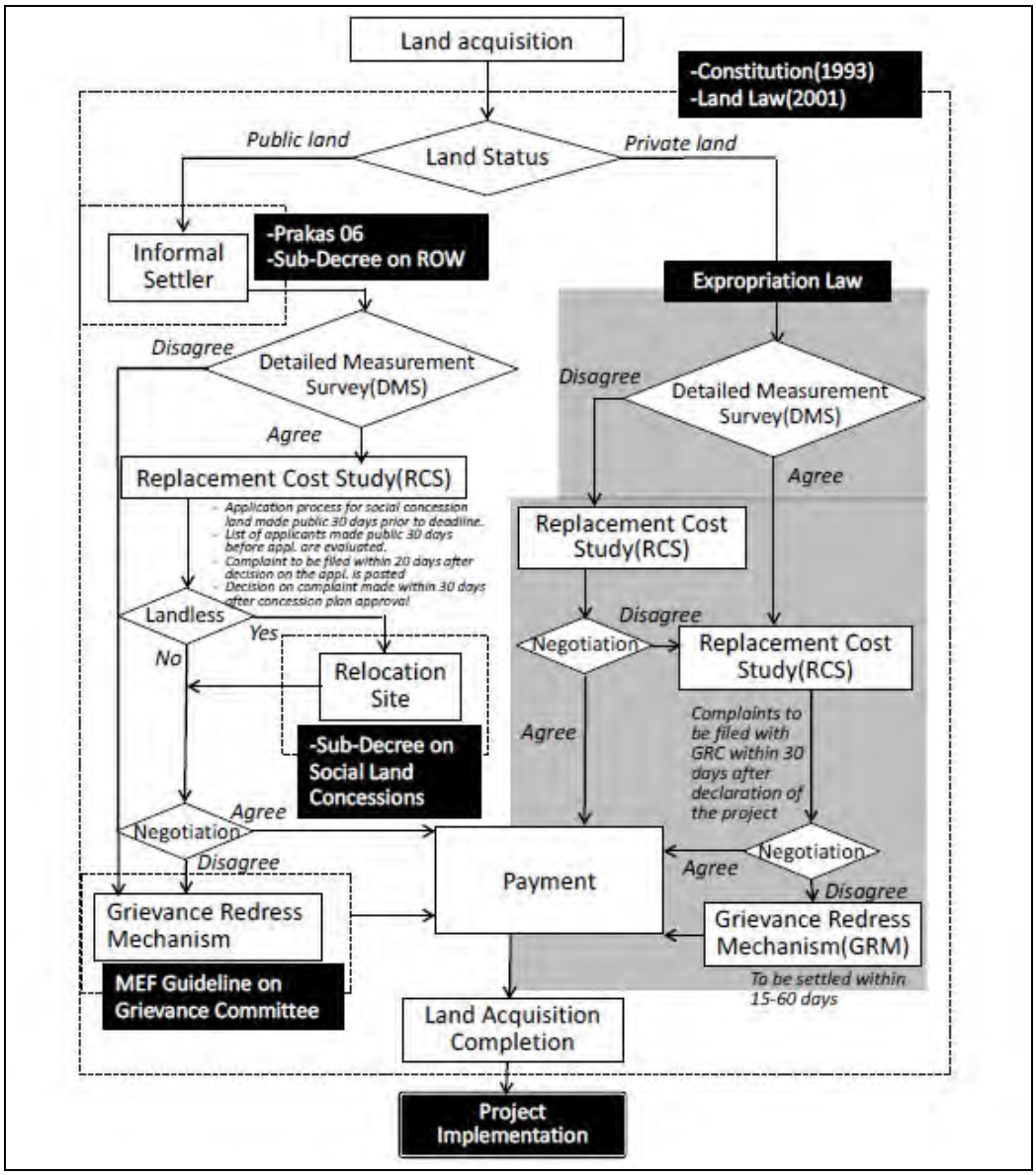
(3) Procedure of Land Acquisition

Acquisition of private land for the public interest shall be in accordance with the Expropriation Law (No. NS/RKM/0210/003, 2010). On the other hand, the acquisition of state land should be in accordance with the Sub-Decree on State Land Management (Sub-Decree No. 118) and it may follow the Prakas (Declaration) No. 06, 1999, on measures to crack down on anarchic land grabbing and encroachment if the area is occupied illegally and also Circular No. 02, S.R 2007, if "related to illegal occupation of state land" and Circular No. 03, S.R 2010, if it involves the "settlement of illegal construction on a state land in cities and urban areas". In any case, a survey should be conducted to identify the situation (**Fig. 2.7.2**).

The Expropriation Law (No. NS/RKM/0210/003, 2010) defines the principles, mechanisms, compensation and procedures for expropriation of private properties relating to construction, rehabilitation and expansion of public physical infrastructure in Cambodia. The Expropriation Committee shall prepare an "expropriation project proposal" subject to the review and approval by the Royal Government. The amount of compensation is determined based on the market price

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

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



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

Fig. 2.7.2 Flowchart of Land Acquisition

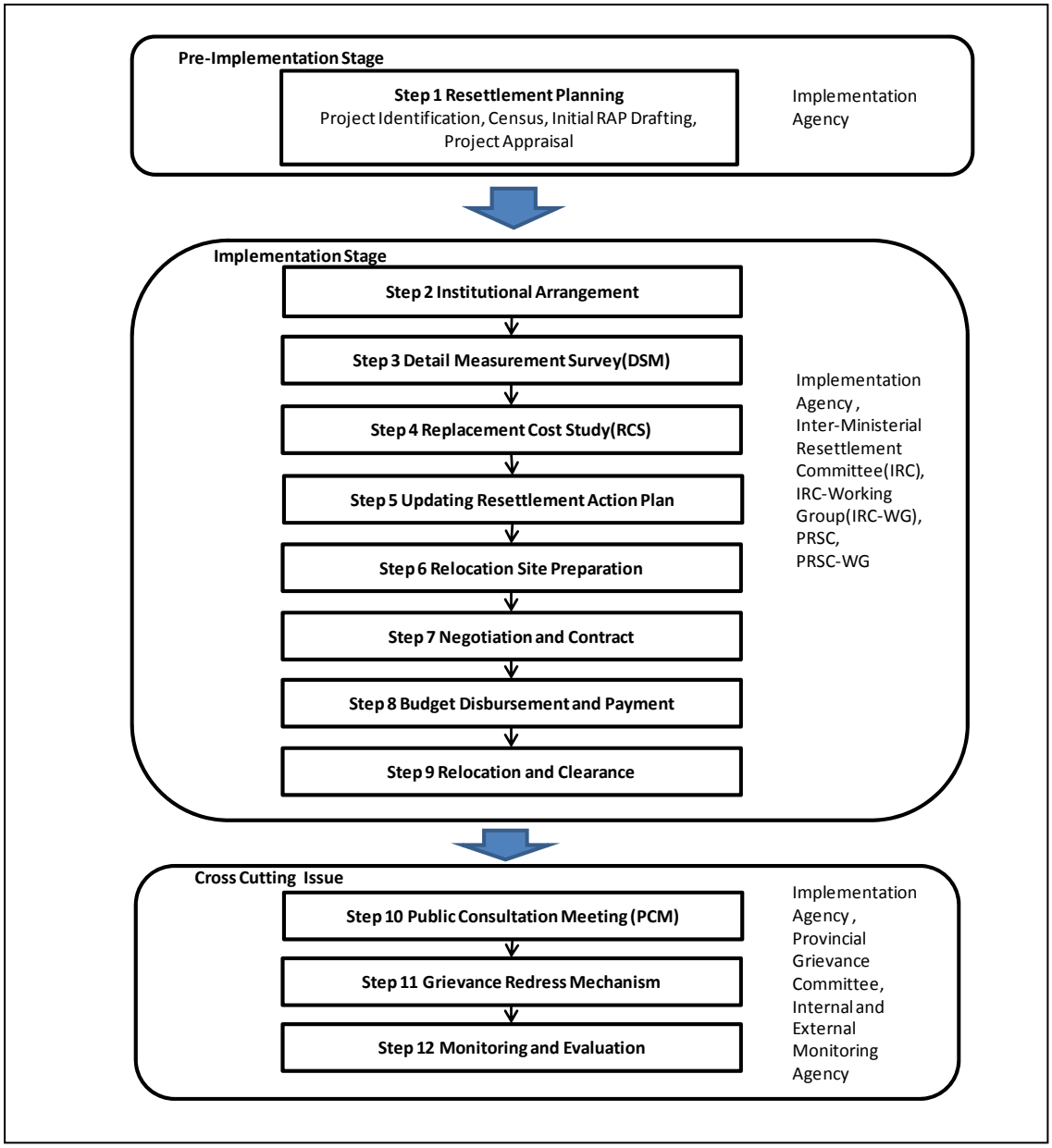
(4) Resettlement Framework in the Country

Resettlement framework is explained in the Standard Operating Procedures for All Externally Financed Projects/Programs in Cambodia (2012, Ministry of Economy and Finance).

The Inter-Ministerial Committee (IRC) was established by the Royal Cambodian Government (RCG) with permanent members within the MEF in 2007 for dealing with the

resettlement issue. The IRC is supported by a newly created Resettlement Department (RD) within the MEF, which is staffed by well-qualified and trained personnel through the JICA and ADB support. The RD assists line ministries to prepare resettlement plans and to have these plans funded and executed, especially, for the Ministries and agencies which do not currently have resettlement units.

All resettlement matters are handled on the central government level, i.e.; the Inter-Ministerial Committee. In the case of resettlement in the project by PPCC, the Department of Public Works will work for the land investigation based on the Aerial Photo. Then, the result of the investigation is submitted to PPCC and PPCC (The City Governor) will thus request the central government to convene the Inter-Ministerial Committee. **Fig. 2.7.3** shows resettlement framework in Cambodia.



Source: JICA Study Team based on the MEF (2012), Basic Resettlement Procedure

Fig. 2.7.3 Workflow of Resettlement Process

2.7.4 Requirement of Study and Assessment of Environmental and Social Consideration in Next Phase

The legislation in the country does not require Strategic Environmental Assessment (SEA) for the Master Plan stage, although the JICA Environmental and Social consideration guideline (2010) does. Here, the SEA level of the study is supposed to be conducted through disclosure of the project at the early stage to obtain feedback for finalizing the Master Plan level decision. A range of the information disclosure of the project/plan to stakeholder is planned to be conducted through the workshops at the time of Progress Report I and II as well as Draft Final Report.

