Sector L: Land Use Control in Inundation Area

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
VOLUME 3: SUPPORTING REPORT

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CHAPTER L1 LAND USE CONTROL IN INUNDATION AREA

L1.1 Case Study for Land Use Control

L1.1.1 Selection of Case Study Area

To deliberate on the countermeasure of land use for flood management of the Chao Phraya River Basin, the situation of the flood prone area should be investigated. For this purpose, the areas for a case study is to be selected from the point of view of regional disaster prevention.

The selection of the areas are carried out by considering the pattern of agricultural land use with potential of inundation height from simulation and situation of specified retention area.

Table L1.1.1 Target Area of the Case Study

Classification of Inundation Area	Position of Flood Management	Selected Area	Height of Inundation Simulation (m)			Retention Area	Land Use					
							Build-up Areas Zone	Agricultural Land Uses				Environment Conservations Zone
			> 3	3 > 1	1 >			Rural and Agriculture Area	Conservation for Rural and Agriculture Area	Land Reform for Agriculture Area	Land Consolidation for Agriculture	
FS: Shallow inundation, shorter duration	Flood Protection City	Bang Racahnm Sinburi, Tahun Him, Pichit			○		○					
FL: Deeper inundation and longer duration	Retention Area	Bang Ban, Ayutthaya		○		○	○	○			○	
W: Flood ways for overflowed water located in west of protection area	Floodway	Nakhon Chaisri, Nakhon Pathom		○								
M: Swamp, deep inundation and long duration	Retention Area	Utahi Thani, Tahun Him, Pichit	○			○	○	○	○		○	○
H: Small scale flood		(N/A)										

L1.1.2 Sing Buri Province (Type FS)

(1) Overview

Sing Buri Province is located in the western side of Chao Phraya River, formed by broad wide paddy field along many channel. R3032 in the west of Noi River and R3454 in the east of Noi River and R3303 of north-to south, R3030 of east–to-west, those roads function as regional main road.

There are housing, and many factory of sugar, machinery located along these regional main roads. High dense housing is located along the Noi River in Bang Rachan district. Farmland is mostly paddy field.

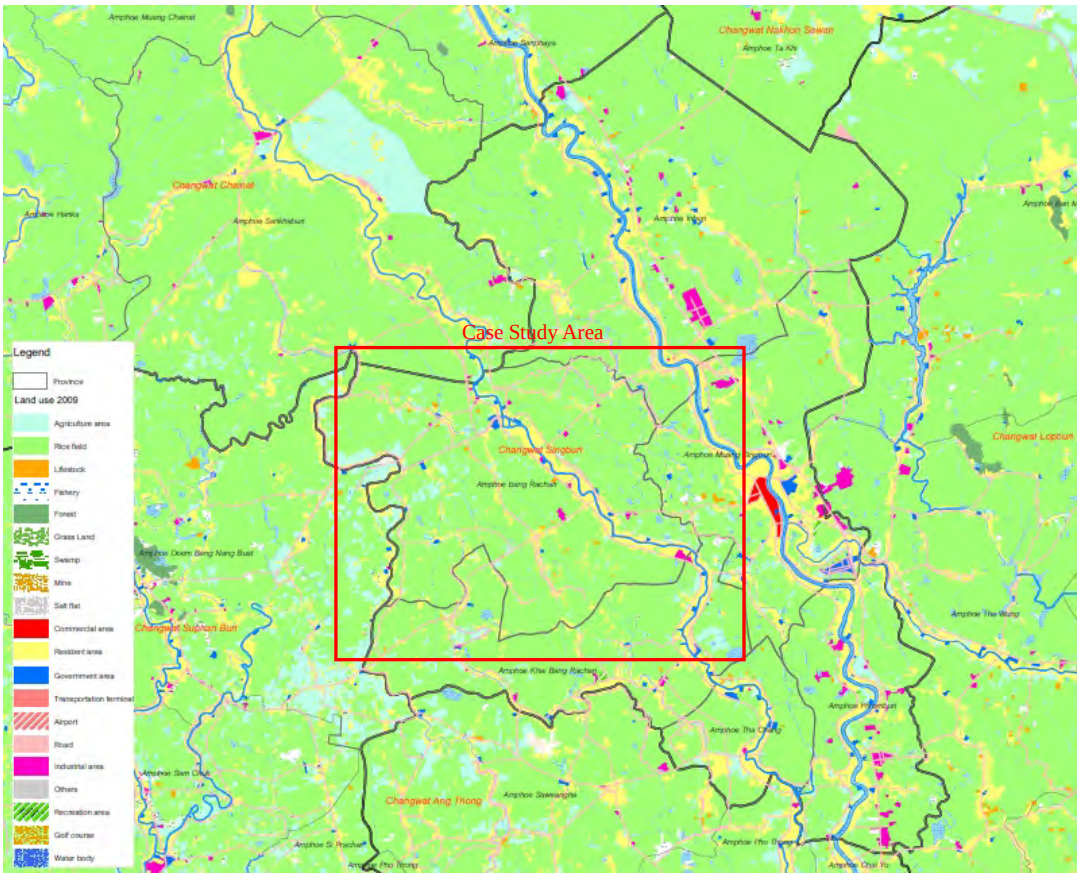


Figure L1.1.1 Current Land Use of Sing Buri Province (2009)

Most of the area is designated for Rural and Agriculture Area by provincial land use plan of Singburi.

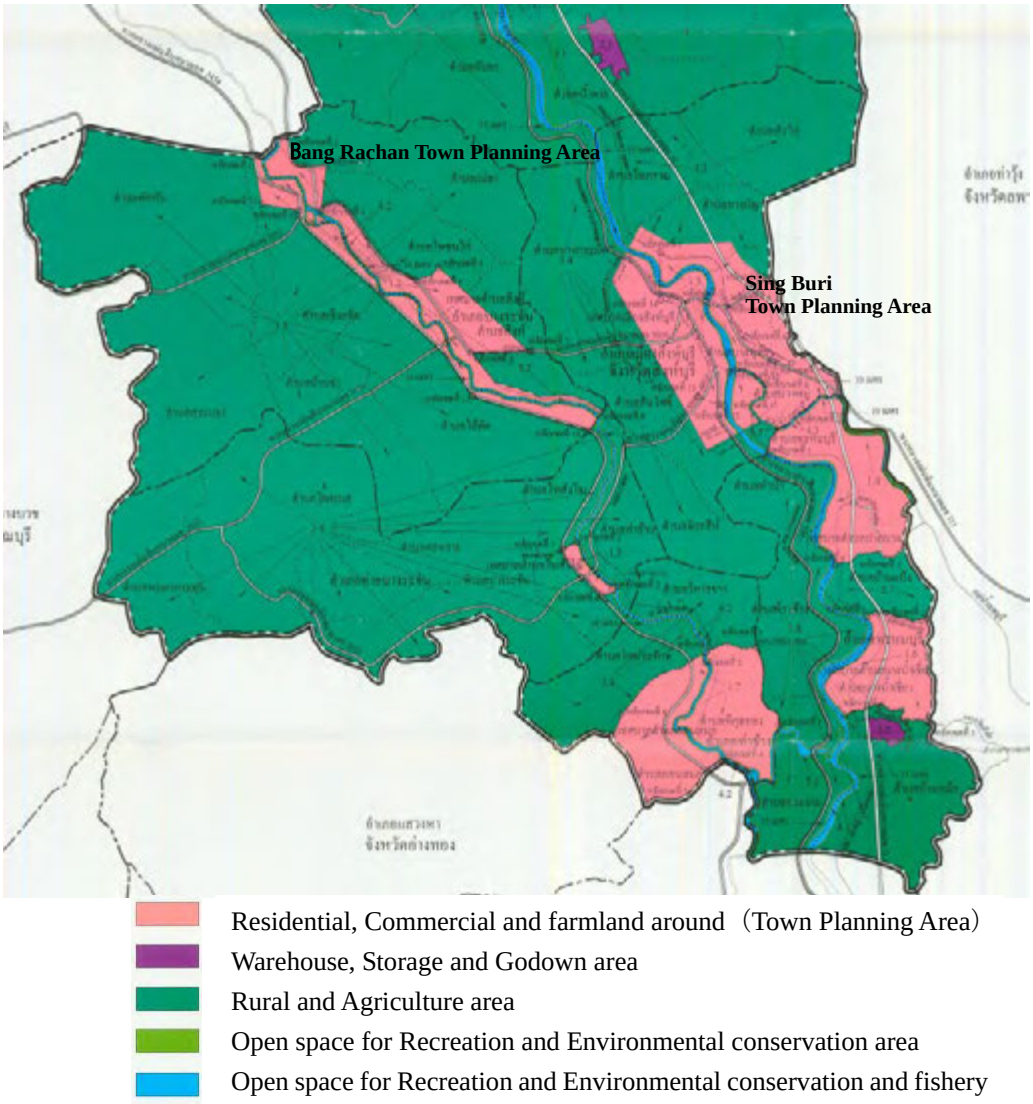


Figure L1.1.2 Land Use Plan of Sing Buri Province

Picture L1.1.1 Noi River in Bang Rachan Township

Picture L1.1.2 Sugar Factory (Inside of Secondary Dyke, Town Planning Area)

Picture L1.1.3 Housing (Outside of Town Planning Area)

(2) Land Use of Bang Rachan District

According to the result of analysis of inundation, this area is supposed to be flooded to less than 1m. The housing is dense along the Noi River, some stockyard of rice and manufactory are located in the agricultural zone.

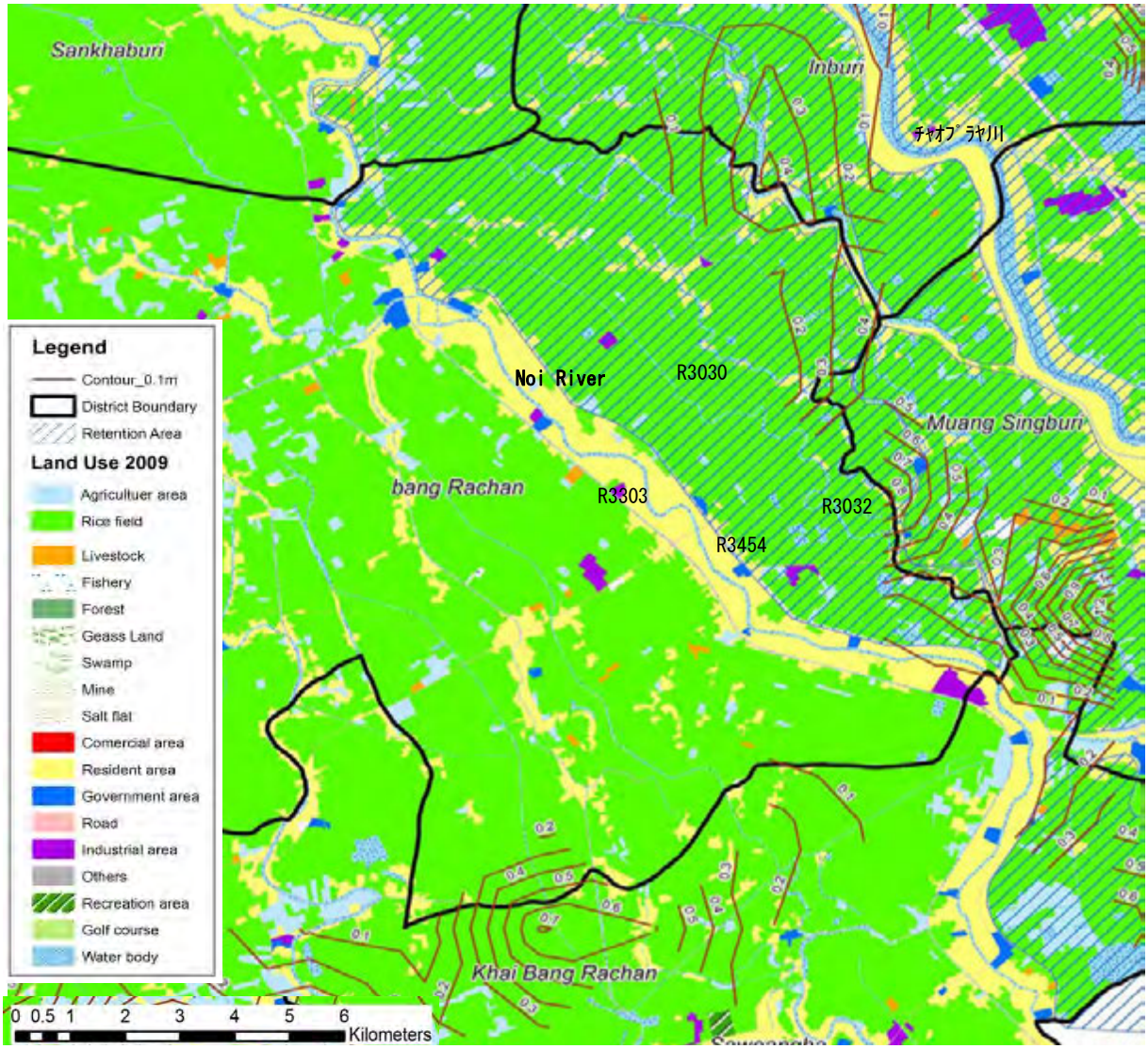


Figure L1.1.3 Land Use of Bang Rachan

CTI Engineering International Co., Ltd.
Oriental Consultants Co., Ltd.
Nippon Koei Co., Ltd.
CTI Engineering Co., Ltd.

In this area, Rural and Agriculture Area is dominantly designated, but housing is dense along the Noi River and its tributaries. The land use of non-agricultural land use is rare, it is probably because no exemption rule is designated in the zone according to the land use regulation of Province. In regulation, these are stipulated that the 10m or more from the Noi River shall be kept in natural from Noi River and 6m or more should be so from the canals or public water sources.

Land Use Regulation of Bang Rachan stipulates residential, commercial and industrial zone along the Noi River and to restrict non-agricultural land use in land readjustment zone.

Table L1.1.2 The Control of Land Use

		Rural and agriculture area
Province Singburi	Purpose	Agriculture or agricultural related purpose, educational institutes, religious institutes, government institutes, public utilities and public assistance.
	Land use not permitted	All types of factories with apart from low impact Fuel oil storage Gas filling facilities Land allocation for, Industry, Commerce, Dwelling Dwelling or commerce in large or large building * Provision of absolute height, : 15m * 10m or more from the Noi River shall be kept in natural from Noi River * 6m or more should be so from the canals or public water sources.
Bang Rachan District	Purpose	(Regulation is under consideration, draft guideline is as follows) Main objective of land use planning and area development is to promote agriculture in the area, as most of this area are in irrigation area.
	In Land Readjastment zone	(Draft guideline for Land Readjustment Zone is proposed as follows) This land in the land readjustment project zone shall be used solely for land readjustment for agriculture, public utilities and public assistance.

L1.1.3 Pichit Province (Type FS and M)

(1) Overview

Yon River and Nan River flow through the center of the region where paddy field spreads and forms the floodplain. Most of the area is affected by inundation, but the slightly elevated area on the alluvial fan bordering the Pin River retards flooding. A large portion of the area near the Yon River Basin and the Nan River Basin is considered to be a water retention area.

Dominant land use in this area is paddy field and truck farm; non-agricultural land use does not appear to spread. Along the national road such as R1118 from north to south, R111, 113, and 1118 west to east, residential and commercial areas are sporadically seen. A large scale development area appears to be located along R104.

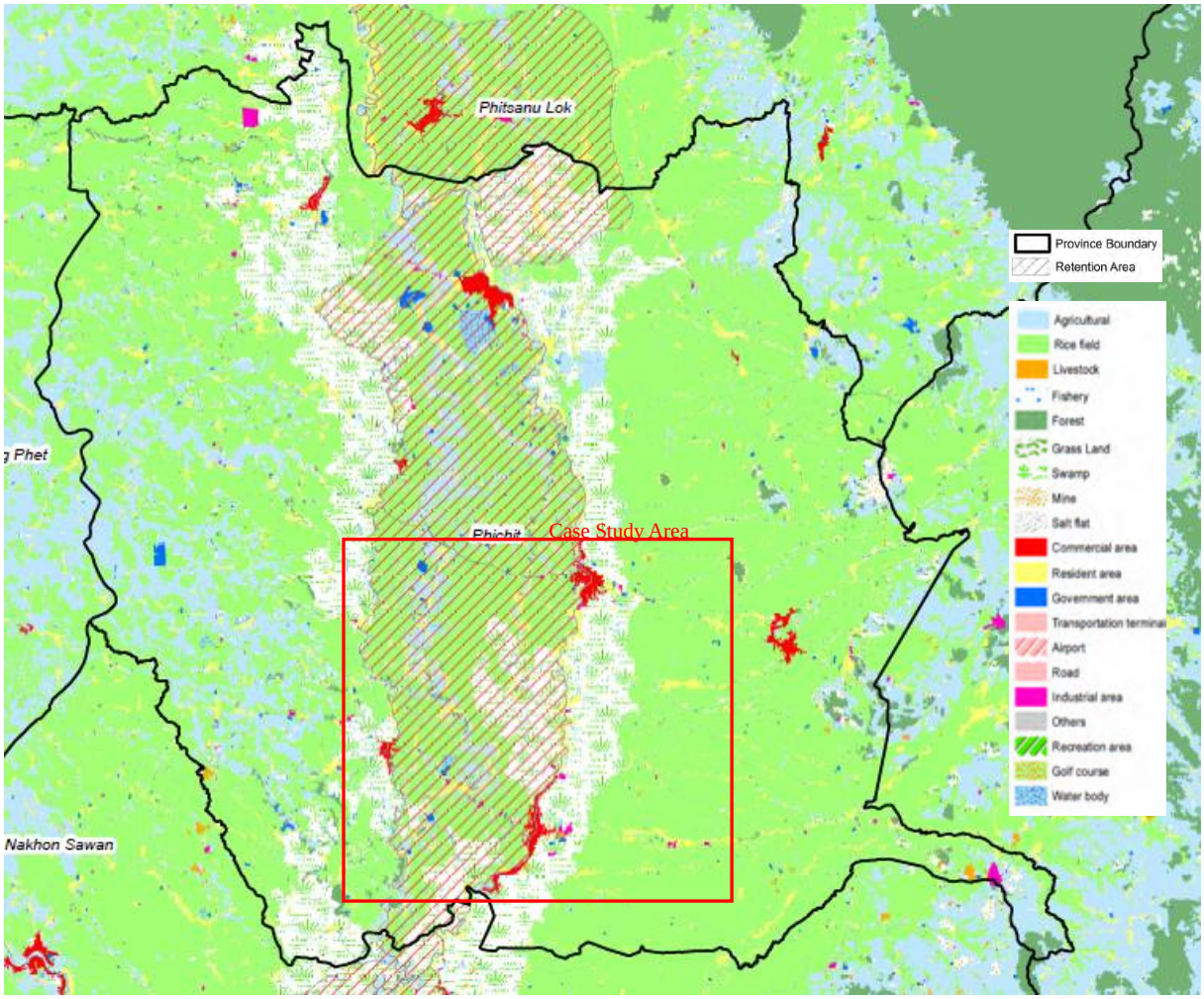


Figure L1.1.4 Current Situation of Pichit Province (2009)

The town planning for all cities and community areas has been proposed and is expected to be approved within 2013.

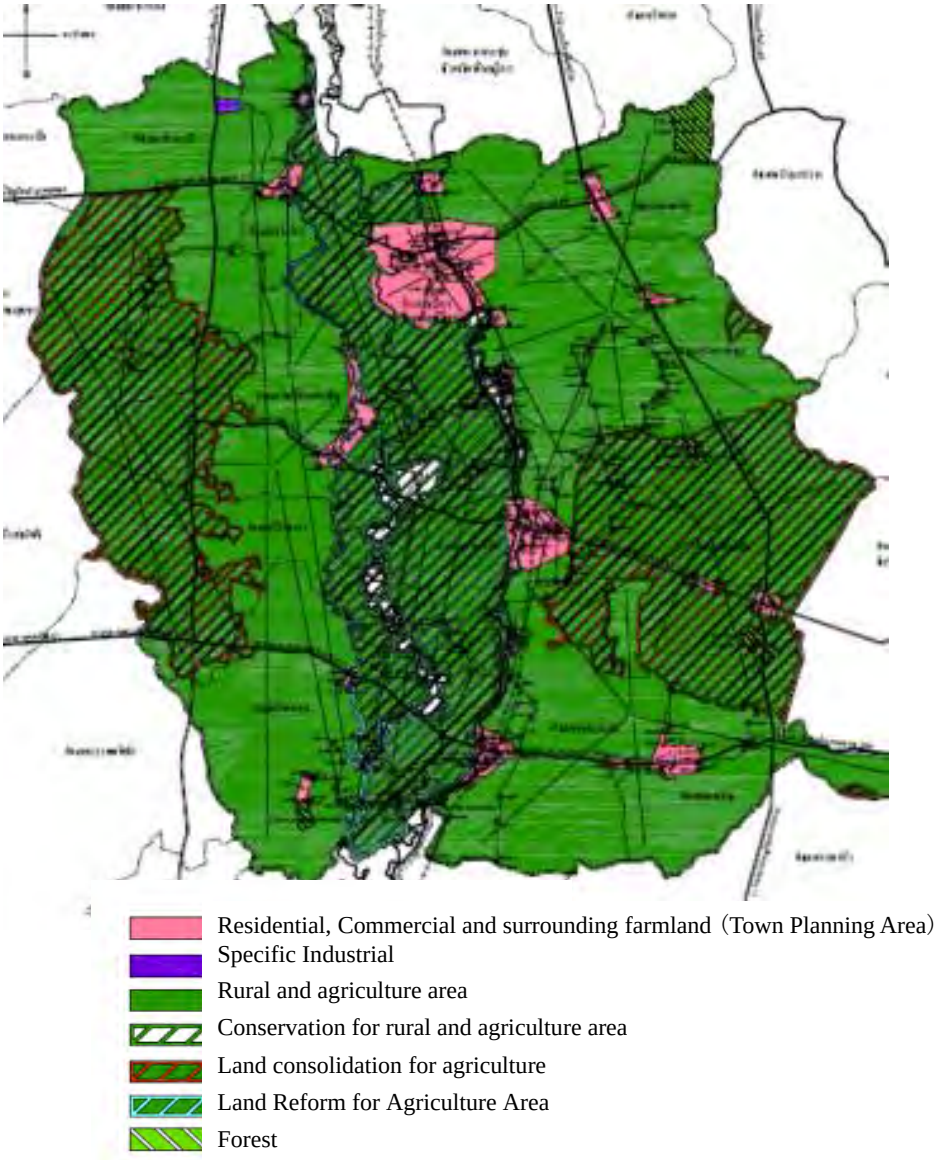


Figure L1.1.5 Land Use Plan of Pichit Province (Under Process for Approval)

L1.1.4 Tahan Hin, Ban Mun Nak District

Tahan Hin, Bang Mun District is located in the hub of traffic where R1118 and R111 intersect 1067 along the Nan River. Although most of this area was inundated in the 2011 flood, the township on the river levee was not affected. The area between the Yon River and the Nan River is considered to be a water retention area apart from township.

There appears to be an exudation of residential land use along R113 from the township of Taphan Hin and along R1067 from the township of Bang Mun Nak. Most of the area of farm lands is designated as rural and agriculture area and it appears that dwellings and factories with low environmental impact are located. As to the area between the Yon River and the Nan River designated for rural and agricultural area, there is little non-agricultural land use.

Since the ratio of exemption of minor land use in rural and agriculture is 10% in Taphan Hin and 25% in Bang Mun Nak, non-agriculture land use may be promoted especially along the main road even in low urbanization impact areas.

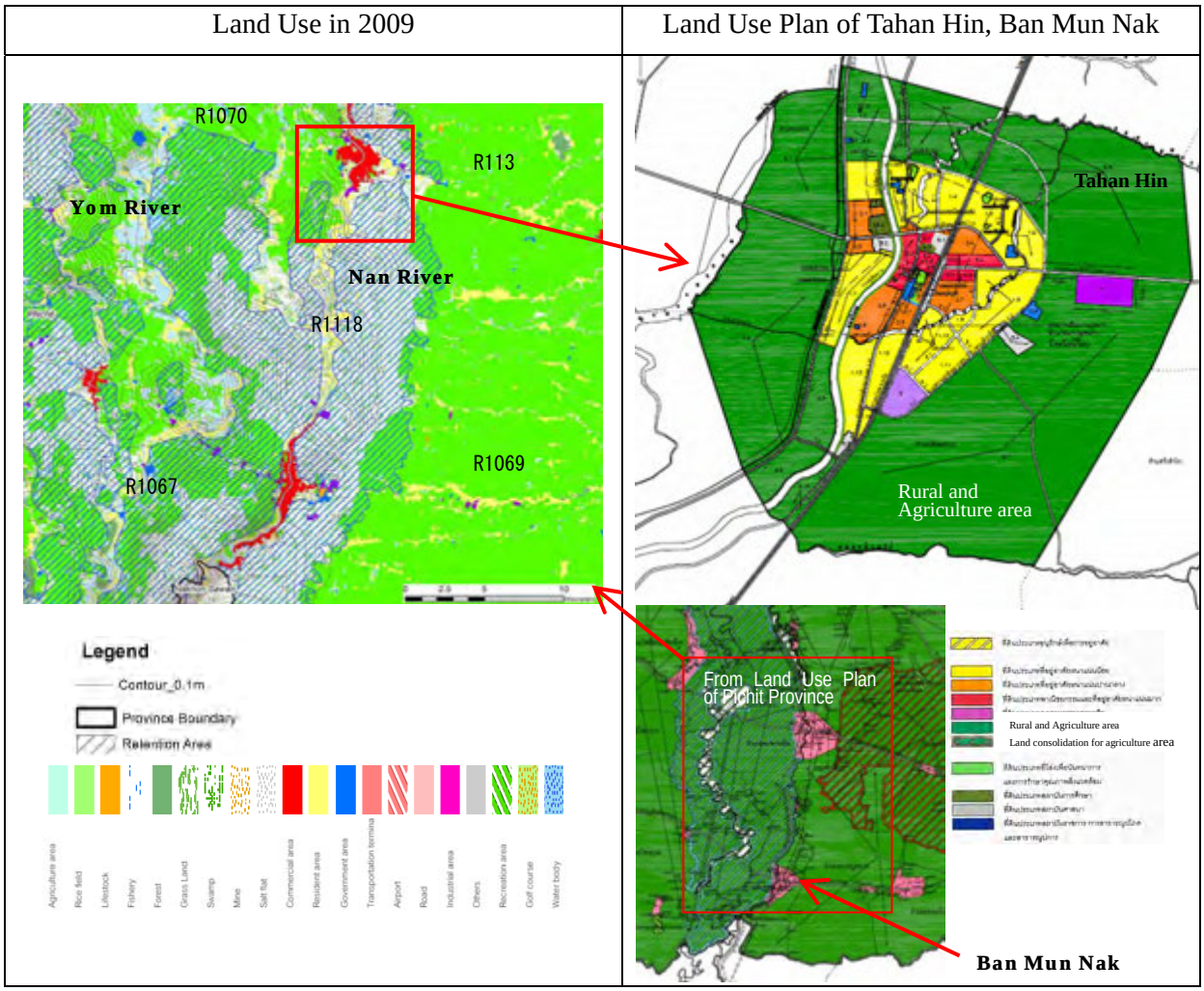


Figure L1.1.6 Land Use and Town Planning of Tahan Hin, Ban Mun Nak District, Pichit

Picture L1.1.4 Land Use along R1070

Picture L1.1.5 North of R1070

Picture L1.1.6 Along R113

Picture L1.1.7 Nan River in the Township of Tahan Hin

L1.1.5 Ayutthaya Province (Type FL)

(1) Overview

Five (5) industrial parks are located adjacent to the Bangkok Metropolitan Area that is the transportation hub. Factories are prominent in the agricultural zone along R9 and along the national roads running from north to south and from east to west in the regions such as R32. Factories are also found along R3111, 3263 in Bang ban, and Bag Chai located to the northwest of Ayutthaya.

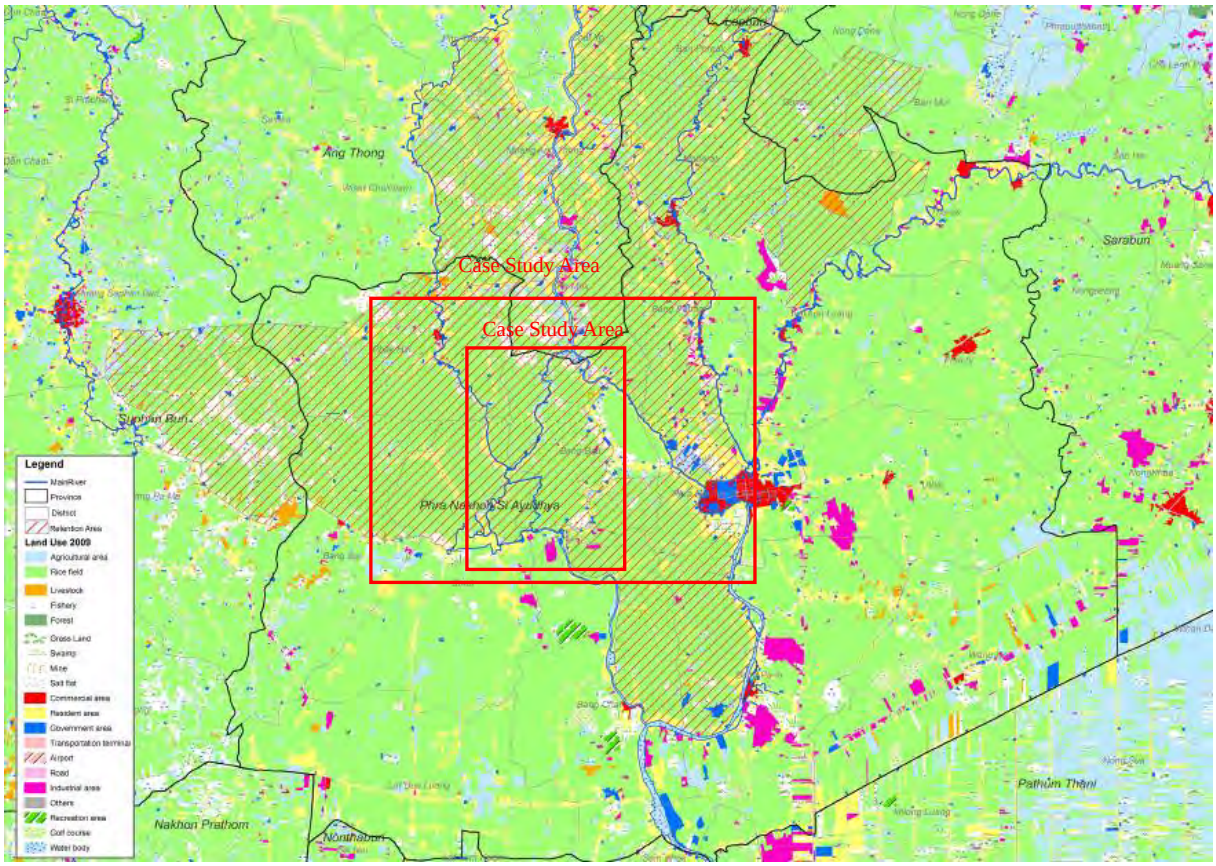


Figure L1.1.7 Situation of Ayutthaya Province (2009)

Most districts in the province have their town planned with fertile paddy fields which receive the blessing of the Chao Phraya River. The urban area and farmlands are distinguished clearly as seen in the condition of land use. Non-agricultural land use is in progress along the main road.

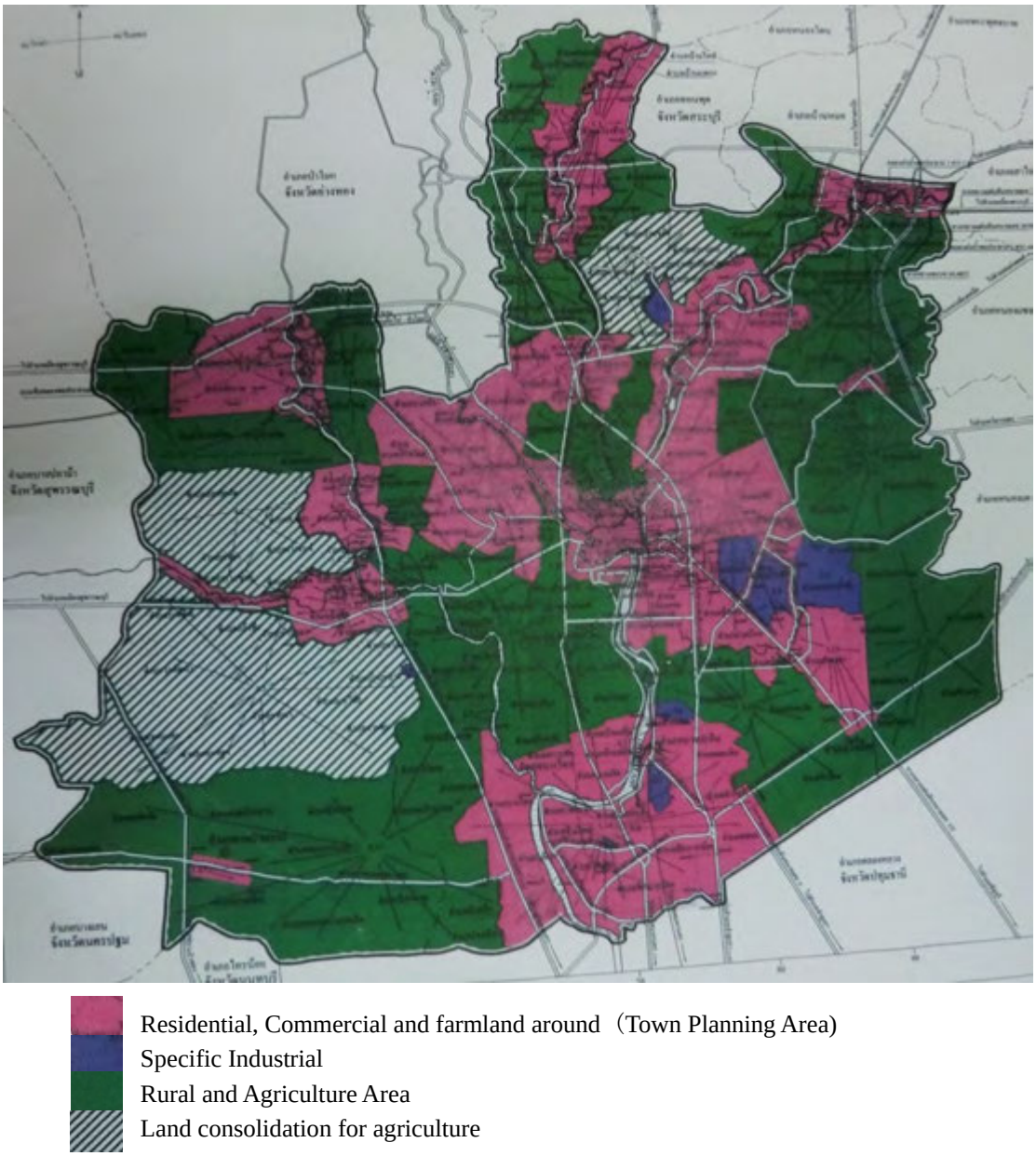


Figure L1.1.8 Land Use Plan of Ayutthaya (Under Process for Approval)

(2) Land Use of Bang Ban District

The area is located in the northwestern part of the City of Ayutthaya. The entire area is irrigated, and almost all were affected by the 2011 flood. The hospital and commercial area in the town center are protected by temporary earth dyke on the outer perimeter road. Almost all farmlands are designated as flood retention area with facilities constructed partially. A significant part of the area along R3111, 3263 and 3412 has been converted into non-agricultural use such as factory with roadside expansion as the economic land use. These areas are designated as rural and agriculture areas, but allow the location of non-agricultural land use such as certain factories with low environmental impact. Additionally, since the ratio of minor use exemption of Bang Ban and the adjacent Sena district is 20%, the location of non-agricultural appears to be promoted in good condition for access.

The area outside of Bang Ban is designated as rural and agricultural area under the provincial land use plan of Ayutthaya. It appears that more locations of non-agricultural land use are being

promoted as minor use exemption of 10%..

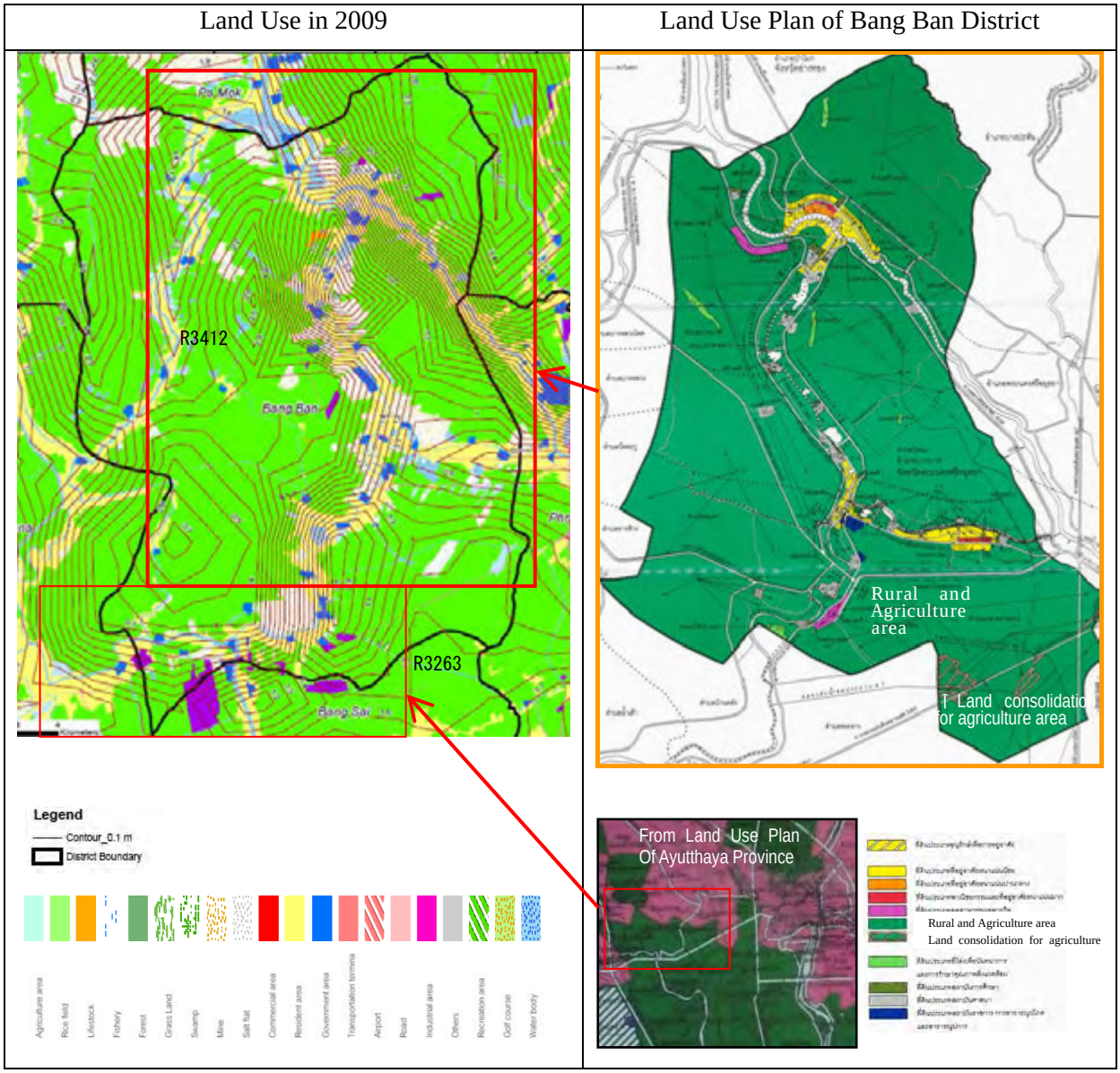


Figure L1.1.9 Land Use and Town Planning of Bang Ban District, Ayutthaya

Picture L1.1.8 Factory in Paddy Field (Factory is a wood processing plant)

Picture L1.1.9 Secondary Dyke Road

Table L1.1.3 Land Use Control in Bang Ban, Ayutthaya

		Rural and Agricultural Area	Conservation for Rural and Agricultural Area	Land Consolidation for Agriculture
Province Ayutthaya	Purpose	Agriculture or agricultural related purpose, educational institutions, religious institutions, government institutions, infrastructure and public assistance.	Agriculture or agricultural related purpose, educational institutions, religious institutions, government institutions, infrastructure and public assistance mainly for environmental preservation and maintenance. Land use for other businesses shall not be allowed for large buildings.	
	Land use not permitted	All types of factories apart from low impact; Gas filling facilities; Fuel oil storage; Hotels more than 9m high; Dwelling and commerce in large building; Golf course	All types of factories apart from low impact; Hazardous objects; Gas filling facilities; Fuel oil storage; Hotels more than 9m high; Dwelling and commerce in large building; Golf course ; Amusement park, etc	
		*Minor use exemption 10% *Provision of absolute height, some open space	※Provision of setback	
Bang Ban District	Purpose	Agriculture or agricultural related purpose, educational institutions, religious institutions, government institutions, infrastructure and public assistance.		Land consolidated area based on legislations
	Land use not permitted	All types of factories apart from low impact Gas filling facilities Fuel oil storage Hotels more than 9m high Dwelling and commerce in large building		
		※Minor use exemption 20%		

L1.1.6 Nakhon Chaisi, Nakhon Pathom (Type W)

(1) Overview

This area is located in the west of Tha Chin River, consists of marshlands formed in flood plain of Tha Chin River system. The area forms a hub function of traffic that connects Bangkok and Myanmar through Kanchanaburi, and also southern part by national inter-regional road R4 and National Railway Bangkok-Badang Busal line.