The programs for the Master Plan will be selected strategically considering the environmental situation. The environmental feature will be confirmed in terms of the environmental impacts having opportunities of stakeholder's consultation to reduce the risk of the impact. The tentative Terms of Reference (TOR) for the study at the Master Plan stage is as shown in **Table 2.7.4**.

Table 2.7.3 Terms of Reference (TOR) for Initial Environmental Examination (IEE) to be prepared

	Items	Required Contents	Resources and Methodology to be taken
1	Introduction	• Project overview: Briefing project background, reasons of the formative project and general situation on the project site. • Objectives of preparing the EIA report. • Methodologies and Scope of Study: This point must be described: the information, the data needed, methodologies of data collection, and data analyst. In case of FEIA report, the project owner shall study methodologies in detail and develop separable new chapter.	Compilation from the results of Technical Review at the progress 1.
2	Legal frameworks	A description of laws, sub-decrees and various policies related to project.	The analysis of legislation related to environmental and social considerations in the country is ongoing at the first stage of the study. The result will be used.
3	Project Description	A description of the project details such as background, owners' experience, Project site, Project type/scope and time of project activities, Action plan of work and Activities program of the project.	Compilation from the result of Technical Review at the progress 1.
4	Description of Environmental Resources	A description about the natural environmental and socio-economic resources (primary and secondary data) in and surrounding the project location included: • Natural Environmental Resources (Physical & Biological) • Socio-economic Resources	Secondary Data from the MOE/DOE or others; e.g., Mekong Wetlands Biodiversity Conservation and Sustainable Use Program, Ramsar site, IUCN websites. This will be compiled from the result of the socio economic study in progress report 1.
5	Public participation	Report on the Public Consultation	The report on the Stakeholders meeting will be prepared.
6	Environmental Impacts and Mitigation Measures	A description of both positive and negative environmental and socio-economic resources impacts arising from their projects' activities; impacts during the project pre-operation (the project design and construction), operation and abundant with mitigation measures, etc.	Drafting of tentative measure by Environmental Specialist based on the result of the Preparatory Study (2014) and confirmation of the measure to the implementation agency.
7	Environmental Management Plan	A description of the draft environmental management plan that the implementation agency should take measure for the impacts, establish a fund and an office with qualified technical staff, appropriate equipment, methodologies and a well-prepared schedule for monitoring environmental quality in close collaboration with relevant institutions in order to mitigate negative socio-economic and environmental resource impacts to a minimum level.	Drafting of tentative measure by Environmental Specialist based on the result of the Preparatory Study (2014) and confirmation of the measure to the implementation agency.
8	Conclusion and	A conclusion of environmental impact assessment	Drafting of tentative measure by

	Items	Required Contents	Resources and Methodology to be taken
	Recommendations	indicating the minimization of impacts to physical, biological and socio-economic resources.	Environmental Specialist based on the result of the Preparatory Study (2014) and confirmation of the measure to the implementation agency.

Source: JICA Study Team

2.8 Social Survey

2.8.1 Outline of Social Survey

A social survey was implemented by sub-contract to know general citizens' impressions, satisfactions and expectations for sanitation, sewage and drainage facilities in Phnom Penh and to include the results in the Master Plan. The survey conducted interview with 100 households as shown in **Table 2.8.1** and **Fig. 2.8.1.** The number of samples in each Khan is determined in consideration with uniform spacial distribution in PPCC. Questionnaire entries are summarised in **Table 2.8.2**.

Table 2.8.1 Number of Samples in each Khan

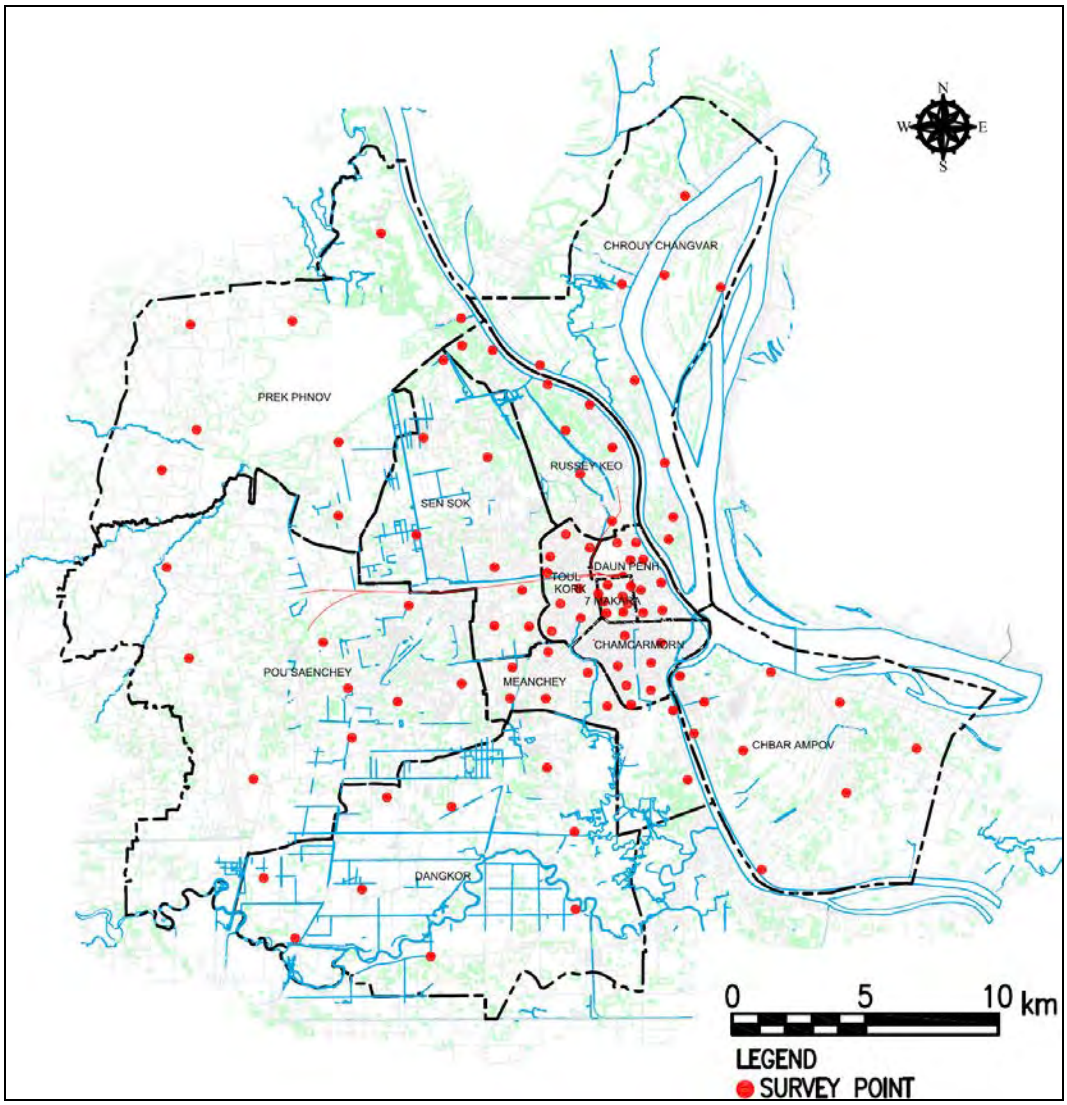
District (Khan)		Number
1	Daun Penh	8
2	7 Makara	8
3	Chamkarmon	8
4	Tuol Kok	8
5	Sen Sok	8
6	Reussey Keo	8
7	Meanchey	8
8	Prek Pnov	8
9	Dangkor	9
10	Po Senchey	9
11	Chroy Changvar	9
12	Chbar Ampov	9
Total		100

Source: JICA Study Team

Table 2.8.2 Questionnaire Entries

Section	Question
General Information	- Type of interviewee, Address, Employment of the master, Number of persons staying in the house, Dwelling years at house, Type of dwelling, House expenditure, and Experience on waterborne diseases
Situation of sewerage measures and sewerage treatment; Willingness to connect sewer pipe and to pay for sewerage system	- Facility for sewage water (Installation of septic tank, etc.) - Method of desludge (Manual or vacuum, agency of desludge, etc.) - Frequency of desludge, Cost of desludge - Satisfaction of current septage management system by PPCC - Willingness to sewer connection and willingness to pay sewerage fee - Needs of reuse of treated water for agricultural use - Needs of compost/fertilizer using treated sludge
Present condition of drainage system; inundation condition	- Present condition of installation of drainage facilities - Satisfaction in current drainage management system - Inundation condition (Depth, Frequency and duration of inundation, etc.)
Present condition of water supply system	- Status of connection to tap water - Satisfaction to current water supply system and amount of water charge

Source: JICA Study Team



Source: JICA Study Team

Fig. 2.8.1 Location Map of Social Survey Points

2.8.2 Result of Social Survey

The results of social survey are as follows.

(1) General Information

Eighty-three percent (83%) out of 100 interviewees are family heads. Regarding employment of family head, 84% of heads are working in tertiary industry, followed by 10% in primary industry and 3% in secondary industry. The average of number of persons living in a house is 5.7 persons. The average of residential duration is 20.5 years. The ratio of owned houses is 84%.

The expenditure for the house per month is shown in **Table2.8.3.**

Table 2.8.3 Expenditure of Household per Month

	Total expenditure of house per month (USD)							
	Less than 100	101-200	201-500	501-1,000	1,001-2,000	More than 2,001	Unknown	Total
Number of answers	3	27	55	10	2	3	0	100

Source: JICA Study Team

Incidence of waterborne diseases is shown in **Table 2.8.4**. Diarrhea and others (itch, etc.) showed high incidence. Chamkamon is the highest in incidence by district (khan).

Table 2.8.4 Incidence of Waterborne Diseases

District (Khan)		Diarrhea	Hepatitis	Typhoid	Cholera	Malaria	Dengue Fever	Dysentery	Others	Total
1	Daun Penh	2	0	0	0	0	0	1	3	9
2	7 Makara	3	2	3	0	1	1	0	1	14
3	Chamkarmon	6	0	1	2	1	1	1	6	19
4	Tuol Kok	2	0	0	0	0	1	0	0	3
5	Sen Sok	0	0	0	0	0	1	0	1	2
6	Reussey Keo	2	0	2	0	0	1	2	1	14
7	Meanchey	3	0	1	0	0	0	0	3	12
8	Prek Pnov	0	0	2	0	0	0	0	1	3
9	Dangkor	1	0	1	0	0	0	1	2	12
10	Po Senchey	0	0	0	0	0	0	0	0	0
11	Chroy Changvar	1	0	1	0	0	0	0	1	8
12	Chbar Ampov	1	0	0	0	0	0	0	3	10
Total		21	2	11	2	2	5	5	22	106

Source: JICA Study Team

(2) Sanitation and Sewerage System

Eighty-seven households out of 100 are using septic tank, followed by 8 households disposing sewage into natural water such as pond and marsh, as well as 4 households disposing sewage into drainage facilities directly. One family has no toilet.

Forty-six households (53%) out of 87 households having a septic tank desludge their septic tank but remaining forty-one households (47%) do not desludge their septic tank. House owners most likely call vacuum car/worker for desludging when their septic tanks are filled up by sludge. Thirty-nine households out of 46 desludge by vacuum car, and remaining by manual labour. The frequency of desludging is once in 2 to 5 years (20 households, 44%), followed by once in a year (9 households, 20%) and once in 5 to 10 years (9 households, 20%). Large part of the houses pays 20-40 USD for desludging, as shown in **Table 2.8.5**.

Table 2.8.5 Cost for Desludging

	Cost of desludge (USD)					
	10--20	20 -30	30-40	40-50	50-60	Total
Number of answers	1	12	15	8	3	39
Ratio (%)	2.6	30.8	38.5	20.5	5.0	100.0

Source: JICA Study Team

Only ten out of 41 households not desludging, want desludging services. The family not being satisfied with the current septage management system, accounts for 67% out of 100 households. Moreover, 92% of households agreed that PPCC manage and administer the septage management services, showing their high expectation about PPCC's commitment.

Willingness to sewer connection, if sewer pipe is installed around their house, is very high with 89 households. However, payable sewerage fee per month is less than 1.50 USD per month in more than 90% households, as shown in **Table 2.8.6**. The amount of less than 1.50 USD per month would be equivalent to about 10-20% of water charge they paid (about 5-10 USD, as discussed later).

Table 2.8.6 Willingness to Pay Sewerage Fee per Month

	Willingness to Pay per Month (USD per Month)								
	0.25-0.50	0.50-1.00	1.00-1.50	1.50-2.00	2.00-2.50	More than2.50	Not Willing	No Answer	Total
Number of answer	7	39	36	2	1	3	1	11	100
Ratio (%)	7	39	36	2	1	3	1	11	100

Source: JICA Study Team

On the other hand, of 100 households, 77 answered “no need” or “have no farm land”, showing very low need for reusing treated water for agricultural use. Seventy-nine households have no experience using compost/fertilizer converted from sewage sludge, showing their less experience.

(3) Drainage System and Inundation Condition

Sixty-six households out of 100 have drainage facilities around their house. Thirty-nine households (66% of 66 households) are not satisfied with the function of the drainage facilities, with the reasons of experiencing inundation more than 2 times per year or every time heavy rain arises. On the other hand, thirty households, which are 88% among the 34 households who have no drainage facilities around their house, wish installation of drainage facilities around their house.

Fifty-eight households have an experience of inundation around their house. The frequency of inundation is summarized in **Table 2.8.7**. Most interviewees answered “Others” has experiences of inundation every time heavy rain arises.

Table 2.8.7 Frequency of Inundation

	Once a year	More than once a year	Once in 2-3 years	Others	Unknown	Total
Number of answers	1	33	0	23	1	58
Ratio (%)	1.7	56.9	0.0	39.7	1.7	100.0

Source: JICA Study Team

Depth and duration of inundation are shown in **Table 2.8.8** and **Table 2.8.9**. As shown in the tables, depth of inundation reaches mostly up to shin and duration last for mostly 2-3 hours.

Table 2.8.8 Depth of Inundation

	Up to ankle	Up to shin	Up to knee	Up to thigh	Up to waist	Total
Number of answers	12	27	15	3	1	58
Ratio (%)	20.7	46.6	25.9	5.2	1.7	100.0

Source: JICA Study Team

Table 2.8.9 Duration of Inundation

	Less than 30 minutes	30 minutes to 1 hour	2-3 hours	4-6 hours	Almost half day	More than half day	Unknown	Total
Number of answers	10	16	15	3	1	10	3	58
Ratio (%)	17.2	27.6	25.9	5.2	1.7	17.2	5.2	100.0

Source: JICA Study Team

Troubles due to inundation are summarized in **Table 2.8.10**.

Table 2.8.10 Troubles due to Inundation

	Cannot go out to work/school	Cannot open for business	Soil the furniture, merchandize or inside house	Smell in the house	Others	Unknown
Number of answers	30	28	26	32	15	5

Source: JICA Study Team

Inundation conditions obtained in the social survey are presented in **Fig. 2.1.19**.

(4) Water Supply

Eighty-two households use tap water, and remaining 18 households do not use tap water. The area where many households do not use tap water is Dangkor and Prek Phnov districts. Water charge per month of eighty-two households is shown in **Table 2.8.11**. Seventy-five percent (75%) of households are satisfied with the function of tap water in consideration of water charge they paid.

Table 2.8.11 Water Charge per Month

Water Charge	Answer	Ratio (%)
Less than 5USD	25	30.5
5USD-10USD	35	42.7
10USD-20USD	16	19.5
More than 20USD	5	6.1
No Answer	1	1.2
Total	82	100.0

Source: JICA Study Team

2.9 Survey on Solid Waste in Drainage Channels

2.9.1 Present Condition of Solid Waste Management in PPCC

In the PPCC, the Waste Management Division (WMD) is responsible for solid waste management. CINTRI, which co-signed with PPCC a long-agreement in 2002 for the period of 49 years, provides collection service of municipal solid waste in PPCC. The waste collected by CINTRI is transported and disposed at the Dangkor solid waste disposal site. According to WMD, the transported volume of wastes per day is approximately 1,900 tons and solid waste receiving charge at the site is 0.75 USD/ton.

The waste transported to the site has been rapidly increasing since the commencement of operations in 2009, in parallel with the rapid increase of population as well as the lack of segregation, 3R activities (Reduce, Reuse and Recycle) and intermediate treatment of solid waste. In the first stage landfill area in the Dangkor solid waste disposal site will be filled with solid waste by the end of 2015, and according to WMD, the second stage landfill area will be in operation in 2016 (but actually the first stage landfill area was still in use, as of January 2016).

Dr. Hul Seingheng of the Institute of Technology of Cambodia and Mr. Yim Mongtoeun of the Royal University of Phnom Penh recently conducted a study on solid waste management in PPCC. Dr. Hul conducted a study on solid waste from households in nine khans (384 households)[15] and analysed their composition. According to the study, 51.9% of solid waste is organic waste such as food and vegetable debris, and 21.9% of the waste is plastics. The sources of the waste are households (55.3%), restaurants (13.8%) and guest houses (8.1%). On the other hand, Mr. Yim estimated waste generation per capita in households at 0.40 kg/capita/day in 2012[16].

Solid waste from households, offices and restaurants in PPCC is transported and temporarily collected in front of their buildings or sites designated by themselves. Then, CINTRI transports the wastes to the Dangkor solid waste disposal site. However, a part of the waste from households and offices near drainage channels are dumped directly into the drainage channels where they accumulate at simplified screens installed at several points.

DSD staffs regularly remove and temporarily collect the wastes on the roadsides to allow them to be transported to the landfill site by CINTRI. Since the dumping of waste is unending and large in amount, daily cleaning by DSD could not catch up because they can only remove a part of the waste at the screens due to lack of staff. The wastes at the screens decrease the flow capacity of the drainage channels and results in inundation especially in the rainy season.

2.9.2 Survey on Solid Waste in Drainage Channels

(1) Methodology

In this survey, the weight and composition of solid waste in the drainage channels were investigated to understand its impact to the drainage function, especially focusing on the Trabek and Tumpun drainage channels. The two channels are major ones in which reduction of drainage function by solid waste is concerned. The survey was conducted in ten points, as shown in **Fig. 2.9.1** and **Table 2.9.1**.

To measure the weight of waste, two survey methods were applied, namely, “Full Measuring Survey” and “Sampling Survey”. In the Full Measuring Survey, whole waste at a survey point was

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[15] Source：Hul Seingheng, Solid waste generation and life-span with credible growth forecasts waste generation, volume and composition, 2015

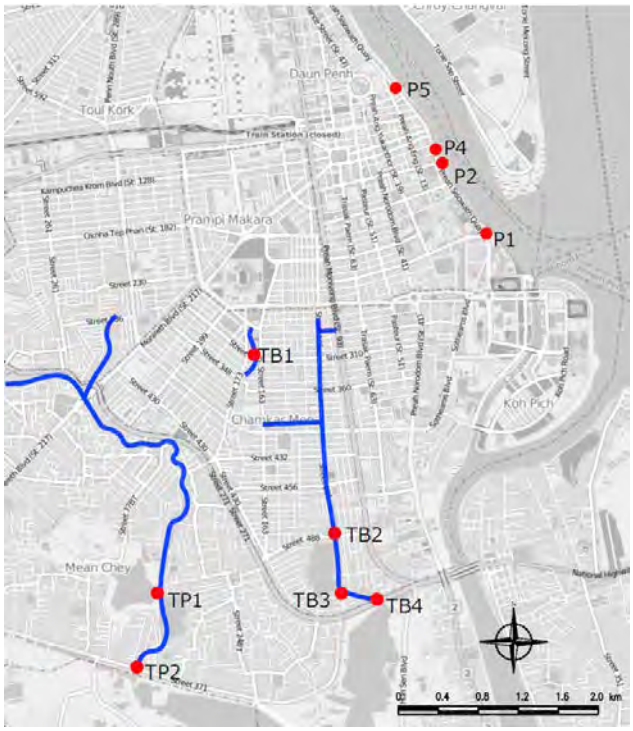
[16] Source：Yim Mongtoeun, Analysis of Waste Generation and Recycling Potential for Development of 3R-based Solid Waste Management in Phnom Penh, Cambodia, 2015

removed and the weight and composition were measured. The Full Measuring Survey was conducted several times to know the daily fluctuation in waste volume. In the Sampling Survey, a part of the solid waste was removed and the weight and composition was measured, and then the whole weight was estimated by multiplying the weight measured and the total area of accumulated waste. The Sampling Survey was applied to such survey points as TB3, TP1 and TP2 because it takes a long time to remove the whole waste at these points due to the heavy volume and/or the difficult working conditions.

At the Full Measuring Survey points of TB1 and TB2, the area of accumulated waste was measured, and then whole waste was removed and wet weight, weight per unit area and composition were measured in the first day. In the second day, total area of waste was measured, and then total weight was estimated by multiplying the total area by weight per unit area measured in the first day.