The level of these inter-regional line has been raised by 1.0 to 2.0 meters from basement.

This area also is expected as an area of southward flood flow to protect Bangkok because the location is western side of the flood protection line.

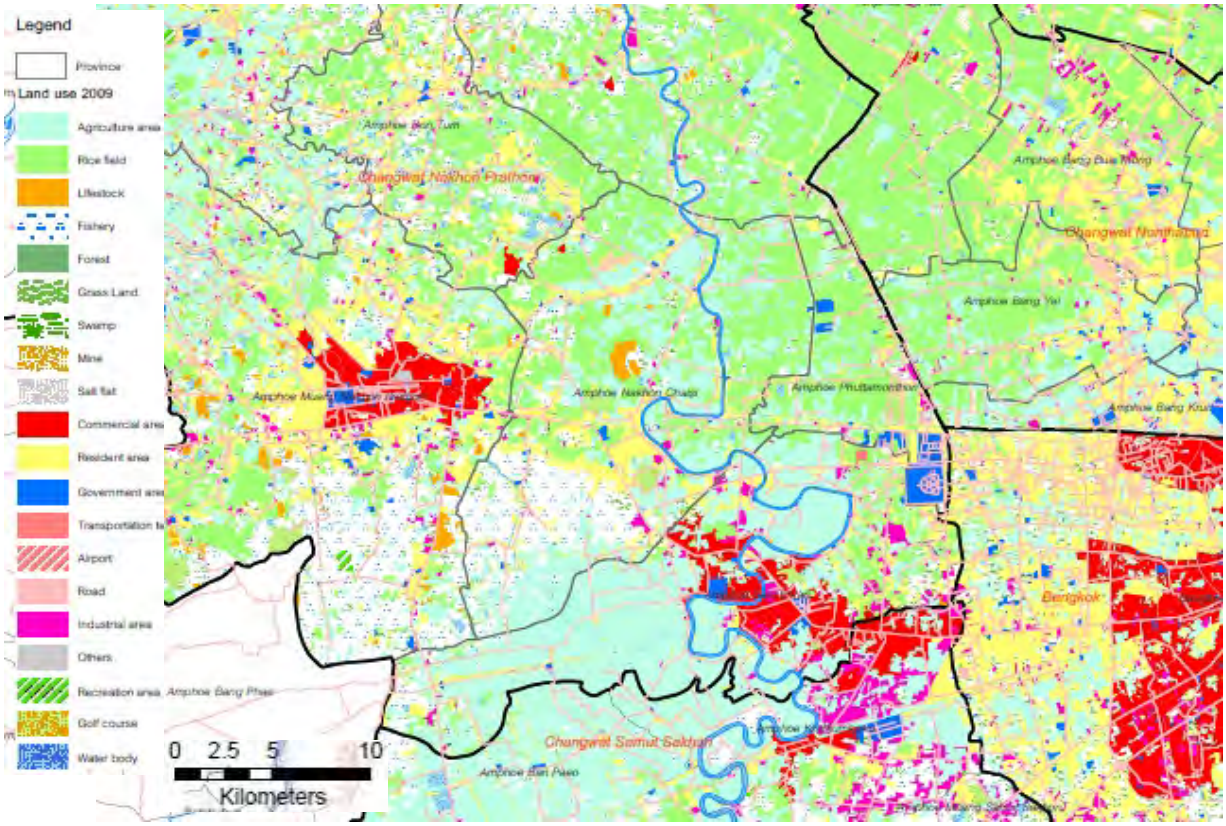


Figure L1.1.10 Current Land Use of Nakhon Chaisi Area (2009)

Picture L1.1.10 Land Use along R4

Picture L1.1.11 Housing along Bang Kaeo Canal

This area is mostly designated as Rural and Agriculture Area and "Conservation for Residential Area.

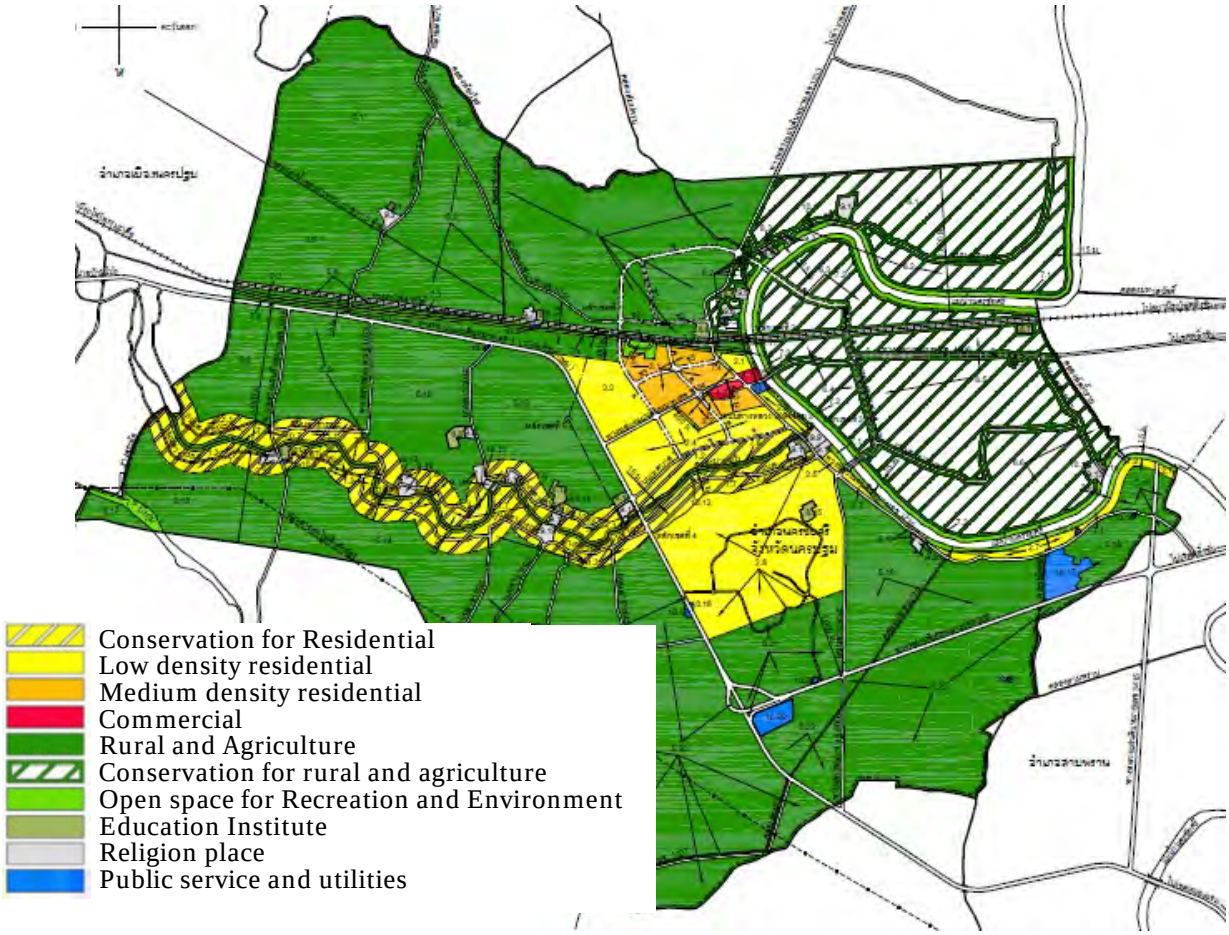


Figure L1.1.11 Land Use Plan of Nakhon Chaisi

Picture L1.1.12 North of Railway

Picture L1.1.13 Factory, west of R4

Picture L1.1.14 Tha Chin River in Nakhon Chaisi Township

(2) Land Use of Nakhon Chaisi District

Conservation for Residential Area is stipulated along Bang Kaew Canal, restricted the building which is not higher than 10 meters and is composed of walls on the 2nd floor except in the bathroom, toilet and kitchen within 100 meters along the canal. However, regarding land use for minor purpose, 10 % exception rule of land use have been stipulated in the regulation.

Rural and Agriculture Area is dominant in the area even along R4, although automotive-related businesses are seen on the road side of R4 because of 20% (partly 10%) exception rule.

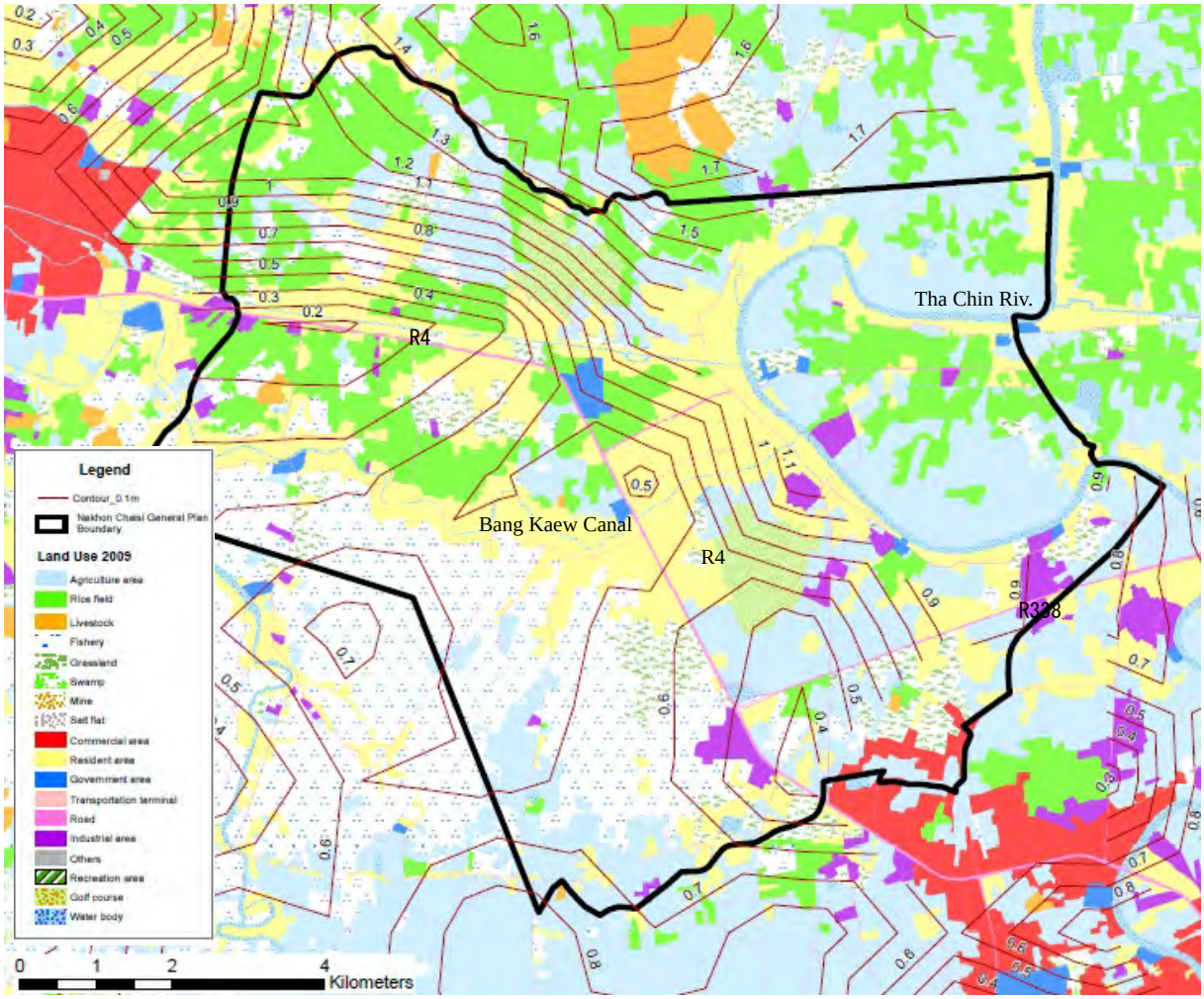


Figure L1.1.12 Land Use and Inundation Contour Line of Nakhon Chaisi District

Table L1.1.4 Land Use Control in Nakhon Chaisi

		Rural and Agriculture Area	Rural and Agriculture Area
Nakhon Chaisi District	Purpose	Residence, government institutes, public utilities and public assistance.	Agriculture or agricultural-related matters, government institutes, public utilities and public assistance.
	Land use not permitted	All types of factories with apart from low impact Fuel oil storage Gas filling facilities Livestocks, snakes, crocodiles etc Preservation and Protection Cemetery and crematory Hotels more than 9m high All types of businesses except businesses with less than 100 square meters of business areas	All types of factories with apart from low impact Fuel oil storage Gas filling facilities Land allocation for commerce, industry Hotels more than 9 m high Dwelling and commerce in large building Garbage disposal Row houses, large buildings, high buildings or specially large buildings
		※Minor use exemption 10% ※Provision of absolute height : 10 m ※Living 2F with wall	※Minor use exemption 20％(partly 10%) ※Provision of absolute height along R4, R338, R3235, R3233 : 15m

L1.1.7 Uthai Thani (Type M)

(1) Overview

This area is located at the confluence points where the Sakae Krang River and the Chao Phraya River converge. The main river has largely meandering flow path with many tributes reflecting flat land. On the other hand the regional flood water is also concentrated during flood because the basin width is relatively narrow lying between the hills of east and west. Therefore, this area is assumed to be a prone area of flood with deeper inundation and longer duration.

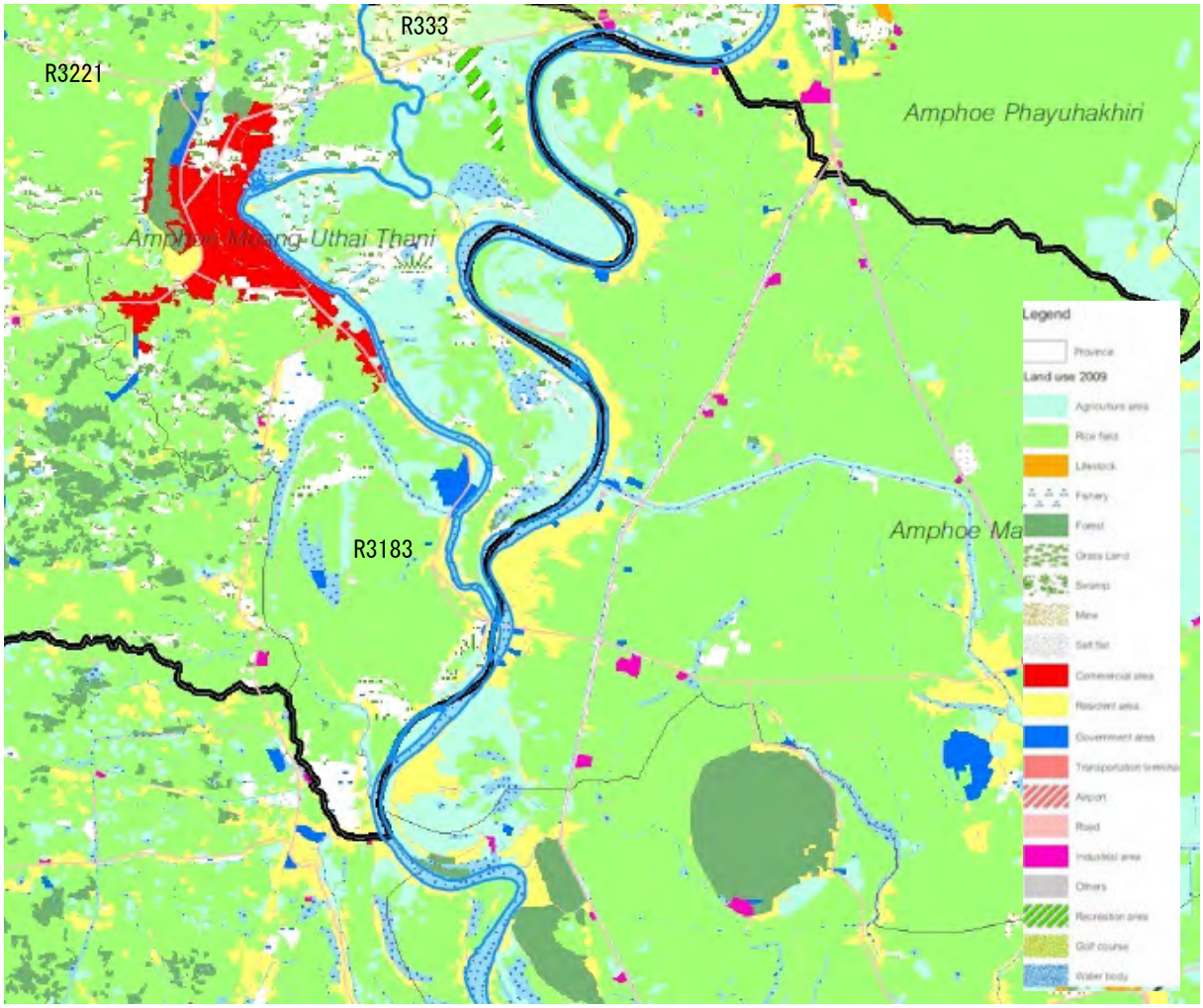
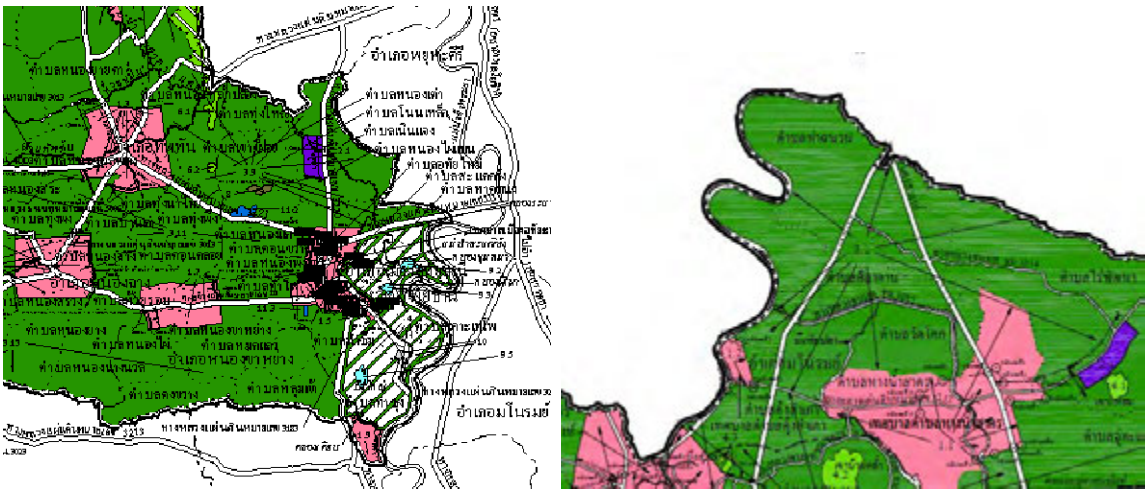


Figure L1.1.13 Current Land Use of Uthai Thani (2009)



- Residential, Commercial and farmland around (Town Planning Area)
- Specific Industrial
- Rural and Agriculture
- Conservation for rural and agriculture
- Land reform for agriculture area
- Open space for Recreation and Environment
- Forest conservation
- Education Institute
- Open space for Recreation and Environmental conservation and fishery
- Religion place
- Public service and utilities

Figure L1.1.14 Land Use Plan of Uthai Thani Area

Picture L1.1.15 Sakae Krang River and Uthai Thani Township

Picture L1.1.16 west of Uthai Thani

Picture L1.1.17 Along R3221

Picture L1.1.18 Raised, east of Uthai Thani

(2) Land Use of Uthai Thani

The deeply inundation area is spread in the area even if after flood measures implemented. This is because the flood stream is concentrated here. The considerable area of the north of R333 is assumed to be covered in deep inundation such as more than 3m, although there is few land use of non-agriculture. The area between the Chao Phraya River and the Sakae Krang River is also assumed to be widely in deep inundation area. However considerable housing is located along the main road.

The exception rule is not stipulated in the province regulation and 70% open space rule and 10m building restriction along the riverside are set up, although small scale housing and commercial use are allowed in the agricultural zone.

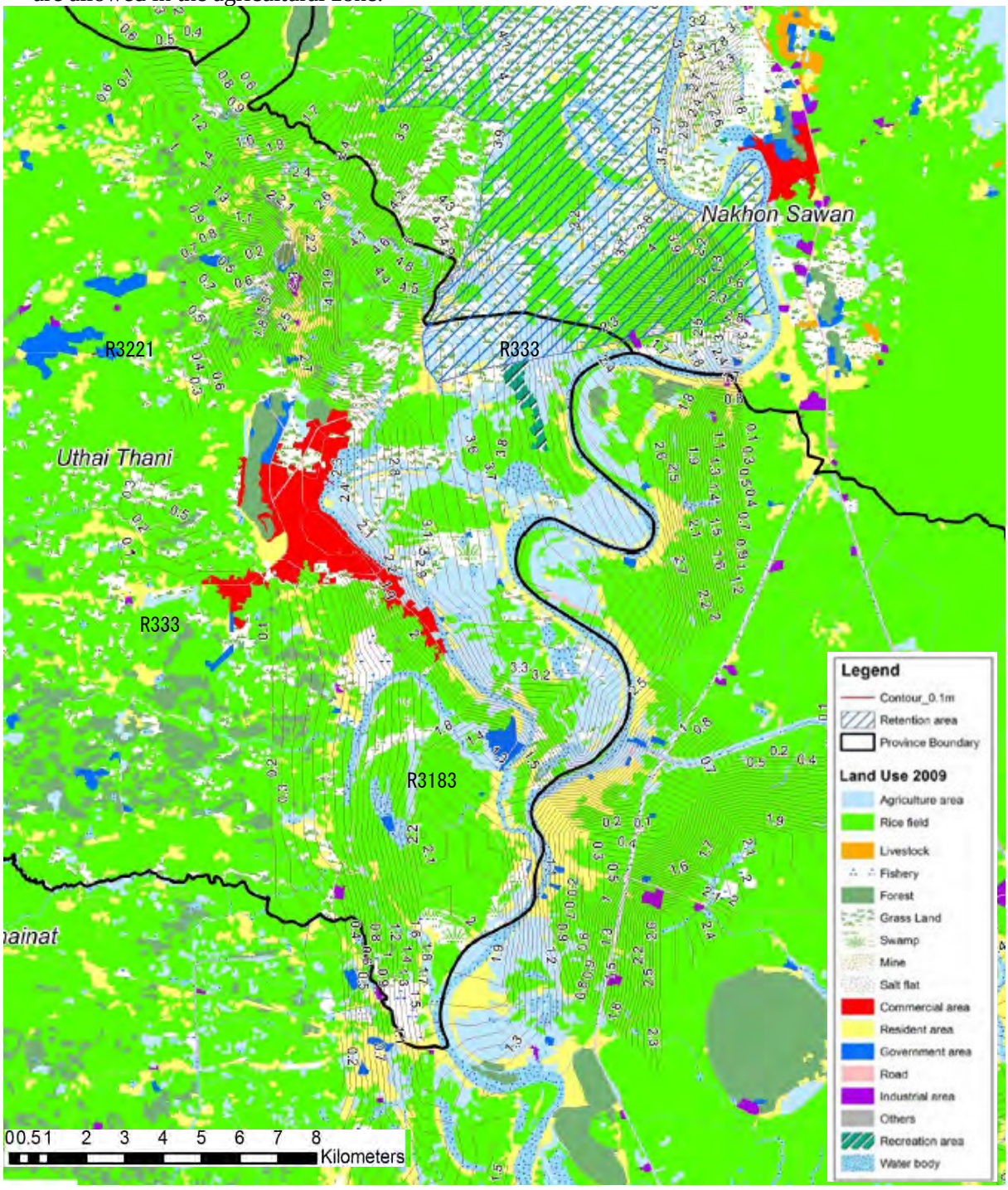


Figure L1.1.15 Land Use and Inundation Contour Line of Uthai Thani (Case10-1)

Table L1.1.5 Land Use Control in Uthai Thai

		Rural and Agriculture Area	Conservation for Rural and Agriculture Area
Uthai Thai Province	Purpose	Agriculture or agricultural related purpose, dwelling, commerce, government institutes, educational institutes, religious institutes, , public utilities and public assistance.	Agriculture or agricultural related purpose, dwelling, commerce, government institutes, educational institutes, religious institutes, public utilities and public assistance as well as environmental quality preservation and promotion.
	Land use not permitted	All types of factories with apart from low impact Gas filling facilities Fuel oil storage Land allocation for commercial or industrial business Dwelling and commerce in large building Golf course	All types of factories according to the factory law except types and categories of factories deemed operable, wastewater plants. Gas filling facilities Fuel oil storage Hotels more than 9m high Land allocation for residential, commercial or industrial business Dwelling and commerce in large building Garbage disposal Trading or collection of scrap materials Golf course Amusement park etc
		※Leave space not less than 70％ ※Land use along the edge of the Sakae Krang River shall leave space on the natural riverside of the Sakae Krang River not less than 10 meters.	※Leave space not less than 70% ※Land use along the edge of the Sakae Krang River , Chao Phraya River shall leave space on the natural riverside not less than 10 meters. ※And Land on the edge of canals or public water sources shall leave space on the natural riverside of canals or public water sources not less than 6 meters.

L1.2 Issues of Land Use Control

L1.2.1 Study on New Land Use Measures for Retention Area

Most of the retention areas considered in the master plan are designated for agricultural land use such as Rural and Agriculture Area, Conservation for Rural and Agriculture Area, partially, Land Reform for Agriculture Area and Land Consolidation for Agriculture Area. Residents of small scale and factory of low environmental impact are permitted to locate in the area of Rural and Agriculture Area and Conservation for Rural and Agriculture area. Since the exemption rule for minor land use has been defined in the range of 5% to 25% of each area in the above-mentioned agricultural land use apart from "Land consolidation for agriculture area," the control on buildings has become insufficient.

It is indispensable that the new strict land use or review of regulations on exemption is to be introduced to control location of buildings in the retention area. Since Land Consolidation for Agriculture Area and Land Reform for Agriculture Area are the target areas of land development for agriculture, these two area should be excluded from the target area for retention.

(1) Introduction for Interim Regulation for Land Use Control to the Area protected by Ring Levee in the Future

In high potential areas for flooding that requires protective measures against inundation such as ring levee and waterside land, the introduction of strict regulations to building construction is needed. Since there is no regulation such as Disaster Risk Area, a new system to specify the hazardous area of flooding is also needed.

(2) Enhance Coordination System of Land Use

To increase the effectiveness of land use policy, cooperation between related organizations is required. The fact that in addition to the Department of Town and Country Planning and the organization for building permits there are organizations that serve to enhance the value of land use such as agricultural land use may give rise to mutual contradiction to each other. Considering the situation that cooperation has not been fully operated, it is necessary to establish the system to ensure the cooperation of relevant organizations for land use control.

L1.3 Proposal of Solution for the Issue

L1.3.1 Policies for the Land Use Control

(1) Basic Policy

To set up countermeasures of land use as a part of the management of Chao Phraya River Basin, the result of study such as past flooding feature, flood control under the MP, and historical and social background of land use in Thailand must be considered. The policy direction of management of land use control of the basin is to be set up as follows.

■To take into account the direction of policy on the basis of mitigation

The characteristics of the flood and land use are summarized as follows.

It is assumed that this master plan responds to a disaster of 100-year probability such as the 2011 flood, but it is also inevitable that flooding will occur during heavy rain of 100-year probability even if flood control measures were implemented. To cope with flood damage, the basic concept of mitigation is that flood damage is to be reduced as much as possible in frequent flood in several years and is to be reduced to a certain level of damage in the event of a disaster of once in several decades to one hundred years.

■To promote guidelines of land use that respects social and historical background

Social and economic activities are a day-to-day life of ordinary people which communities have cultivated over a long period. Although mitigation is a basic policy, it is inevitably reproachable to put the cart before the horse if the measures appear to act as impediment to people's daily life and economic activities.

Measures of land use for mitigation should lead to improve the quality of life of the people that respects social environment and historical background taking account of inheritance of land use in the current situation and existing system.

■Enhancement of land use coordination system

At the time of construction of large scale land development, improvement, and property, it is required to make effective use of land that took into consideration the potential flooding from the point of view of the Chao Phraya River Basin management.

If an application of this large scale land use has been made, a project shall be implemented on the basis of sufficient cooperation of related organizations with consideration for flood as a part of river management.

(2) Concept of Land Use

The concept of land use management is set as follows based on the basic policy.

The concept 1:
To implement effective land use regulation

The concept 2:
To promote land use following the regulation proposed in theconcept 1

The concept 3:
To relocate the land use

The concept 4:
To create a system of performance under the full coordination of related organizations for implementation.

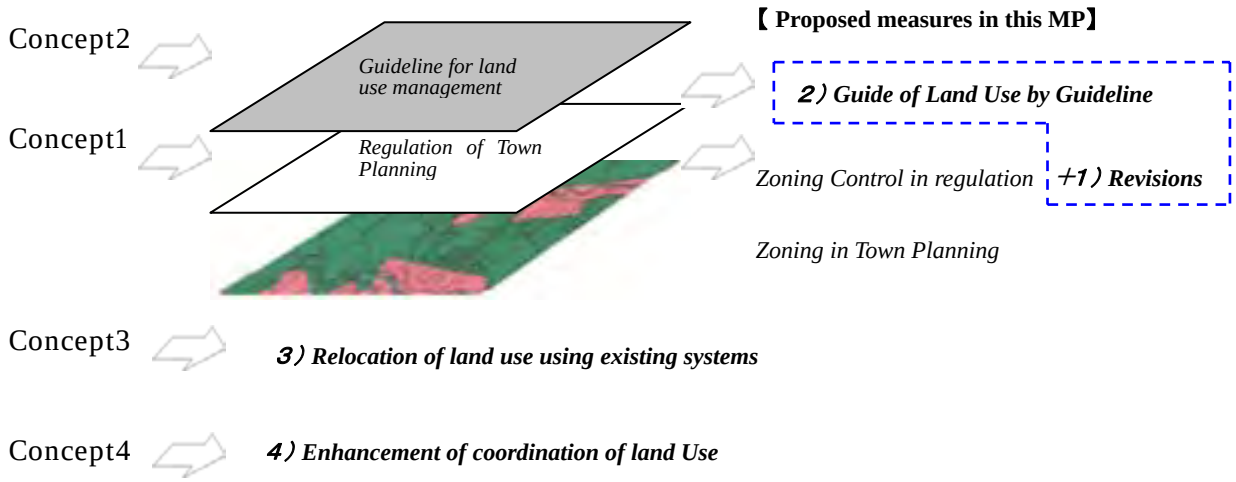


Figure L1.3.1 Image of Land Use Management Based on Concept

L1.3.2 Specific measures of Land Use Management

(1) Revision of Existing System

In areas at the risk of inundation, control of land use should be applied to minimize flood damage depending on the characteristics of flooding. The risk analysis results of flood analysis are to be used as an appraisal of flood vulnerability.

From the fact that Town Planning has been set up in Changwat, Amphoe level in the flood prone area on the Chao Phraya River Basin, it is proposed that the control is collateral by revision or abolition of the provisions of each regulation of town planning promulgated as Ministerial Regulation. The new regulation is applied on the occasion of proposal of building permission after promulgation.

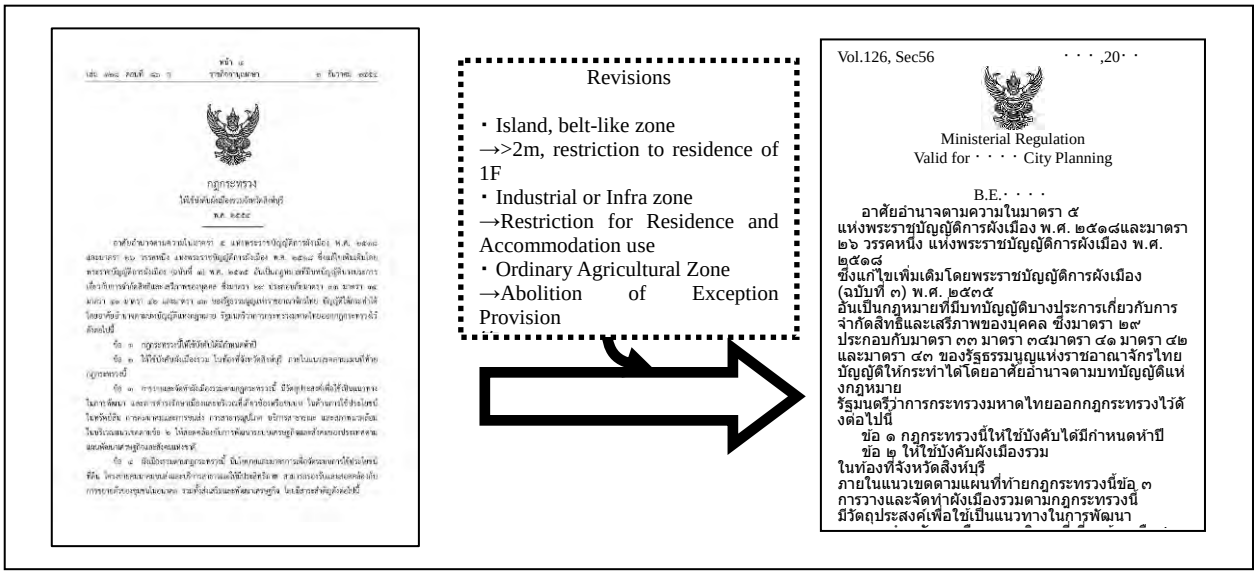
Basic policy and contents of application is as follows.

- In coherent area of high density township of Town Planning Area, protection of town is a basic policy so that new land use control should not be implemented.
- In area designated as the residential use zone[*1] in island-like or belt-like zone along the highway, residences on the first floor are subject to restriction in the area where inundation depth is predicted to exceed 2m.
- In area designated as industrial or infrastructure use zone[*2] in individual zone, protection of the area is a basic measure and is subject to restriction for residence and accommodation use other than factory, warehouse, etc.
- In area designated as ordinary agricultural use zone[*3], buildings related to agriculture are permitted. Every building is supposed to be permitted in a certain percentage in accordance with the provisions of exception. Since this situation leads to the expansion of flood damage, exception rule is not to be applied to the regulation in the area where inundation depth is predicted to exceed 2m.

*1 Residential use zone:
Zone with residence such as Conservation for Residential Area, Low density residential area, Medium density residential area, High density residential and commercial area, Commercial area.

*2 Industrial or infrastructure use zone:
Zone located by industrial facilities such as Industrial and warehouse area, Specific Industrial, Warehouse, Storage and Godown, General Industrial Non-pollution industrial and ware house, Conservation for tourism, Public service and utilities area.

*3 Ordinary agricultural use zone:
Zone with agricultural land use, such as Rural and Agriculture area, Conservation for rural and agriculture area.



Existing Regulation for Land Use

Regulation in the Future

Figure L1.3.2 Image of Revision of Existing Land Use Regulations

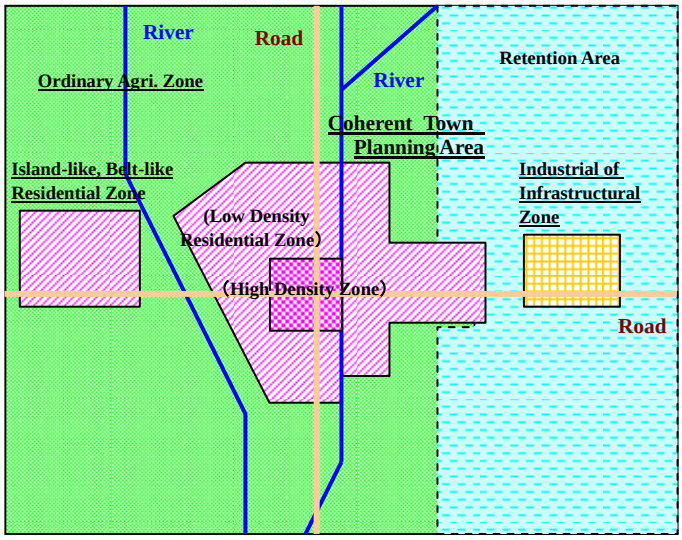


Figure L1.3.3 Image of Location of Town Planning Area

Table L1.3.1 Tentative Contents of Specific Measures of Land Use Management

				Land Use Zoning				
Category of Flood Area	Flood Depth	Retention Area	Features	Town Planning Area	Island-like, Belt-like Residential Zone	Industrial, Infrastructure Zone	Ordinary Agricultural Zone	New Designation
			Example		Nakhon Chai Sri	Nakhon Chai Sri, Ayutthaya	All area	―
FS	―		Relatively shallow inundation and shorter duration		―	Continuation of Current System	Continuation of Current System	Continuation of Current System
FSR	―	○	Relatively shallow inundation and shorter duration. Water level is controlled.	Basically Protection --- Continuation of Current System	―	―	―	―
FL	＞2m		Deeper inundation and longer duration.		―	Basically Protection Not allowed to residential and commercial	Basically Protection Abolition of Exception Provision	Not allowed
FLR	＞2m	○	Deeper inundation and longer duration. Water level is controlled.		―	Basically Protection Residential and accommodation not allow	Inundation control Abolition of Exception Provision	Not allowed
W	＞2m		Flood ways for overflowed water located in west of protection area		Allowed to flood Uninhabitable to ground floor	Basically Protection Residential and accommodation not allow	Allowed to flood Uninhabitable to ground floor	Allowed with uninhabitable to ground floor
M	＞2m		Swamp, deep inundation and long duration		―	Basically Protection Residential and accommodation not allow	Allowed to flood Abolition of Exception Provision	Not allowed
MR	＞2m	○	Swamp, deep inundation and long duration. Water level is controlled.		―	Basically Protection Residential and accommodation not allow	Inundation control Abolition of Exception Provision	Not allowed
H	―		Small scale floods from the east hilly		Continuation of Current System	Continuation of Current System	Continuation of Current System	Continuation of Current System

Upper : Land Use Policy

Under : Land Use Control Measure

(2) New Measure for Guide of Land Use – Creation of Land Use Guideline -

For further reduction of flood damage, the induction of land use is to be introduced in flood prone area. It is proposed that this induction of land use is implemented under the "Guideline of Land Use for Flood Mitigation" based on the features of flood area considering the backlash against the free use and disposal of land.