At survey points of five pumping stations (P1, P2, P4, P5, and TB4), resident workers of the pumping stations rake up wastes and temporarily collect them at the side of the screen several times a day. Therefore, the survey of weight and composition of waste was conducted utilizing them.

Composition of solid waste was categorized, as shown in **Table 2.9.2**. In the category, "Others" includes waste which cannot be easily segregated because the waste contains a mixture of tiny plastics, floating mud and sand, as well as fallen leaves.



Source: OSM data ©2011 CC-BY-SA Openstreetmap.org contributors

Fig. 2.9.1 Survey Points

Table 2.9.1 Present Condition of Survey Points

Survey point	Items	Condition for raking up waste	Method	Overview
P1	Pumping Station No.1	• It is possible to remove waste by rake. • Resident DSD staffs remove waste at screen several times in a day.	**Full Measuring Survey: Two times**	
P2	Pumping Station No.2	Ditto	**Full Measuring Survey: Two times**	

Survey point	Items	Condition for raking up waste	Method	Overview
P4	Pumping Station No.4	Ditto	**Full Measuring Survey: Two times**	
P5	Pumping Station No.5	Ditto	**Full Measuring Survey: Two times**	
TB1	Tributary Open channel of Trabek Channel	• Distance from top of channel to water surface is more than 2 m. • Cleaning has been implemented nearly once a week, but all wastes are not removed at one time.	**Full Measuring Survey: Two times** (In the second time, weight is estimated by weight per unit area and total area)	
TB2	Trabek Channel (Rd.488)	• This is a point where waste is heavily accumulated in Trabek channel. • Cleaning is implemented nearly every day, but all waste is not removed at one time.	**Full Measuring Survey: Two times** (In the second time, weight is estimated by weight per unit area and total area)	
TB3	Upstream of Trabek Pumping Station	• Waste area is 330 m × 25 m =8,250 m^2. • Surrounding area of waste is illegally occupied by people. • Cleaning has been implemented once or twice a year (before the rainy season).	**Sampling Survey** Collect the waste for 1 m × 2 m=2 m^2, 1.3 m × 2.5 m=3.3 m^2, targeting the range where it can be collect by pontoon.	
TB4	Trabek Pumping Station	• Resident DSD staffs at the pumping station remove waste at screen several times a day.	**Full Measure Survey: Two times**	
TP1	Upstream of Tumpun Pumping Station	• Waste area is 310 m × 25 m =7,750 m^2. • Cleaning is implemented once or twice a year (before the rainy season).	**Sampling Survey** Collected waste area is 3 m×1.5 m=4.5 m^2, targeting eastern river bank of the channel.	

Survey point	Items	Condition for raking up waste	Method	Overview
TP2	Tumpun Pumping Station	• Waste area is 40 m × 2 m =80 m^2. • Waste collection can be collected by using a pontoon of DSD in the pumping station. • Cleaning has been implemented nearly once in 3 days to a week, but all wastes are not removed at one time.	**Sampling Survey** Collected waste area is 4 m × 2 m=8m^2, targeting area of two nets (length: 4 m, width: 2 m).	

Source: JICA Study Team

Table 2.9.2 Categories of Waste Composition in this Survey

Categories	Contents	
Plastics	Plastic bottle, Plastic bag and Styrofoam	
Glass bottle and Cans	Glass bottle and Can	
Paper	Paper and Cardboard	
Organic Waste	Vegetable waste, Coconut shell and Food waste	
Clothes	Clothes, Shoes and Bag	
Others	Floating mud mixed with plastics, Wood waste and Waterweed	
Construction Waste	Bricks and Concrete block	Unidentified in this survey
Metal	Steel sheet and Metals	

Source: JICA Study Team

(2) Survey Results

The results of waste weight and waste composition in each point are shown in **Table 2.9.3** and **Table 2.9.4.** Total amount of waste at points, at which Full Measuring Survey was conducted (P1, P2 P4, P5, TB1, TB2, and TB4), amounts to 2,296.2 kg/day. This amount is equivalent to 0.1% of waste transported to Dangkor solid waste disposal site in a day. Weight per unit area in TB3, TP1 and TP2, at which Sampling Survey points was conducted, was 21.0 kg/m^2, 20.8 kg/m^2 and 14.2 kg/m^2. Of the three points, weight per unit area of TB2 was smallest because: heavy organic waste has been trapped already on the screen of TP1, which is located upstream of TP1; and thus the TB2 mainly traps floating light waterweed.

Weight per unit area at TB1 and TB2 in Trabek drainage channel, which collects wastewater in the built-up area of PPCC, were 13.8 kg/m^2 and 17.6 kg/m^2. Difference in the weight between TB1 and TB2 was 4 kg/m^2. The difference results from waterlogged organic waste consisting of coconut shell (refer to **Photo 2.9.1**). Weight per day in TB2 amounts to 2,038.5 kg, which is equivalent to waste of 5,100 people, based on the waste generation (0.4 kg/capita/day) estimated by Mr. Yim, as previously mentioned.

At almost all points, composition was dominated by “Plastics” (plastic bottle, plastic bag and so on) and “Others”. At points in pumping stations (P1, P2, P4, P5, and TB4), “Others”, consisting of floating mud mixed with plastics, was largest. On the other hand, plastics and organic waste were large in weight at the survey points of TB1, TB2, TB3 and TP1, which are located at drainage channel.

Table 2.9.3 Result of Waste Weight Survey

Point	Method	Wet weight per day (kg)	Note
P1	Full Measuring Survey	4.9	Average weight of 1st and 2nd survey :8.3 kg and 1.5 kg[1)]
P2	Full Measuring Survey	10.0	Average weight of 1st and 2nd survey : 8.5 kg and 11.5 kg
P4	Full Measuring Survey	21.3	Average weight of 1st and 2nd survey : 26.5 kg and 16 .0kg
P5	Full Measuring Survey	86.6	Average weight of 1st and 2nd survey : 124.8 kg and 48.3 kg
TB1	Full Measuring Survey	15.9	・ 1st Survey, 14.6 kg/m^2 of weight per unit area was obtained by 22 kg of waste weight and 1.6 m^2 of area.

Point	Method	Wet weight per day (kg)	Note
			・ 2nd Survey, 36.5 kg of waste weight was given by multiplying 0.7 m^2 of area by above weight per unit area.
TB2	Full Measuring Survey	2,038.5	・ 1st Survey, 17.6 kg/m^2 of weight per unit area was obtained by 2,246.5 kg of waste weight and 128.0 m^2 of area. ・ 2nd Survey, 1,820 kg of waste weight was given by multiplying 104.0 m^2 of area by above weight per unit area.
TB3	Sampling Survey	—	・ Waste of 111.2 kg was picked up from areas of 1 m×2 m=2 m^2 and 1.3 m×2.5 m=3.3 m^2, 5.3 m^2 in total. Thus 21.0 kg/m^2 of waste weight per unit area was obtained. ・ Waste weight is estimated at 173,250 kg by multiplying waste weight per unit area by 8,250 m^2 of area of waste.
TB4	Full Measuring Survey	119.2	Average weight of 1st and 2nd survey : 137.3 kg and 101.0 kg
TP1	Sampling Survey	—	・ Waste of 93.7 kg was picked up from areas of 3 m×1.5 m=4.5 m^2, thus 20.8 kg/m^2 of weight per unit area was obtained. ・ Waste weight is estimated at 161,200 kg by multiplying waste weight per unit area by 7,750 m^2 of area of waste.
TP2	Sampling Survey	—	・ Waste of 113.5 kg was picked up from areas of 4 m×2 m=8m^2. Thus 20.8 kg/m^2 of waste weight per unit area was obtained. ・ Waste weight is estimated at 568 kg by multiplying waste weight per unit area by 80 m^2 of area of waste.
Total		2,296.2	This amount is equivalent to 0.1% of waste weight per day transported to Dangkor solid waste disposal site (approximately 1,900 ton)

Note) At Sampling Survey points, total weight was estimated by waste weight per unit area and total area of waste; therefore, above figure is not total weight in a day.
1) Big difference in measured wet weight of 1st and 2nd survey originated from the amount of wet clothes.
Source: JICA Study Team

Table 2.9.4 Result of Waste Composition Survey

Unit : %

Point		Plastics	Glass bottle and Can	Paper	Organic Waste	Clothes	Others
P1	Pumping Station	**48.2**	0.0	0.0	0.0	9.6	42.2
P2	Ditto	21.2	1.2	0.0	0.0	0.0	**77.6**
P4	Ditto	26.4	0.0	0.0	0.0	1.9	**71.7**
P5	Ditto	20.7	0.3	0.2	0.6	2.2	**76.0**
TB1	Drainage Channel	**62.8**	1.6	0.0	12.4	4.8	18.4
TB2	Ditto	36.4	0.3	0.0	**56.1**	6.2	1.0
TB3	Ditto	**53.1**	1.2	0.0	30.3	10.2	5.2
TB4	Pumping Station	34.5	1.0	0.0	9.5	6.8	**48.2**
TP1	Drainage Channel	**49.9**	3.7	0.0	31.4	13.4	1.6
TP2	Pumping Station	36.7	0.1	0.0	5.4	8.3	**49.5**

Source: JICA Study Team
Note) Bold figures indicate the largest at each survey point.


[Situation of accumulated waste]


[Coconut shell accumulated on screen]


[Plastics and food waste wrapped in plastic bag in drainage channel]

Source: JICA Study Team

Photo 2.9.1 Condition of Accumulated Waste

(3) Discussion

Based on the survey result, salient features of accumulated waste, effect of waste to drainage function and countermeasure for the issues are discussed below.

【Salient features of accumulated waste】

- At survey points of the pumping station, floating mud mixed with plastics dominated, and at survey points of drainage channels, plastics and organic waste dominated in composition.

- At TB2, amount of heavy organic waste including coconut shell, is larger than that of TB1, located upstream of TB2. This is because: (i) coconut shell cannot be dumped in underground drainage pipe, (ii) stretch from TB1 to TB2 is open channel, (iii) roads along stretch from TB1 to TB2 are utilised by a lot of pedestrians and cars and many restaurant and business establishments are located, and thus people are likely to dump solid waste in the channel.

- Coconut shell is hard, large in volume and not easily decomposed; therefore, they accumulate at screen unless removed. Coconut shell has the same effect as plastics in the drainage channel when plastic bags adhere to them at the screen.

- In Cambodia, styrofoam and food waste from households are often wrapped in plastic bags and disposed; therefore, the waste bulks and be trapped easily at the screen (refer to **Photo 2.9.1**).