The contents of the guidelines are proposed as follows.

- Induction of land use is carried out by applying the guidelines to new construction or renovation of buildings.
- The basic policy of induction is to reduce flood damage as much as possible taking into account the features of building use, flood area and its position as a Retention Area.
- Induction contents is indicated by a matrix chart of regional flooding features and building use
- As for a building use as Residential and Commercial, not buildable or uninhabitable to ground floor are to be induced depending on the depth of inundation to reduce human and economic damage.
- As for a building use of Industrial and Infrastructural, not buildable or installation of facilities for flooding are to be induced depending on the depth of inundation.
- As for a building use of Religion, Cultural and Educational, the raising of the ground or the height of first floor considering the high water flooding besides flood wall or levee are to be induced for the functions responsible for emergency measures such as a shelter during flooding.
- As for a building use for Agricultural, installation of flood protection such as raising ground level are to be induced to ensure an environment of agricultural production.
- As for a building use for Public Service, the raising of the ground or flood wall or levee are to be induced in view of its important function for restoration, saving victims and shelters in flooding.
- As for a building use of Tourism and Recreation, the raising of the ground or flood wall or levee are to be induced in view of ensuring the safety of visitors.

This guideline shall serve to supplement the provisions of the Town Planning Regulation described above. It is assumed that the Building Control Bureau of DTP is responsible for the promulgation and publicity of this guideline. The Building Permission Office of the local government is expected to refer to this guideline on the occasion of pre-consultation of building permit application.

- Residential, Commercial: Detached Houses, Housing Complex, Store, Shop house, Office, Theater, Hotel etc.
- Industrial and Infrastructural: Factory, Auto-repair Shop, Warehouse etc.
- Religion, Cultural and Educational: Museum, Reference Library, School, Vocational College, College, University, Wat etc.
- Agricultural: Farm Product Storage, Processing Facilities
- Public Service: Administrative Facilities
- Tourism and Recreation: Resort Facilities, Tourist Facilities, Local Product Shop, Golf Club House etc.

Table L1.3.2 Tentative Scheme of Building Control in accordance with Feature of Flooding

Features of flooding Area			Building Use					
Category of Flood Area	Retention Area	Features	Residential・Commercial	Industrial・Infrastructure	Religion・Cultural・Education	Agriculture	Public Service	Tourism・Recreational
FS		Relatively shallow inundation and shorter duration	△1	△1	○	○	○	○
FSR	○	Relatively shallow inundation and shorter duration. Water level is controlled.	△2	△1	△1	○	○	○
FL		Deeper inundation and longer duration.	×	△1	△1	△1	△1	△1
FLR	○	Deeper inundation and longer duration. Water level is controlled.	×	×	△1	△1	△1	△1
W		Flood ways for overflowed water located in west of protection area	△2	△1	△1	△1	△1	△1
M		Swamp, deep inundation and long duration	×	×	△1	△1	△1	△1
MR	○	Swamp, deep inundation and long duration. Water level is controlled.	×	×	△1	△1	△1	△1
H		Small scale floods from the east hilly	△1	△1	○	○	○	○

Policy of Land Use restriction: ○: Buildable as usual △: Buildable conditionally (Condition 1: With levee or raising of the ground level; 2: Uninhabitable to ground floor) ×: Not buildable newly, renovation

(3) Relocation of Land Use by Using Existing Systems

The flood area covers most of the Chao Phraya River Basin and high dense residential areas extended linearly along the river. Although flood water depth at the flood will continue to decline because of measures for flood, it is expected that more than 1m inundation occurs in the area of FL, W and M.

Since measures 1) and 2) are applied during new construction and restoration of building, the works will require a considerable amount of year.

It is deemed appropriate that the community works to develop resilient area.

Measures to protect the area from flooding are in follows.

- protection of the area by structure ; levee or flood wall etc.
- relocation to the raised land keeping community to reduce the influence of flood

In this case, it is considered that the application of Land Readjustment* as existing systems can be carried out in accordance with the arrangement of parcels of land and the development of roads and other infrastructure.

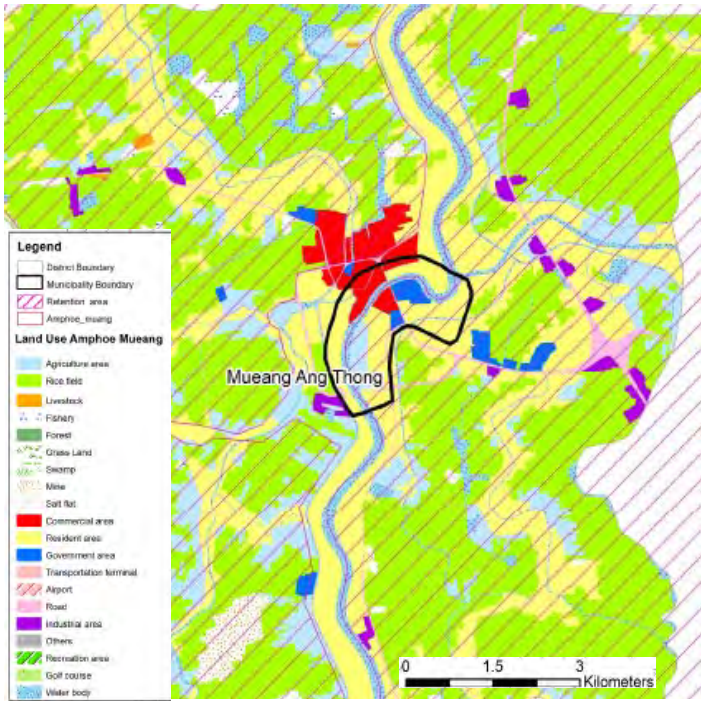
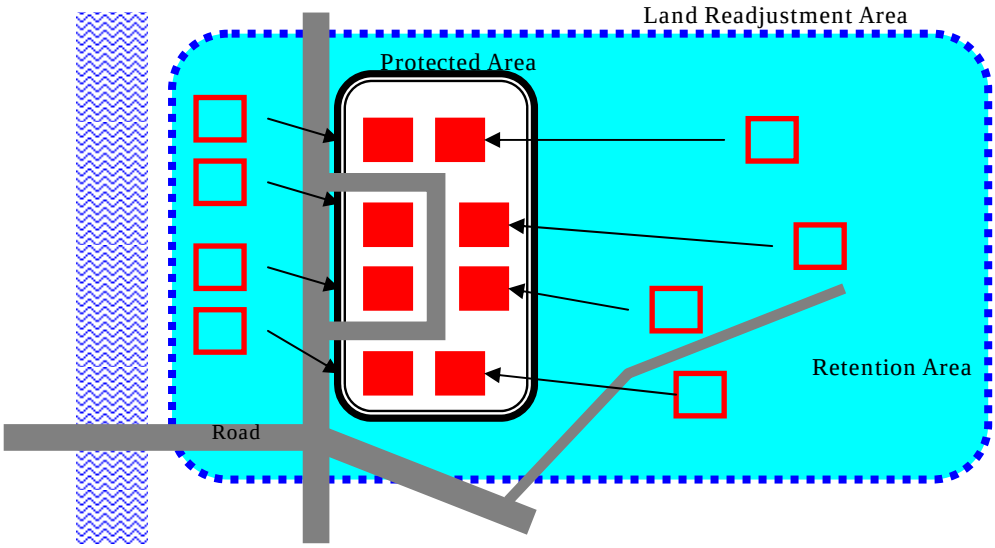


Figure L1.3.4 Map of Land Use Around Ang Thong



* Based on Land Readjustment Act B.E.2547（A.D.2004）

Figure L1.3.5 Image of Land Readjustment By Integrating Land Relocation

(4) Enhancement of Coordination of Land Use

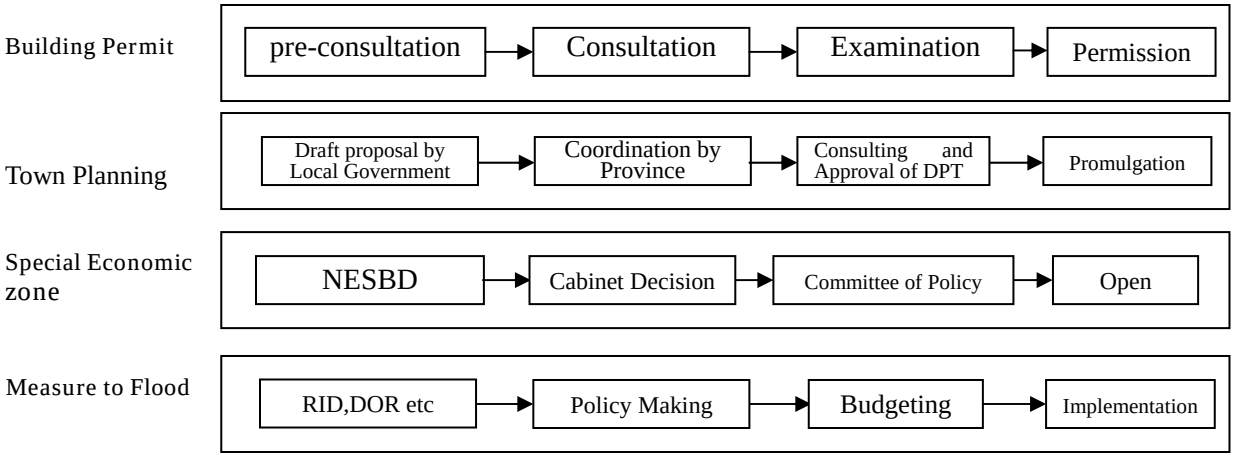
To secure cooperation in particular flooding from the perspective of disaster risk reduction as a consultative body, the establishment of a "Coordination Committee of Land Use in Flood-Prone Area" (tentative name) is assumed to work as an organization to consider policies related to large scale of land use, such as special economic zone and to discuss land use under flood control measures in consideration of potential of flood.

【Assumed Members and Matters of coordination】

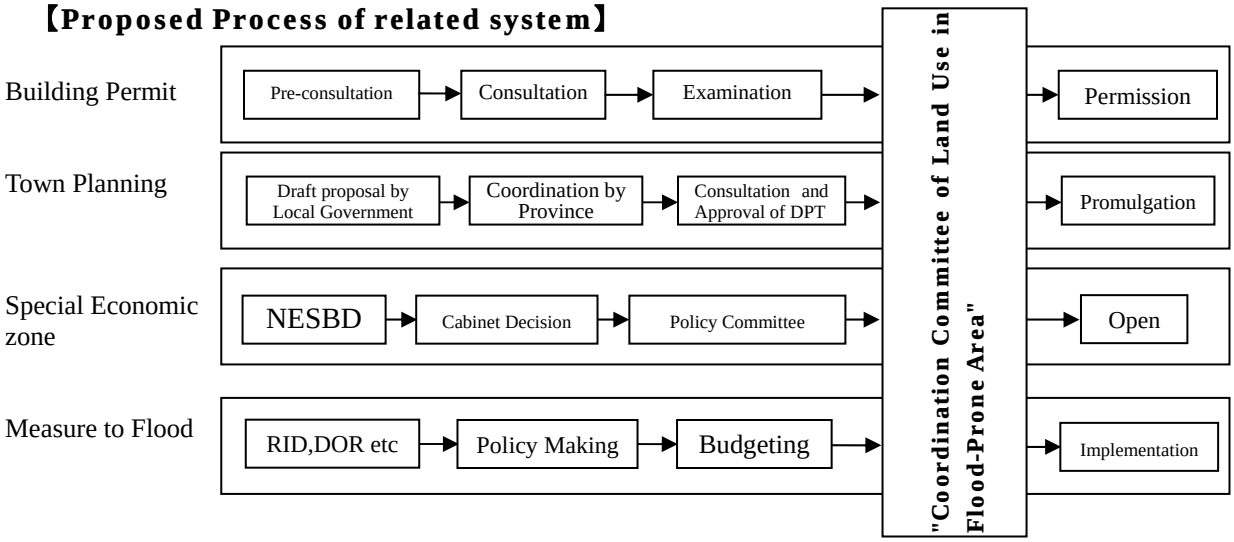
Membership is assumed to consist of the Royal Irrigation Department (RID), the Ministry of Agriculture and Cooperatives, the Department of Public Works and Town & Country Planning (DPT), the Department of Roads (DOR), the Department of Highway (DOH) of the Ministry of Interior, the National Economic and Social Development Board (NESDB), the Ministry of Industry, etc. Matters of coordination are assumed as follows.

- Positioning of the area based on the flood potential
- Vulnerability assessment in predicted inundation
- Effect for mitigation
- Advice on measures against flood based on the guideline, etc

【Existing Process of Related System】



【Proposed Process of related system】



Sector M: Inland Rain Storm Drainage

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
VOLUME 3: SUPPORTING REPORT

SECTOR M: TABLE OF CONTENTS

LIST OF TABLES

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CHAPTER M1 EXISTING CONDITION OF PROTECTION AREA

M1.1 General

After the 2011 flood the Thai Government designated the most economically important area of some 5,600km^2 that covers Bangkok and 9 industrial estates. as "Flood Protection Area." The economic area is going to be enclosed by flood walls or heightened roads and canal dikes in order to prevent floodwater from entering the zone. The enclosing works have already started and are expected to be completed by January 2014.

With the enclosing works the protection zones will be much safer against floodwater from the outside that troubled these zones very much in 2011. Instead, management of storm water generated in the zones by local rainfall becomes more important. In this section, a strategy for the inland storm water drainage of the flood protection area is proposed.

M1.2 Outline of Protection Area

The Thai Government is constructing flood walls and or heightening roads/dykes around the area. The area is further being divided into three zones by flood walls or heightening roads/dykes. The three zones are named, from the north, "Outer Protection Zone", "Middle Protection Zone" and "Inner Protection Zone" respectively. The safety level is higher, located more southerly. Bangkok area, which is the Inner Protection Zone is given the highest safety level. According to the website of ONWFP, the safety levels of the three zones are explained as follows:

- Outer Protection Zone: Some parts of this zone are flooded in case of downpour and mass-runoff,
- Middle Protection Zone: Less flooded than the outer zone, and
- Inner Protection Zone: Flooding is allowed in very low areas only.

Estimated population, area, population density are presented in the following table.

Table M1.2.1 Area and Population of Protection Zones

Zone	East/ West	Estimated Population* （1,000）	Area （km^2）	Population Density （1/km^2）	Safety Level
Outer Protection Zone	East	314	946	332	Some parts of this zone are flooded in case of downpour and mass-runoff.
	West	475	861	552	
	Total	789	1,807	437	
Middle Protection Zone	East	1,078	1,558	692	Less flooded than the outer zone.
	West	571	511	1,117	
	Total	1,649	2,069	797	
Inner Protection Zone	East	3,930	1,073	3,663	Flooding is allowed in very low areas only
	West	1,817	691	2,630	
	Total	5,747	1,764	3,238	
Total	East	5,322	3,577	1,488	-
	West	2,863	2,063	1,388	
	Total	8,185	5,640	1,451	

*: Based upon 2010 statistics.

The flood map of the 2011 flood, the land use map and the elevation map for the protection zones are presented in Figure M1.2.1, Figure M1.2.2 and Figure M1.2.3 respectively.

During the 2011 flood, flood water that flew down over the northern flood plains rather than over the river banks broke into these zones. The inundation depth is more in the outer and middle zones than in the inner zones.

As for the land use, agricultural areas are dominant in the outer and middle areas, but urban areas spread over the inner zone that covers most of Bangkok.

The elevation map based upon the LP data shows that the protection zones gently declines toward the south, and that hollow areas are distributed in the inner zone and the southern part of the eastern middle zone.

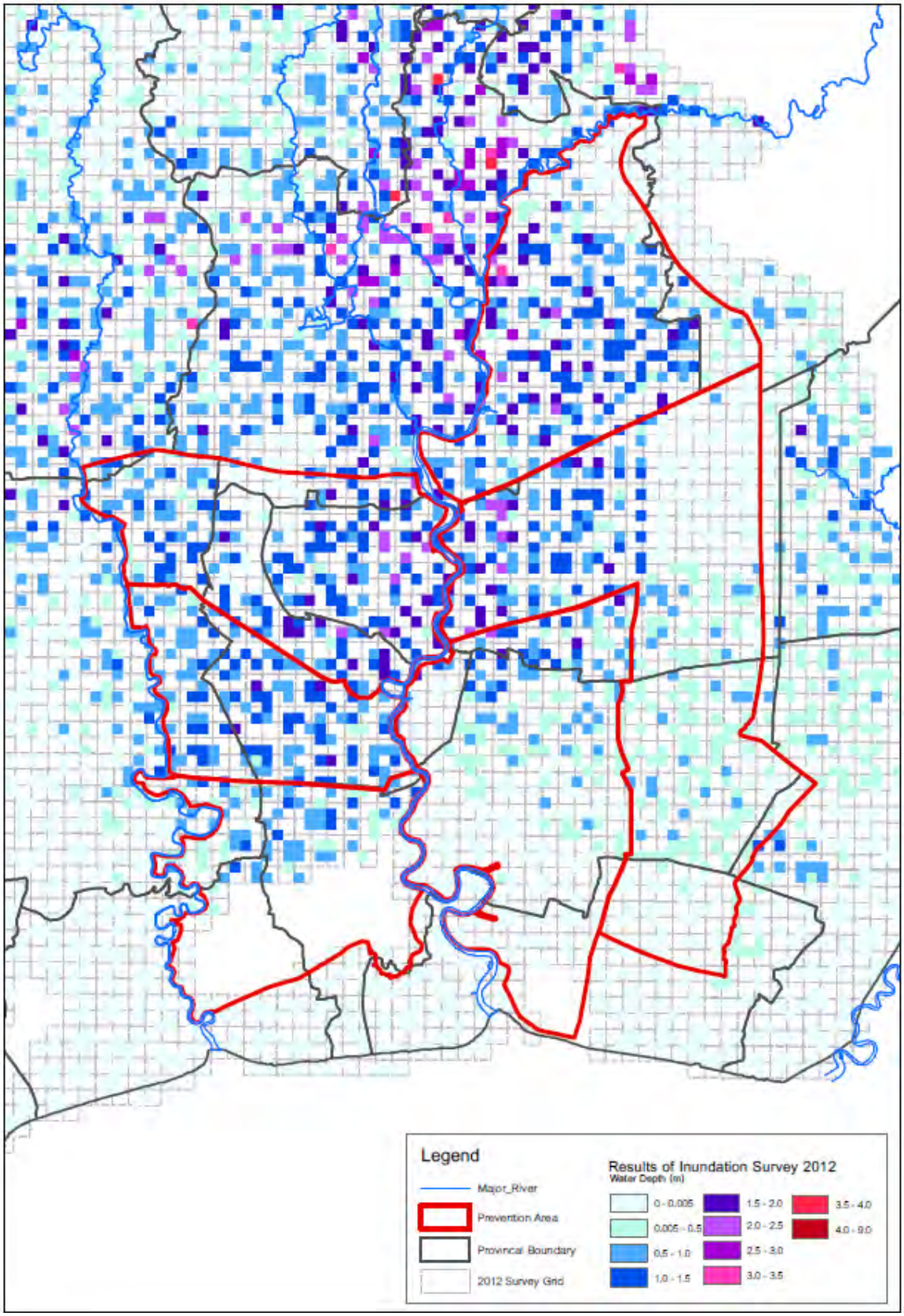

Figure M1.2.1 Flood Inundation Map Based on Flood Marks Survey for 2011 Flood

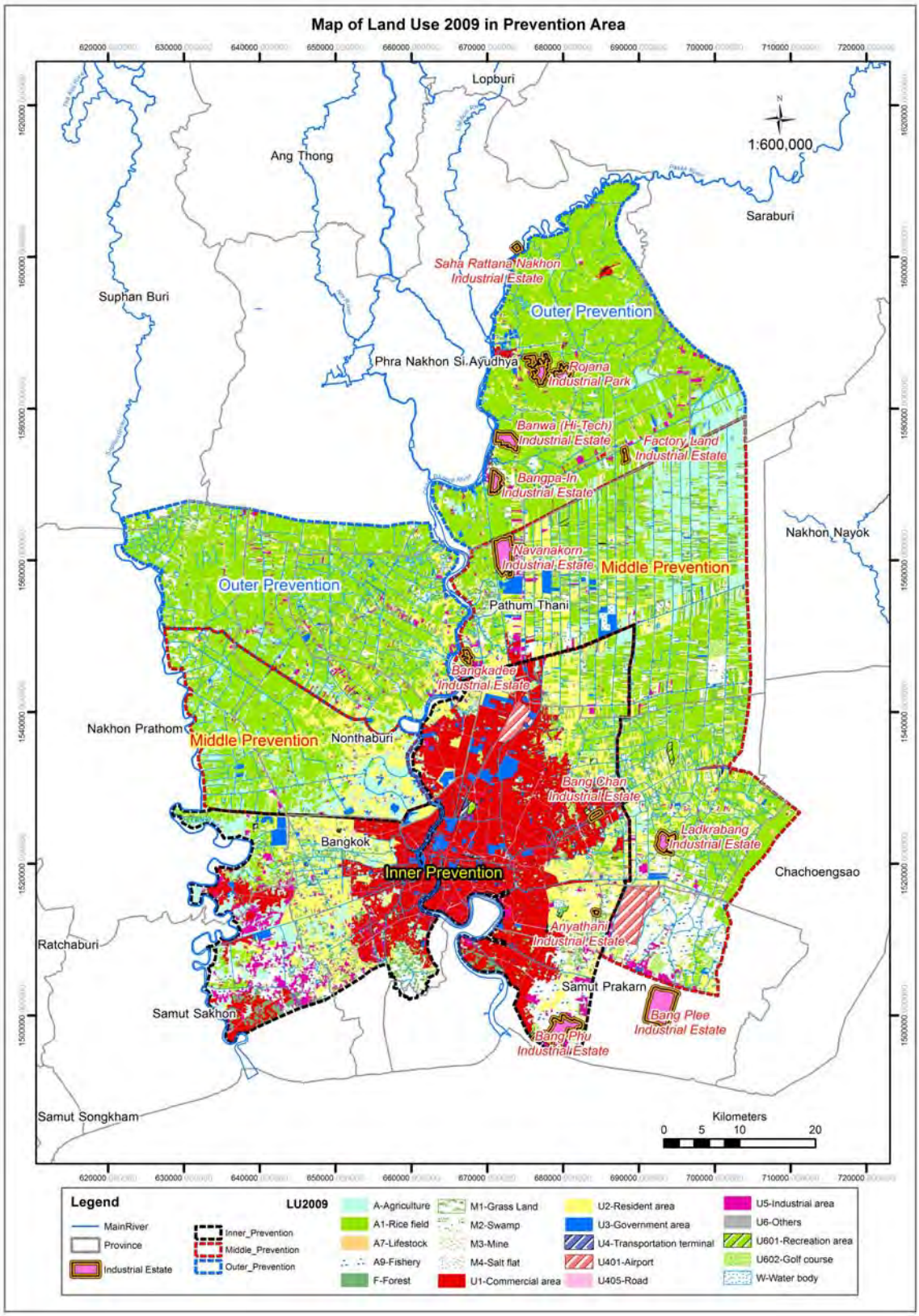

Figure M1.2.2 Existing Land Use of Protection Zones

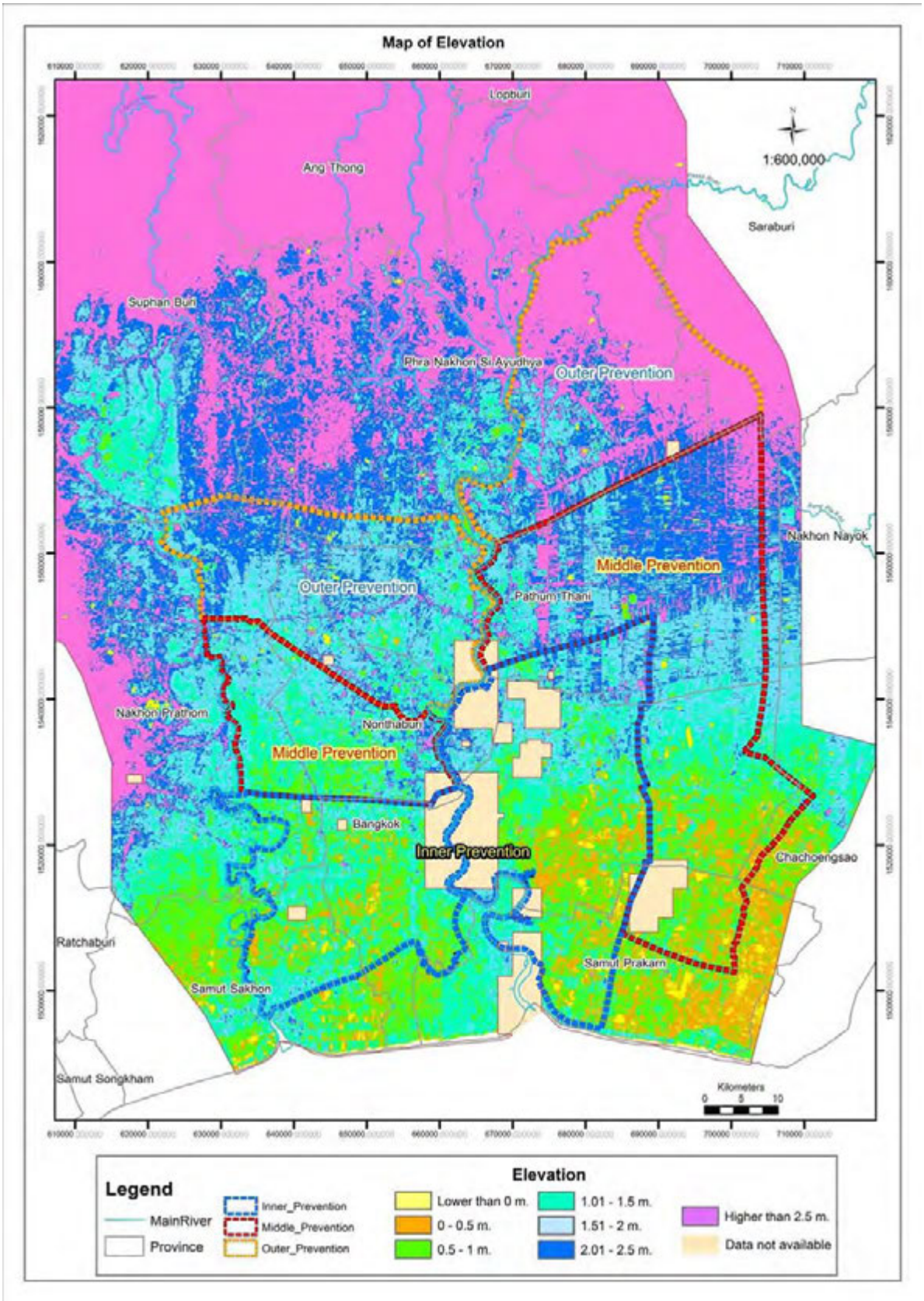

Figure M1.2.3 Elevation Map of Protection Zones

M1.2.1 Existing Flood Protection and Storm Water Drainage Measures

The existing measure for flood protection and storm water drainage in the protection zones is the polder system that is commonly applied in Thailand. Namely, a protection area is surrounded by ring dykes to prevent floodwater from entering into the area of which inland storm water is drained out through a regulator or pumped out depending upon the water level of the outside.

Presently, DOH and DOR are constructing flood walls and heightening roads/dykes along the boundaries of the protection zones. The height of the flood walls and the heightened roads/dykes is at the maximum water level of the 2011 flood plus 50 cm. The works have already started and is estimated to be completed by January 2014.

Regarding the inland storm water drainage, RID, BMA and municipalities with support from DPT are developing drainage canals and pump stations for each jurisdiction area.

(1) Storm Water Drainage in Agricultural Areas

Followings are information on storm water drainage in agricultural areas collected from RID:

- Most of the protection zones fall in the RID Region 11, but the eastern outer zones covers Nakhon Luang and South Pasak Irrigation Projects of RID Region 10.
- 80% to 90% of agricultural areas are paddy field and fish ponds are distributed near the sea.
- Nakhon Luang and South Pasak Operation and Maintenance Offices of RID Region is promoting change of cropping pattern so as to avoid cropping in flood season.
- Drainage outlets are Chao Phraya River, Nakhon Nayok River, Bang Pakong Rivers and the sea for the eastern zones, while Tha Chin River and Chao Phraya Rivers for the western zones on the other hand. When the water level of the outside (rivers or the sea) is low, gravity drainage is possible but pumping is necessary when it is high.
- The pumps are operated so as to maintain the water level in the protection zones as high as possible during the irrigation season but as low as possible during the flood season.
- In order not to give an adverse impact to BMA area, pumping drainage to Chao Phraya River is avoided as much as possible.
- During the 2011 flood, pumps of RID Region 11 were operated continuously for 4 months from September to December with about 50% to 80% of working rate.
- In the southern lower areas near the sea it is very difficult to collect water to the pump stations due to almost horizontal or negative slope. Houses on the canal banks also disturb water flow during a flood.
- After the 2011 flood, dredging of canals, installation of water pushing machines and installation of semi-permanent pumps were implemented as flood mitigation measures.
- Especially regarding the installation of the pumps, a total of 240 sets of semi-permanent pumps (120 pumps to each of the eastern and western areas) were added to existing regulators in the RID Region 11. With this installation, the total pump capacity increased by 75% from 970 m^3/s to 1,690 m^3/s. Since the total drainage area is about 3,800 km^2, the pump capacity increased from 0.25$m^3/s/km^2$ to 0.44$m^3/s/km^2$ as presented in Table M1.2.2.
- RID considers that there is no need for further increase the pump capacity, and that it should renovate the urgently installed semi-permanent pumps to make them permanent structures.

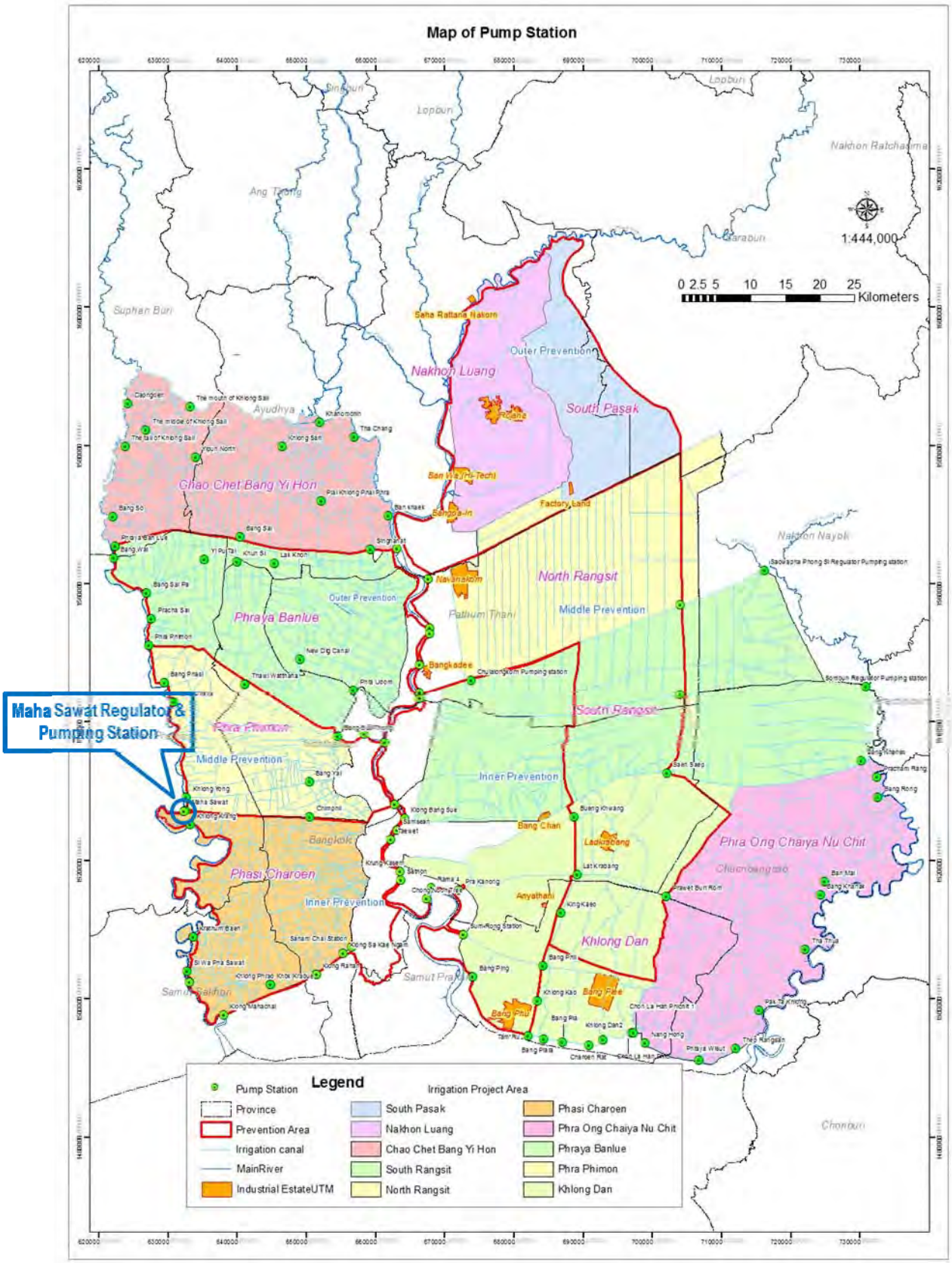

Figure M1.2.4 Location of Major Pump Stations

Table M1.2.2 Drainage Pumps in RID region 11

No	Outlet	Pump Capacity (m^3/s)			Remarks
		Permanent	Semi-permanent	Total	
East	Chao Phraya R.	167.2	54.0	221.2	
	Nakhon Nayok R.	33.6	54.0	87.6	
	Bang Pakong R.	101.6	90.0	191.6	
	Gulf	336.8	48.0	384.8	
	Internal drain	136.0	114.0	250.0	
	Subtotal	639.2	360.0	999.2	
West	Chao Phraya R.	53.0	93.0	146.0	
	Tha Chin R.	276.4	267.0	543.4	
	Internal Drain	1.6	-	1.6	
	Sub-total	329.4	360.0	689.4	
Total		968.6	720.0	1,688.6	

Bang Talat Regulator and Pump Station (RID Nonthaburi), two semi-permanent pumps (black ones) were urgently installed after the 2011 flood. (taken on Nov.16, 2012)

Flood wall is under construction on the southern bank of Phraya Banlue Canal (taken on Nov.17, 2012)

Figure M1.2.5 Flood Mitigation Works after 2011 Flood

(2) Storm Water Drainage in BMA

Followings are information on storm water drainage in the BMA area:

- Flood walls have been constructed along the Chao Phraya River against water levels of 100-year return period. The existing levels of the walls are at 2.5m to 3.0m MSL. During the 2011 flood, overflow took place only in a small uncompleted section, but there was no overflow in the other sections.
- Planning scale in terms of return period for inland storm water drainage facilities is three to ten years. BMA has many drainage pumps with a total capacity of 1,584 m^3/s over the 1,568 km^2 of its territory. Out of them 1,032m^3/s is pumped to the Chao Phraya River (East: 695 m^3/s, West: 337m^3/s). The remainder is for internal drainage between polders
- Since the total drainage area of the pumps to the Chao Phraya River is about 1,050 km^2, its specific capacity per 1 km^2 is 1.0$m^3/s/km^2$, almost the same as 1 to 2 $m^3/s/km^2$ of drainage projects for municipalities supported by DPT.
- During the 2011 flood the pumps were operated 20 to 24 hours a day for about a month continuously according to BMA.

- When the water level of Chao Phraya River is so high that overflow is about to happen, pumps are stopped by judgement of the pump station.
- After the 2011 flood, BMA prepared a short-term, mid-term and long-term plans for flood mitigation, as shown in Table M1.2.3. Regarding improvement of drainage system, BMA plans dredge drainage channels to increase their flow capacity. Augmentation of the pump capacity has not been planned in five years except for pumps for three drainage tunnels that are planned to be constructed by 2017.

Table M1.2.3 Flood Mitigation Measures by BMA after 2011 Flood

Term	Measures	Budget	Remarks
Short-term (3 to 6 months)	Dredging of main drainage canals	1.5 bil. Baht	
	Increase efficiency of drainage system, initiate warning system, setting of flow meter	0.684 bil. Baht	
Mid-term (2012)	Repair of flood wall of Chao Phraya R, Bangkok Noi canal and Mahasawat Canal.	Not available	
	Heightening of flood walls of Chao Phraya R. and the canals	Not available	Lower : 2.5 to 2.8m msl Middle: 2.8 to 3.0m msl Upper: 3.0 to 3.5m msl
	Heightening of King's Dike	Not available	1.5 -2.9 to 3.0m msl
Long-term (2013-2017)	Strengthening and elevating of flood walls of Chao Phraya R, Bangkok Noi canal and Mahasawat Canal and King's dike.	67.8 billion Baht	
	Developing of canal capacity		
	Increase of flow discharge to the Gulf		Ex. 3 new drainage tunnels
	Development of retention ponds		
	Provision of materials and equipment		
	Development of flood control center		

M1.2.2 Extraction of Issues on Storm Water Drainage in Protection Zones

Issues on storm water drainage in the protection zones are extracted and summarized as follows:

- A main cause of the 2011 flood damage in the protection zones is not inland storm water but flood flow from the outside areas. Namely the flood was generated from not the inside but the outside. Flood water that generated from higher northern flood plains invaded the protection zones, climbing roads/dykes and meandering through buildings. The flood water caused extensive inundation over the protection zones, the lowest areas of the Chao Phraya River Basin. It took more than four months to drain the inundation water completely by pumps. After the 2011 flood, however, the drainage capacity was very much improved by the installation of the semi-permanent pumps as well as canal dredging. According to RID Region 11, the pump capacity is now much enough to cope with the inland storm water which is generated in the area. In the next subsection, the simple water balance calculation is made for the west middle protection area (Phra Pimon Irrigation Project Area) as the sample to verify if its pump capacity is enough against inland storm water.
- The heightening of roads/dykes and the construction of flood walls will divide the irrigation projects areas to the protection zones and the outside areas. Since the drainage systems have been developed in principle separately by each irrigation project area, it should be confirmed whether such division will affect the existing drainage systems or not. For example, pump stations are located on Nakhon Nayok and Bang Pakon Rivers and along the sea coast will be useless for the inland storm water drainage of the protection zones because they will be left outside of the protection area. New pump stations might be necessary where canals cross the protection boundary.
- If land slope is considered, inland storm water generated in the east outer protection zone and the east middle protection zone should be drained to the Chao Phraya River. However, this might cause a rise of the river water level. It is necessary to examine effects of the pump drainage to the

Chao Phraya River that has 1,400 m^3/s pumps even only in Pathum Tani Province and its downstream stretches.