【Effect to drainage function and Countermeasure for the issues】

- Persistent plastics accumulate and continuously trap waste smaller than screen mesh until they are removed from the screen. Although these waste do not remarkably influence drainage function during the dry season, the waste trapped in floating plastic bags and waste wrapped with plastic bags and food tray trigger abnormal rise of water level, especially in rainfalls in the rainy season. The abnormal rise of water level induces inundation. Therefore, cleaning the screen in the drainage channel is recommendable more than once a day, especially in the rainy season.

- In addition to the periodical cleaning to prevent decreasing cross-section of drainage channel and inundation, raising public awareness is also essential to control pollution source, since waste dumping in the drainage channel largely depends on people’s daily activities, as previously mentioned.

CHAPTER 3 STRATEGY FOR FORMULATION OF SEWAGE MANAGEMENT MASTER PLAN

3.1 Summary of Issues

Current conditions and issues related to sewage management in PPCC, as well as countermeasures to solve the issues, are summarized in **Table 3.1.1** based on the study results discussed in **Chapter 2**.

Table 3.1.1 Current Conditions and Issues Related to Sewage Management in PPCC and Countermeasures (1/2)

Items/current conditions and issues	Countermeasures and roadmap to solve the issues
1. Technical Aspects	
1.1 Deterioration of water quality in Cheung Aek Lake basin	
Cheung Aek Lake basin, located in southern part of Phnom Penh, extremely suffers from water pollution. Results of water monitoring conducted in the Study (see **Figs. 2.5.5** to **2.5.8**), reveal the situation as follows: [Water quality of Cheung Aek Lake: • Influent BOD_5 Max. 200-300 mg/L • Effluent COD_{Mn} Max. 18 mg/L (Standard: COD_{Mn} 8 mg/L)	➢ Sewage from the area should be treated, introducing off-site treatment system, considering investible funds of Phnom Penh ［Reasons］ • Existing pipe network covers 100% of the basin and thus it is easy to collect sewage from the basin using the network. • Population density of more than half of the basin is over 300 persons/ha in the target year of 2035, as described later. • The area is located inside of inner dike and sewage generated from the area is not diluted, which is different from condition in Bangkok (In Bangkok, backwater from canal dilute sewage and the efficiency of treatment is affected).
1.2 Lack of Septage Management	
In Phnom Penh, most of people use septic tank as a sanitary facilities and Waste Management Office PPCC, is responsible for septage (sludge from septic tanks) management. PPCC has however no septage disposal site yet.	➢ To secure land in PPCC to dispose septage and increase in frequency of desludging septage. ➢ To secure land in PPCC to dispose treated sludge, before sewage treatment plant is in operation. [Reasons] • At present, a lagoon for treating leaching effluent in Dangkor solid waste disposal site temporarily accept septage due to the lack of treatment facilities for septage, but there exists a concern that the lagoon would be overloaded and thus water quality would be deteriorated due to the septage. • Dangkor solid waste disposal site was constructed in 2009 with total area of 31.4 ha. At present, 11 ha of the area is in commission and their lifetime would end in 2018 based on the estimation. In addition, rapid population growth decreases the capacity of the site. Thus, the disposal site would have no room to accept septage and sewage sludge from STP in the future.
2. Organizational and Institutional Aspects	
2.1 Establishment of implementation body responsible for sewage management (department/staff)	
In PPCC, it is not clear if which department is responsible for formulating sewage management plan and implementation plan.	➢ To empower existing department or to establish new department responsible for formulating sewage management plan, implementation plan, establishing framework of sewerage connection and sewage charge collection.
2.2 Determination of scope of works for central and provincial government	
At present, scope of works and allocation for sewage management among central (MPWT) and provincial (DPWT) government are not clear.	➢ To determine scope of work of central (MPWT) and provincial (DPWT) government and then, (i) to provide them budget for and jurisdiction over sewage management, and (ii) to train engineers to implement them.
2.3 Securing technical level and human resources for sewage management	
Engineers for sewage management are insufficient especially in operation of sewage treatment plant.	➢ To cultivate key engineers in the field of sewage management and implementation by inviting experienced engineers from other countries or dispatching engineers to the countries. ➢ To continuously train engineers by the key engineers mentioned above, through On-the-Job Training (OJT)
2.4 Insufficient managing and monitoring of industrial wastewater	
It is not enough to manage installation of treatment plants and monitor whether	➢ To increase budget for monitoring and to centralize authorities over regulating factories.

Items/current conditions and issues	Countermeasures and roadmap to solve the issues
industrial wastewater meets discharge standard by MIH, which is responsible for managing industrial wastewater.	➢ To share strategies for regulating and monitoring factories and to formulate activities plan with MOE.
2.5 Lack of guideline for sewage management in large-scale development area	
Large-scale development area has expanded in recent years. However, guideline for sewage management is not available in PPCC and thus developers install their treatment plant in accordance with their own strategy.	To establish guideline for sewage management in large-scale development area in order to enforce developers to install sewage facilities by their responsibility.
3. Financial Aspects	
3.1 Insufficient fund	
DPWT, PPCC has insufficient budget for implementing sewage management projects. In addition, central government has insufficient budget allocation for sewage management.	➢ To secure funds by soft loan. ➢ To establish autonomous or semi-autonomous authority to implement projects and collect sewerage fee from users.
3.2 Establishment of autonomous sewerage authority	
To allocate burden for sewage and drainage management between the authorities concerned Ratio of allocated burden for sewage and drainage management will be a big issue for authorities concerned in particular in construction and O&M of combined sewer system.	➢ It is essential to allocate initial and running cost between PPCC and autonomous sewerage authority in order not to threaten operation of the autonomous sewerage authority.
Sewerage fee collection system Existing sewerage management bodies in Sihanoukville and Siem Reap have been collecting sewerage fee, targeting large commercial facilities such as hotels and restaurants but they face difficulties in collecting enough charges covering O&M cost of sewerage facilities.	➢ To study on set up of sewerage fee system, sewerage fee collection system to widely collect the charges, especially from wealthy and ordinary households, which dominate in number in PPCC. ➢ To study alternative to include sewerage fee in some tax charges.
3.3 Collaboration with PPWSA	
PPWSA distributes 10% of water charge to PPCC for sewage and drainage management. The amount of 10% accounts for about 7,300 million Riel annually but the amount would be insufficient to cover sewage treatment.	➢ In case of PPWSA is responsible for sewerage management together with water supply, elaborate coordination will be required between MIH and MPWT, which have jurisdiction over water supply and sewage management, respectively. ➢ A listed company, PPWSA might be reluctant to incorporate sewage management, which might be unprofitable. The following schemes should be considered: • To set up policy that the Government shoulder the soft loan covering construction cost; • To turn off water supply service to users who do not pay for sewerage fee; and • To establish cost-effective sewerage fee collection system in collaboration with sewerage management body.

Source: JICA Study Team

Further, the envisaged bodies to implement countermeasures, as well as needs of assistance from donors and priorities for the countermeasures listed in **Table 3.1.1**, are summarized in **Table 3.1.2**.

Table 3.1.2 Current Conditions and Issues related to Sewage Management in PPCC and Countermeasures (2/2)

Items/current conditions and issues	Implementing body	Requirements of assistance from the donors	Priority
1. Technical Aspects			
1.1 Deterioration of water quality in Cheung Aek Lake basin	DPWT	➢ Assistance from the donors is indispensable, because PPCC has limited experience of sewage management, especially in planning and	[1st Priority] Reason: it is urgent to improve the area generating most of the pollution load and deteriorating water environment in and around

Items/current conditions and issues	Implementing body	Requirements of assistance from the donors	Priority
		construction of sewage treatment plant.	Phnom Penh.
1.2 Lack of septage management	Waste Management Division /DPWT /DOE	➢ Procedure to secure and purchase disposal site is taken care of by the government with own fund. ➢ Fund from donors might be required to construct facilities in the disposal site.	[1st Priority] Reason: It is urgent to secure septage disposal site because most people in Phnom Penh currently use septic tank as major sanitary facilities. In addition, increasing in frequency of desludging is essential.
2. Organizational and Institutional Aspects			
2.1 Establishment of implementation body responsible for sewage management (department/staff)	DPWT	➢ Implemented with own fund	[1st Priority] Reason: It is essential to smoothly commence sewage treatment in PPCC.
2.2 Determination of scope of work for central and provincial government	MPWT/DPWT	➢ Ditto	[2nd Priority] Reason: Step-by-step implementation will be required with coordination among the agencies concerned.
2.3 Securing technical level and human resources for sewage management	MPWT/DPWT	➢ Implemented by combination of assistance from donors and own fund	[1st Priority] Reason: It is essential to smoothly commence sewage treatment in PPCC.
2.4 Insufficient management and monitoring of industrial wastewater	MIH/MOE/DOE	➢ Implemented with own fund	[2nd Priority] Reason: Step-by-step implementation will be required with coordination among the agencies concerned.
2.5 Lack of guideline for sewage management in large-scale development area	Urbanization Division/DPWT	➢ Ditto	[2nd Priority] Reason: Step-by-step implementation will be required with coordination among the agencies concerned in PPCC.
3. Financial Aspects			
3.1 Insufficient fund	MEF/MPWT/ PPCC	➢ Soft loan is to be secured from donors. ➢ It is desirable to establish sewerage management authority with own fund but it is acceptable to receive support from donors in terms of coordination and introduction of good approach.	[1st Priority] Reason: It is essential to smoothly commence sewage treatment in PPCC.
3.2 Establishment of autonomous sewerage authority	PPCC/MPWT/MIH /DPWT	➢ Ditto	[1st Priority] Reason: Ditto
3.3 Collaboration with PPWSA	PPCC/MPWT/MIH /DPWT /PPWSA	➢ Ditto	[1st Priority] Reason: Ditto

Source: JICA Study Team

3.2 Planning Frame

Facilities design, legal and institutional setup plan, as well as human resource development plan, are required for sewage management. For facilities design, the following planning frame is set up.

3.2.1 Target Year

Target year of the Study is the year 3035, as with the "Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City" and "White Book on Development and Planning of Phnom Penh", which is to be approved shortly with the issuance of Sub-Decree.

3.2.2 Planning Frame

(1) Setting-up of Off-site and On-site[17] Treatment Area

(a) Approach

The Sewage Management Plan is formulated as the combination of on- and off-site treatment, considering development status, topological feature and availability of existing drainage (combined sewer) network in the target area. Off-site treatment area is determined in consideration of analysis of relevant plans/projects, development status, population density and availability of existing combined sewer network, financial analysis, as well as acceptable financial burden to PPCC. As for on-site treatment area, installation of pit latrine is proposed for households without toilet and study on introduction of septic tank or decentralized treatment system are carried out for households in which pit latrine or septic tank is installed.

(b) Candidate Sites for Construction of Sewage Treatment Plant

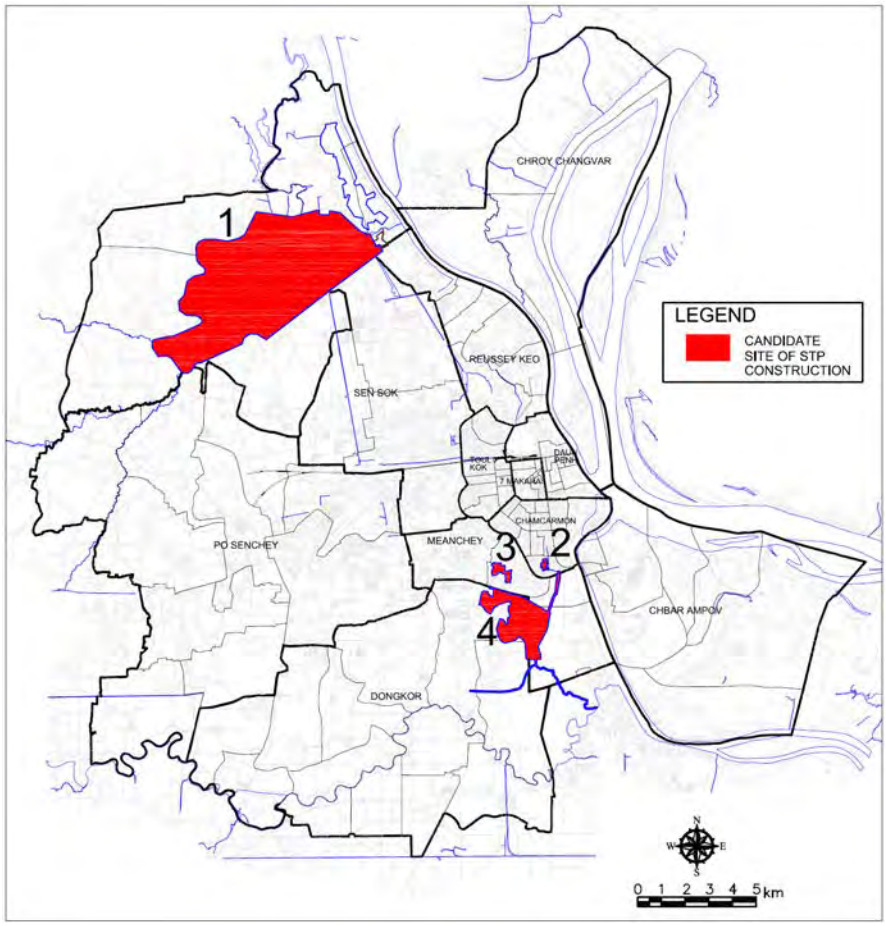
In the consultation with PPCC, four candidate sites for construction of sewage treatment plant in off-site area are proposed, as shown in **Table 3.2.1** and **Fig. 3.2.1**. Of the four sites, Tamok Lake and Cheung Aek Lake are studied because the two lakes have a defined line of control.

Table 3.2.1 Candidate Sites for Construction of Sewage Treatment Plant

No.	Name	Area (ha)	Depth (m)		Owner/Administrator	Remarks
			Dry Season	Rainy Season		
1	Tamok Lake	3,270	3.0-4.5	2-3 m plus that of dry season, at maximum	Owner: PPCC Administrator: PPCC/ MOWRAM	
2	Trabek Lake	Unknown	1.0-2.0	Same as that of dry season	Owner: PPCC Administrator: PPCC	Definite boundary is not defined in laws such as Sub-Decree
3	Tumpun Lake	Unknown	1.0-2.0	Ditto	Owner: PPCC Administrator: PPCC	Ditto
4	Cheung Aek Lake	520	2.0-3.0	2-3 m plus that of dry season, at maximum	Owner: PPCC Administrator: PPCC/ MOWRAM	

Source: JICA Study Team, based on information from PPCC

[17] In the Master Plan, off-site treatment is defined as the sewage treatment system consisting of sewer network and sewage treatment plant. On the other hand, on-site treatment is defined as sewage treatment system consisting of individual facilities such as septic tank and Johkasou or decentralized system such as community plant.



Source: JICA Study Team, based on information from PPCC

Fig. 3.2.1 Location of Candidate Sites for Construction of Sewage Treatment Plant

(2) Preliminary Study on Setting-up of Off-site Treatment Area

In Phnom Penh, Tamok Lake and Cheung Aek basins are fully urbanized and densely populated, considering planning population and population density for the target year 2035 in "Project for Comprehensive Urban Transport Planning in Phnom Penh Capital City", JICA.

Population density suitable for introducing off-site treatment in general ranges from more than 250 to 300 persons/ha[18]. In light of the population density, Cheung Aek basin (estimated population density in 2035 is about 230 persons/ha) can obviously be included in the area suitable for introducing off-site treatment. On the other hand, Tamok Lake basin (estimated population density in 2035 is about 80 persons/ha) would somewhat be premature to introduce off-site treatment. The following approach is therefore employed to evaluate the applicability of on- and off-site treatment.

(a) Catchment Area of Cheung Aek Lake

As discussed above, applicability of on-site treatment in Cheung Aek catchment area is very low, considering urbanization in the target year, including high population density, scarce open space, and verticalization. In contrast, applicability of off-site treatment is very high, considering about 100% of coverage ratio if drainage pipe in the area with which the area is easily serviced. Therefore, applicability of off-site treatment is studied in Cheung Aek area is studied.

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[18] Source: Guideline for Cost-Effective Sewerage System in Developing Countries (August 2004), Infrastructure Development Institute- Japan

A study on application of off-site treatment is carried out for the catchment area of Cheung Aek Lake basin, targeting the area as shown in **Fig. 3.2.2**. Name of the off-site area is "Cheung Aek Treatment Area". Based on the preliminary study, the treatment area is estimated to be 41 km^2 and present (year 2014) and future population (year 2035) in the area is 720 and 1,070 thousand.

(b) Catchment Area of Tamok Lake

Alternative study on selection of on- and off-site treatment is carried out. Boundary of off-site treatment area for the alternative study is as shown in **Fig. 3.2.2**.

Moreover, some studies are conducted on septage disposal site, which is not yet secured by Phnom Penh, how to collect and transport the septage to the site and division of roles of the departments concerned.

Source: JICA Study Team

Fig. 3.2.2 Target Area for Selection of Off-site Treatment Area

(3) Sewage Management in Large-scale Development Area

Present condition of sewage management in large-scale development area is summarized in **Table 3.2.2**. In principle, the developer is responsible for establishing its sewage treatment system in the site, and operates and maintains them to treat sewage from the development area.

Table 3.2.2 Current Condition of Sewage Management in Large-Scale Development Area

No.	Name	Area (ha)	Type of Use(Note 1)	Combined /Separate	Sewage Treatment System
1	Boueng Kok	133	Commercial and Office, Residential (40,000)	Combined	Individual house: Septic tank Buildings: Any type of treatment plant can be applied under the responsibility of owner of building.
2	Diamond City	80	Commercial and Office, Residential (5,000)	Combined	Lagoon
3	Camko City	119	Residential (10,000)	Separate	Activated Sludge Process
4	Grand Phnom Penh	233	Commercial and Office, Residential (12,000)	Combined	Bio-Filter (Septic tank, product of Thailand)
5	Chroy Changvar	13	Commercial	Combined	Unknown
6	Satellite City	380	Commercial and Office, Residential (40,000)	Combined	Unknown
7	Pratinum City	140	Residential (8,000)	Combined	Two-stage septic tank (individual and downstream end of the area)
8	ING City	2,572	Residential (300,000)	Separate	Activated Sludge Process
9	BTP	10	Residential (1,000)	Combined	Two-stage septic tank (individual and downstream end of the area)

Note 1: Values in parentheses show planning population
Source: JICA Study Team, based on information by PPCC

(4) Management of Industrial Wastewater

Owners of factories are responsible for installing sewage treatment plant and discharge treated wastewater to sewer or directly to public water bodies to meet effluent standard. MIH and DPWT/PPCC should inspect whether they installs the treatment facilities and meet effluent standard.

(5) Sewage Generation per Capita

Sewage generation and pollution load per capita for the formulation of Master Plan are detailed in **Section 3.3**.

3.2.3 Strategy for Phased Schedule

Proposed components in the Master Plan are scheduled in three phases; namely, Short-Term (present to year 2020), Medium-Term (year 2021 to 2030) and Long-Term (after year 2031). The proposed component includes structural and non-structural measures.

3.3 Planning Conditions for Off-Site Treatment Area

3.3.1 Projection of Water Use

(1) Projection of Water Use

In the M/P, water use per capita is projected employing the following formula in "The Study on the Master Plan of Greater Phnom Penh Water Supply (Phase 2), 2006, JICA".

$$y = y_0(1+r)^x$$

where,

y : water use x-year from the reference year (L/person/day)

y_0 : water use of the reference year (L/person/day)
r : yearly average growth rate
x : number of years after the reference year

As discussed in **Subsection 2.3.3**, water use per capita per day in Phnom Penh increases at the rate of about 2.0% each year. On the other hand, PPWSA predicts water use in Phnom Penh in "The Study on the Master Plan of Greater Phnom Penh Water Supply (Phase 2), 2006, JICA", up to 2020. However the value of 145 L/capita/day for year 2020 projected in the Study, is already lower than that of present. Water use for the target year is therefore projected in the Study, with the following cases; namely, increasing rate of 1.0%, 1.5% and 2.0%.