- In the southern area near the sea coast land slope is very flat or negative. It is very difficult to collect water to pump stations and consequently, there are some pump stations that cannot work at their full capacity because collected water is less than the capacity.

CHAPTER M2 STUDIES ON PUMP CAPACITY

M2.1 Verification of Pump Capacity by Simple Water Balance Calculation

Verification of the existing pump capacity in the RID Region 11 area is made by a simple water balance calculation for the west middle protection zone (Phra Pimon Irrigation Project Area) which is a typical pump drainage area in terms of specific pump capacity.

Table M2.1.1 Drainage Pumps in West Middle Protection Areas

Drainage Outlet	Pump Capacity (m^3/s)				Drainage Area (km^2)	Specific Capacity ($m^3/s/km^2$)
	Permanent	Semi-permanent	Total			
Chao Phraya River	22.2	18.0	40.2	193.2	551	$0.35 m^3/s/km^2$
Tha Chin River	78.0	75.0	153.0			

M2.1.1 Calculation Conditions

Calculation conditions are described in Table M2.1.2. Daily rainfall of five months from August to December 1983 of Bangkok Station of TMD (No. 455201) is used as a model rainfall. The total 5-month rainfall is 1,661mm, which caused serious flood damage over Bangkok and its vicinity areas, is the maximum in 41 years from 1970 to 2011.

The simple water balance calculation used pond model. It is also assumed that inland storm water is drained only by the pumps during all the calculation period, although in reality gravity drainage is possible when the river water is low enough.

Table M2.1.2 Calculation Conditions

Item	Contents	Remarks
Calculation Period	August to December 1983 (5 months)	
Calculation method	Water Balance Calculation (pond model), Natural drainage (gravity) is not considered. Paddy is assumed to store water of 20 cm.	
Rain data	TMD Bangkok Station (No.455201)	
Elevation-Area-Storage Volume Relationship	Obtained from LP data (100mx100m mesh data)	
Pump operation	All pumps starts with the full capacity (193 m^3/s) when the inner water level reaches the operation start water level (1.5 (Allowable maximum water level)-0.5 = 1.0m MSL). If the water level is lowered below the operation start water level, the pumps are stopped.	
Consumptive use of water (CUW)	5mm/day	

M2.1.2 Calculation Results and Considerations

Calculation results are presented in Figure M2.1.2 and Figure M2.1.3, and considerations are summarized as below:

- The specific pump capacity of this protection zone, 0.35 $m^3/s/km^2$ is smaller than 0.44 $m^3/s/km^2$, the average pump capacity in the RID area excluding the BMA area. Therefore, if it is taken into consideration that even this less pump-equipped zone has enough capacity to cope with the heavy rainfall in 1983, it is natural to consider that the other RID areas also generally have a sufficient capacity.
- However, it has to be noted that the applied calculation which is based on the simple pond model and water flow in canal networks is not considered at all.

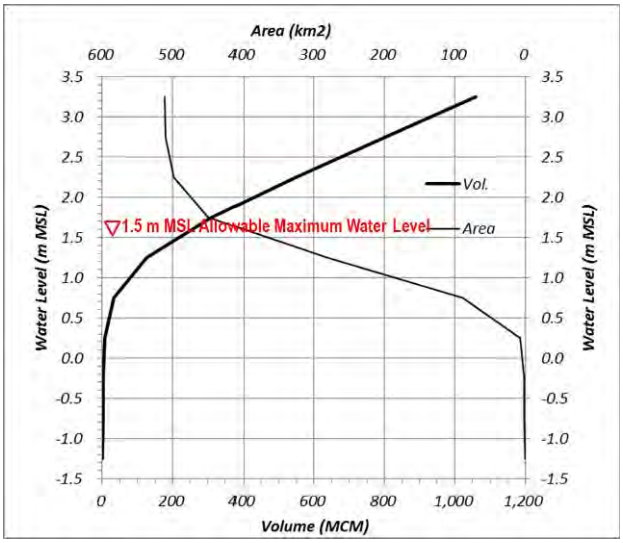

Figure M2.1.1 Water Level – Area – Storage Volume Curve

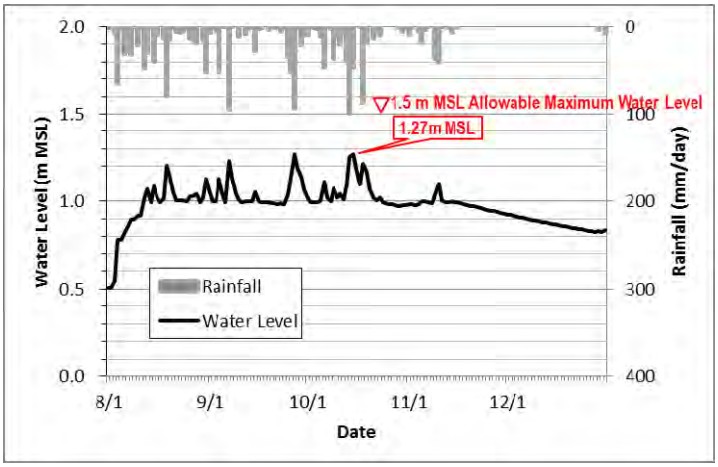

Figure M2.1.2 Calculation Results (Water Level Graph)

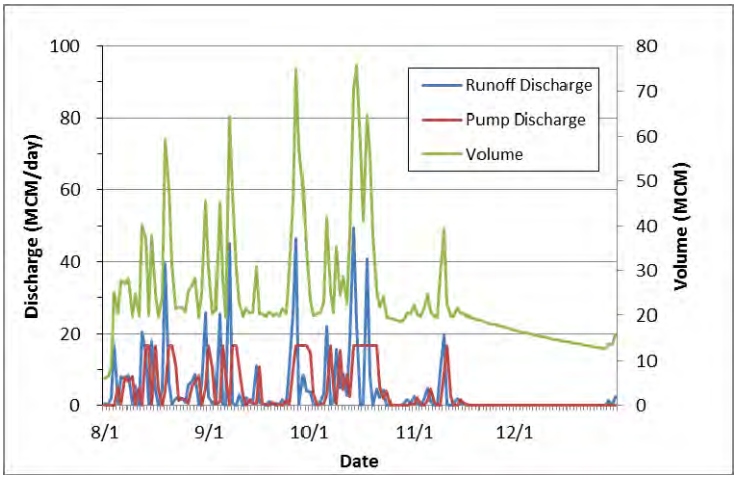

Figure M2.1.3 Calculation Results (Discharge and Storage Volume Graphs)

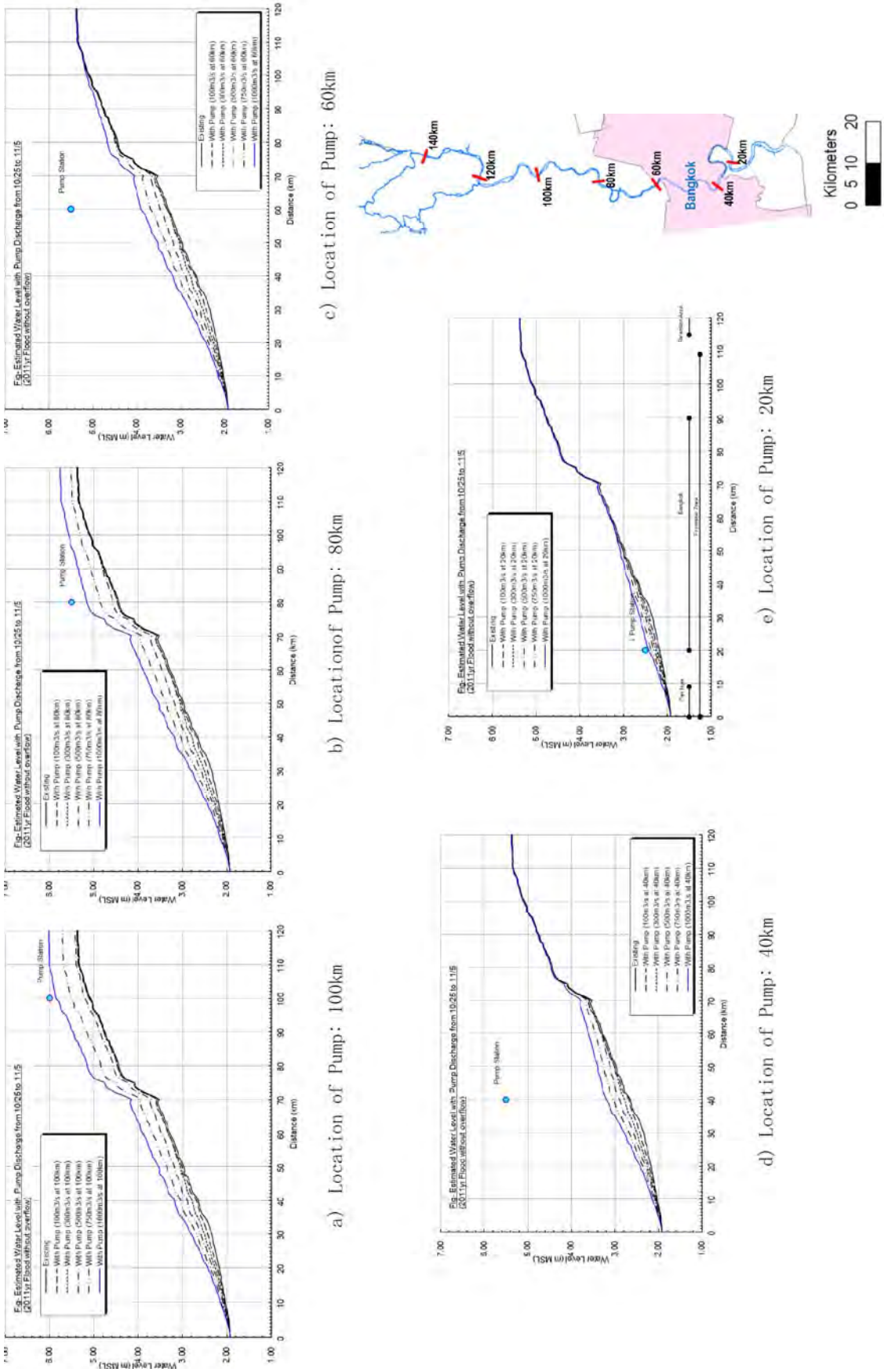

Figure M2.1.4 Longitudinal Profile of Maximum Water Level

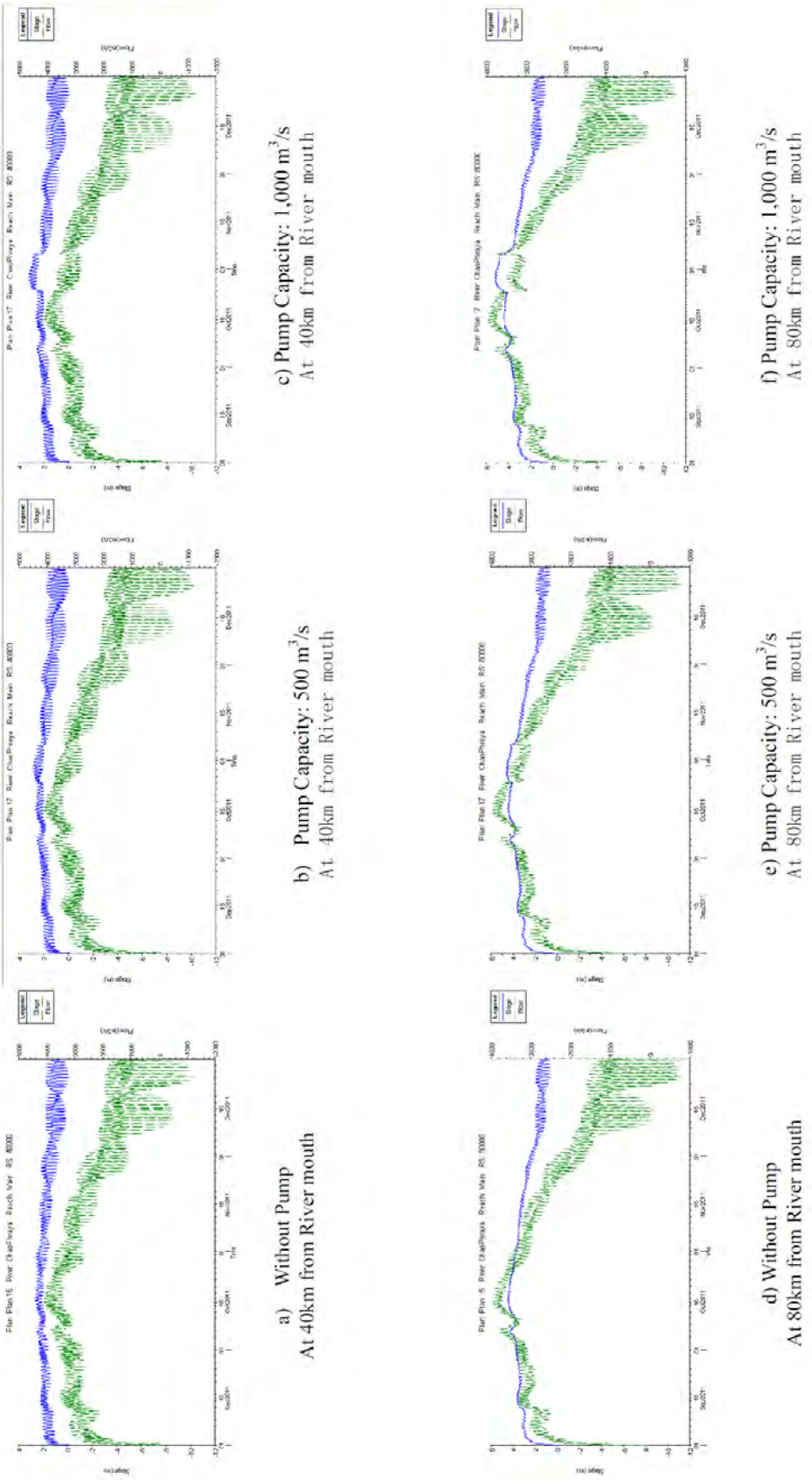

Figure M2.1.5 Hydrographs of Water Level and Discharge

Sector N: Forest Restoration

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
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CHAPTER N1 INTRODUCTION

N1.1 Basic Policy

N1.1.1 Present Condition of Forest Area

Forest management in Thailand is conducted by the Royal Forest Department (RFD). The forest area of the country was reduced from 53.33% to 30.92% between 1960 and 2006 because of rapid population growth and economic development. As the result the forest area in the watershed have been devastated and the capacity for water absorption has diminished. In addition, surface erosion, slope failures, landslides, flash floods and drought have increased. Current decrease of the forest area is mainly due to agricultural expansion, other land uses, intensified shifting cultivation and poaching.

The water holding function in forest area is generally in evidence, and it is desirable that the restoration of degraded forest and the recovery of water holding property are required in order to reduce flood runoff and sediment discharge. For recovering the function of water absorption require to restore the forest area.

Presently the ratios of forest covers at the upper reaches of the tributaries of the Chao Phraya River Basin are largely varied. The ratios of forest covers of the Yom River (47%) and the Nan River (50%) in the eastern side of the Chao Phraya River Basin are lower than the forest cover ratios of Ping River (68%) and Wang River (74%) in the western side of the basin. Accordingly the flood runoff ratios are to be largely varied among of the tributaries of the Chao Phraya River and restoration of the degraded forest is an urgent task for the upper basins of tributaries. .

The 10th National Economic, Social and Development Plan (NESDP 2007 – 2011) has set a target of 40% forest cover or 204,800 km². The present forest area is 171,585.65 km², covering 33.44% of the country. The RFD has been fighting to increase the forest land, by restoration of the degraded forest area, and changing farmland in forest into forest land, reforestation in wide area through a tree planting campaign.

The present five year plan (2012-2016) of the RFD was prepared due to the Master Plan for Water Resources Management by the Strategic Committee for Water Resources Management (SCWRM). The Master Plan aims to solve problems and reduce flood damages..

The important actions are the forest restoration and conservation, and ecosystem conservation in order to restore the degraded forest upstream, which is an essential source for water absorption and delay runoff at mid-stream and downstream.

N1.1.2 Approach

It is necessary for the eight (8) river basins: the Ping, Wang, Yom, Nan, Chao Phraya, Sakae Krang, Pasak and Tha Chin Rivers to restorate the degraded forest areas, to conserve water resources and to carry out flood management. A wide area of the forest land upstream has been classified as degraded forest and the conservation of the forest area and the restoration of the degraded forest upstream should be major issues in the basin. The RFD has prepared an action plan for restoration of the degraded forest area in the Chao Phraya River Basin. The action plan will be examined and necessary measures will be proposed.

Note: From ADB, Rapid Flood Management Assessment (P 5-5, 5-6)

Figure N1.1.1 Conditions of Degraded Area in the Upper Reaches in the Nan and Ping Rivers

CHAPTER N2 RESTORATION OF DEGRADED FOREST AREA

N2.1 Degraded Forest Area

As for the eight tributaries of the Chao Phraya River Basin (Ping, Wang, Yom, Nan, Chao Phraya, Sakae Krang, Pasak and Tha Chin rivers), the forest area is estimated to be 66,034 km², of which 13,500 km² is classified as degraded forest. In the upper reaches of the four (4) rivers (the Ping, Wang, Yom and Nan rivers) the forest area is 59,970 km², of which 9,524 km² is classified as degraded forest area. The forest area and degraded forest are as summarized in the following table.

The degraded forest area has been identified due to the Forestation and Forest Restoration Manual. The conditions are as follows:

- Fruit trees over 2-meter tall no more than 20 trees/rai,
- 130-cm tall tree with diameter from 50-100 cm no more than 8 trees/rai,
- Over 100-cm tall trees no more than 2 trees/rai or
- Trees which do not fit any of those criteria no more than 16 trees/rai.

Table N2.1.1 Forest Area and Degraded Forest Area

No.	Sub Basin	Basin Area (km²)	Forest Area (km²)	%	Degraded Forest Area (Km²)			
					Conservation Forest	Reserved Forest	Total	%
1	Ping River	34,537	23,369	67.66	1,678.40	2,057.60	3,736.00	15.99
2	Wang River	10,793	7,951	73.67	265.60	388.80	654.40	8.23
3	Yom River	24,047	11,194	46.55	555.20	1,272.00	1,827.20	16.32
4	Nan River	34,682	17,456	50.33	931.20	2,376.00	3,307.20	18.95
5	Chao Phraya	23,873	846	3.55	80.00	510.40	590.40	69.79
6	Sakae Krang River	4,907	1,556	31.72	766.40	550.40	1,316.80	84.63
7	Pasak River	15,626	2,522	16.14	126.40	1,236.80	1,363.20	54.05
8	Tha Chin	14,196	1,140	8.04	73.60	670.40	744.00	65.26
Chao Phraya River Basin		162,661	66,034	40.60	4,476.80	9,062.40	13,539.20	20.50

Upper River Basin (Nakhon	104,059
Chao Phraya River Basin	162,661

N2.2 Forest Restoration Policy

The RFD's policy for restoration of forest is based on as follows.

- To apply the royal ideas of King Bhumibol and Queen Sirikit as a framework and guideline for forest, reforestation, soil conservation and weir construction.
- To conserve and restore forest resources and ecosystem for flood prevention, solution and mitigation.
- To promote community participation in forest resources conservation and restoration because communities must live sustainably with forest.
-

The RFD has set a target for the restoration of the degraded forest area of 8.46 million km² of the eight (8) river basins in the Chao Phraya River Basin by the restoration of forest resources and ecosystem within five (5) years. The implementation requires the participation of provincial governments and communities in the forest area.

In the Thailand numerous communities are living with forest

- More than 1,000 recorded species of plants contain medicinal properties and 30,000-40,000 households harvest them on a full-time basis.
- About 60% of the rural population or roughly 30,000 communities living near forests rely on edible plants for their daily needs and 500 species of these plants are sold in local markets throughout the country.
- Currently more than one (1) million households are living within the Thailand's National Forest Reserve. The forest dwellers depend on the forest mainly for non-timber forest products.

N2.3 Measures for Restoration of Forest

The restoration project is composed of reforestation, soil conservation, and weir construction in the National Reserved Forest as follows:

N2.3.1 Preparation of Seedling Plantation

Seedling plantation is carried out by the RFD, communities and educational institutions. The total amount of seedling for ecosystem restoration was 82,600,000 in 2012. Seedlings of large wood has been prepared for planting in 2013.

N2.3.2 Reforestation and Restoration of Degraded Forest

(1) Reforestation for Restoration of Ecosystem

- Reforestation in the surveyed degraded forest of 580,000 Rai (928 km², which is suitable for ecosystem restoration.
- Reforestation for restoration of ecosystem by communities totaling 99,500 Rai (159.2 km²): slow growing trees, fast growing trees and edible wildwood.

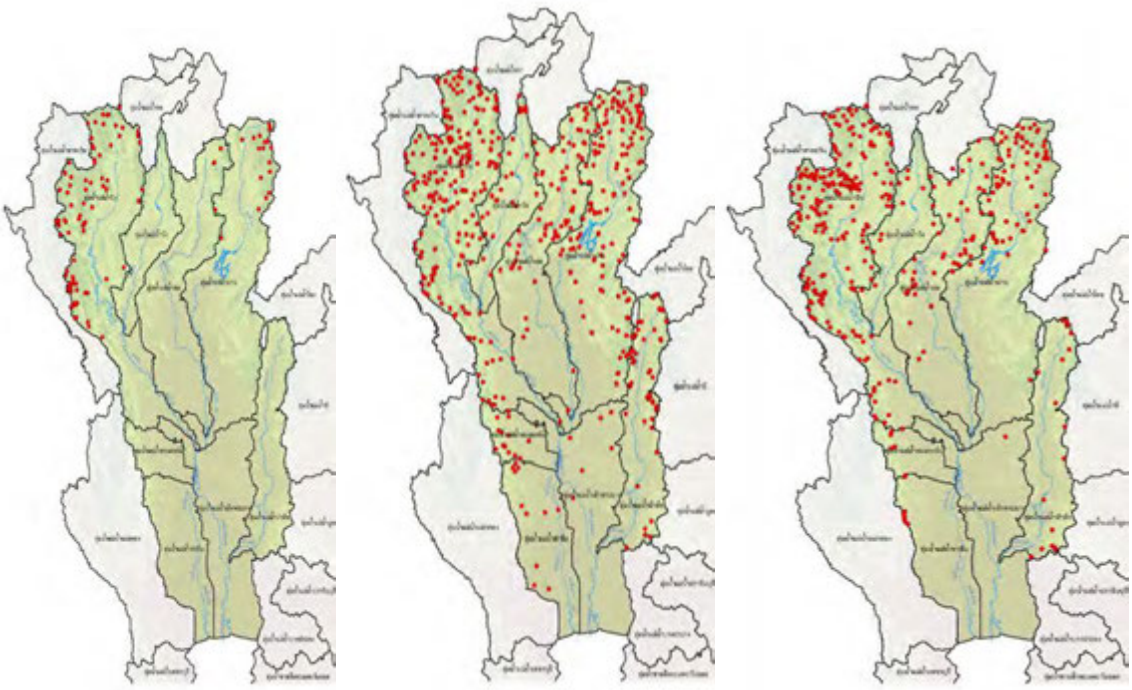
(2) Rattan Planting

Rattan seedlings were planted in 100,000 Rai (160 km²) in 2012. A total of 24,000,000 rattan seedlings have been prepared for planting in 2013.

(3) Vetiver planting for soil conservation

Some 100,000,000 Vetiver seedlings will be planted in horizontal lines transversing the slope of areas.

(4) Community Participation in Reforestation and Sustainable Nourishment Promotion: 8 areas



Paddy Field to Forest Area | Reforestation Area | Vetiver Planting Area

Figure N2.3.1 Location Maps of Forest Restoration Measures for Degraded Forest Area

(5) Check Dam Construction

The following check dams are planned to be implemented after the survey of area conditions is carried out.

- 11,000 semi-permanent check dams:
- 3,050 permanent check dams:
- 15,000 small check dams:

Location of check dam construction sites are shown in the following figure.

Check Dam Types

Semi-Permanent Check Dam

Semi-permanent check dam is made of reinforced concrete or brick and cement. Dam crest is 3-5 m long, and constructed in canal 3-5 m wide to strengthen the canal that is expecting a great water volume cluster descending from the integrated check dams. This type of check dam shall be constructed around the second order stream since it is able to trap small sediment and suspended sediment and store some water.

Permanent Check Dam

Permanent check dam is made of reinforced concrete. Its crest is no longer than 5 m and constructed in a canal no wider than 5 m. Due to wider size of canal and greater volume of water, this type of check dam has to be even stronger to delay severity and store a large water volume to take advantage of it as long as possible. Suspended sediment can be trapped and water can be stored, serving as a water source for the community.

Source: "Check Dam Construction Manual" by Public Forestation Division, Forestation Promotion Office, Department of Forestry, MONRE

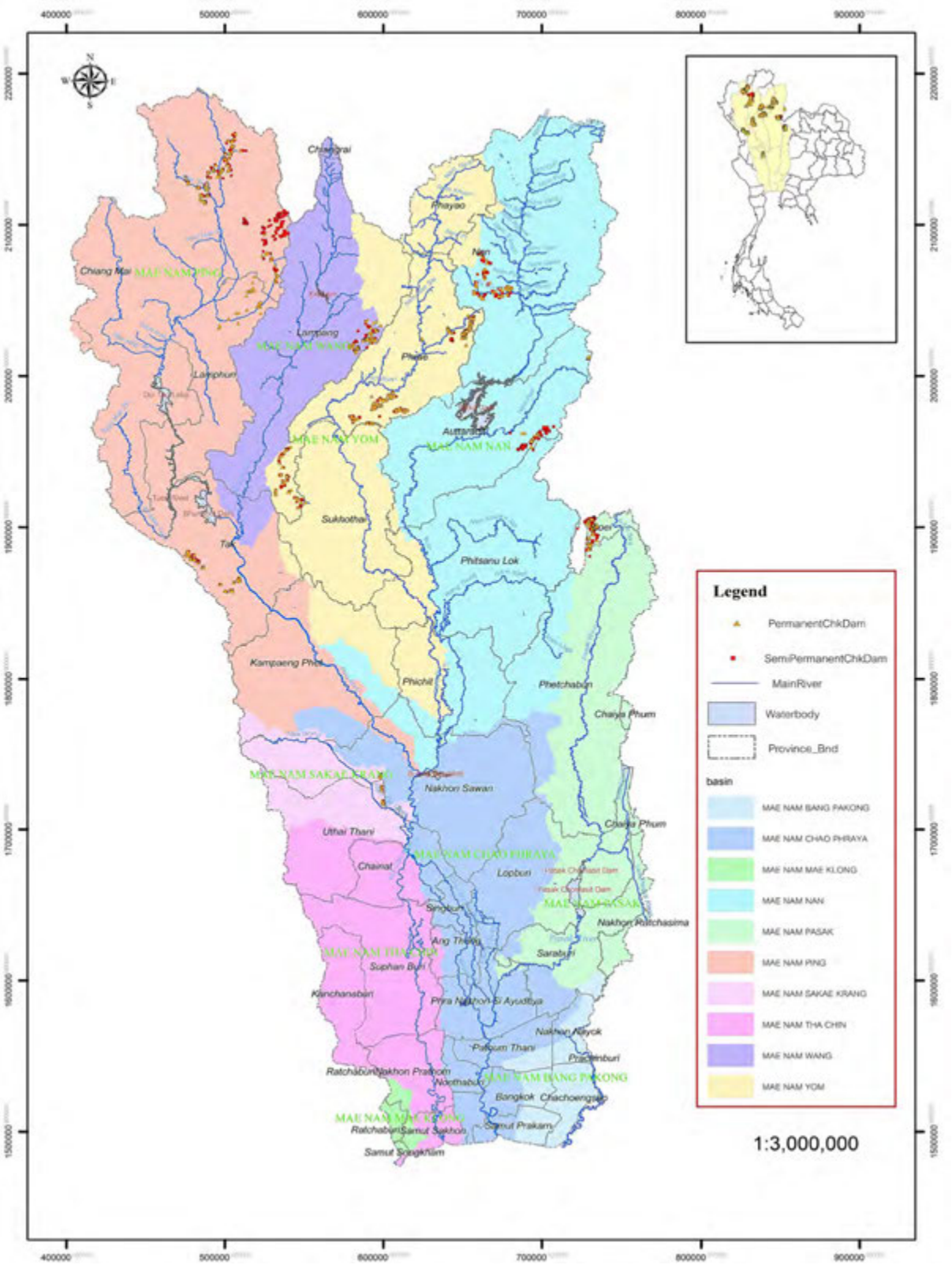


Figure N2.3.2 Location Map of Check Dam Construction

CHAPTER N3 IMPLEMENTATION PLAN

The implementation plan for 2012-2013 and five years are shown in the following Table N4.1.1 and Table N4.1.2.

Table N4.1.1 Restoration of Forest for Planting and Construction in 2012-2013

No.	Main Basin	Seedling Plantation	Vetiver Planting for Soil and Water Conservation	Paddy Field to Change for Forest Land	Semi-Weir	Permanent Weir
		Quantity (Million Seedling)	Quantity (Million Seedling)	Quantity (Rai)	Number of Weire	Number of Weir
1	Ping River	28.88	3.00	900.00	662	175
2	Wang River	7.00	3.75	300.00	289	90
3	Yom River	17.98	7.00	900.00	525	162
4	Nan River	15.21	4.00	600.00	336	95
6	Sakae Krang River	2.77	0.50	300.00	92	31
7	Pasak River	10.76	1.75	300.00	296	57
Total		82.60	20.00	3,300.00	2,200	610

Source : Action Plan and Budget Restoration Project, Forest and Soil Conservation, Weir Construction in National Reserved Forest

Table N4.1.2 Five-Year Implementation Plan

Activity	Unit	Implementation Year					
		Year 1	Year 2	Year 3	Year 4	year 5	Total
1. Seedling plantation to support reforestation	Million seedling	82.6	43	44	44	44	257.6
2. Plantation for reforestation	Million rai	0.060	0.300	0.140	0.140	0.140	0.780
3. Vetiver planting	Million seedling	20	20	20	20	20	100
4. Paddy field to exchange forest land	Rai	3,300	3,300	3,300	3,300	3,300	16,500
5. Weir construction	Number of Weir	5,810	5,810	5,810	5,810	5,810	29,050

Source : Action Plan and Budget Restoration Project, Forest and Soil Conservation, Weir Construction in National Reserved Forest

CHAPTER N4 EXAMINATION OF FOREST MANAGEMENT EFFECTS

N4.1 Effects of Forest Restoration

To restore the forest in the Chao Phraya River Basin, the RFD has been conducting restoration of the degraded forest area of 13,500 km² by reforestation, vetiver planting, rattan planting and construction of check dams. By restoring the degraded forest area which is about 20% of the forest area in the Chao Phraya River Basin, the upper reaches of the Ping, Wang, Yom and Nan rivers will increase their water holding capacity and the stability of slopes with the reduction of surface soil erosion and sediment disasters.

The water holding capacity of forests depend on thickness of surface soil and forest type covering ground. The Royal Forest Department (RFD) has estimated 687.84 m³/m² (0.43 m³/m²) in average based on the maximum water storage capacity of the forest area in the upper basin. The water holding capacity in the forest area will increase by restoration of the degraded forest area (13,500 km²) because the forest area will expand from 66,000 km² to 80,000 km². Naturally the water holding capacity of forest area is expected to increase, and also the potential of sediment discharge caused by surface erosion is expected to decrease.

N4.2 Required Further Study

The RFD aims to restore the degraded forest area within 5 years, and after 2017 it shall be necessary to implement a reforestation project and a forest ecosystem conservation project in order to attain the target of 40% forest cover. The RFD has to formulate the long-term plan.

Accordingly, the Project for the Comprehensive Flood Management Plan for the Chao Phraya River Basin should require the restoration and conservation of the forest area and ecosystem from 2017 onwards as a part of the comprehensive flood management plan. According to the report of the RFD, in the upper reaches of the Chao Phraya River Basin, flood and sediment disasters such as slope failure, landslide, debris flow and flash flood have often occurred in the rainy season, so that reforestation and simultaneously, the soil conservation plan are important.

Currently the RFD has adapted vetiver planting for prevention of slope erosion, and permanent and semi-permanent check dams as forest and ecosystem conservation measures. To stabilize the watersheds, it is necessary to promote reforestation and forest conservation in order to attain the goal of the flood disaster risk management.

Sector O: Cost Estimation

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

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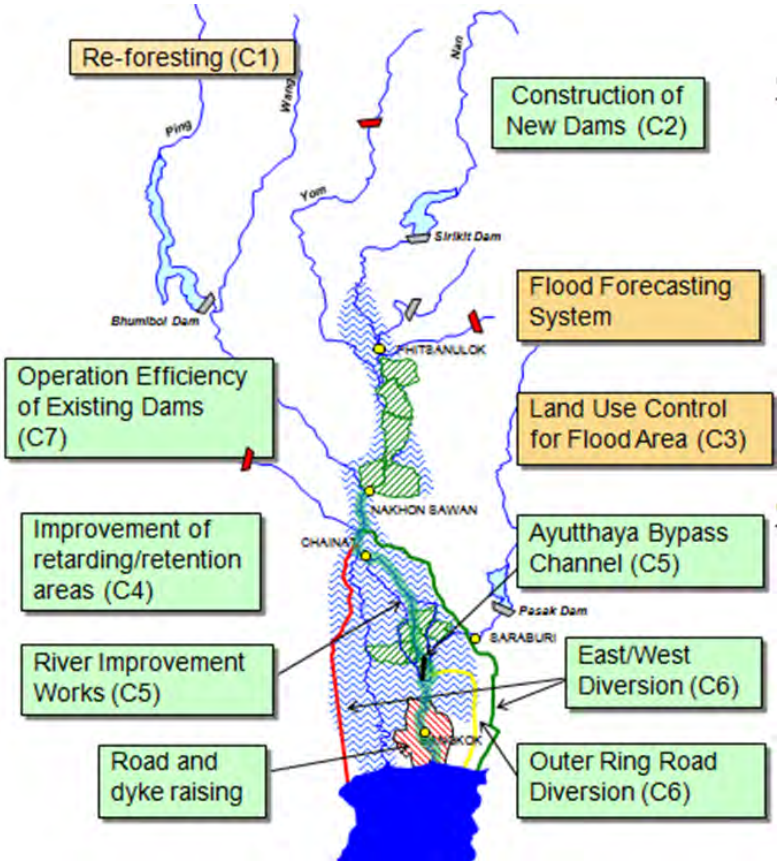
CHAPTER O1 COST ESTIMATE

O1.1 General

O1.1.1 Components of Measures

In the master plan, several countermeasures as shown in Figure O1.1.1 have been studied. Among them, this chapter deals with the cost estimate for the following measures.

1) River Improvement (Ayutthaya Bypass Channel and Dyke Improvement) (C5) ;
2) Construction of new dams (C2) ;
3) Construction of flood diversion channel (C6) ;
4) Improvement of retarding/retention areas (C4) ; and
5) Storm water drainage (C9)



Source: JICA study team

Figure O1.1.1 Location of Master Plan Countermeasures

O1.1.2 Conditions of Cost Estimate

(1) Price Level and Currency

Price level of the project cost is the domestic price level as of December, 2012 indicated in Thai Baht. The applied exchange rate is as follows:

- 1 USD = 30.7775 Baht (1Baht = 0.032 USD)
- 100 JPY = 35.7960 Baht (1Baht = 2.794 JPY)

[Bank of Thailand Selling Rate as of 28 December, 2012]

(2) Composition of Project Cost and Estimation Method

The project cost (financial cost) of each component is composed of the following item:

1) Construction Cost
2) Engineering Cost (cost for survey and design)
3) Other Costs (costs for EIA and government administration)
4) Physical Contingency
5) VAT
6) Land Cost
7) Compensation Cost
8) Price Escalation

Item 1) is composed of direct construction cost and indirect construction cost. Direct construction cost was estimated multiplying the work quantity of the major work item based on the preliminary facility design by the unit cost of such work item. The unit cost was set based on the collected cost information such as cost estimation report in the feasibility study by RID and contract document of the previous relevant project by RID, as shown in Table O1.1.1.

Table O1.1.1 Reference Cost Information provided by RID

Document	Prepared by
Feasibility Study Report	
Water Management Project East of Chao Phraya River (West Diversion Channel), 2012	Panya Consultant, etc.
Feasibility Study on the Development of Flood Prone Low-Land in Chao Phraya River Basin, 2009	Team Consultant, etc.
Contract Document	
Mae Kuang Irrigated Agriculture Development Project Phase II (contract signed in 1987)	Consultant: Sanyu Consultants, etc.; Contractor: Vianini Lavori
Pasak Irrigation Project (Kaeng Khoi – Ban Mo Pumping Irrigation) (contract signed in 2001)	Consultant: Sanyu Consultants, etc.; Contractor: See Sang Karn Yotah

Indirect construction cost was estimated to be 15% to the direct construction cost, based on the instance of feasibility study and previous construction contract. Item 2) to Item 5) was estimated by the ratio to Item 1) and/or sum of other items. The ratio is as shown in Table O1.1.2.

Table O1.1.2 Ratio for Cost Estimation of Item 2), 3), 4) and 5)

Item	Ratio to Item 1)
2) Engineering Cost	
Site survey (Topographic, Geotechnical, etc.)	5 % of 1)
Design work	5 % of 1)
3) Other Costs	
EIA	5 % of (1) + 2))
Government administration	10 % of (1) + 2))
4) Contingency	10 % of (1) + 2) + 3))
5) VAT	7 % of (1) + 2) + 3) + 4))

Items 6) and 7) were estimated on the basis of necessary land to be acquired and houses/factories to be relocated worked out based on the preliminary design and the unit cost. The unit cost was set based on the data in the feasibility study.

Item 8) was set on the assumption that the annual price escalation is 2.5%, based on the IMF estimate of inflation 2012–2017.

CHAPTER O2 RIVER IMPROVEMENT

O2.1 Project Feature

O2.1.1 Improvement of Chao Phraya River

Longitudinal height of parapet wall is horizontal and step wise, which is higher than record-high water level in the 2011 flood, but actual slope of water level is slanted. In addition, some part of the parapet wall is lower than DHWL + freeboard (50cm). Therefore, dike elevation up to DHWL + freeboard shall be executed.

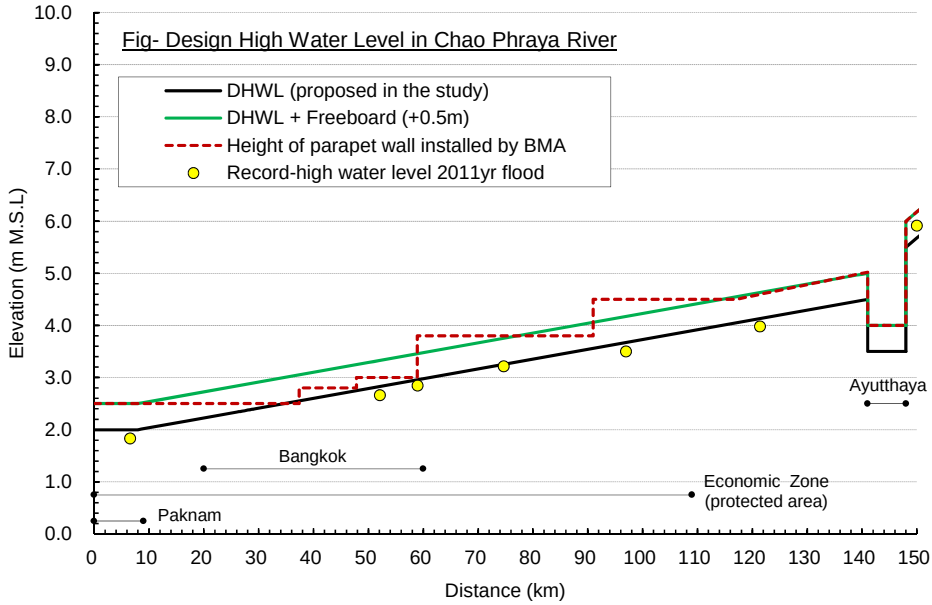


Figure O2.1.1 Installation of Parapet Wall along the Lower Chao Phraya River

O2.1.2 Improvement of Tha Chin River

To increase discharge capacity at lower reaches of the Tha Chin River and to protect the economic zone, the following countermeasures are adopted:

i) Four (4) shortcuts are installed;

ii) Primary dyke or concrete parapet wall is newly constructed at left side from river mouth (Samut Sakhon Province, Mueang Samut Sakhon) to 90 km point (Nakhon Pathom Province, Nakhon Chai Si);

iii) Secondary dyke at left side is elevated to “Design High Water Level plus Freeboard” from 90 km to 141 km point (Suphan Buri, Song Phi Nong); and

iv) South side dyke along Bunlue Canal is elevated to “Design High Water Level plus Freeboard”.

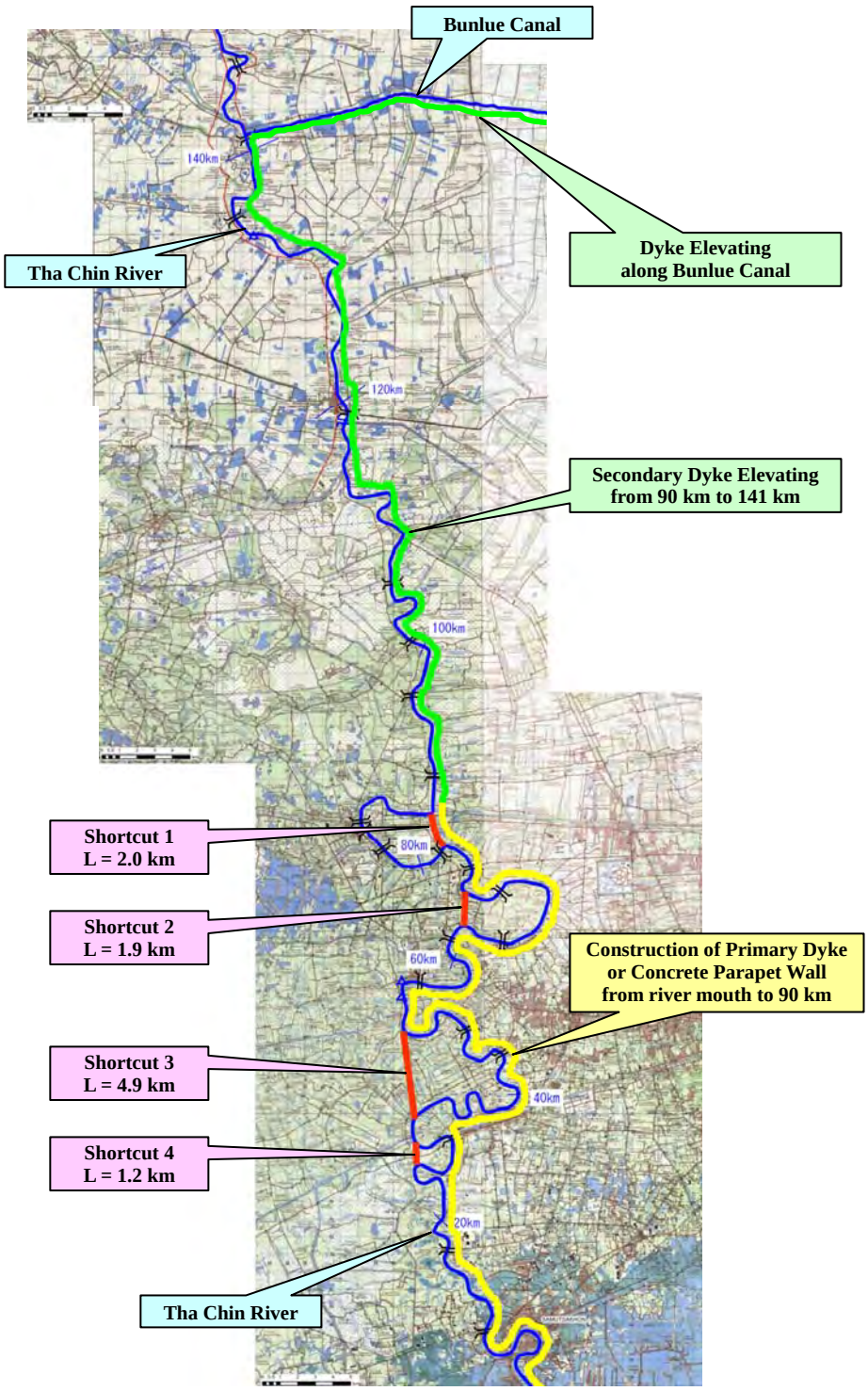
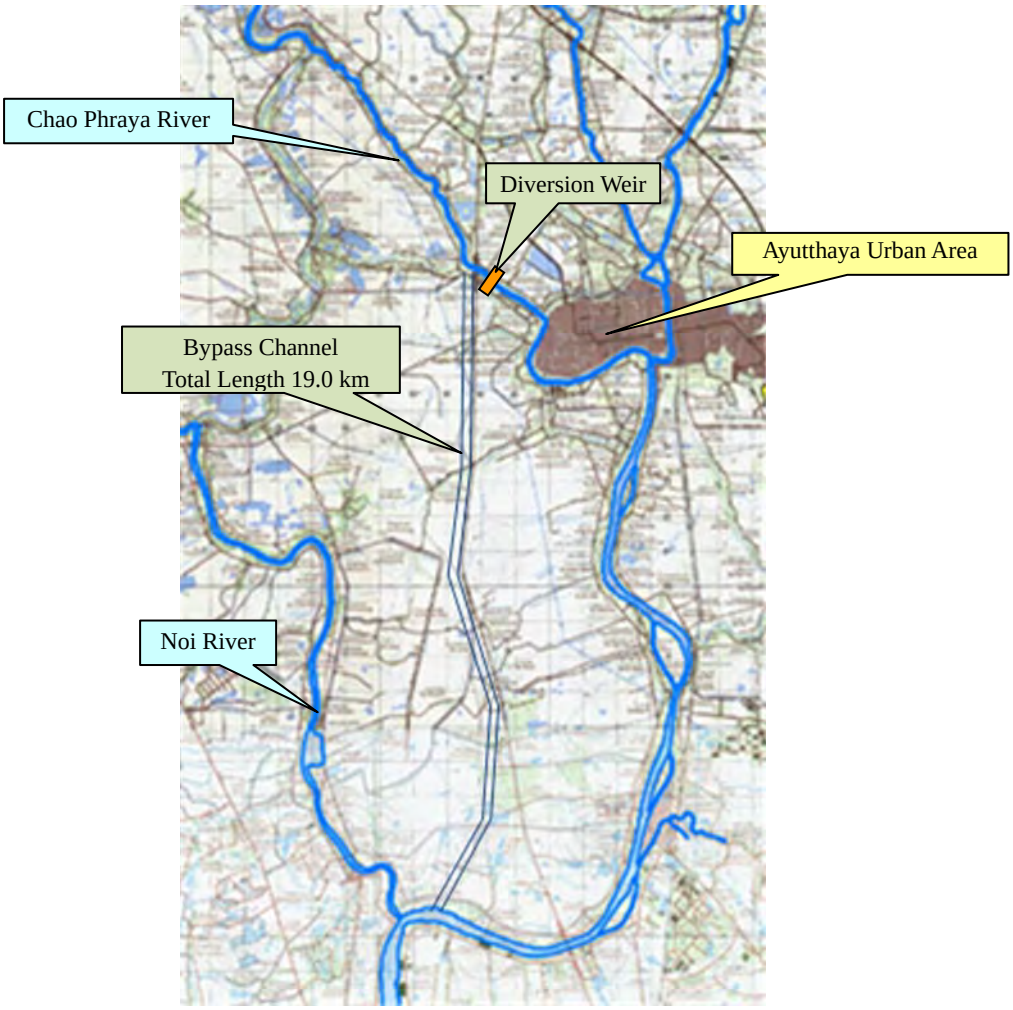


Figure O2.1.2 River Improvement in Tha Chin River

O2.1.3 Ayutthaya Bypass Channel

(1) Location

This countermeasure is to construct a bypass channel from upstream side of Ayutthaya urban area to the confluence with the Noi River on the Chao Phraya River. The location of the channel is shown in Figure O2.1.3.

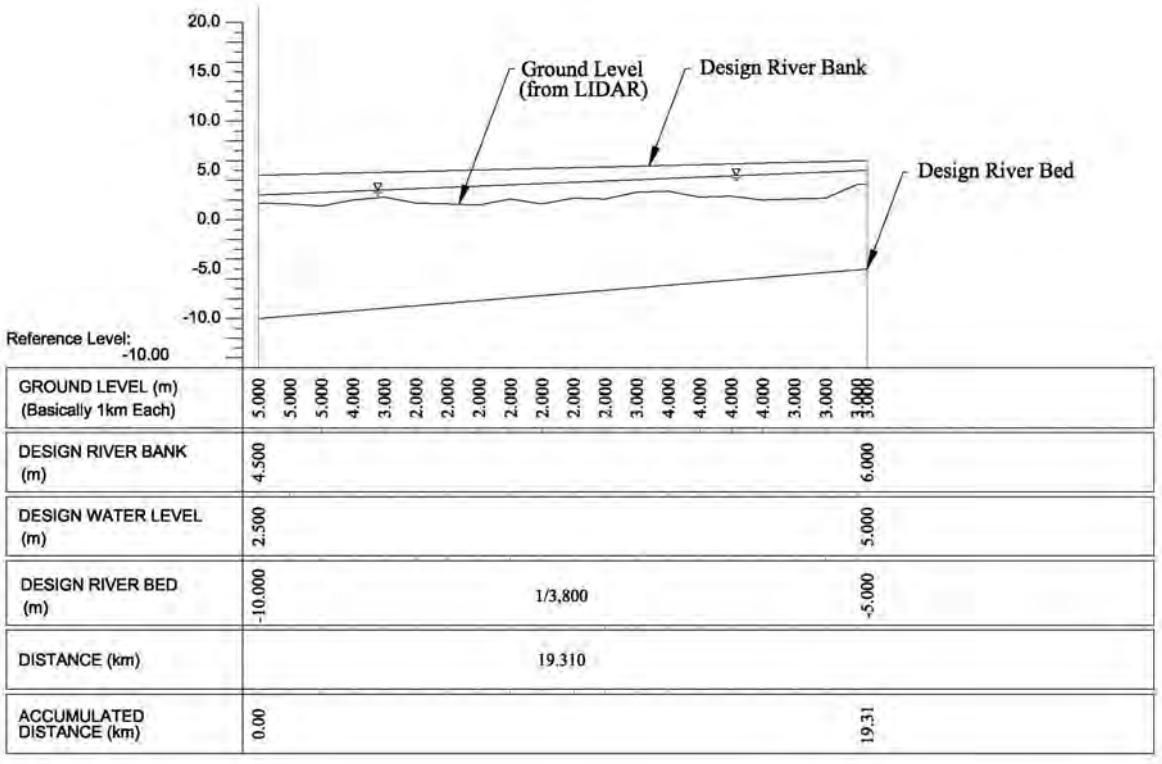


Source: JICA study team

Figure O2.1.3 Location of Ayutthaya Bypass Channel

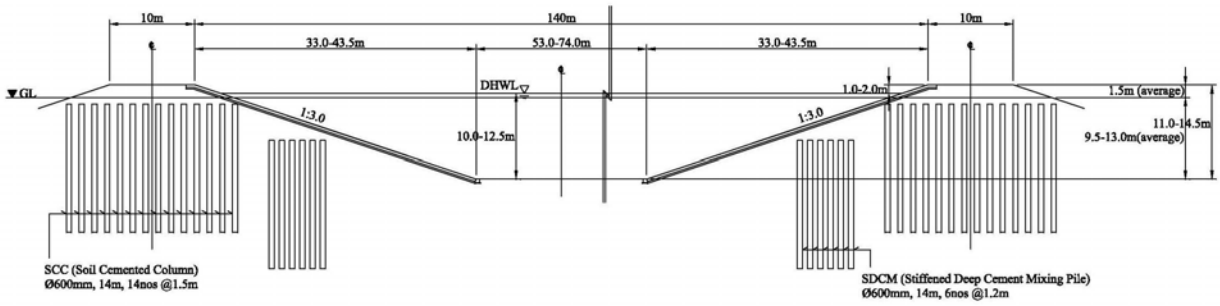
(2) Project Feature

The design capacity of diversion channel is 1,400 m^3/s. The profile and cross section of the channel is shown in Figure O2.1.4 and Figure O2.1.5.



Source: JICA study team

Figure O2.1.4 Profile of Ayutthaya Bypass Channel



Source: JICA study team

Figure O2.1.5 Standard Cross Section of Ayutthaya Bypass Channel

The construction work is composed of the following major work item:

- Earth Works (including ground improvement works)
- Road Works
- Concrete Works (Canal lining concrete)
- Crossing Facilities (Bridge, Gate, Siphon)

O2.2 Cost Estimate

O2.2.1 Unit Cost of Major Work Item

The unit cost of earthworks and ground improvement work was built-up with unit prices of construction resources such as equipment rental cost and fuel price.

Regarding the other work item, the unit cost was calculated in reference to the cost estimation for the previous feasibility study report. The unit cost for land acquisition and compensation was also set in reference to the feasibility study report. The price level of the said reports was 2011, thus the price escalation in 2011–2012, that is 5%, was considered for working out the unit cost for this study.

O2.2.2 Project Cost

The estimated project cost is summarized in Table O2.2.1.

Table O2.2.1 Project Cost for River Improvement

Unit: million baht

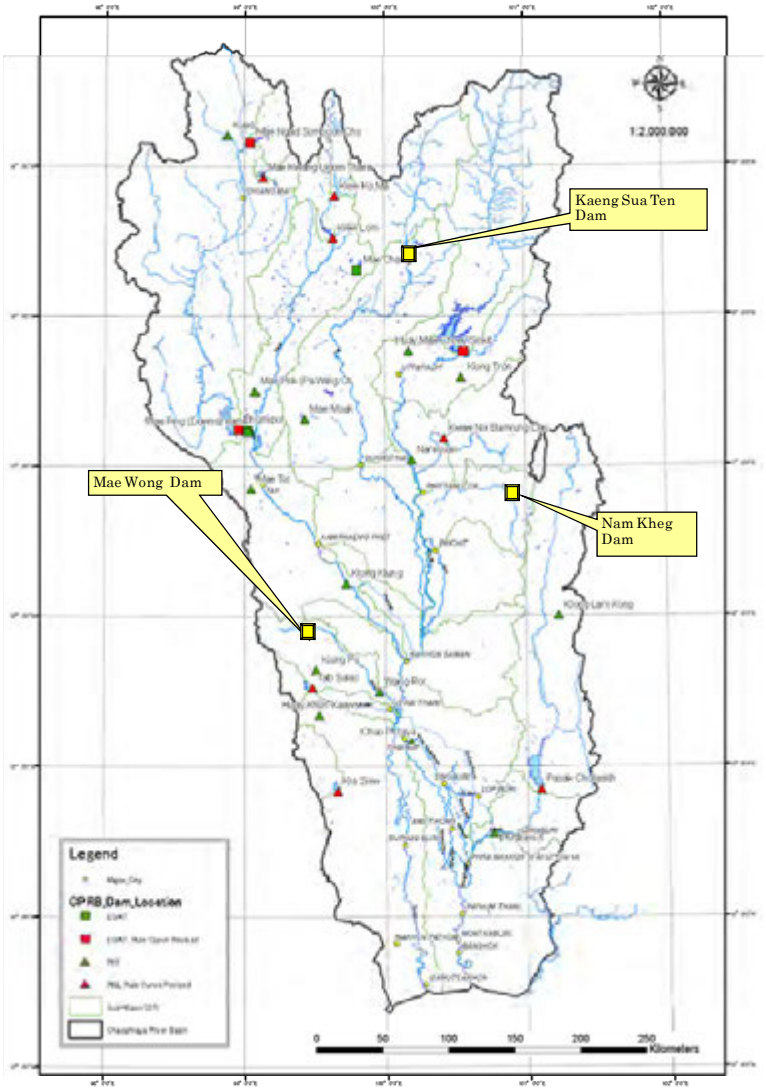
Item		Ayutthaya Bypass	Dyke Improvement	
			SCWRM M/P	Combination 1 or 2
1.	Construction Cost	9,407	6,364	6,903
2.	Engineering Cost	941	636	690
3.	Other Costs (EIA, Admin.)	1,552	1,050	1,139
4.	Physical Contingency	1,190	805	873
5.	VAT	916	620	672
6.	Land Cost	4,208	1,800	2,646
7.	Compensation Cost	66	0	1,010
Total Cost		18,279	11,275	13,933

CHAPTER O3 CONSTRUCTION OF NEW DAMS

O3.1 Project Feature

O3.1.1 Location

Figure O3.1.1 shows the location of the three (3) proposed dams (Kaeng Sua Ten Dam, Nam Kheg Dam, and Mae Wong Dam) in the Chao Phraya River Basin.



Source: JICA Study Team

Figure O3.1.1 Location Map of New Dams Proposed in the Chao Phraya River Basin

O3.1.2 Project Feature

Table O3.1.1 shows the project feature of the three dams, based on the feasibility study by RID. The design feature of Nam Kheg and Mae Wong dam were determined by analogy to the design of Kaeng Sua Ten Dam.

Table O3.1.1 Project Feature of Proposed New Dams

Item	Kaeng Sua Ten Dam	Nam Kheg Dam	Mae Wong Dam
River Basin	Yom River	Nam River	Sakae Krang River
Planning Feature			
Catchment Area	3,538 km^2	937 km^2	612 km^2
Crest Elevation	261m MSL	538 m MSL	210 m MSL
Crest Length	540 m	757 m	903 m
Reservoir Area	66.8 km^2	11.2 km^2	17.6 km^2
HWL/LWL	258 m/218 m	530 m/421 m	205 m/180 m
Effective Storage	1,125 MCM	542 MCM	238 MCM
Maximum Design Discharge	5,360 m^3/s	3,030 m^3/s	2,470 m^3/s
Design Feature			
Dam Type	Rock Fill Type	Rock Fill Type	Rock Fill Type
Dam Hight	69 m	128 m	56 m
Dam Slope (Up/Down stream)	1 : 3.0 / 1 :2.0	1 : 3.0 / 1 : 2.0	1 : 3.0 / 1 : 2.0
Dam Crest Width	10.0 m	8.0 m	12.0 m
Dam Bottom Width	355.0 m	648.0 m	292.0 m
Dam Embankment Volume	3,910,000 m^3	18,275,000 m^3	4,420,000 m^3
Diversion Tunnel	D 10.0m, L=455m	D 7.5m, L=748 m	D 6.8m, L=392m
Grouting	L=35m x 722 nos.	L=65m x 1011 nos.	L=30m x 1206 nos.

The construction work is composed of the following major work item:

- Construction of diversion tunnel
- Excavation and transportation for dam foundation and spillway
- Quarry excavation and transportation (spoil)
- Quarry excavation (rock) and transportation for dam embankment
- Dam embankment (core)
- Dam embankment (rock)
- Grouting
- Spillway concrete
- Spillway gate

The work volume was calculated based on the preliminary design for the said feasibility study and with several assumptions.

O3.2 Cost Estimate

O3.2.1 Unit Cost of Major Work Item

The unit costs of major work items were worked out in reference to the Contract BQ (Bill of Quantities) of a previous and relevant project, the Mae Kuang Project conducted by RID, and converted to the 2012 price level.

O3.2.2 Project Cost

The estimated project cost is summarized in Table O3.2.1.

Table O3.2.1 Project Cost for New Dam

Unit: million baht

Item		Kaeng Sua Ten Dam	Nam Kheg Dam	Mae Wong Dam	Total
1.	Construction Cost	12,944	21,182	6,945	41,071
2.	Engineering Cost	1,294	2,118	695	4,107
3.	Other Cost (EIA, Admin.)	2,136	3,495	1,146	6,777
4.	Physical Contingency	1,637	2,680	879	5,196
5.	VAT	1,261	2,063	677	4,001
6.	Land Cost	5,460	874	1,373	7,706
7.	Compensation Cost	647	1,059	347	2,054
Total Cost		25,379	33,471	12,061	70,911

CHAPTER O4 CONSTRUCTION OF FLOOD DIVERSION CHANNELS

O4.1 Project Feature

O4.1.1 Location

Figure O4.1.1 shows the planned route of three diversion channels: (i) West Diversion Channel; (ii) East Diversion Channel; and (iii) Outer Ring Road Diversion Channel.

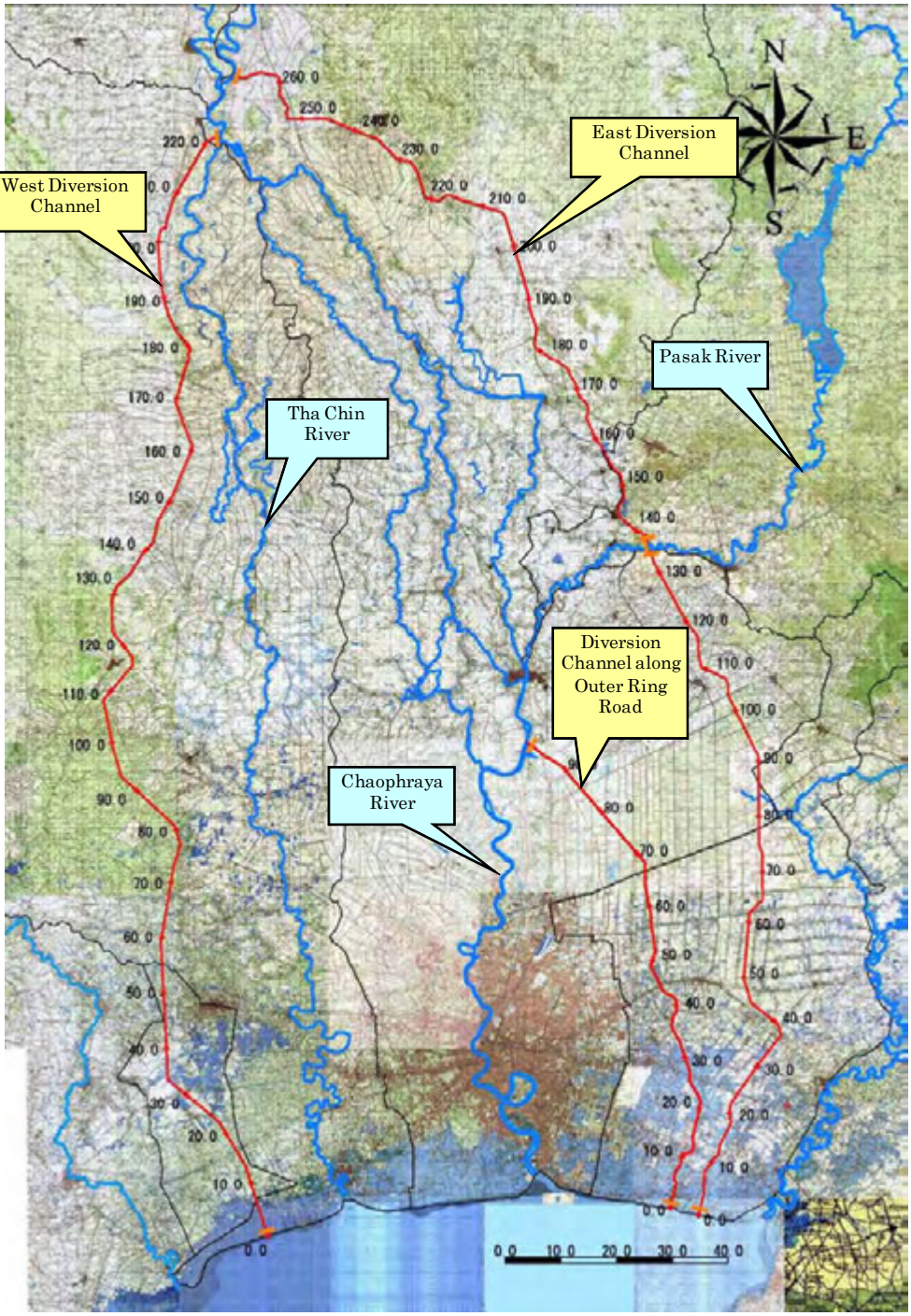


Figure O4.1.1 Location Map of Three New Diversion Channels

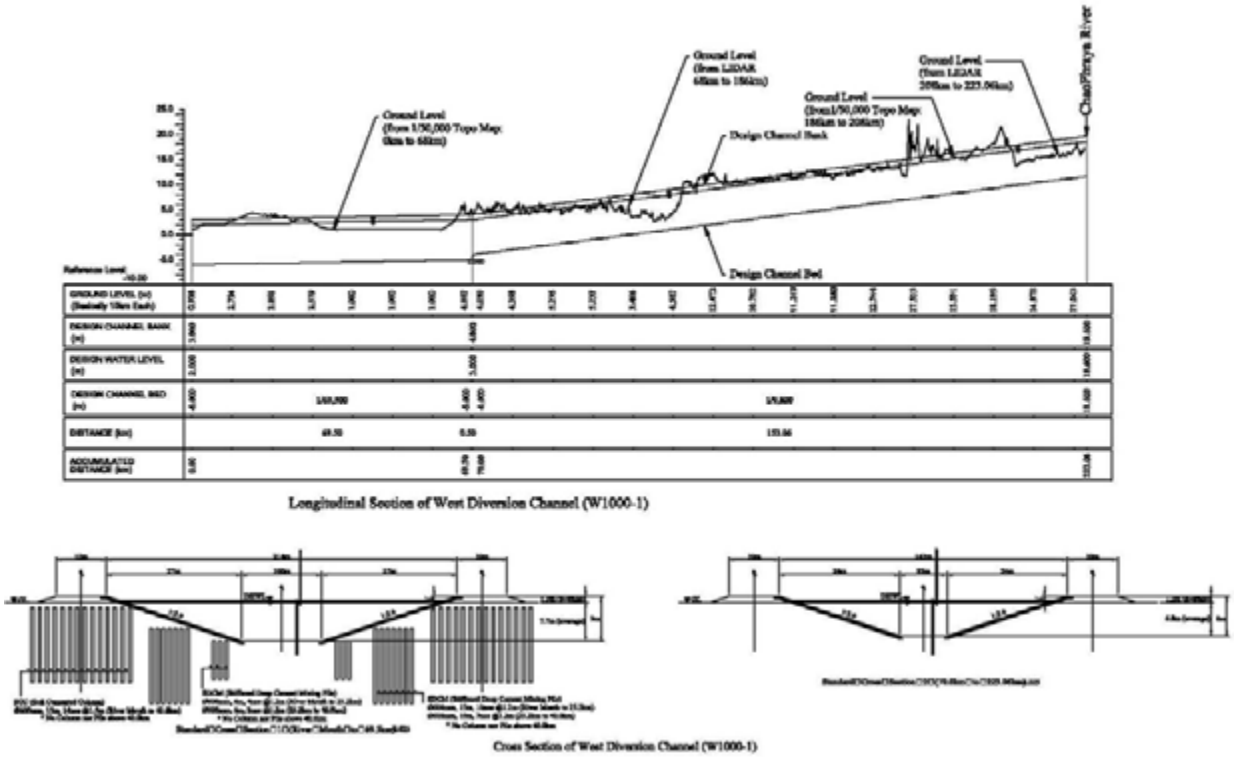
O4.1.2 Project Feature

Alternatives to the diversion channel as shown in Table O4.1.1 were studied and cost for each alternative was worked out.

Table O4.1.1 Alternatives to Diversion Channels

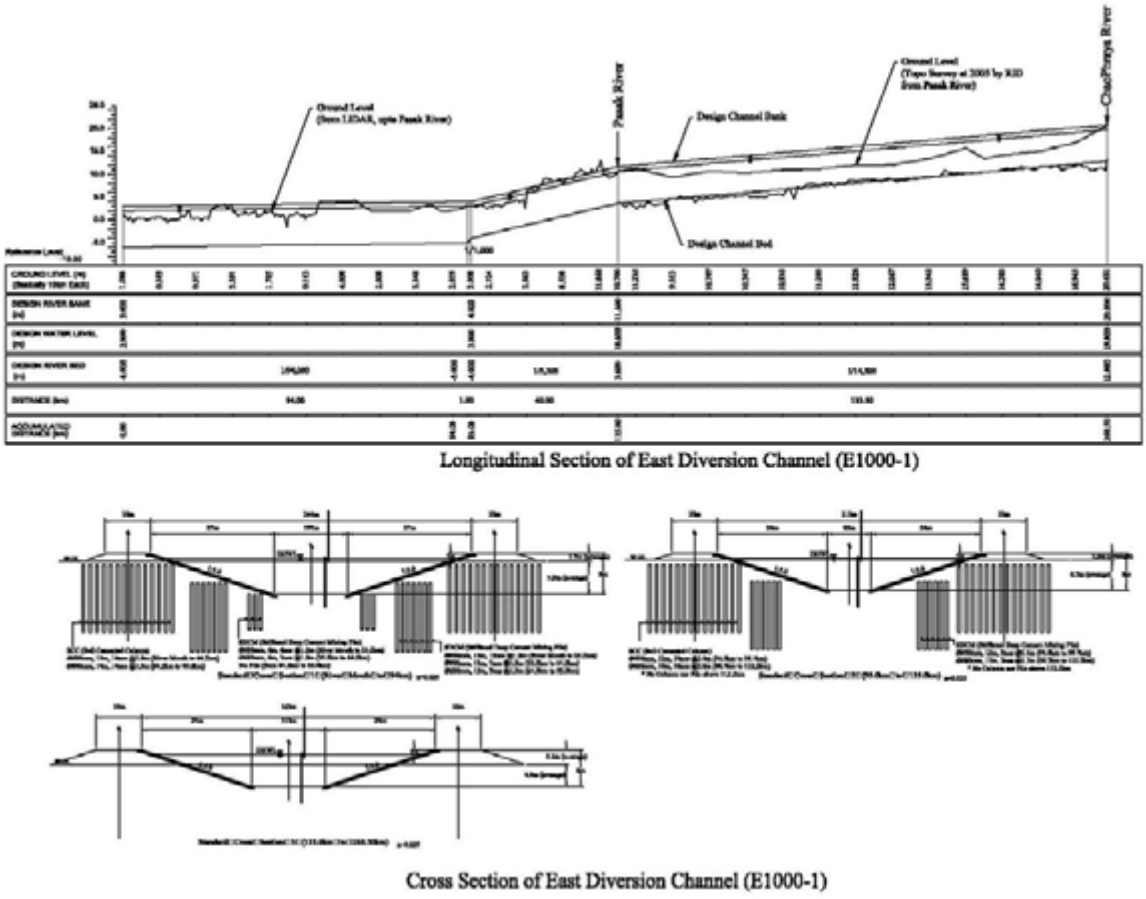
Alternative	Design Capacity	Type of Channel	Concrete Lining
West Diversion Channel			
W1000-1	1,000 m^3/s	Excavated channel	Lining on slope portion
W1000-2	1,000 m^3/s	Excavated channel	Lining on slope and bottom portion
W1000-3	1,000 m^3/s	Embankment channel	No lining concrete
W1500-1	1,500 m^3/s	Excavated channel	Lining on slope portion
East Diversion Channel			
E1000-1	1,000 m^3/s	Excavated channel	Lining on slope portion
E1000-2	1,000 m^3/s	Excavated channel	Lining on slope and bottom portion
E1000-3	1,000 m^3/s	Embankment channel	No lining concrete
E1500-1	1,500 m3/s	Excavated channel	Lining on slope portion
Outer Ring Road Diversion Channel			
O500-1	500 m^3/s	Excavated channel	Lining on slope portion
O500-2	500 m^3/s	Excavated channel	Lining on slope and bottom portion
O1000-1	1,000 m^3/s	Excavated channel	Lining on slope portion
O1000-2	1,000 m^3/s	Excavated channel	Lining on slope and bottom portion

The profile and cross section of W1000-1, E1000-1, and O500-1 are shown in Figure O4.1.2, Figure O4.1.3 and Figure O4.1.4, respectively.



Source: JICA study team

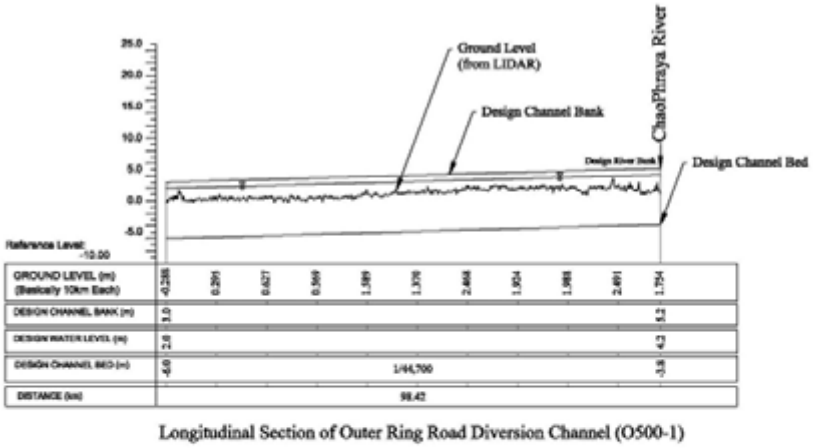
Figure O4.1.2 Profile and Cross Section of West Diversion Channel (W1000-1)



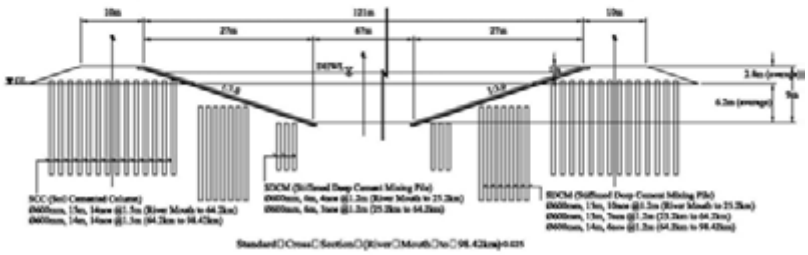
Longitudinal Section of East Diversion Channel (E1000-1)

Cross Section of East Diversion Channel (E1000-1)

Figure O4.1.3 Profile and Cross Section of East Diversion Channel (E1000-1)



Longitudinal Section of Outer Ring Road Diversion Channel (O500-1)



Cross Section of Outer Ring Road Diversion Channel (O500-1)

Figure O4.1.4 Profile and Cross Section of Outer Ring Road Diversion Channel (O500-1)

The construction work is composed of the following major work item:

- Earth Works (including ground improvement works)
- Road Works
- Concrete Works (Canal lining concrete)
- Crossing Facilities (Bridge, Gate, Siphon)

Route

The diversion channel was designed connecting the lower part of Ayutthaya and the Gulf of Thailand. Since the layout of Outer Ring Road was not fixed presently, the diversion channel can not be along with it. Hence, the new and rectilinear route was proposed in order to apply the most effective hydraulic gradient. Geological features and land use were also considered with satellite photos, topographic maps in 1:50,000 scale, elevation data with 1:50:000 maps and LiDAR data to fix the route of the diversion channel.

Longitudinal River Bed Gradient

Considering the existing ground slope and the standard cross section described below, the longitudinal river bed gradient was set at 1:44,700.

Standard Cross Section

In order to lower the design water level, the cross section mainly designed with excavation and small heightening of river banks was designed with an embankment. Lowering the water level was aiming at lowering the risk of the unexpected corruption of embankment since the rainy season in Thailand lasts for a couple of months with rise of water level. The effect of the inland storm water drainage is also large if the water level in the diversion channel is low.

Bank Slope and River Bed

In the feasibility study of the east flood way done by Thai government, the slope of river bank was set at 1:2.0 in the upstream side and 1:3.0 in the downstream side. Those are distinguished by Pasak River. In the Outer Ring Road Diversion Channel, the slope of the river bank was designed at 1:3.0 because the speed of water flow during floods would be small and soil of the ground was very week. Initially, two kinds of bank and river bed protection were proposed. The one is the protection only for bank slopes and the other is for the bank slopes and the river bed. Considering the difficulty of the maintenance of the rigid and smooth surface of the river bed protection, the protection only on the bank slopes were selected.

Pile Foundation

The lower part of the Chao Phraya River basin consists of an expansive low land with soft ground. In the feasibility study report, a figure of soil distribution made by geotechnical and environmental research and development center in Kasetsart University, Thailand was introduced and slope stability analyses was performed with additional boring sampling. According to the soil distribution figure, the lower stretches of the east flood way was covered by the Soft Bangkok Clay, and the bank slopes and the roads were strengthened by two types of the foundation pillars. One of the piles is a soil cemented column (SCC) with the diameter of 600mm, and the other is a stiffened deep cement mixing pile (SDCM) also with the diameter of 600mm. Details of those piles were not mentioned in the report but SDCM has the core (180mm × 180mm) in the center of SCC.

The other research on geomorphic characteristics of the Chao Phraya River basin done by Mr. Ohkura in National Research Center for Disaster Prevention, Japan and Ms. Haruyama in Institute of Science and Technology at Waseda University, Japan categorized the lower reach of the Chao Phraya River as lagoons.

Hence, the foundation piles are considered to be necessary to protect the stability of the bank slopes and the roads of the Outer Ring Road Diversion Channel. Since the soil distributions and the geomorphic characteristics along the Outer Ring Road Diversion Channel are similar to the one of the east flood way proposed by Thai government, the same design of the foundation piles was applied for the Outer Ring Road Diversion Channel.

Crossing Road

The diversion channel crosses a lot of roads so that bridges are required. Referring to the pitch of the bridges on Chainat-Pasak irrigation canal, which is at approximately 3km, 33 bridges along 98.3km in length of the diversion channel were proposed. Basically, all of the national roads totaling 14, which will be disconnected by the diversion channel, were connected with new bridges. Additionally, 19 supporting bridges were proposed (not defining the location). The widths of the bridges for the national roads were set at the ones of the crossing roads measured on the satellite photo and the ones for the supporting bridges were set at 7m, which is the minimum width for road bridge in the standard of DOH.

Crossing Canal and River

The diversion channel also crosses a lot of canals and rivers. All of them with the width of or more than 2m were connected with siphons. The width of the canals and rivers were measured on the satellite photos and those were applied to the ones of siphons. The height of the siphons were basically set at a half of the width of them and set at less than 10m.

Major rivers around the diversion channel are connected with a canal along the coast of the Gulf of Thailand. Those rivers are drained into the gulf with pumping systems. If the diversion channel is connected to one of the rivers or the canal, it places an extra stream on the existing pumping system. Hence, the diversion channel was connected to the Gulf of Thailand individually and the canal was connected with a siphon.

Gate

The diversion channel is to drain river water to the sea smoothly during the flood so the two gates, one at the diversion point and the other at the diversion channel mouth, are basically closed during the ordinary time and open during the flood.