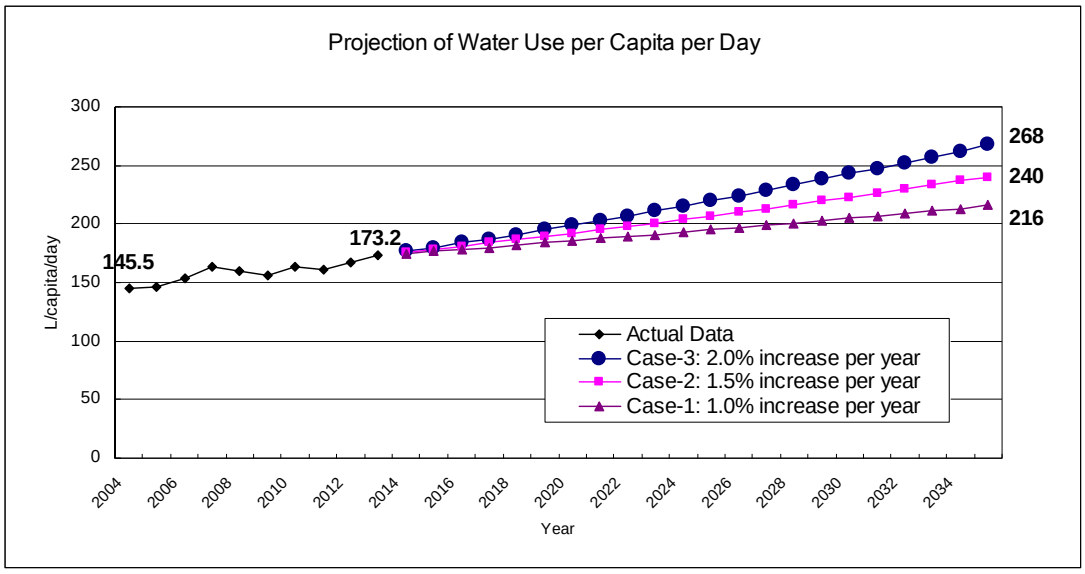
Case-1: Growth rate 1.0%: Current growth rate (2.0%) cuts by half (1.0%) due to such reasons as enhancement of water-saving awareness.
Case-2: Growth rate 1.5%: Medium growth rate of Case-1 and Case-3; namely, 1.5% is assumed.
Case-3: Growth rate 2.0% : Current growth rate of 2.0 is maintained up to 2035.

As shown in **Table 3.3.1** and **Fig. 3.3.1**, result of Case-3 shows about 270 L/capita/day water use in 2035, which is close to Japan's (289 L/capita/day, domestic and commercial water use in 2011) and thus deems to be slightly excessive. On the other hand, sharp drop of increase by applying 1.0% growth rate might be unreasonable. Thus 240 L/capita/day in 2035, applying medium growth rate of 1.5%, is employed in the Master Plan to project sewage generation.

Table 3.3.1 Water Use Projection per Capita per Day for the Target Year of 2035

Year	Actual	Case-1 1.0%	Case-2 1.5%	Case-3 2.0%
2004	145.5	-	-	-
2005	145.8	-	-	-
2006	153.6	-	-	-
2007	163.7	-	-	-
2008	159.4	-	-	-
2009	156.6	-	-	-
2010	163.4	-	-	-
2011	161.2	-	-	-
2012	167.5	-	-	-
2013	173.2	-	-	-
2014	-	175	176	177
2015	-	177	178	180
2016	-	178	181	184
2017	-	180	184	187
2018	-	182	187	191
2019	-	184	189	195
2020	-	186	192	199
2021	-	188	195	203
2022	-	189	198	207
2023	-	191	201	211
2024	-	193	204	215
2025	-	195	207	220
2026	-	197	210	224
2027	-	199	213	229
2028	-	201	217	233
2029	-	203	220	238
2030	-	205	223	243
2031	-	207	226	247
2032	-	209	230	252
2033	-	211	233	257
2034	-	213	237	262
2035	-	216	240	268

Source: JICA Study Team



Source: JICA Study Team

Fig. 3.3.1 Water Use Projection per Capita per Day for the Target Year 2035

(2) Ratio of Domestic and Other Usage

Ratio of domestic and other usage is set at 60 to 40, in consideration of actual data in **Table 2.3.4** and those of neighbouring countries.

Table 3.3.2 Ratio of Domestic and Other Usage in Neighbouring Countries

	Ho Chi Minh	Jakarta	Kuala Lumpur	Manila	Osaka	Seoul	Shanghai	Bangkok
Year	2001	2001	2001	2001	2001	2001	2001	2009
Domestic water use	73	59	53	61	54	71	64	52
Non-domestic water use	27	41	47	39	46	29	36	48

Source: Preparatory Survey Report on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City in the Republic of the Union of Myanmar, 2014, JICA

(3) Ratio of Daily Average, Daily Maximum and Hourly Maximum

Ratio of daily average and daily maximum for domestic and commercial use is set at 1.0:1.1 based on actual data of PPWSA. Ratio of daily maximum and hourly maximum is set at 1.0:1.5, also based on actual data provided by PPWSA. On the other hand, ratio of daily average and daily maximum, as well as hourly maximum for industrial use is set at 1.0:1.0:2.0, based on "Guideline for Sewerage Facilities Planning and Designing", Japan. Daily maximum is employed to design sewage treatment plant and hourly maximum is employed to design pipe network and pumping stations.

(4) Sewage Generation Ratio

Sewage generation ratio of 85%, intermediate value of 80% and 90% is applied with reference to WHO's guideline, "A Guideline to the Development of On-site Sanitation" and typical values ranging from 80 to 90% employed in the neighbouring countries.

(5) Ratio of Commercial and Industrial Use

PPWSA has no data related to ratio of commercial and industrial use. However, about 90% of commercial and industrial users execute contracts with PPWSA to be supplied by water tap of 15 mm in diameter. According to PPWSA, a contractant supplied by 15 mm pipe uses not more than 50 m^3/day. In general, amount of use not more than 50 m^3/day, can be regarded as

commercial use. As a result, 90% of total commercial and industrial use is regarded as commercial, while the remaining 10% is regarded as industrial use.

(6) Ground Water Infiltration

Actual data of groundwater infiltration is not available in Phnom Penh. On the other hand, in the capital cities of neighbouring countries, unit groundwater infiltration of 10 m^3/ha/day is applied to Bangkok and Yangon, while 7.5 m^3/ha/day is applied to Manila. In the Study, 7.5 m^3/ha/day is applied to estimate groundwater infiltration considering that the 10 m^3/ha/day applied to Bangkok includes incremental water from canal. However, upper limits of 15% of dairy maximum is set up in the Master Plan, referring to intermediate value of groundwater infiltration, ranging from 10 to 20% of daily maximum of domestic and commercial use in accordance with the "Guideline for Sewerage Facilities Planning and Designing in Japan", Japan Sewage Works Association.

(7) Sewage Generation per Capita

Sewage generation per capita is computed based on the amount of water use, as summarised in **Table 3.3.3**.

Table 3.3.3 Sewage Generation per Capita (Off-Site Treatment Area)

	Amount of Water Use (L/capita/day)				Generation Ratio (%)	Generation per Capita (L/capita/day)
	Domestic	Commercial	Industrial	Total		
Daily average	150	80	10	240	85	**205**
Daily maximum	160	95	10	265	85	**225**
Hourly maximum	240	140	20	400	85	**340**

Source: JICA Study Team

3.3.2 Water Quality for Designing

(1) Target Parameters

Sewage treatment plant, which is a key component of the off-site treatment system, is designed targeting removal of BOD, TSS and total coliform, since the treatment plant will not discharge the treated water to closed water.

(2) Pollution Load per Capita

(a) BOD

Influent BOD concentration of sewage treatment plant is computed, employing 45 g/capita/day, which is maximum of typical BOD load per capita ranging from 40 to 45 g/capita/day applied in developing countries located in the tropical region, considering relatively high BOD in six times of water quality monitoring results in the Study, recorded at Trabek Pumping Station, which receives extensive amount of sewage in PPCC. The 45 g/capita/day includes domestic and commercial pollution load.

Industrial wastewater can be discharged to sewer under the condition that the owner of the industrial facilities installs pre-treatment plant to meet BOD effluent standard of 80 mg/l as indicated in **Table 2.5.3**.

(b) TSS

TSS load is set up considering average ratio of BOD to TSS (BOD:TSS=1.0:1.05), which is typical value of quality monitoring conducted in the Study at Trabek Pumping Station (see **Table 2.5.7**).

(3) Design Effluent Water Quality for STP

Upper limits of design effluent water quality for STP are summarized in **Table 3.3.4,** including those of Cambodia and the neighbouring countries of Thailand, Vietnam and Myanmar. Of the limits, neighbouring countries' are definitely typical for effluent standard of STP targeting removal of BOD and TSS. On the other hand, standard of "Public Water Area and Sewer", namely, BOD=80 mg/L and TSS=120 mg/L, are to be applied to Phnom Penh because Phnom Penh has no "Protected Public Water Area". However, those upper limits for Phnom Penh seem to be relatively lax and suitable only for primary treatment, compared to those of the neighbouring countries. In fact, the standard might not correspond to the one for secondary treatment.

Treatment methods studied in the Master Plan will be able to treat water to BOD concentration of 30 to 40 mg/L as a whole. Therefore, effluent water quality for "Protected Public Water Area", which exceeds standard of "Public Water Area and Sewer", are applied to design STP proposed in the Master Plan in consideration of (i) to optimize facilities' performance, (ii) to be consistent to the trend of standard of secondary treatment in the neighbouring countries and (iii) to effectively reduce pollution load in order to preserve water quality of public water bodies.