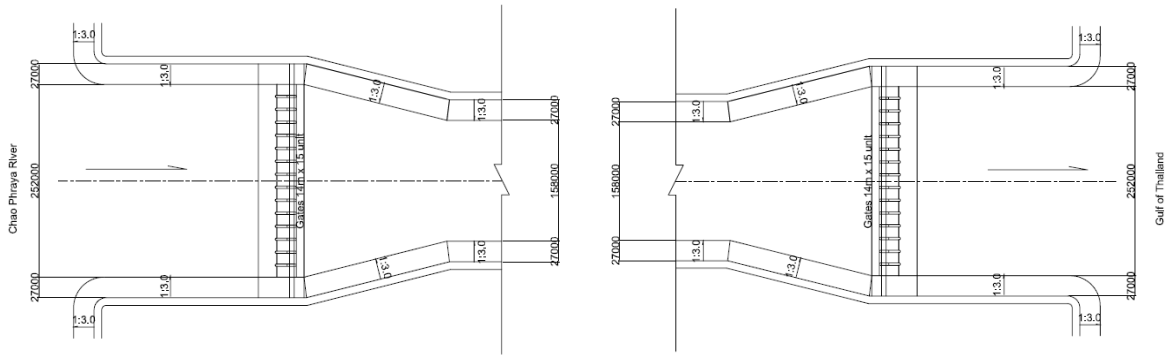


Figure O4.1.5 Gate at Diversion Point and Tidal Gate

O4.2 Cost Estimate

O4.2.1 Unit Cost of Major Work Item

The same unit costs as of “2. River Improvement” have been applied as unit costs of major work items.

O4.2.2 Project Cost

Estimated project cost for each of the alternatives is summarized in Table O4.2.1.

Table O4.2.1 Project Cost for Diversion Channel

Unit: million baht

Item		E1000-1	E1000-2	E1000-3	E1500-1
1.	Construction Cost	119,973	125,369	75,924	157,857
2.	Engineering Cost	11,997	12,537	7,592	15,786
3.	Other Cost (EIA, Adm.)	19,796	20,686	12,527	26,046
4.	Physical Contingency	15,177	15,859	9,604	19,969
5.	VAT	11,686	12,212	7,395	15,376
6.	Land Cost	32,224	27,939	167,099	43,824
7.	Compensation cost	1,164	997	8,899	1,623
Total Cost		212,016	215,598	289,041	280,480

Unit: million baht

Item		W1000-1	W1000-2	W1000-3	W1500-1
1.	Construction Cost	90,262	94,488	72,701	119,733
2.	Engineering Cost	9,026	9,449	7,270	11,973
3.	Other Cost (EIA, Adm.)	14,893	15,591	11,996	19,756
4.	Physical Contingency	11,418	11,953	9,197	15,146
5.	VAT	8,792	9,204	7,081	11,663
6.	Land Cost	21,952	19,336	118,075	30,776
7.	Compensation cost	1,366	1,204	9,402	1,910
Total Cost		157,710	161,224	235,721	210,956

Unit: million baht

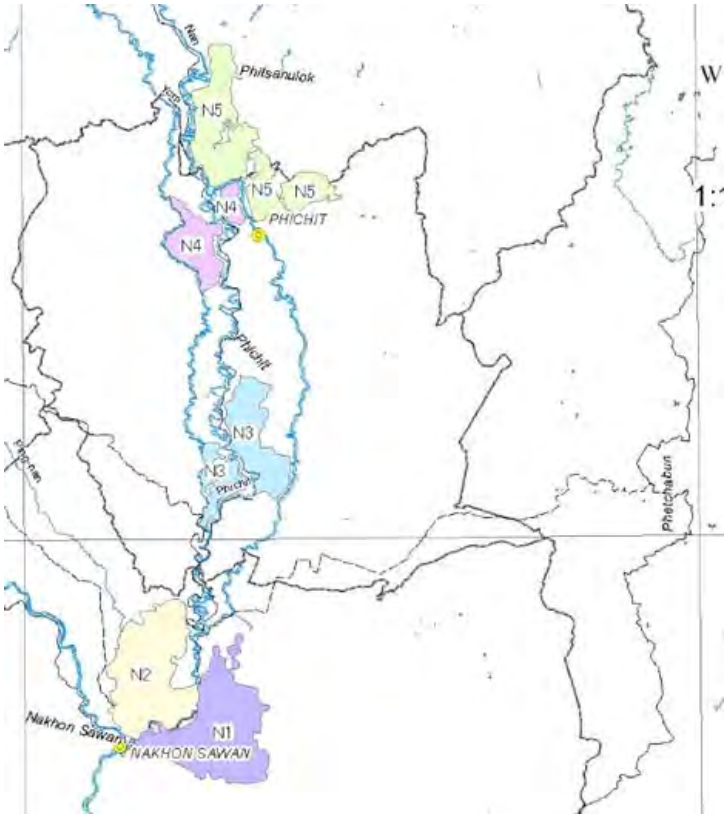
Item		O500-1	O500-2	O1000-1	O1000-2
1.	Construction Cost	47,908	47,723	69,341	70,307
2.	Engineering Cost	4,791	4,772	6,934	7,031
3.	Other Cost (EIA, Adm.)	7,905	7,874	11,441	11,601
4.	Physical Contingency	6,060	6,037	8,772	8,894
5.	VAT	4,667	4,648	6,754	6,848
6.	Land Cost	18,821	16,908	29,701	25,875
7.	Compensation cost	482	452	772	678
Total Cost		90,634	88,415	133,715	131,234

CHAPTER O5 IMPROVEMENT OF FLOOD RETARDING AREA

O5.1 Project Feature

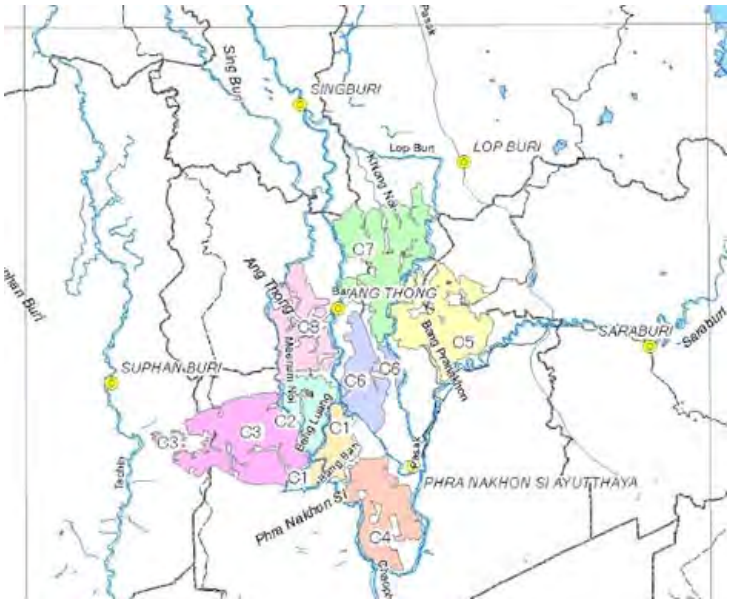
O5.1.1 Location

Improvements for the 13 retarding areas (5 in the north of Nakorn Sawan and 8 in the north of Ayutthaya) were planned by RID based on the "Feasibility Study on the Development of Flood Low Lands in Chao Phraya Basin (2009)." Location of the retarding area is shown in Figure O5.1.1 and Figure O5.1.2.



Source: JICA Study Team

Figure O5.1.1 Location Map of Retarding Area (North of Nakhon Sawan)



Source: JICA study team

Figure O5.1.2 Location Map of Retarding Area (North of Ayutthaya)

O5.1.2 Project Feature

The feature of the retarding area to be improved is shown in Table O5.1.1.

Table O5.1.1 Feature of Retarding Area

Name		Retention Area (km^2)	Capacity (MCM)	Ave. Water Depth (m)
North of Nakhon Sawan				
N1	Borapetch Swamp – Chum Sang	219	233	1.1
N2	Chum Sang – Gao Liao	165	238	1.4
N3	Tapan Hin – Bang Moon Nak – Po Talay	147	240	1.6
N4	Mueang Phichit – Po Tab Chang	86	147	1.7
N5	Bang Kratum	209	303	1.2
North of Ayutthaya				
C1	Bang Ban 1	52	126	2.4
C2	Pa Moke – Phak Hai	190	125	0.7
C3	Phak Hai – Bang Yeehon	190	257	1.4
C4	Bang Ban 2	117	279	2.4
C5	Don Pud - Maharaj	152	257	1.7
C6	Tung Pookhao Thong – Bang Pahun	89	249	2.8
C7	Chaiyo – Baan Prak	166	259	1.6
C8	Angthong (West side)	99	186	1.9

The works for improvement of the above of each retarding area is composed of construction /restoration of the following facilities:

- Pumping stations
- Gate
- Siphon, Culvert canal
- Natural canal, Irrigation canal
- Bridge
- Dyke embankment, Road

The amount of the above works for each of the retarding area was set according to the facility plan presented in the said feasibility study report.

O5.2 Cost Estimate

O5.2.1 Unit Cost for Major Work Item

The unit cost of the above work was worked out in reference to the said feasibility study report and converted to 2012 price level.

O5.2.2 Project Cost

The estimated project cost for each retarding basin is summarized in Table O5.2.1.

Table O5.2.1 Project Cost for Improvement of Flood Retarding Area

Unit: million baht

Item		N1 – N5	C1 – C8	Total
1.	Construction Cost	8,855	21,710	30,564
2.	Engineering Cost	885	2,171	3,056
3.	Other Costs (EIA, Admin.)	1,461	3,582	5,043
4.	Physical Contingency	1,120	2,746	3,866
5.	VAT	862	2,115	2,977
6.	Land Cost	11	1,072	1,083
7.	Compensation Cost	-	-	-
Total Cost		13,195	33,396	46,590

CHAPTER O6 FLOOD FORECASTING SYSTEM

O6.1 Cost Estimate

Estimated project cost for the flood forecasting system is summarized in the following table.

Table O6.1.1 Project Cost for Flood Forecasting System

Unit: million baht

Item		Flood Forecasting System
1.	Construction Cost	2,727
2.	Engineering Cost	273
3.	Other Costs (EIA, Admin.)	450
4.	Physical Contingency	345
5.	VAT	266
6.	Land Cost	0
7.	Compensation Cost	0
Total Cost		4,061

CHAPTER O7 PROJECT COST WITHOUT PRICE ESCALATION

O7.1 Summary of Each Project Cost for Measures

Estimated each project cost (financial base cost) for the measures is summarized in Table O7.1.1.

Table O7.1.1 Summary of Each Project Cost for Measures

Unit: million baht

Item		C2: New Dams	C4: Retarding Area	C5: River Improvement		
		Kaeng Sua Ten, Nam Kheg and Mae Wong Dam	Total of N1 to N5, C1 to C8	Ayutthaya Bypass	Dyke Improvement	
					SCWRM M/P	Combination 1 or 2
1.	Construction Cost	41,071	30,564	9,407	6,364	6,903
2.	Engineering Cost	4,107	3,056	941	636	690
3.	Other Cost (EIA, Admin.)	6,777	5,043	1,552	1,050	1,139
4.	Physical Contingency	5,196	3,866	1,190	805	873
5.	VAT	4,001	2,977	916	620	672
6.	Land Cost	7,706	1,083	4,208	1,800	2,646
7.	Compensation Cost	2,054	0	66	0	1,010
Financial Base Cost		70,911	46,590	18,279	11,275	13,933

Item		C6: Flood Diversion Channel			
		East Diversion Channel (E1000-1)	East Diversion Channel (E1500-1)	West Diversion Channel (W1000-1)	West Diversion Channel (W1500-1)
1.	Construction Cost	119,973	157,857	90,262	119,733
2.	Engineering Cost	11,997	15,786	9,026	11,973
3.	Other Cost (EIA, Admin.)	19,796	26,046	14,893	19,756
4.	Physical Contingency	15,177	19,969	11,418	15,146
5.	VAT	11,686	15,376	8,792	11,663
6.	Land Cost	32,224	43,824	21,952	30,776
7.	Compensation Cost	1,164	1,623	1,366	1,910
Financial Base Cost		212,016	280,480	157,710	210,956

Item		C6: Flood Diversion Channel		
		Outer Ring Road Diversion Channel (O500-1)	Outer Ring Road Diversion Channel (O1000-1)	Flood Forecasting System
1.	Construction Cost	47,908	69,341	2,727
2.	Engineering Cost	4,791	6,934	273
3.	Other Cost (EIA, Admin.)	7,905	11,441	450
4.	Physical Contingency	6,060	8,772	345
5.	VAT	4,667	6,754	266
6.	Land Cost	18,821	29,701	0
7.	Compensation Cost	482	772	0
Financial Base Cost		90,634	133,715	4,061

O7.2 Alternative Combination Cases

Three alternative combination cases as shown in Table O7.2.1 were studied for comparison.

Table O7.2.1 Alternative Combination Cases

Cases	Measures	
SCWRM M/P	C2: New Dams	Kaeng Sua Ten, Nam Kheg and Mae Wong Dam
	C4: Improvement of Retarding Area	Total of N1 to N5 and C1 to C8
	C5: River Improvement	Dyke Improvement
	C6: Diversion Channel	West Diversion Channel (W1500-1)
		Outer Ring Road Diversion Channel (O500-1)
	C8: Flood Forecasting System	Forecasting System
Proposed Combination 1	C5: River Improvement	Dyke Improvement
		Ayutthaya Bypass Channel
	C6: Diversion Channel	Outer Ring Road Diversion Channel (O500-1)
	C8: Flood Forecasting System	Forecasting System
Proposed Combination 2	C5: River Improvement	Dyke Improvement
		Ayutthaya Bypass Channel
	C6: Diversion Channel	Outer Ring Road Diversion Channel (O1000-1)
	C8: Flood Forecasting System	Forecasting System

O7.3 Project Cost without Price Escalation

Estimated project cost without price escalation is summarized in Table O7.3.1.

Table O7.3.1 Project Cost without Price Escalation

SCWRM M/P Module		Description	Capacity (m^3/s)	Project Cost (million baht)		
				SCWRM M/P	Proposed Combination 1	Proposed Combination 2
C1	Reforestation	-	-	*NE* *	*NI* **	*NI*
C2	Construction of New Dams	3 dams	-	70,911	*NI*	*NI*
C3	Land Use Control for Flood Area	-	-	NE	*NI*	*NI*
C4	Improvement of Retarding / Retention Areas	13 retention ponds	-	46,590	*NI*	*NI*
C5	River Improvement	River channel improvement	-	11,275	13,933 ****	13,933 ****
		Ayutthaya Bypass Channel (L=19km)	1,400	*NI*	18,279	18,279
C6	Flood Diversion Channel	West diversion channel (L=223km)	1,500	210,956	*NI*	*NI*
		Outer ring road diversion channel (L=98km)	500	90,634	90,634	-
			1,000	-	-	133,715
C7	Operation Efficiency of Existing Dams	Bhumibol, Sirikit, Kwae Noi, Pa Sak dams	-	*NB* ***	*NB*	*NB*
C8	Flood Forecasting System	-	-	4,061	4,061	4,061
Total		-	-	**434,428**	**126,907**	**169,988**

* *NE*: Not estimated (included in SCWRM M/P)
** *NI* : Not included in the proposed combinations
*** *NB*: Budget allocation is not necessary
**** Including river improvement of the Tha Chin River
Note 1: The costs in the respective columns include construction, engineering service, administration, land acquisition, resettlement, physical contingency, price escalation and valued added tax.
Note 2: Nonstructural measures proposed in the study are not included in the cost estimate.

CHAPTER O8 DISBURSEMENT SCHEDULE

O8.1 SCWRM Master Plan

O8.1.1 Implementation Schedule

Figure O8.1.1 shows the implementation schedule for SCWRM Master Plan.

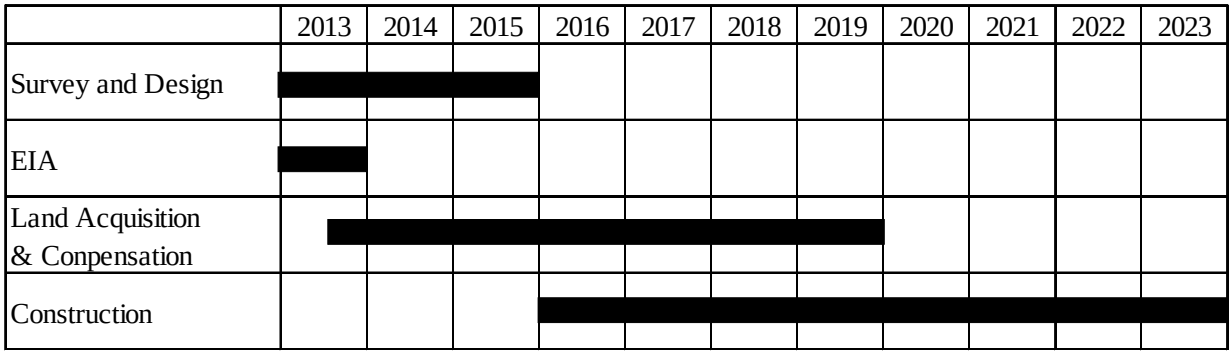


Figure O8.1.1 Implementation Schedule for SCWRM Master Plan

As shown above, prior to commencement of the construction works, EIA, land acquisition and compensation will be commenced. The construction period is estimated to be at least 8 years.

O8.1.2 Disbursement Schedule

Based on the above implementation schedule, the disbursement schedule for SCWRM M/P was worked out. The disbursement schedule is summarized in Table O8.1.1.

Table O8.1.1 Disbursement Schedule for SCWRM Master Plan

Unit: million baht

Item	Total	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Construction Cost	248,368	0	0	0	24,837	24,837	37,255	49,674	37,255	24,837	24,837	24,837
Engineering Cost	24,837	4,967	9,935	9,935	0	0	0	0	0	0	0	0
Other Cost	40,981	8,196	3,278	3,278	3,278	3,278	3,278	3,278	3,278	3,278	3,278	3,278
Physical Contingency	31,419	1,316	1,321	1,321	2,812	2,812	4,053	5,295	4,053	2,812	2,812	2,812
VAT	24,192	1,014	1,017	1,017	2,165	2,165	3,121	4,077	3,121	2,165	2,165	2,165
Land Cost	60,186	12,037	12,037	12,037	6,019	6,019	6,019	6,019	0	0	0	0
Compensation Cost	4,446	889	889	889	445	445	445	445	0	0	0	0
Sub-total	434,428	28,420	28,478	28,478	39,555	39,555	54,171	68,788	47,708	33,092	33,092	33,092
Price Escalation	73,527	710	1,442	2,190	4,106	5,198	8,651	12,979	10,420	8,235	9,268	10,327
Total	507,955	29,130	29,920	30,668	43,661	44,753	62,822	81,767	58,128	41,327	42,360	43,419

O8.2 Proposed Combination 1 and Combination 2

O8.2.1 Implementation Schedule

Figure O8.2.1 shows the implementation schedule for the proposed Combination 1 and Combination 2.

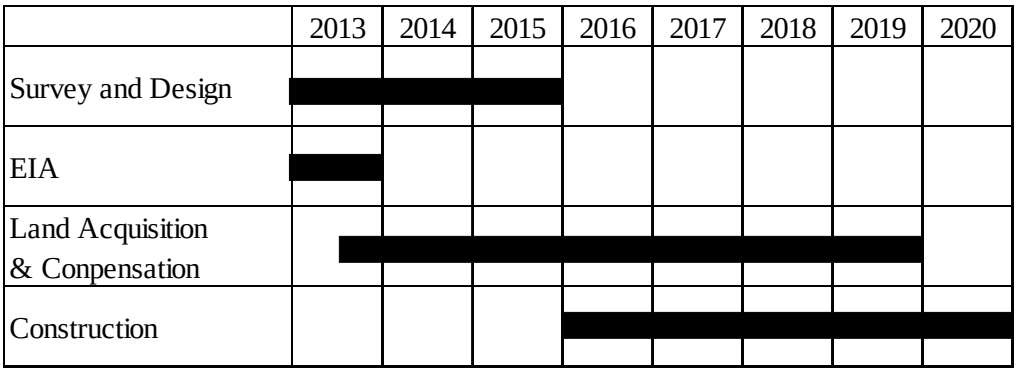


Figure O8.2.1 Implementation Schedule for Proposed Combination 1 and Combination 2

As shown above, prior to commencement of the construction works, EIA, land acquisition and compensation will be commenced. The construction period is estimated to be at least 5 years.

O8.2.2 Disbursement Schedule

Based on the above implementation schedule, the disbursement schedule for the proposed Combination 1 and Combination 2 were worked out. The disbursement schedule is presented in 6 and summarized in Table O8.2.1 and Table O8.2.2.

Table O8.2.1 Disbursement Schedule for Proposed Combination 1

Unit: million baht

Item	Total	2013	2014	2015	2016	2017	2018	2019	2020
Construction Cost	66,945	0	0	0	6,694	20,083	20,083	13,389	6,694
Engineering Cost	6,694	1,339	2,678	2,678	0	0	0	0	0
Other Cost	11,046	2,209	2,209	2,209	884	884	884	884	884
Physical Contingency	8,469	355	489	489	758	2,097	2,097	1,427	758
VAT	6,521	273	376	376	584	1,614	1,614	1,099	584
Land Cost	25,675	5,135	5,135	5,135	2,567	2,567	2,567	2,567	0
Compensation Cost	1,558	312	312	312	156	156	156	156	0
Sub-total	126,907	9,623	11,199	11,199	11,643	27,402	27,402	19,522	8,919
Price Escalation	16,485	241	567	861	1,209	3,601	4,376	3,684	1,948
Total	143,393	9,863	11,765	12,060	12,851	31,002	31,777	23,206	10,868

Table O8.2.2 Disbursement Schedule for Proposed Combination 2

Unit: million baht

Item	Total	2013	2014	2015	2016	2017	2018	2019	2020
Construction Cost	88,378	0	0	0	8,838	26,513	26,513	17,676	8,838
Engineering Cost	8,838	1,768	3,535	3,535	0	0	0	0	0
Other Cost	14,582	2,916	2,916	2,916	1,167	1,167	1,167	1,167	1,167
Physical Contingency	11,180	468	645	645	1,000	2,768	2,768	1,884	1,000
VAT	8,608	361	497	497	770	2,131	2,131	1,451	770
Land Cost	36,555	7,311	7,311	7,311	3,655	3,655	3,655	3,655	0
Compensation Cost	1,848	370	370	370	185	185	185	185	0
Sub-total	169,988	13,194	15,274	15,274	15,615	36,419	36,419	26,017	11,775
Price Escalation	21,981	330	773	1,174	1,621	4,786	5,816	4,909	2,572
Total	191,969	13,523	16,047	16,448	17,236	41,205	42,235	30,926	14,347

O8.3 Project Cost with Price Escalation

Estimated project cost with price escalation is summarized in the following table.

Table O8.3.1 Project Cost with Price Escalation

SCWRM M/P Module		Description	Capacity (m^3/s)	Project Cost (million baht)		
				SCWRM M/P	Proposed Combination 1	Proposed Combination 2
C1	Reforestation	-	-	*NE* *	*NI* **	*NI*
C2	Construction of New Dams	3 dams	-	70,911	*NI*	*NI*
C3	Land Use Control for Flood Area	-	-	NE	*NI*	*NI*
C4	Improvement of Retarding / Retention Areas	13 retention ponds	-	46,590	*NI*	*NI*
C5	River Improvement	River channel improvement	-	11,275	13,933 ****	13,933 ****
		Ayutthaya Bypass Channel (L=19km)	1,400	*NI*	18,279	18,279
C6	Flood Diversion Channel	West diversion channel (L=223km)	1,500	210,956	*NI*	*NI*
		Outer ring road diversion channel (L=98km)	500	90,634	90,634	-
			1,000	-	-	133,715
C7	Operation Efficiency of Existing Dams	Bhumibol, Sirikit, Kwae Noi, Pa Sak dams	-	*NB* ***	*NB*	*NB*
C8	Flood Forecasting System	-	-	4,061	4,061	4,061
Price Escalation (2013 to 2020 or 2023)		-	-	73,527	16,485	21,981
Total		-	**-**	**507,955**	**143,393**	**191,969**

* *NE*: Not estimated (included in SCWRM M/P)
** *NI* : Not included in the proposed combinations
*** *NB*: Budget allocation is not necessary
**** Including river improvement of the Tha Chin River
Note 1: The costs in the respective columns include construction, engineering service, administration, land acquisition, resettlement, physical contingency, price escalation and valued added tax.
Note 2: Nonstructural measures proposed in the study are not included in the cost estimate.

Sector P: Economic Evaluation

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
VOLUME 3: SUPPORTING REPORT

SECTOR P: TABLE OF CONTENTS

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CHAPTER P1 METHODOLOGY

P1.1 General

The main objective of the economic evaluation here is to examine the investment efficiency of the component of the Master Plan from the viewpoint of national economy using cost-benefit analysis in cases where it can be applied. Market prices have been converted to economic ones where the influence of market distortion is removed, (the so-called shadow prices). Opportunity costs are used for the costs of goods and services whose markets do not exist. Willingness-to-pay is used for benefits whose markets do not exist. Internal Rate of Return (IRR) is used here as the indicator of efficiency of project investment. IRR is defined as the discount rate which makes the present value of the flow of costs incurred in the project the same as that of benefit, or which makes the Net Present Value (NPV) 0 (zero), showing what percentage of profit the investment will be paid back with. IRR used in economic evaluation is called Economic Internal Rate of Return (EIRR).

P1.2 Preconditions

The following preconditions are assumed in the economic evaluation. Additional preconditions will be clarified as necessary.

(1) With-Project and Without-Project

"Without-Project" is the case where flood is managed by the currently existing systems. "With-Project" is the case where the project component is implemented into the currently existing systems. By comparing the with-project and without-project, costs and benefits accruing are estimated to calculate EIRR.

(2) Evaluation Period

Evaluation period covers the whole project life from the preparation of construction. It is decided as 2013 to 2050 (38 years after the commencement of the project). Although the project may be working longer, it does not affect so much after 30 years due to discounting.

(3) Standard Conversion Factor (SCF)

A conversion factor is the ratio between the economic price value and the financial price value for a project output or input. When it is calculated for the economy as a whole, it is called as Standard Conversion Factor (SCF) or an average conversion factor. Since border prices are regarded as economic prices, SCF is used for bringing such goods that are valued in domestic price level and those that are valued in border price level to a common base. In addition, SCF is simply the inverse of the Shadow Exchange Rate Factor (SERF), which is the ratio of the shadow exchange rate to the official exchange rate by definition.

SCF is calculated with the following formula:

$$SCF = \frac{M + X}{(M + Tm) + (X - Tx + Sx)} = \frac{\text{Border Price}}{\text{Domestic Market Price}}$$

where,

M	:	Total Import (CIF)
X	:	Total Export (FOB)
Tm	:	Total Import Tax
Tx	:	Total Export Tax
Sx	:	Total Export Subsidy

As shown in the Table below, SCF of Thailand is estimated as 1 (one).

Table P1.2.1 Standard Conversion Factor of Thailand

(Unit: million Baht)

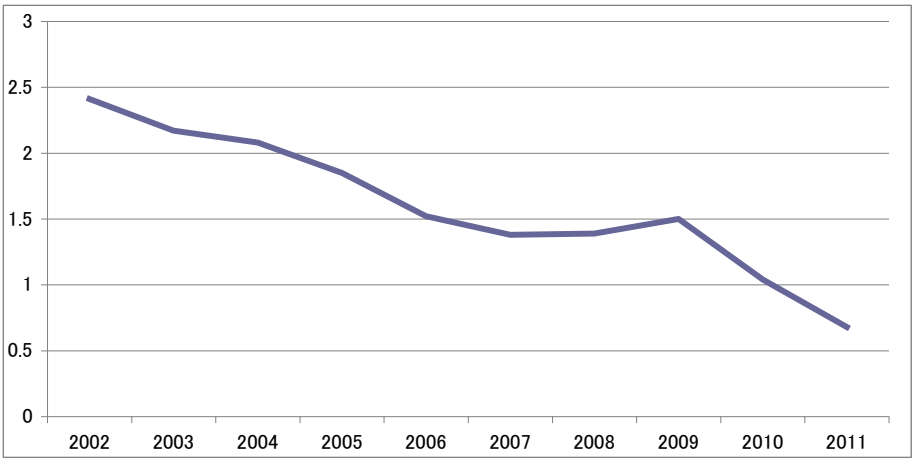
		2007	2008	2009	2010	2011
Imports of goods and services (current Baht)	(1)	5,544,488	6,708,781	5,226,526	6,452,512	7,631,792
Exports of goods and services (current Baht)	(2)	6,259,581	6,941,526	6,180,052	7,203,299	8,109,950
Customs and other import duties (current Baht)	(3)	87,440	96,000	76,482	92,675	99,111
Taxes on exports (current Baht)	(4)	4,164	500	400	168	239
Export subsidies*	(5)	0	0	0	0	0
(6) = (1) + (2)	(6)	11,804,069	13,650,307	11,406,578	13,655,811	15,741,742
(7) = (1) + (2) + (3) - (4) + (5)	(7)	11,887,345	13,745,807	11,482,660	13,748,318	15,840,614
Shadow Exchange Rate Factor (8) = (7)/(6)	(8)	1.01	1.01	1.01	1.01	1.01
Standard Conversion Factor (9) = (6)/(7)	(9)	0.99	0.99	0.99	0.99	0.99

*) Thailand is a member country of WTO, which prohibits most subsidies directly linked to the volume of exports.
Source: World Bank

(4) Shadow Wage Rate

Shadow Wage Rate (SWR) is an estimate of the economic price of labor. It is generally regarded that wage rates for skilled labor reflect the equilibrium between demand and supply in the market while those for unskilled labor do not because the supply usually exceeds the demand and the floor rate is decided not by the market mechanism but by the government or socially. Thus, SWR is usually required to be estimated for unskilled labor.

Considering the low unemployment rate and its downward trend in Thailand, Shadow Wage Rate Factor (SWRF) or the ratio between its shadow wage rate and its price for unskilled labor can be estimated as 1 (one) as seen in the figure below.



Source: International Monetary Fund, World Economic Outlook Database, October 2012

Figure P1.2.1 Unemployment Rate in Thailand

(5) Price Level

Price level is set at 2012. Price data before 2012 is adjusted to the 2012 level by applying the inflation rate.

(6) Social Discount Rate

Twelve percent (12%) is employed as the social discount rate for this economic analysis.

P1.3 Costs

Incremental costs are included in the evaluation by comparing "with-project" and "without-project situations." Costs are calculated in the form of cash flow of each year during the evaluation period. The following cost items are considered:

(1) Capital Cost

Capital cost includes costs of construction of facilities and equipment, and consulting services. Economic evaluation includes physical contingencies but excludes price escalations.

(2) Operation and Maintenance Cost

Operation and maintenance cost for each year is included. Price escalation is not included.

(3) Depreciation

Since the money allocated and subject to depreciation is not actually spent at that time, it is not included in the cost items.

P1.4 Benefits

Incremental benefits are included in the evaluation by comparing with-project and without-project situations. The benefits are calculated in the form of cash flow of each year during the evaluation period. Benefits of a flood management project are the reduction or mitigation of damages caused by floods. Flood damages include the following items in general:

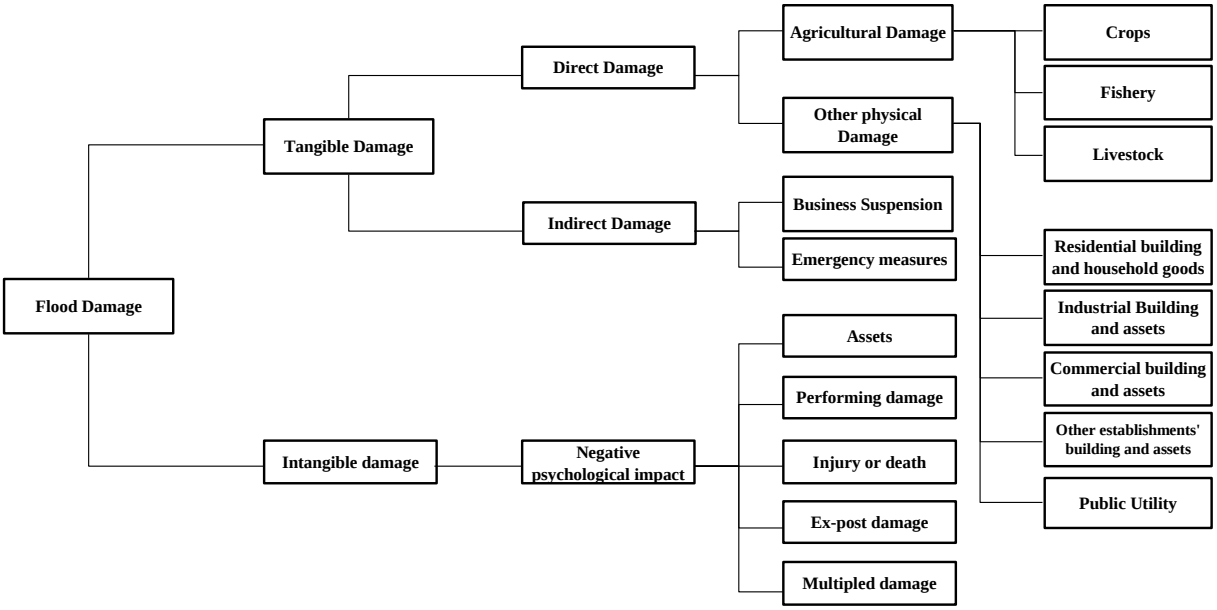


Figure P1.4.1 Flood Damages

Among flood damages in the above figure, tangible ones are trired to be estimated for the benefits of the project in principle.

As for the direct damage caused by flood, generally, it can be calculated by the following formula:

[Direct Damage in the Area (Baht)] = [Area Size (km^2)] × [Damageable Value (Baht/km^2)] × [Damage Rate by Inundation Depth].

The damageable value is the maximum amount of asset value that will be damaged by the inundation. It is assumed that damage rate is a function of inundation depth (m) and the function should be estimated. Since the flood cuasing inundation is a probalitity event, the damage value to be caluculated is the yearly expected value based on the probability of flood occurance (sum of dameges multiplied by each flood probability).

Estimation of indirect damages varies for each category. It will be disussed later in actural calculation for each category.

CHAPTER P2 ECONOMIC EVALUATION OF MASTER PLAN

P2.1 Conditions for Evaluation

P2.1.1 Economic Prospects of Thailand

One of the Japanese prestigious commercial banks, the Bank of Tokyo-Mitsubishi UFJ, published a report on the middle-term economic prospects of Thailand in January 2013. The report says that Thai economy would show a steady growth or 4.5% - 4.9% growth, which is near the potential grwoth rate for the next ten years. A turning point of Thai econmy would be an establishment of ASEAN Economic Community (AEC) which is planned to start in 2015, where intra-regional trade, investment and moves of labor will be liberalized and an integrated market will come about. It is expected that Thailand will strengthen its role as a prodcution center in ASEAN with its advantages including concentration of industries such as automobiles and electronic devices as well as FTA network developed in ASEAN.

Resources of its growth are consumption and export. Although the light industries will be transfered to CLM countries where labor cost is much lower than Thailand, trade between such countries will be increased. Expansion of FTA network in ASEAN will pull up Thai economy continousely. On the other hand, per capita GDP of Thailand is expected to reach 10,000 USD in 2030 and matuarized consumption sucn as service consimption will be vitalized then. Following is the scenario of the economic growth of Thailand up to 2022.

(1) 2012 to 2014: Average growth rate is 4.5% to 4.9%.

The growth rate in 2012 would increase to the middle of 5% level due to the rebound from flood damage in 2011 but that in 2013 will lower again due to the rebound by high growth in 2012. Investment for flood management by the Government as well as increase in direct investment with the expectation of ASEAN Economic Community **(**AEC) establishment will keep a steady growth. Significant increase in minimum wage in 2012-2013 will increase consumption and support the growth.

(2) 2015 to 2018: Average growth rate is the middle of 4% level.

Thailand will strengthen its role as a production center of ASEAN taking advantage of the AEC establishment. Expansion of consumption as well as increase in export within ASEAN will speed up the growth gradually and the growth rate will reach 5% level in 2018.

(3) 2019 to 2022: Average growth rate is 4.0% to 4.4%.

Growth rate will lower gradually as Thailand will enter a population onus period and the effect of transition of Chinese economy to stable growth economy will materialize. Production of low value-added products will shift to CLM countries due to the increase in labor costs in Thailand. Its dependence on export will lower relatively although it is still a driving force of growth. On the other hand, increase in urbanization as well as increase in per capita GDP to 8,000 USD will pull up the growth by expanding mature consumption such as services.

[Reference]

Oxford Economics, an economic forecasting company in UK, made the following forecast for the Thai economy in the "County Economic Forecast" dated May 24, 2012. It forecasted higher growth than that of the Bank of Tokyo-Mitsubishi UFJ for a few years after the flood recovery.

Year	2011	2012	2013	2014	2015	2016
GDP Growth (%)	0.1	5.3	6.5	5.6	5.4	4.9

Source: Oxford Economics, "Country Economic Forecast," May 24, 2012.

P2.1.2 Analysis of Questionnaire Survey on Flood Damage

(1) Manufacturing

In order to examine economic impacts by the 2011 flood, flood damage analysis is conducted with data obtained from a questionnaire survey in manufacturing factories of the seven flooded industrial estates (Aug-Oct 2012). Examinations, results and evaluation of the analysis are as follows:

(a) Relationship between Inundation Depth and Damage Rate of Assets (Whole Sectors)

Examinations are done with all effective data on relationship between inundation depth above the floor and damage rate of assets such as fixed and inventory assets. Data show that lots of damage rate values are scattered at the same depth, indicating no statistically significant relations. The determination coefficients (R^2), 0.0042 for fixed assets and 0.015 for inventory assets also support the results.

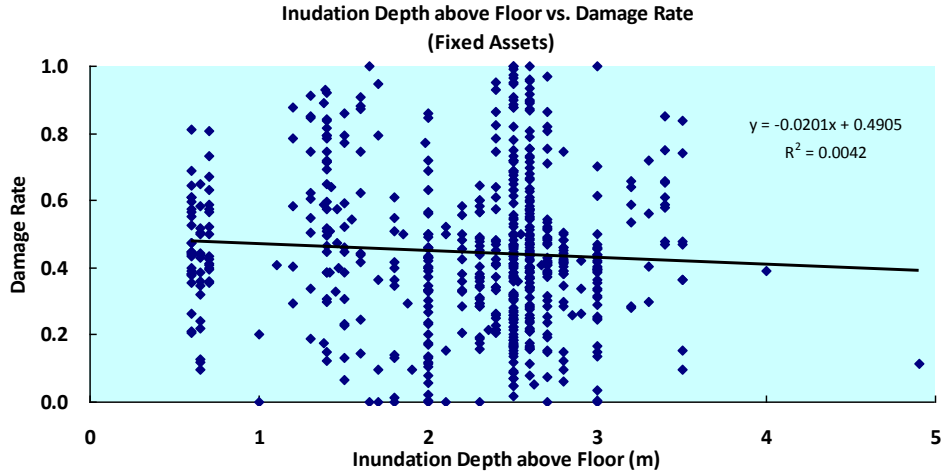


Figure P2.1.1 Relationship between Inundation Depth and Damage Rate (Fixed Assets)

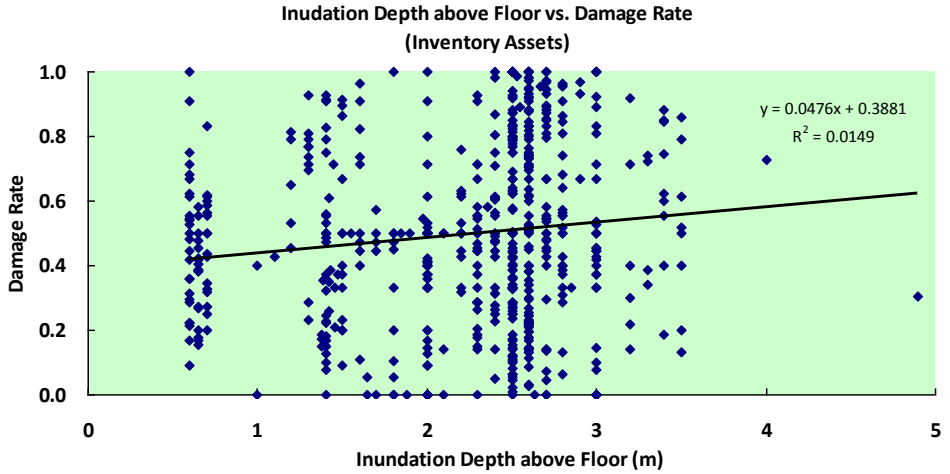


Figure P2.1.2 Relationship between Inundation Depth and Damage Rate (Inventory Assets)

(b) Relationship between Inundation Depth and Damage Rate of Assets (by Sector)

Considering no relations using the data in whole sectors, another examination is conducted by dividing the data by sector such as: I) Food & Textile; II) Chemical & Metals; III) General Machinery; IV) Electronic Machinery; and V) Others. They indicate that all determination correlations are much lower than those for statistical significance in both assets.