Table 3.3.4 Upper Limits of Design Effluent Water Quality for STP

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

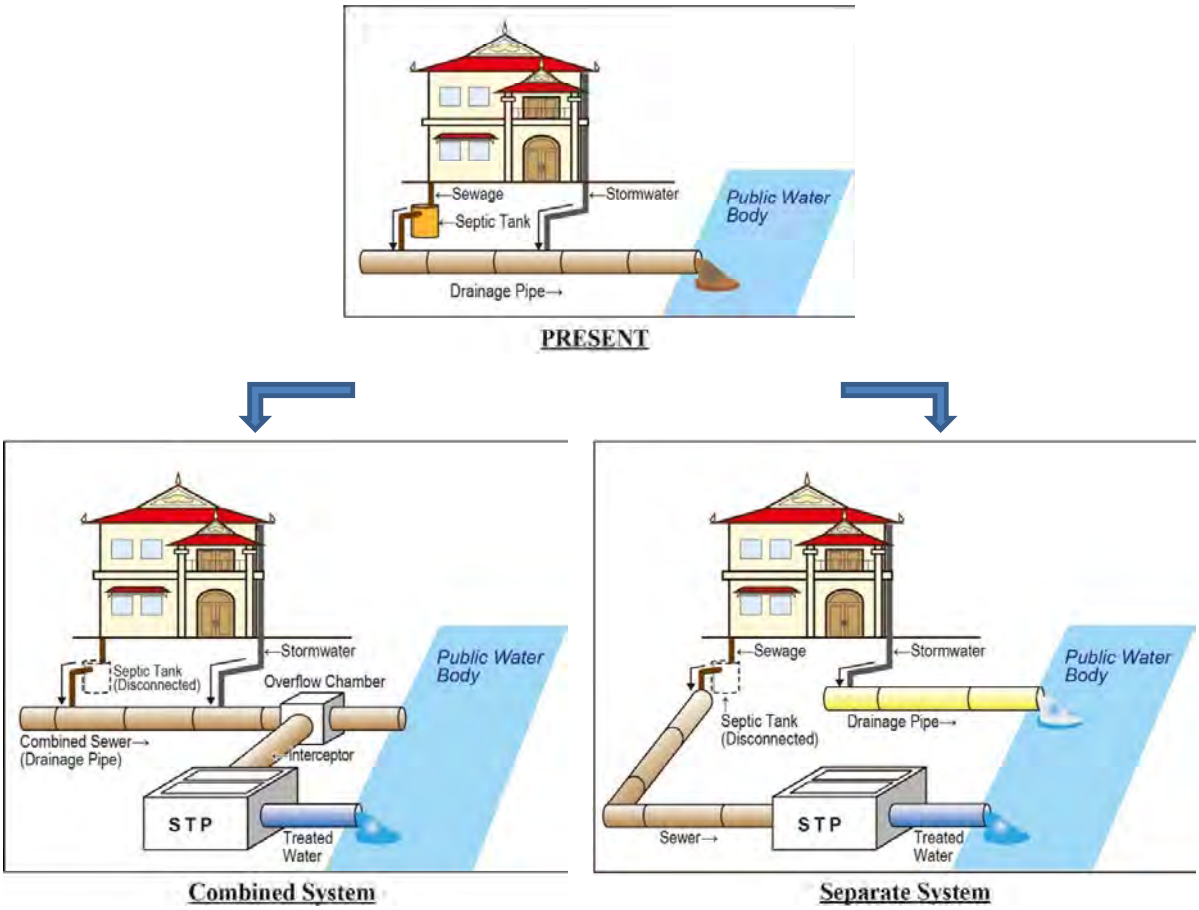
Note 1) Filtered sample shall be monitored for Lagoon
Note 2) 50 mg/L shall be applied to Lagoon
Note 3) National Standard is not available in Myanmar
Source: Sub-Decree on Water Pollution Control, Annex 2, Effluent standard for pollution sources discharging wastewater to public water areas or sewer.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

3.3.3 Structural Measures

(1) Collection System

Cheung Aek Treatment Area will adopt combined system, considering 100% of service ratio[19] of the existing drainage pipe network, in combination with the installation of interceptor in downstream of Trabek and Tumpun open channels. On the other hand, an alternative study of on- and off-site treatment is conducted for Tamok Treatment Area. As for off-site treatment in Tamok Treatment Area, separate system is studied, considering low installation rate of drainage piles in the area. In **Fig. 3.3.2**, image of sewage collection systems are illustrated as a reference.

[19] Covering ratio of 100% was obtained by the site survey conducted in the Study.



Note: Separate System requires installation of inlet pipe from each household
After the connection of sewer system, septic tank in each household can be disconnected .
Source: JICA Study Team

Fig. 3.3.2 Image of Sewage Collection Systems

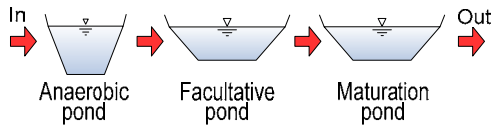
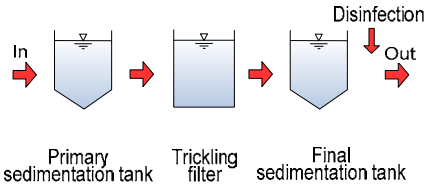
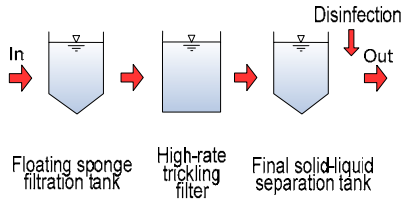
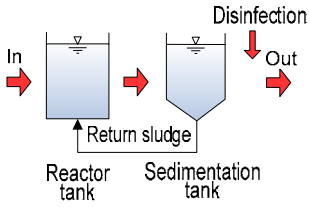
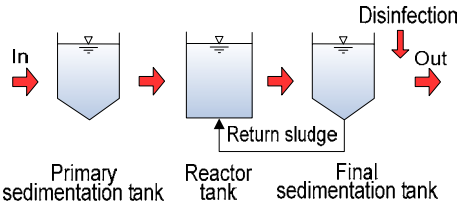
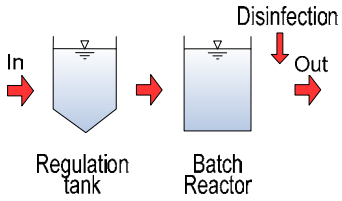
(2) Wastewater Treatment Method

The following wastewater treatment methods are to be studied and their applicability to Phnom Penh are evaluated. As discussed later, estimated sewage of Cheung Aek and Tamok in 2035 exceeds more than 100 thousand m^3/day, and thus aerated lagoon is not applicable to such amount of sewage. Therefore, aerated lagoon is not evaluated in the Master Plan.

- Lagoon
- Aerated Lagoon
- Tricking Filter
- Oxidation Ditch (OD)
- Conventional Activated Sludge Process (CASP)
- Sequential Batch Reactor (SBR)

On the other hand, Pre-treated Trickling Filtration (PTF), which has been recently developed in Japan as an upgraded technology of traditional Trickling Filter system, is included in the evaluation. As a result, six wastewater treatment methods are evaluated as summarized in **Table 3.3.5**.

Table 3.3.5 Off-site Treatment Methods Evaluated

Method	Typical Flow Sheet	Salient Features
Lagoon		• Wastewater is treated without machinery. Oxygen is introduced into the lagoon by photonic synthesis and thus wastewater is purified. • Among the four methods, O&M is the easiest and unit cost for treatment is the lowest. On the other hand, land requirement is the largest.
Trickling Filter (TF)		• Wastewater is treated by sprinkling them to filter bed in the trickling filter. • Energy consumption is much smaller than treatment methods using blower. • Land requirement is larger than that of CASP. • It is difficult to control offensive odor and generation of flies from filter bed.
Pre-treated Trickling Filtration (PTF)		• This is new Japanese technology upgrading trickling filter by introducing new media to save processing time and space. • Filter bed can be easily washable and thus prevent offensive odor and generation of flies from filter bed. • Land requirement is smaller than CASP.
Oxidation ditch (OD)		• Endless channel is employed for wastewater circulation. Equipment is simplified and easier O&M is achieved compared with activated sludge process. • Land requirement is smaller than that of aerated lagoon, while bigger than that of activated sludge process.
Conventional Activated sludge process (CASP)		• Among the four methods, the highest efficiency in pollution load reduction and the smallest land requirement is achieved. • On the other hand, machinery equipment is large in number and unit cost of treatment is the highest. Further sophisticated technique is required.
Sequential Batch Reactor (SBR)		• All the processes of (i) feeding/mixing, (ii) aeration, (iii) sedimentation and (iv) decant, are executed in batch reactor. • Land requirement is smaller than that of CASP since primary and final sedimentation tanks are not required. • Skilled techniques are required to control the batch reactor, in particular sludge sedimentation and withdrawal.

Note: This table only summarizes technical features of each treatment method and the number of application of the method is discussed in **Chapter 4**.
Source: JICA Study Team

(3) Sludge Treatment Method

Typical sludge treatment configuration, consisting of thickener, digester and dewatering equipment, is studied, considering effects of sufficient volume reduction and stabilization, as well as cost performance and easiness of O&M. In addition, re-use of treated sludge is considered, if enough demands are expected around the STP.

3.4 Planning Conditions of On-site Treatment

3.4.1 Projection of Water Use

Amount of water use (175 L/capita/day), which is rounded up actual amount of 173.2 L/capita/day in PPWSA in 2014, is employed for amount of water use in target year 2035, under the assumption that urbanization in on-site treatment area delays compared to that in off-site treatment area. The 175 L/capita/day is equivalent to about 70% of 240 L/capita/day, the amount in off-site treatment area, and same amount in 2014 of Dangkor District, which is located in suburban area.

Sewage amount in on-site treatment is estimated, adopting generation ratio of 80%, which is lower limit of typical range (80 to 90%), under the assumption that the amount of water used in the garden increases and thus the water will not reach to sewer pipe, in comparison with that in off-site treatment area. Same ratio of daily average and maximum as well as hourly maximum in off-site area, is employed in estimating those in on-site area. Consequently, sewage generation is projected as summarized in **Table 3.4.1**.

Table 3.4.1 Sewage Generation per Capita (On-site Treatment Area)

	Amount of Water Use (L/capita/day)				Generation Ratio (%)	Generation per Capita (L/capita/day)
	Domestic	Commercial	Industrial	Total		
Daily average	105	65	5	175	80	**140**
Daily maximum	160	95	5	195	80	**160**
Hourly maximum	240	140	10	295	80	**240**

Source: JICA Study Team

3.4.2 Pollution Load per Capita

As with amount of water use, pollution load will be estimated at 70% of off-site's considering delay in urbanization and improvement of living standard, compared to those of off-site area.

3.4.3 Structural Measures

Alternative study will be conducted on (i) promotion of septic tanks or pit latrines which are commonly utilised as sanitary facilities and (ii) introduction of other on-site treatment facilities such as Johkasou and community plants.

3.5 Effects of Environmental Improvement by the Proposed Sewage Management Plan

(1) Effect on Pollution Load Reduction of Implementation of Proposed Sewage Management Plan

Effect on pollution reduction with and without projects proposed in the Master Plan implementation, will be quantitatively evaluated.

(2) Others

Other than the effects on pollution reduction, such side effects as elimination of waterborne disease will be evaluated.

3.6 Other Considerations

3.6.1 Non-Structural Measures

Implementation bodies and institutional set-up are proposed for smooth implementation of initial attempt of off-site treatment in PPCC. Also, measures to strengthen existing institutions, develop human resources, secure budget and set legal framework, are proposed for facilitating on-site treatment such as septic tank, in area where only pit ratline is installed or no sanitary facilities are installed.

3.6.2 Land Expropriation

Sewerage facilities consist of pipe network, pumping station and sewage treatment plant. Of the facilities, pipes are in principle proposed to be laid under public roads. Pumping stations and sewage treatment plant are in principle proposed in the public land to avoid land expropriation of public land as much as possible. In public area, the facilities will not be proposed to occupy area in which illegal residents are living, unless absolutely necessary. Compensation will be proposed, if the occupation in the area is necessary.

3.6.3 Environmental and Social Considerations

Environmental and social impacts of all the proposed on- and off-site facilities are to be minimized in pre-construction, construction and operation stages. Resettlement is in particular to be avoided as much as possible in the site selection of facilities designing.