Table P2.1.1 Relationship between Inundation Depth and Damage Rate of Assets (by Sector)

Classification		I	II	III	IV	V
		Food & Textile	Chemical & Metals	General Machinery	Electronic Machinery	Others
Det. Correlation (R^2)	Fixed	0.0070	0.0007	0.0004	0.0024	0.0133
	Inventory	0.0055	0.0098	0.0304	0.0140	0.0302

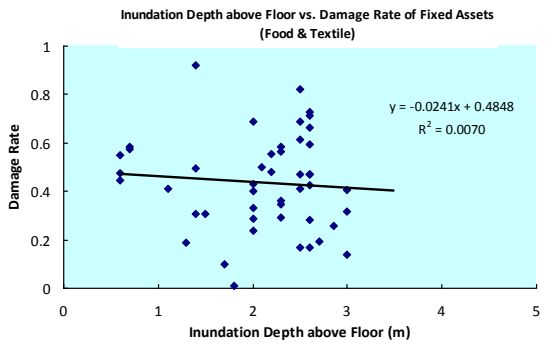


Figure P2.1.3 Relationship between Inundation Depth and Damage Rate of Fixed Assets (Food & Textile)

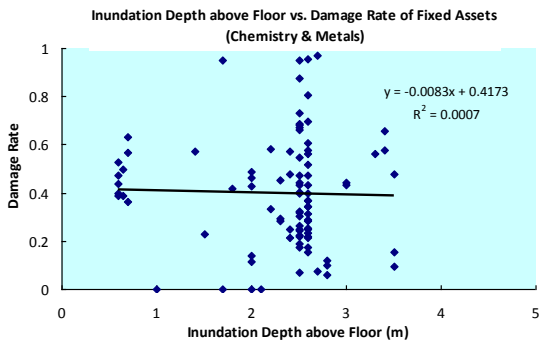


Figure P2.1.4 Relationship between Inundation Depth and Damage Rate of Fixed Assets (Chemical & Metals)

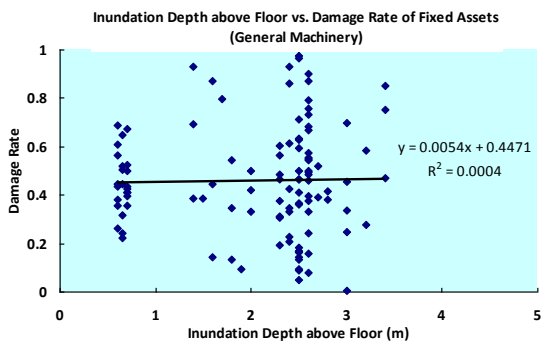


Figure P2.1.5 Relationship between Inundation Depth and Damage Rate of Fixed Assets (General Machinery)

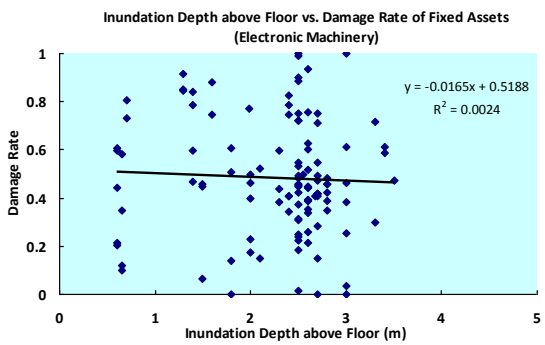


Figure P2.1.6 Relationship between Inundation Depth and Damage Rate of Fixed Assets (Electronic Machinery)

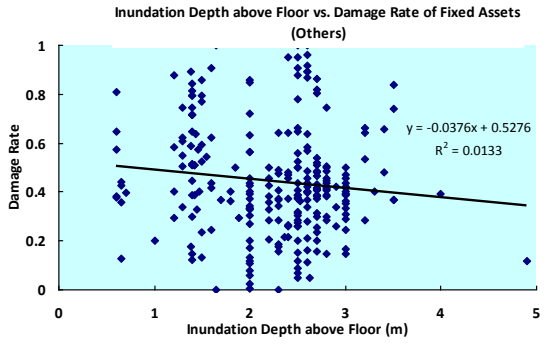


Figure P2.1.7 Relationship between Inundation Depth and Damage Rate of Fixed Assets (Others)

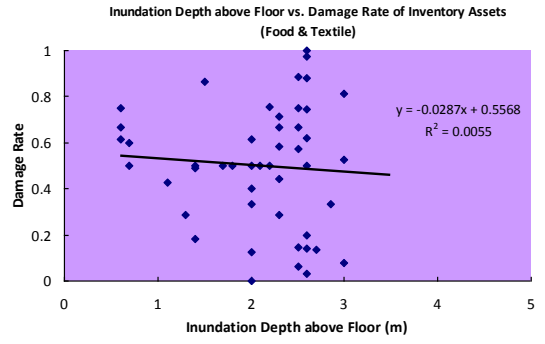


Figure P2.1.8 Relationship between Inundation Depth and Damage Rate of Inventory Assets (Food and Textile)

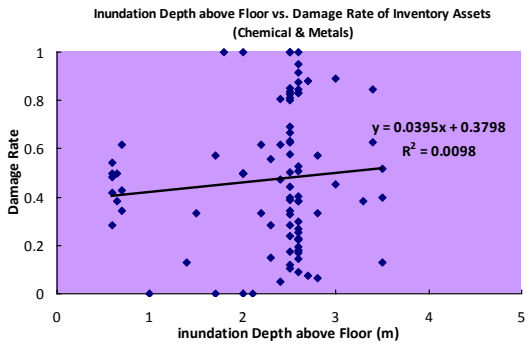


Figure P2.1.9 Relationship between Inundation Depth and Damage Rate of Inventory Assets (Chemical & Metals)

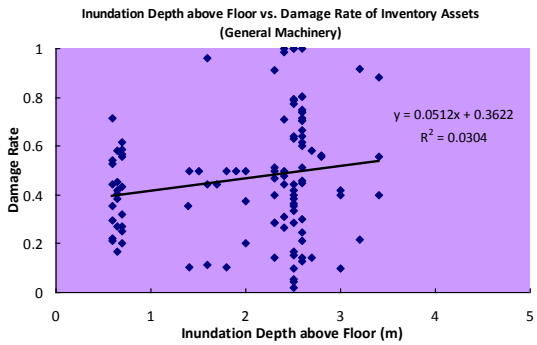


Figure P2.1.10 Relationship between Inundation Depth and Damage Rate of Inventory Assets (General Machinery)

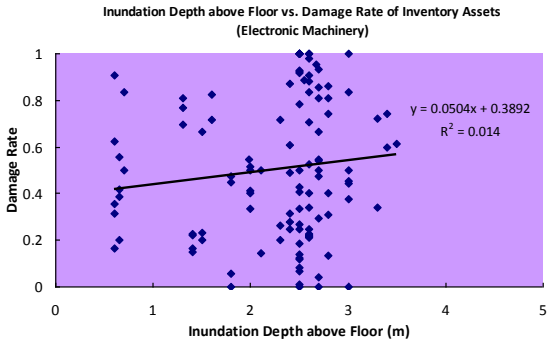


Figure P2.1.11 Relationship between Inundation Depth and Damage Rate of Inventory Assets (Electronic Machinery)

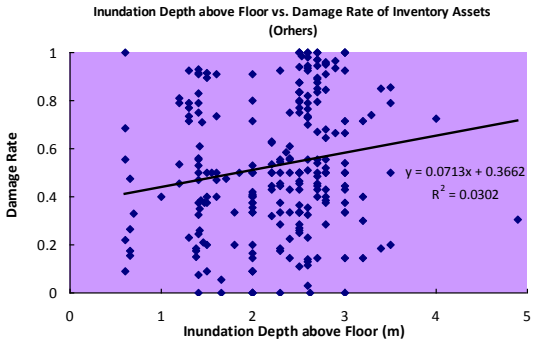


Figure P2.1.12 Relationship between Inundation Depth and Damage Rate of Inventory Assets (Others)

(2) Households

Like the case in manufacturing, damage analysis on households is conducted with data obtained from a questionnaire survey from the residents living in the flooded areas in the Chao Phraya River Basin (Aug-Oct 2012). Examinations, results and evaluation of the analysis are as follows:

(a) Relationship between Inundation Depth and Damage Rate of Assets (Whole Households)

Similar to the method in Manufacturing, examinations are done with all effective data on relationship between inundation depth above the floor and damage rate of assets such as buildings and household goods in Figure P2.1.13 and Figure P2.1.14, respectively.

The determination correlations (R2) obtained from the graphics indicate little significant relations in statistics with 0.0994 for buildings and 0.1161 for household goods.

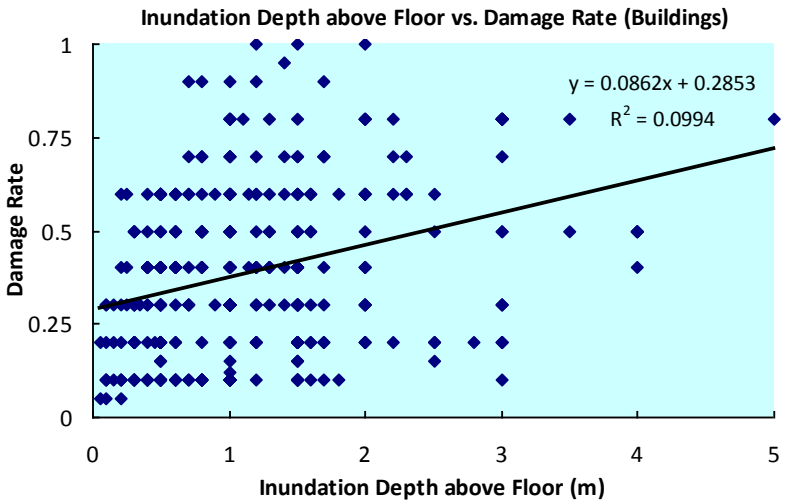


Figure P2.1.13 Relationship between Inundation Depth and Damage Rate (Buildings)

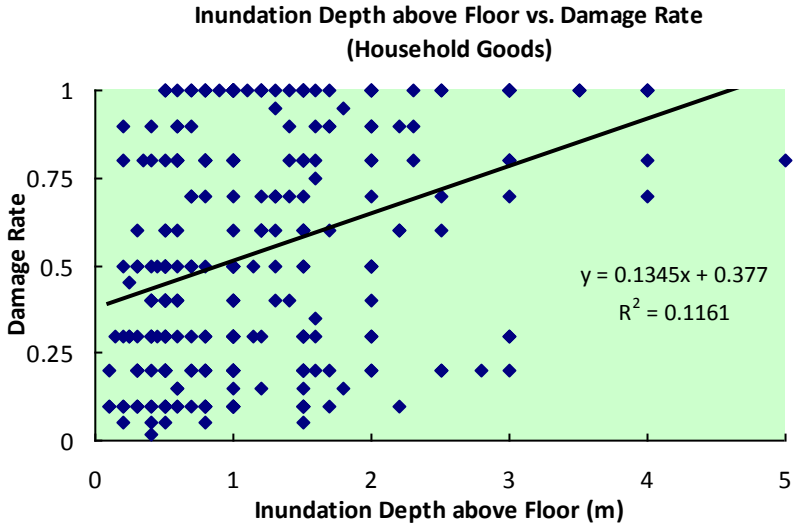


Figure P2.1.14 Relationship between Inundation Depth and Damage Rate (Household Goods)

(b) Relationship between Inundation Depth and Damage Rate of Assets (by Floor Space)

To examine the scale of damage by living standards, per capita floor space of a house is assumed to be a factor of living standards. Three classifications of floor space are set as: I) less than 30m^2/head; II) 30-100 m^2/head; and III) more than 100m^2/head, considering the balance of data volume. The results of statistical analysis are shown in Table P2.1.2 and in Figure P2.1.15 to Figure P2.1.20, respectively.

Table P2.1.2 Relationship between Inundation Depth and Damage Rate (by Floor space)

Classification		I	II	III
		< 30m^2/head	30-100m^2/head	> 100m^2/head
Det. Correlation (R^2)	Buildings	0.1681	0.1178	0.1549
	Household Goods	0.1346	0.1107	0.2657

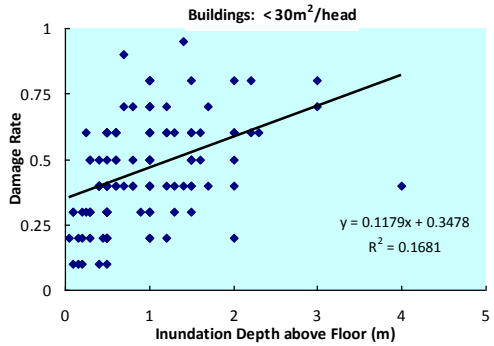


Figure P2.1.15 Relationship between Inundation Depth and Damage Rate of Buildings (< 30m2/head)

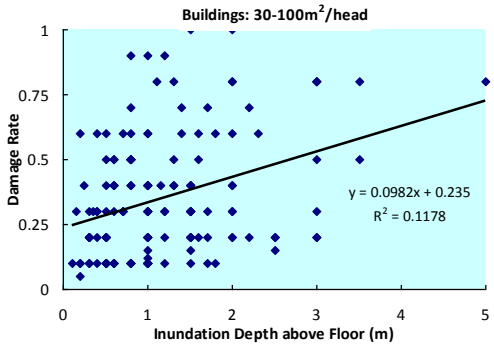


Figure P2.1.16 Relationship between Inundation Depth and Damage Rate of Buildings (100- 30m2/head)

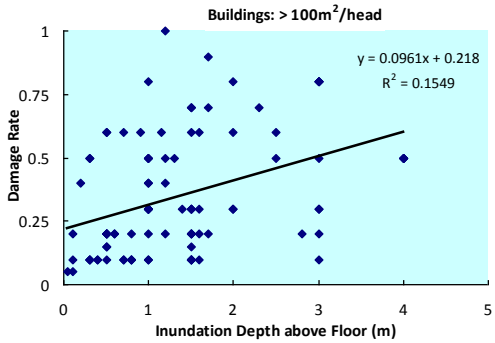


Figure P2.1.17 Relationship between Inundation Depth and Damage Rate of Buildings (> 100m2/head)

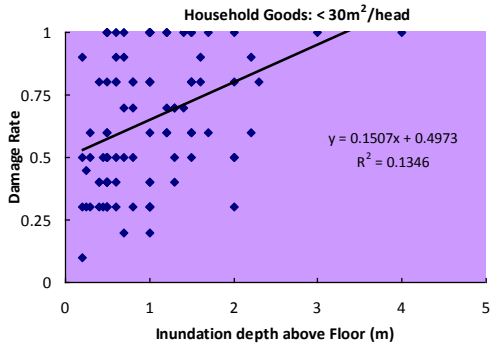


Figure P2.1.18 Relationship between Inundation Depth and Damage Rate of Household Goods (< 30m2/head)

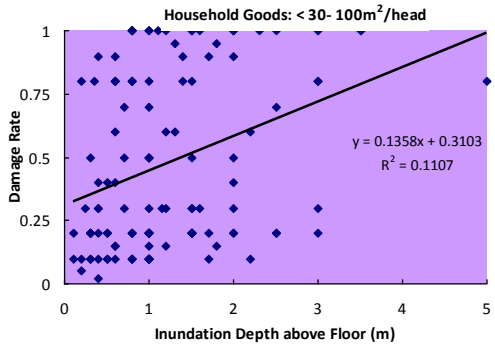


Figure P2.1.19 Relationship between Inundation Depth and Damage Rate of Household Goods (30- 100m2/head)

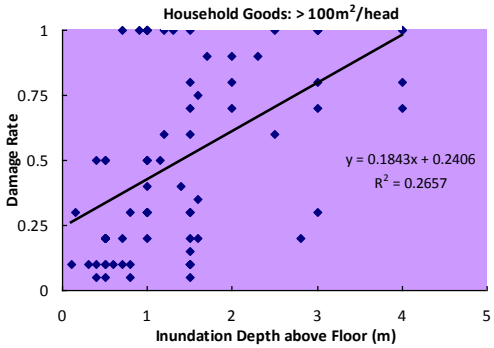


Figure P2.1.20 Relationship between Inundation Depth and Damage Rate of Household Goods (> 100m2/head)

The values of R^2 seem to be better by the classification but all values could not be statistically significant for using flood damage estimation.

(c) Relationship between Inundation Depth and Damage Rate of Assets (by Story of House)

Based on an assumption that the house structure might give an effect on damages by the flood, the relationship between inundation depth and damage rate of assets by story of house (one- and two-story) is evaluated.

The results showing in Table P2.1.3 and Figure P2.1.21 to Figure P2.1.24 unveil that no significant relationships were found between the two parameters, even though a tendency of higher correlations for two-story houses is observed. A negative correlation is seen in the building damage with one-story houses shown in Figure P2.1.21.

Table P2.1.3 Relationship between Inundation Depth and Damage Rate of Assets (by Story of House)

Classification		One-story	Two-story
Det. Correlation (R^2)	Buildings	0.0326	0.0416
	Household Goods	0.0959	0.1194

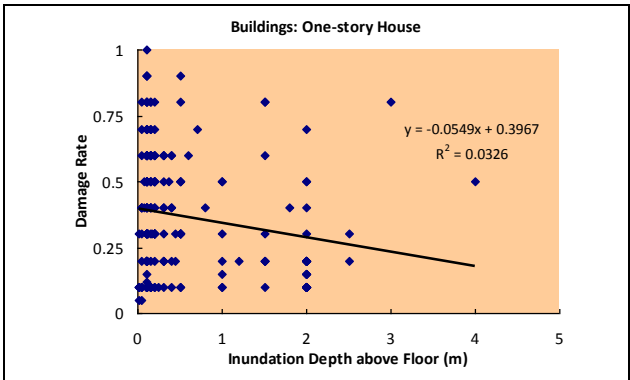


Figure P2.1.21 Relationship between Inundation Depth and Damage Rate of Buildings (One-story of House)

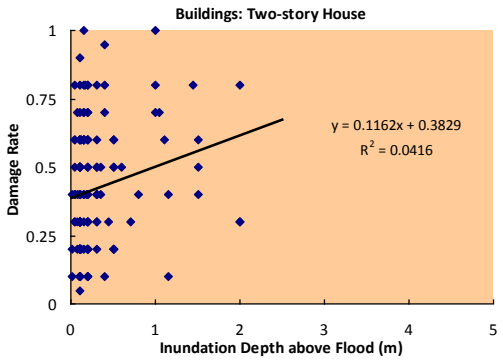


Figure P2.1.22 Relationship between Inundation Depth and Damage Rate of Buildings (Two-story of House)

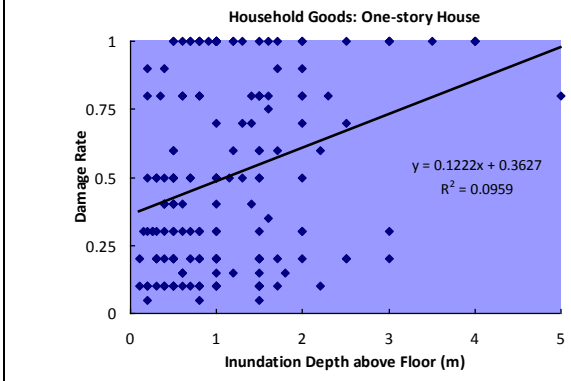


Figure P2.1.23 Relationship between Inundation Depth and Damage Rate of Household Goods (One-story of House)

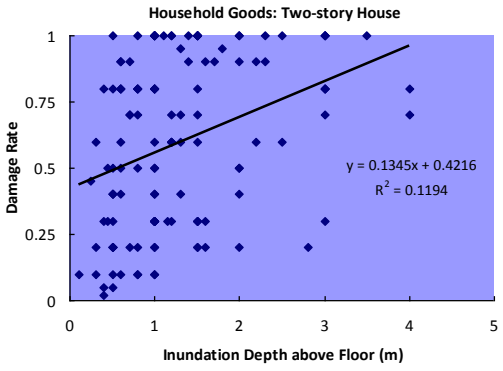


Figure P2.1.24 Relationship between Inundation Depth and Damage Rate of Household Goods (Two-story of House)

P2.2 Costs

Costs are economic ones where the transfer payments; namely, taxes and duties, are excluded. Following items are included in the cost calculation: (i) Construction; (ii) Engineering; (iii) Other (EIA, admnistration); (iv) Physical contingencies; (v) Land aqiusition; (vi) Compensation; and (vii) O&M. Costs of (i) to (vi) will accrue once as capital costs before and/or in the construction period. O&M cost will accrue every year after the construction is completed and the facilites start to be used. Capital costs are shown in the followint table.

Table P2.2.1 Economic Capital Costs (SCWRM M/P)

(Unit: Million Baht)

Item		New Dams	Retarding Area	River Improve-ment	Diversion Channel		Flood Forecasting System	Total
		Kaeng Sua Ten, Nam Kheg and Mae Wong Dam	Total of N1 - N5, C1 - C8	Dyke Improvement	West Diversion Channel (W1500-1)	Outer Ring Road Diversion Channel (O500-1)		
1.	Construction	41,071	30,564	6,364	119,733	47,908	2,727	248,368
2.	Engineering	4,107	3,056	636	11,973	4,791	273	24,837
3.	Other (EIA, Adm.)	6,777	5,043	1,050	19,756	7,905	450	40,981
4.	Physical Contingency	5,196	3,866	805	15,146	6,060	345	31,419
5.	Land Acquisition	7,706	1,083	1,800	30,776	18,821	0	60,186
6.	Compensation	2,054	0	0	1,910	482	0	4,446
Total		66,911	43,613	10,655	199,294	85,968	3,795	410,236

Table P2.2.2 Economic Capital Costs (Proposed Combination 1)

(Unit: Million Baht)

Item		River Improvement		Diversion Channel	Flood Forecasting System	Total
		Dyke Improvement	Ayutthaya By-Pass	Outer Ring Road Diversion Channel (O500-1)		
1.	Construction	6,903	9,407	47,908	2,727	66,945
2.	Engineering	690	941	4,791	273	6,694
3.	Other (EIA, Adm.)	1,139	1,552	7,905	450	11,046
4.	Physical Contingency	873	1,190	6,060	345	8,469
5.	Land Acquisition	2,646	4,208	18,821	0	25,675
6.	Compensation	1,010	66	482	0	1,558
Total		13,261	17,363	85,968	3,795	120,387

Table P2.2.3 Economic Capital Costs (Proposed Combination 2)

(Unit: Million Baht)

Item		River Improvement		Diversion Channel	Flood Forecasting System	Total
		Dyke Improvement	Ayutthaya By-Pass	Outer Ring Road Diversion Channel (O1000-1)		
1.	Construction	6,364	9,407	69,341	2,727	87,839
2.	Engineering	636	941	6,934	273	8,784
3.	Other (EIA, Adm.)	1,050	1,552	11,441	450	14,493
4.	Physical Contingency	805	1,190	8,772	345	11,112
5.	Land Acquisition	2,800	4,208	29,701	0	36,709
6.	Compensation	0	66	772	0	838
Total		11,655	17,363	126,961	3,795	159,774

P2.3 Benefits

P2.3.1 Flood Analysis in Different Flood Scale for Economic Evaluation

Flood damages in different flood scales are calculated since an annual average damage reduction is required for evaluation of B/C, In this project, the flood analysis in five flood scales such as 2-year, 10-year, 30-year, 50-year and 100-year return period is condcuted. This analysis conunted the dike breaaches and local rainfall in flood plain area because economic evaluatin should be examined considering conceivable maximum flood risk. The inundation maps is shown in Figure P2.3.1to Figure P2.3.20.

Assumed dike breach points are selected according to the following condition,

(1) Relative elevation between embankment and dike exceeds more than 2.0m and,

(2) Duration that water level is higher than DHWL in Chao Phraya River, and the average dike height minus 50cm in Pasak River, is more than thirty days

Assumed dike breach points in Chao Phraya River and Pasak River are shown in Figure P2.3.21 to Figure P2.3.24.

P2.3.2 Result of Flood Analysis in Different Flood Scale

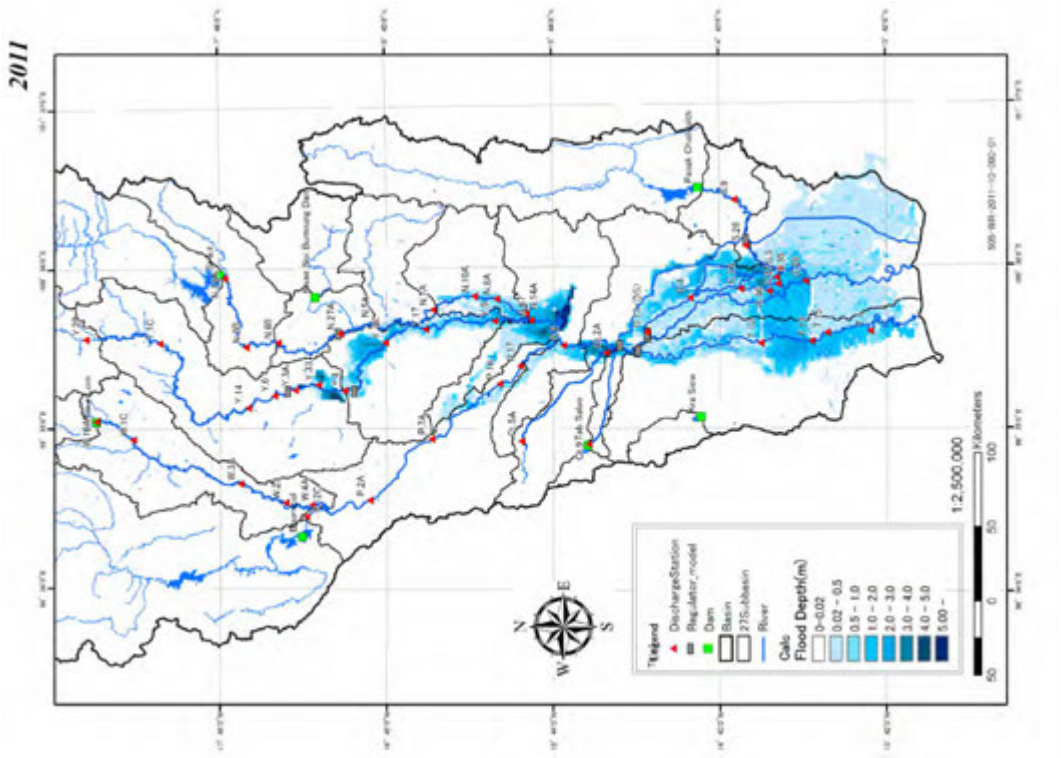


Figure P2.3.1 Inundation Map
(Case 0-1, Return Period: 10-year, counting assumed dike breaches and local rainfall))

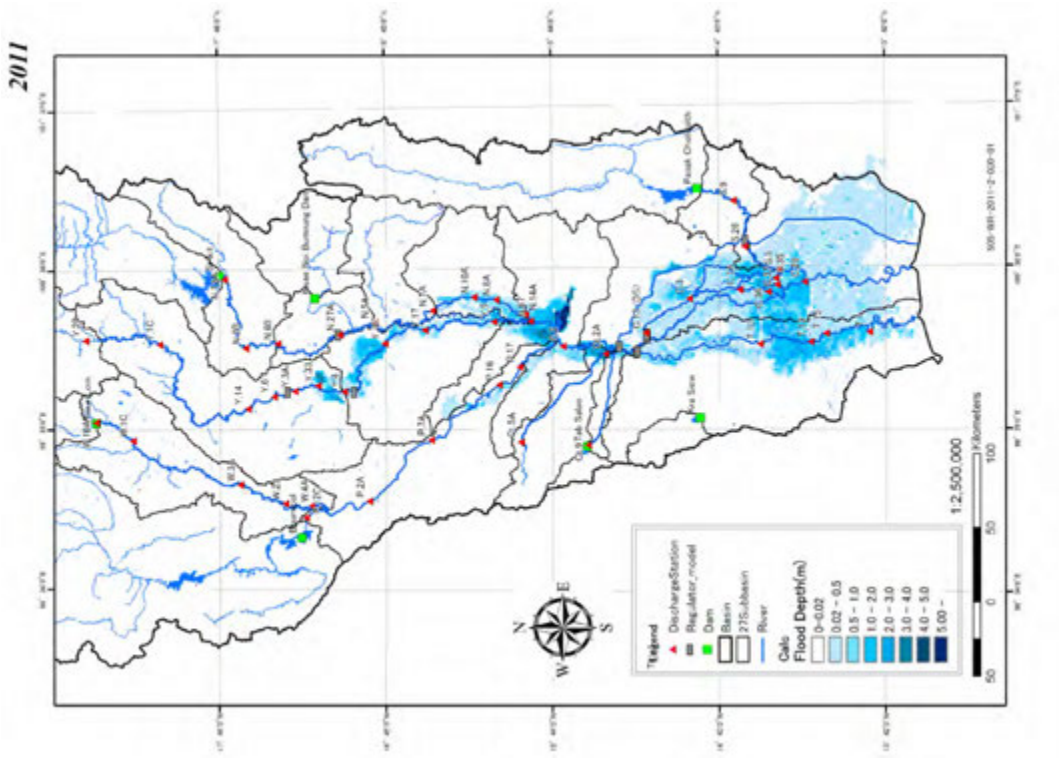


Figure P2.3.2 Inundation Map
(Case 0-1, Return Period: 2-year, counting assumed dike breaches and local rainfall))

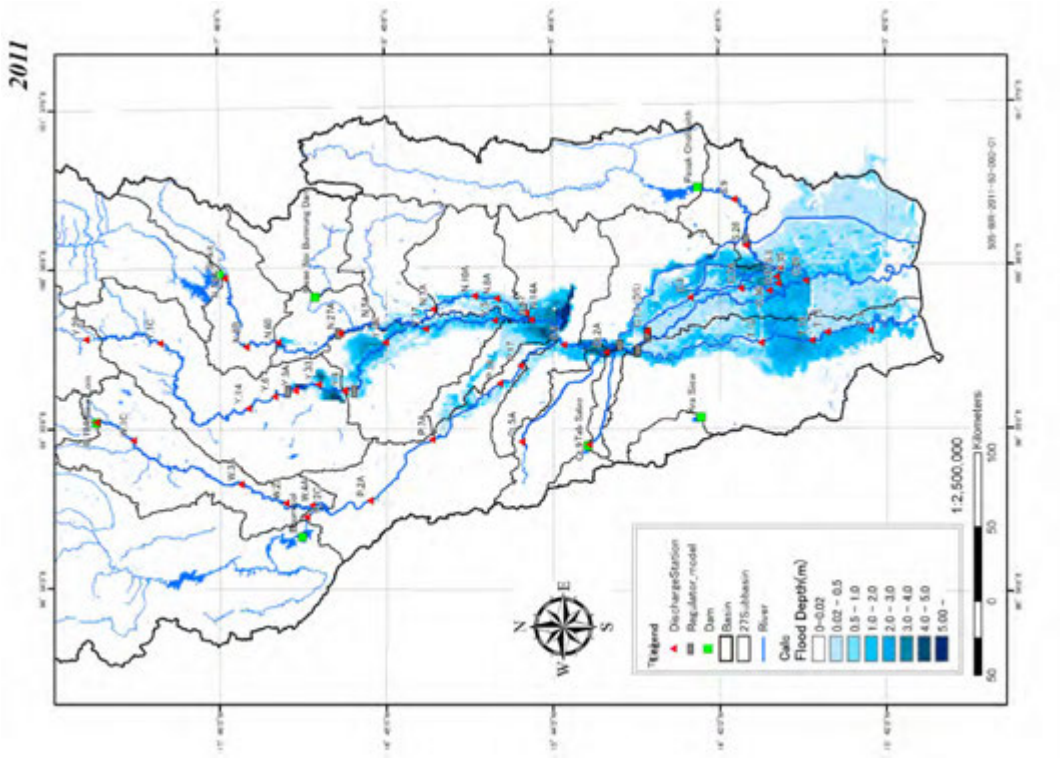


Figure P2.3.3 Inundation Map (Case 0-1, Return Period: 50-year, counting assumed dike breaches and local rainfall))

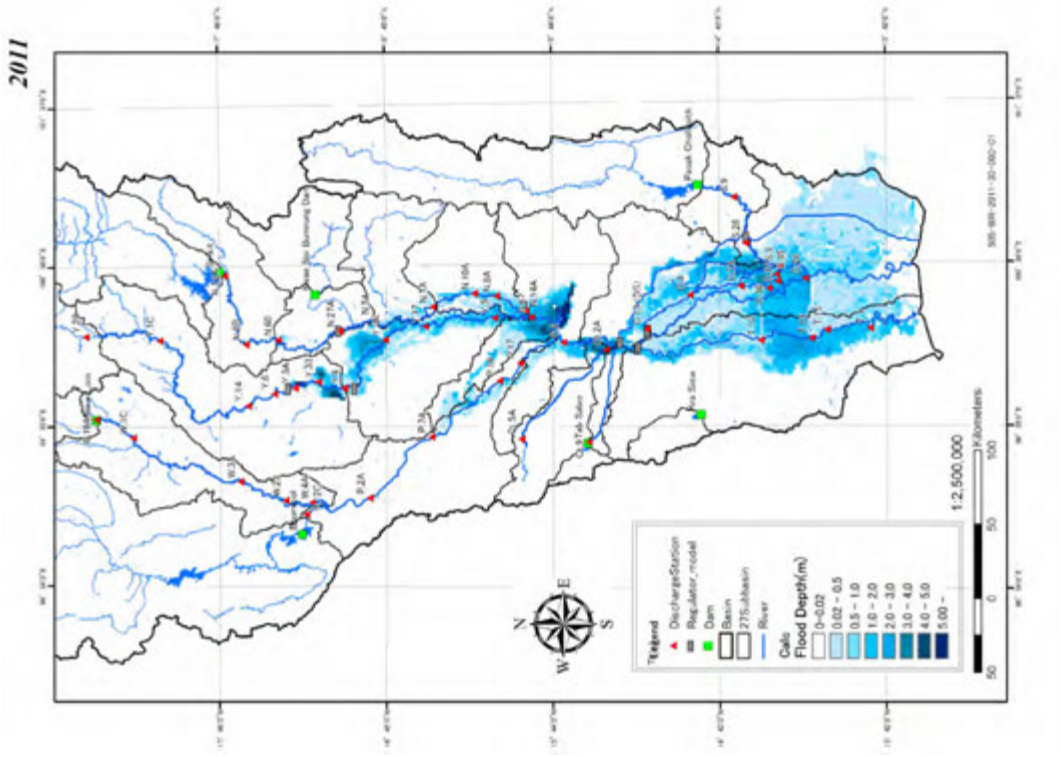


Figure P2.3.4 Inundation Map (Case 0-1, Return Period: 30-year, counting assumed dike breaches and local rainfall))

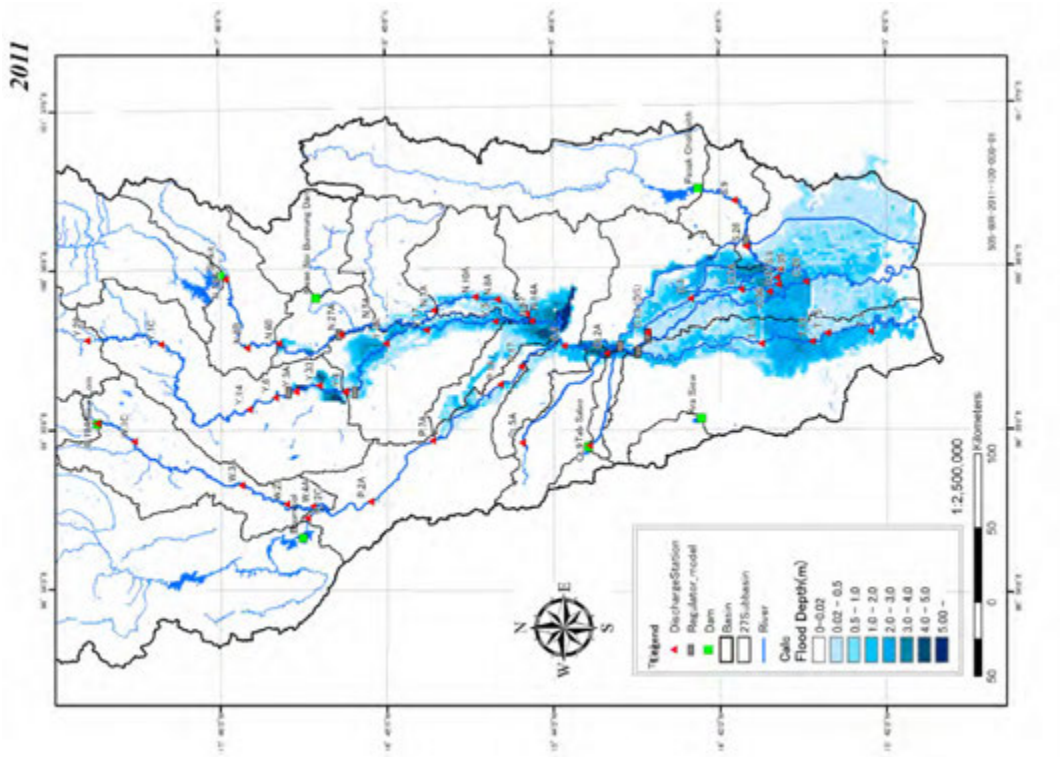


Figure P2.3.5 Inundation Map
(Case 0-1, Return Period: 100-year, counting assumed dike breaches and local rainfall))

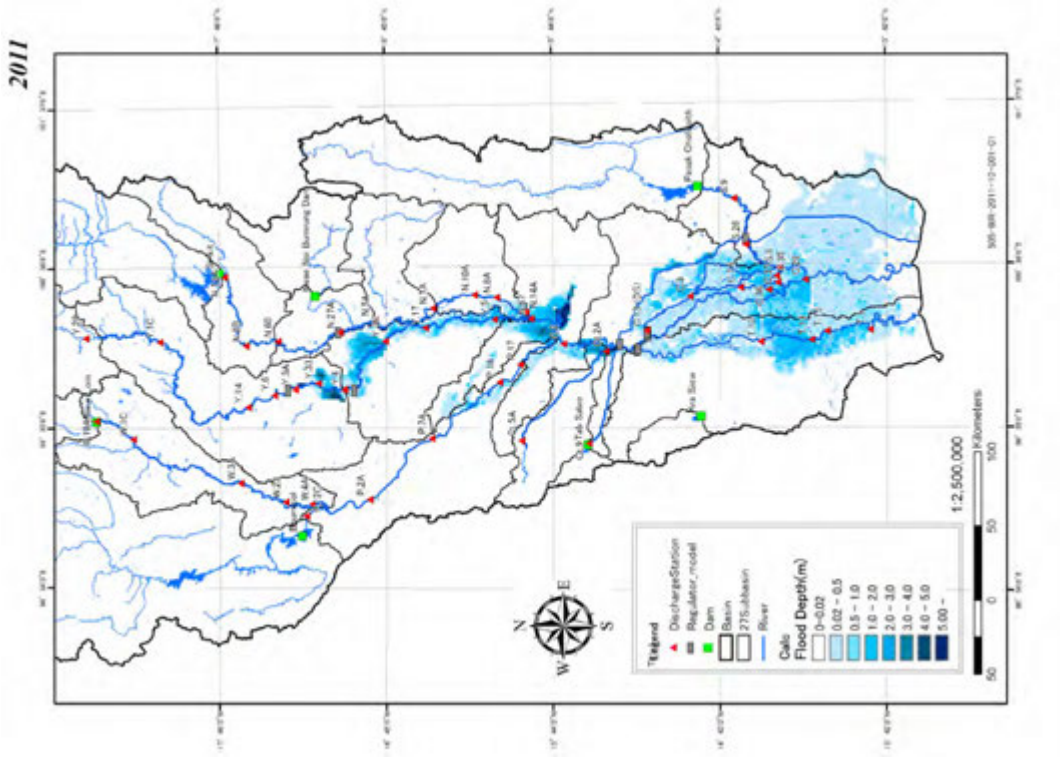


Figure P2.3.6 Inundation Map (Case 1-1, Return Period: 10-year, counting assumed dike breaches and local rainfall))

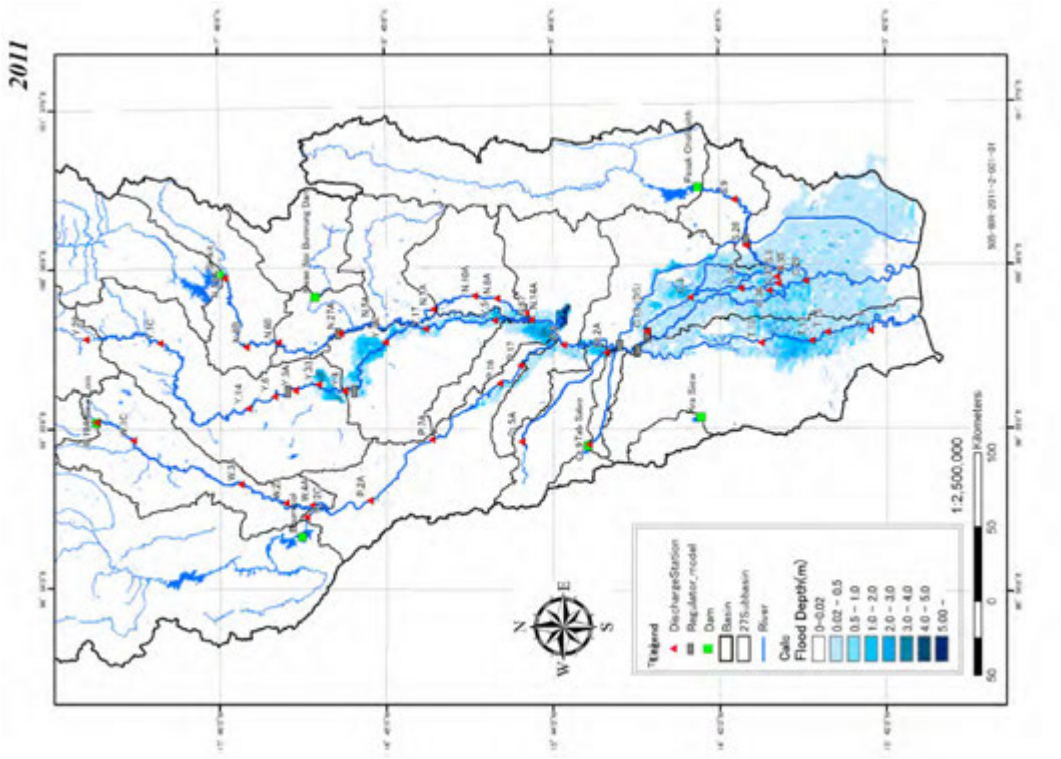


Figure P2.3.7 Inundation Map (Case 1-1, Return Period: 2-year, counting assumed dike breaches and local rainfall))

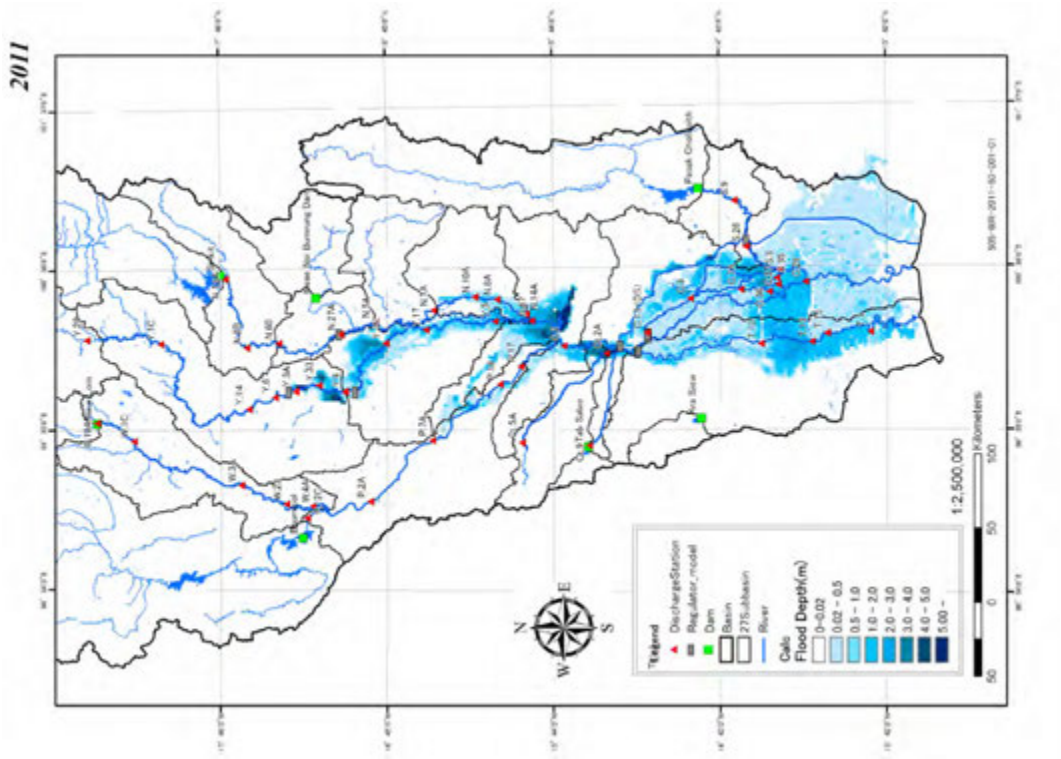


Figure P2.3.8 Inundation Map
(Case 1-1, Return Period: 50-year, counting assumed dike breaches and local rainfall))

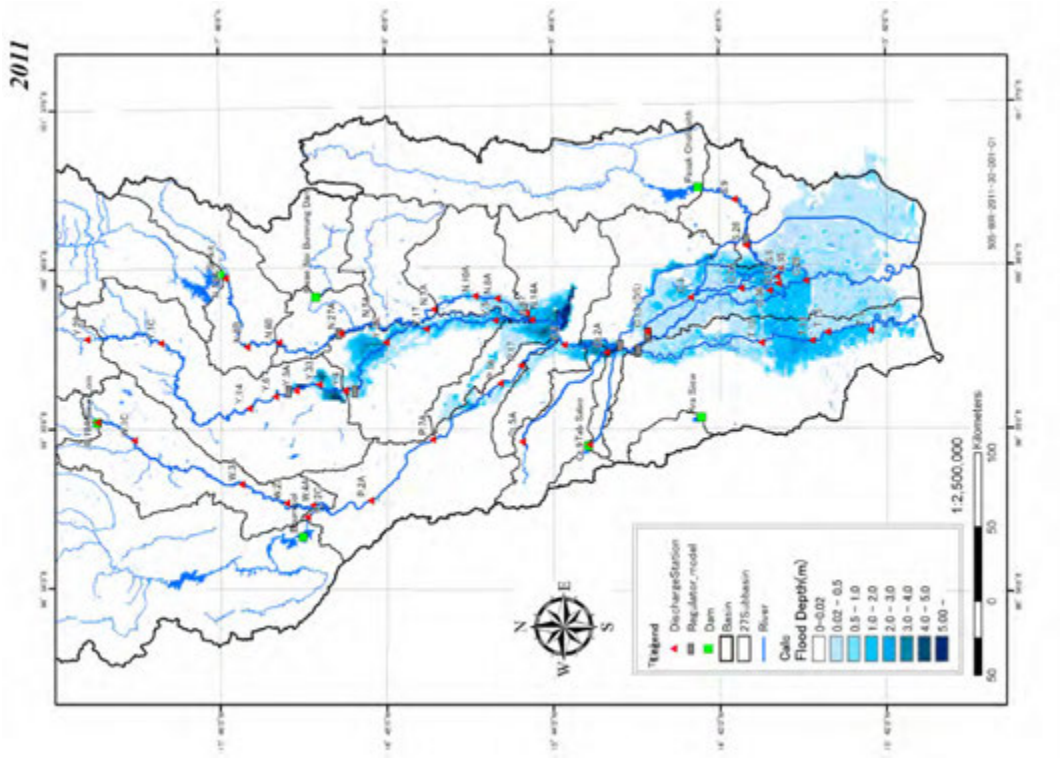


Figure P2.3.9 Inundation Map
(Case 1-1, Return Period: 30-year, counting assumed dike breaches and local rainfall))

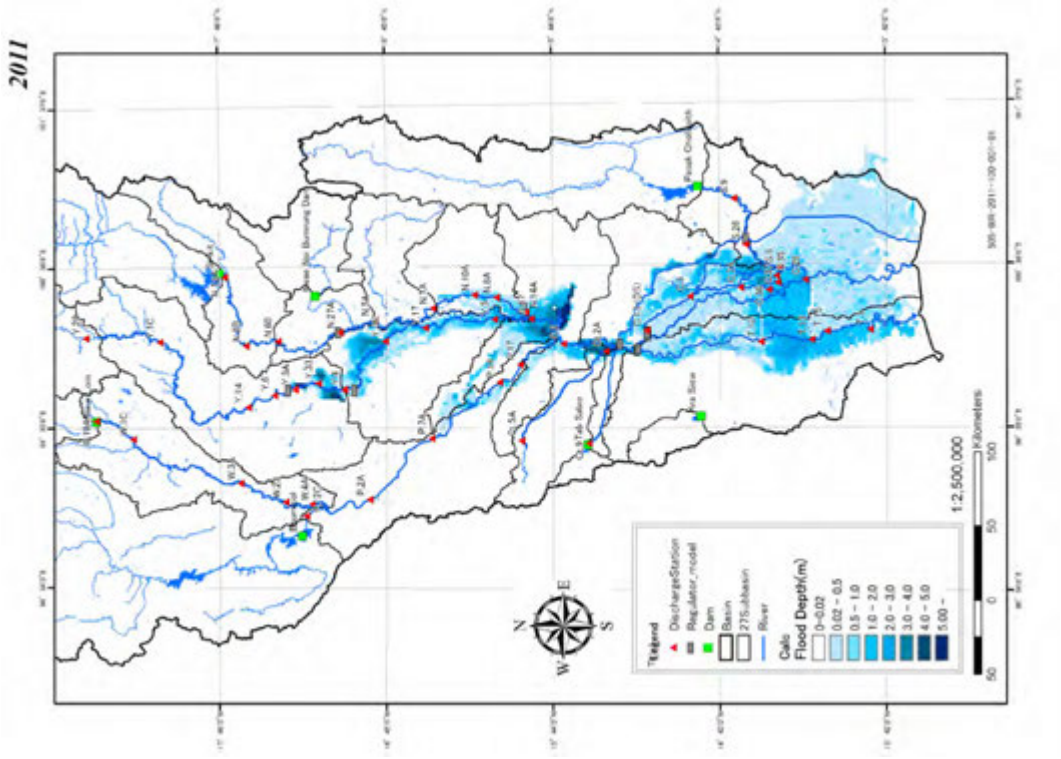


Figure P2.3.10 Inundation Map
(Case 1-1, Return Period: 100-year, counting assumed dike breaches and local rainfall))

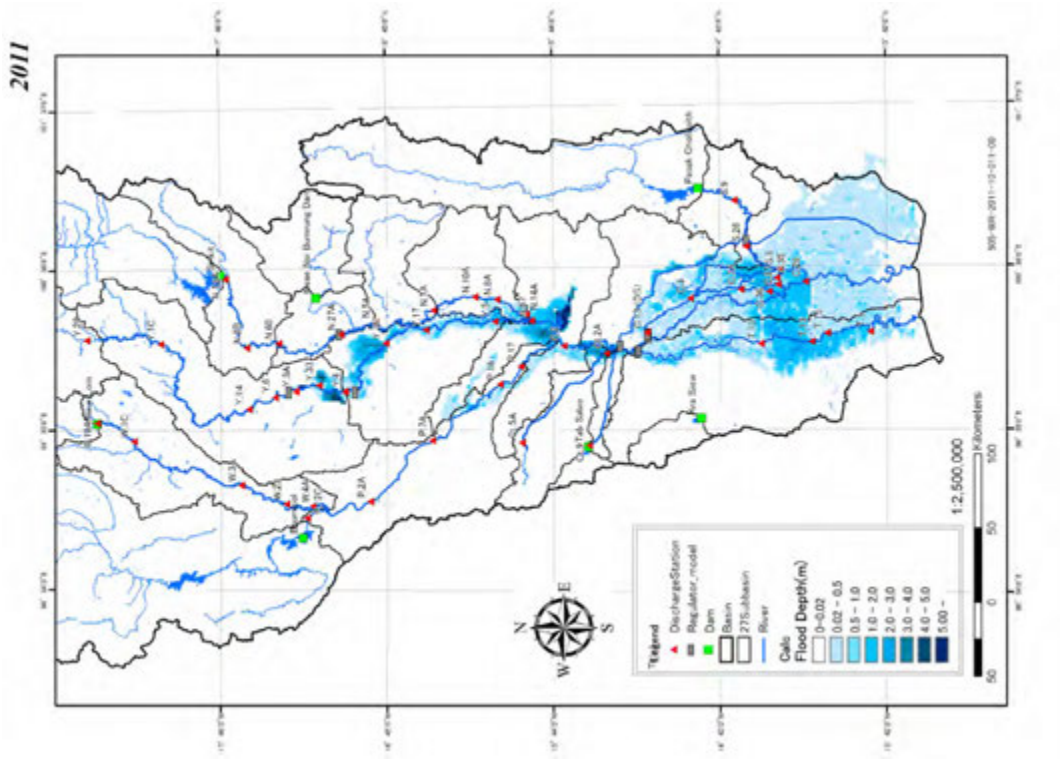


Figure P2.3.11 Inundation Map
(Case 11-0, Return Period: 10-year, counting assumed dike breaches and local rainfall))

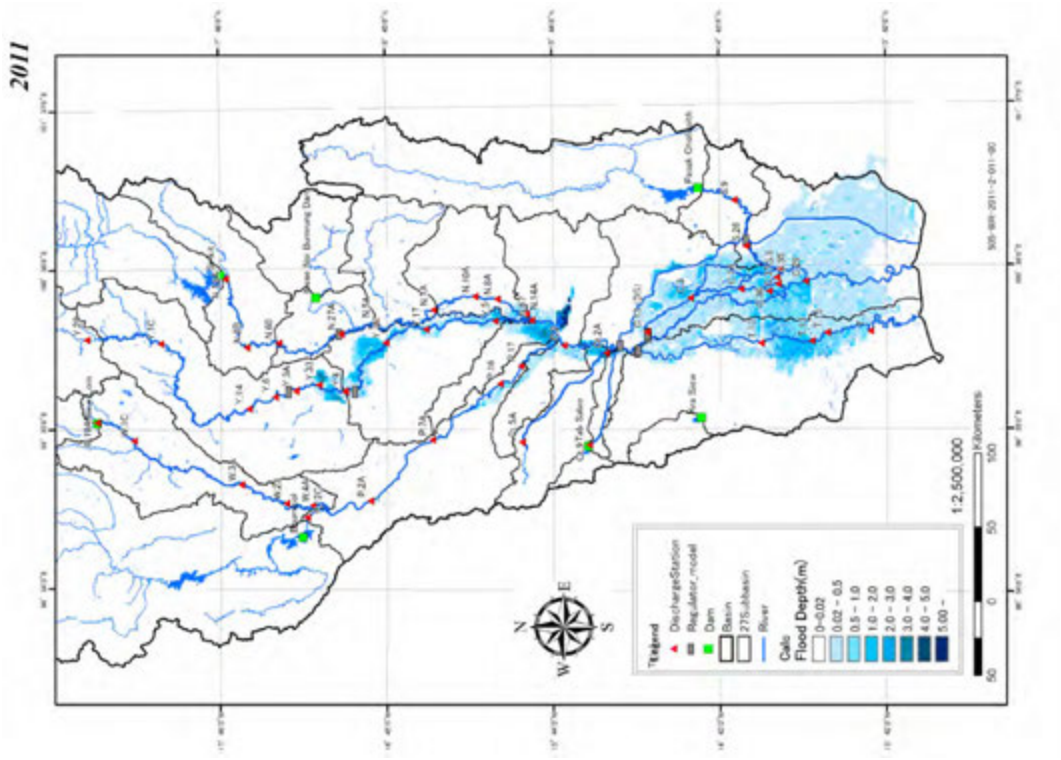


Figure P2.3.12 Inundation Map
(Case 11-0, Return Period: 2-year, counting assumed dike breaches and local rainfall))

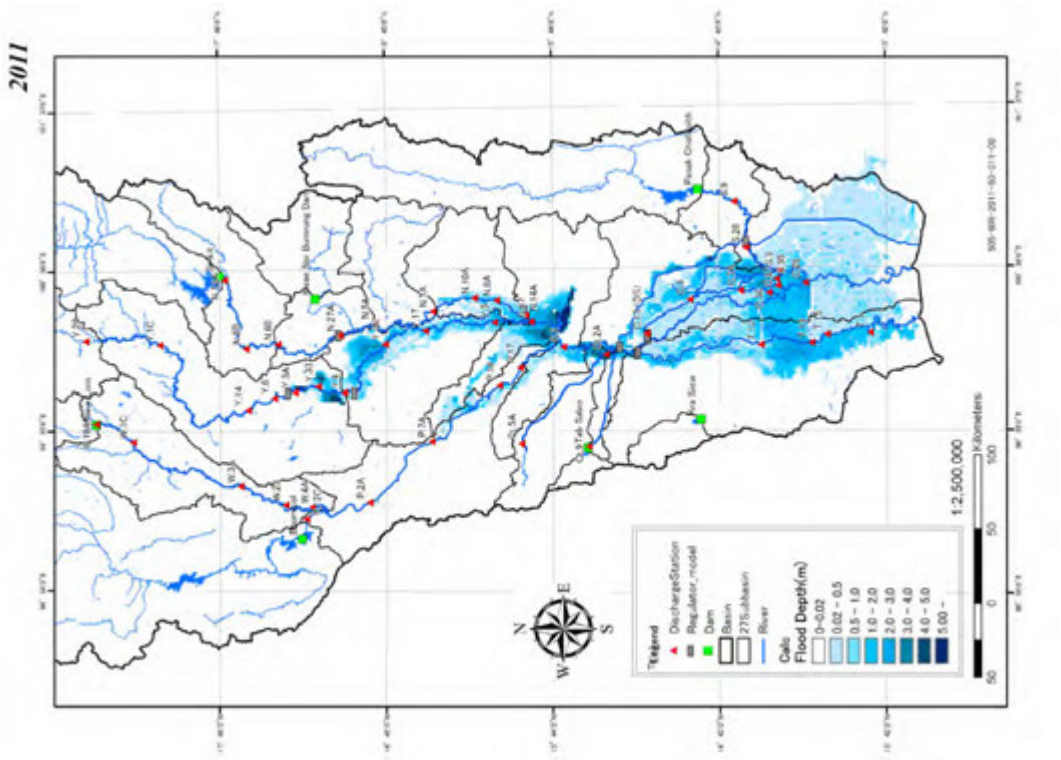


Figure P2.3.13 Inundation Map
(Case 11-0, Return Period: 50-year, counting assumed dike breaches and local rainfall))

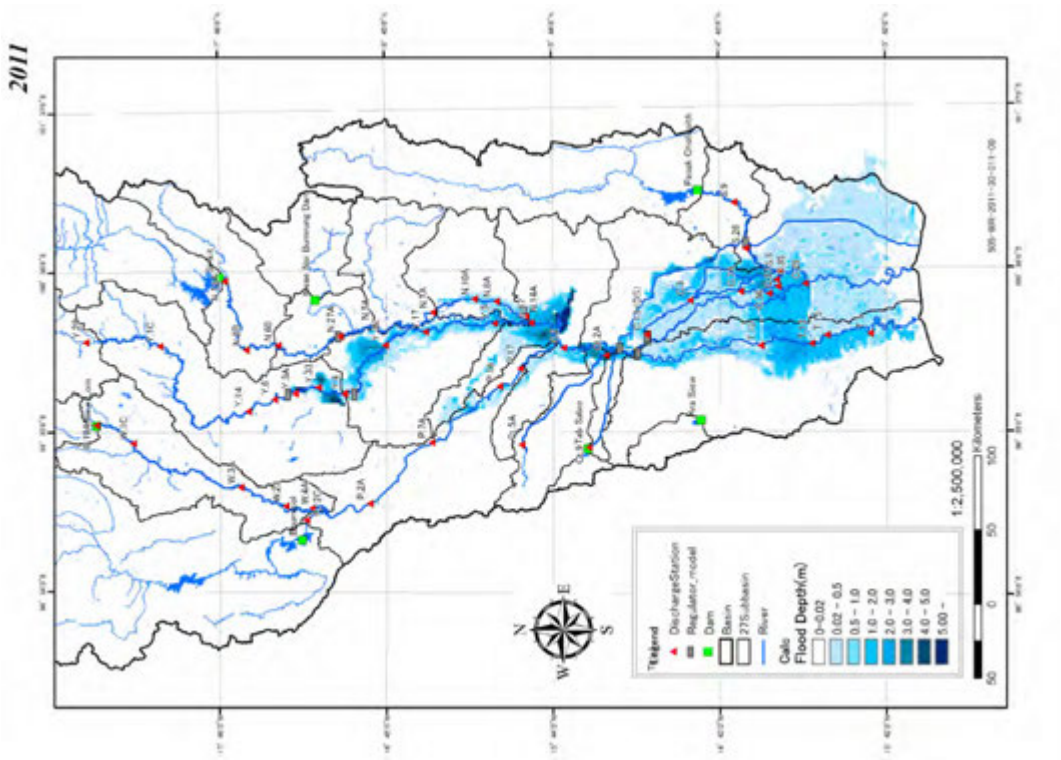


Figure P2.3.14 Inundation Map
(Case 11-0, Return Period: 30-year, counting assumed dike breaches and local rainfall))

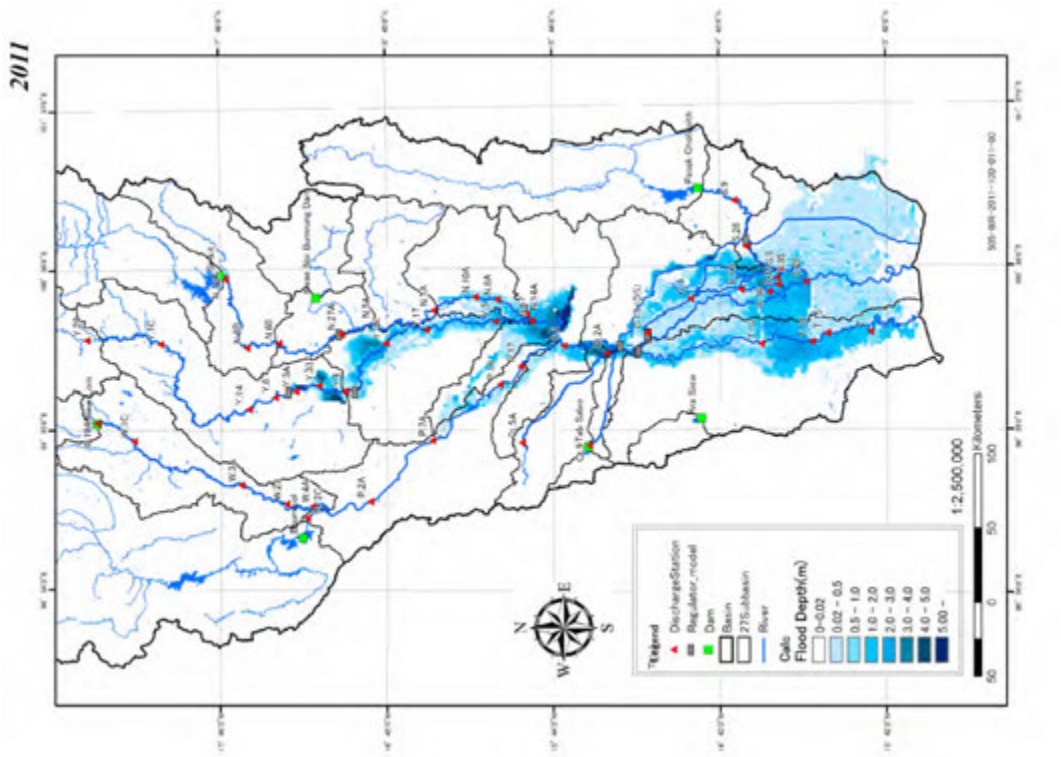


Figure P2.3.15 Inundation Map
(Case 11-0, Return Period: 100-year, counting assumed dike breaches and local rainfall))

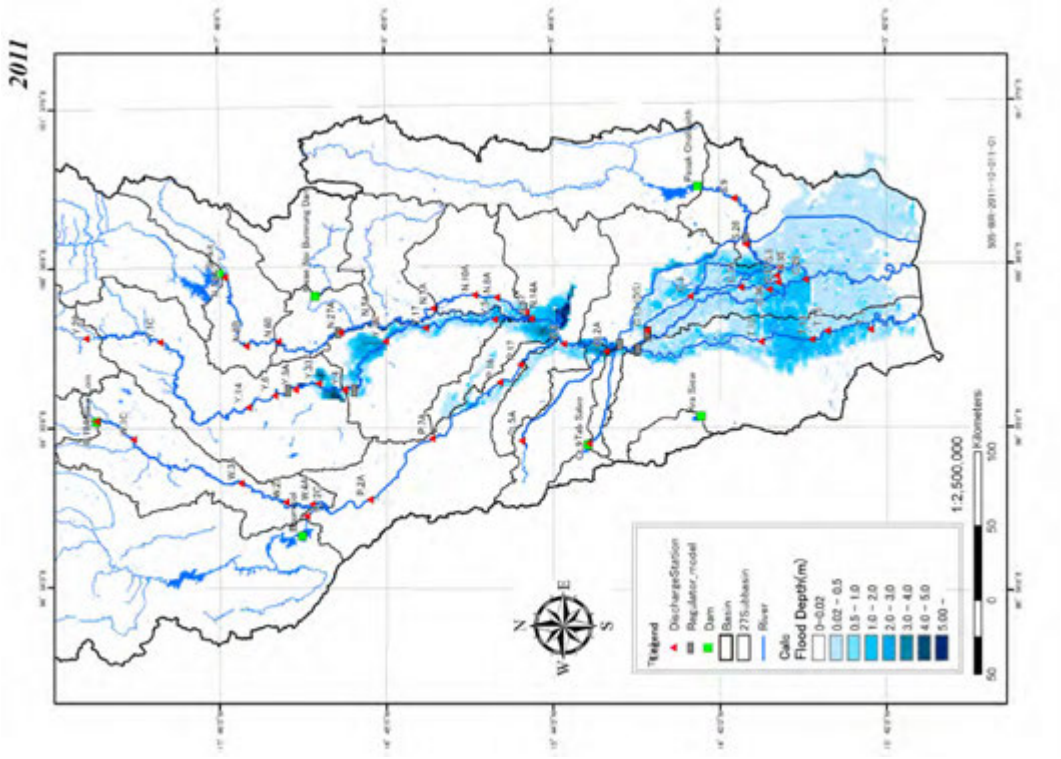


Figure P2.3.16 Inundation Map
(Case 11-1, Return Period: 10-year, counting assumed dike breaches and local rainfall))

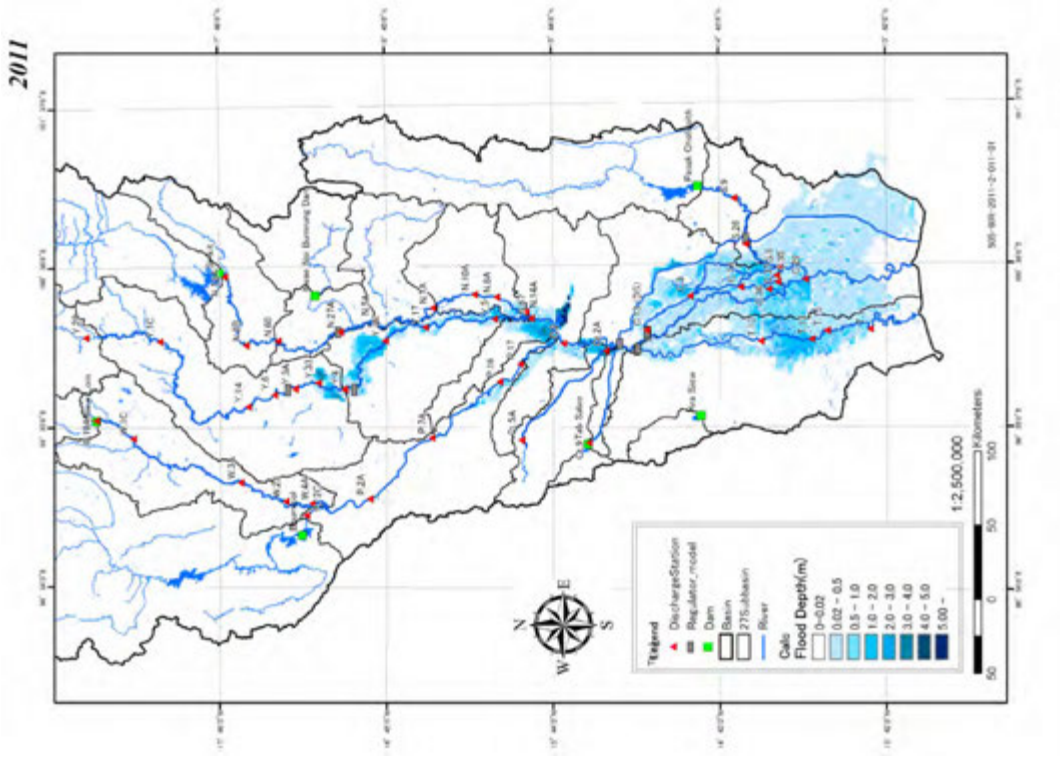


Figure P2.3.17 Inundation Map
(Case 11-1, Return Period: 2-year, counting assumed dike breaches and local rainfall))

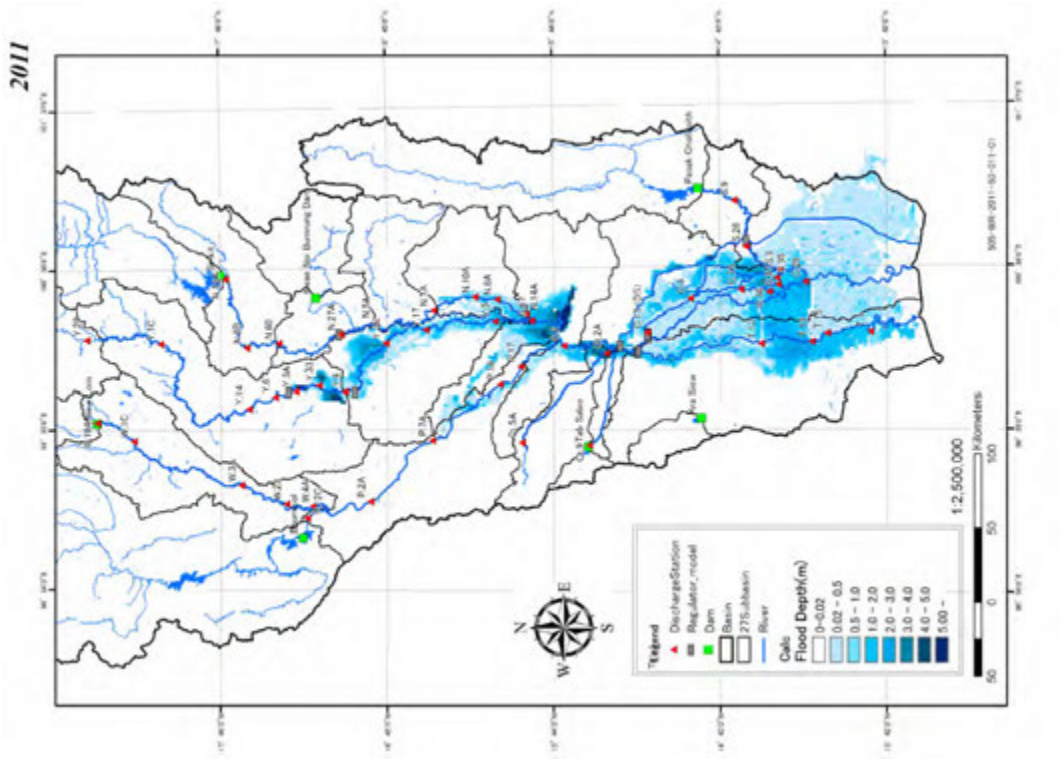


Figure P2.3.18 Inundation Map
(Case 11-1, Return Period: 50-year, counting assumed dike breaches and local rainfall))

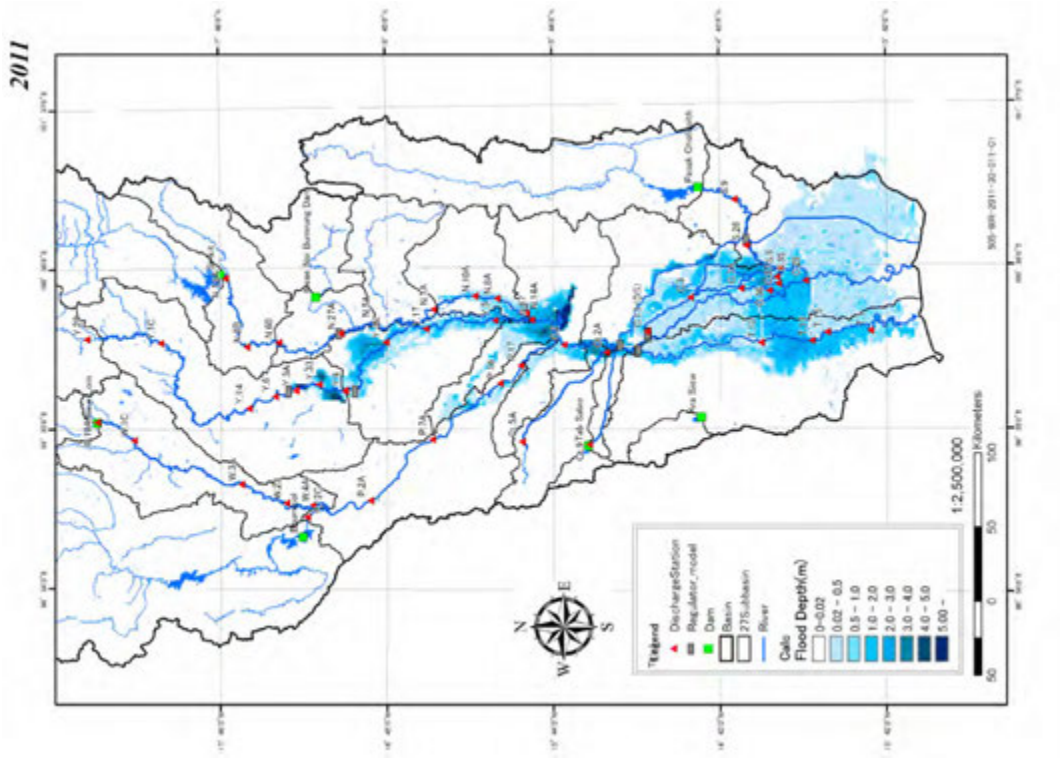


Figure P2.3.19 Inundation Map
(Case 11-1, Return Period: 30-year, counting assumed dike breaches and local rainfall))

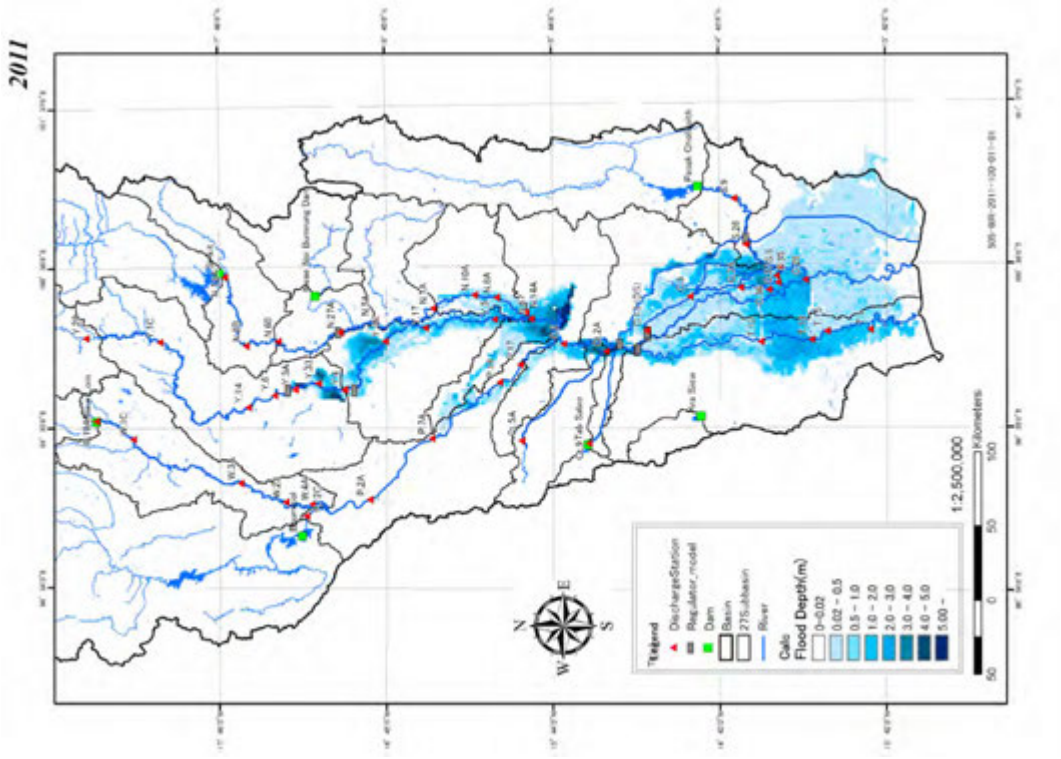


Figure P2.3.20 Inundation Map
(Case 11-1, Return Period: 100-year, counting assumed dike breaches and local rainfall)

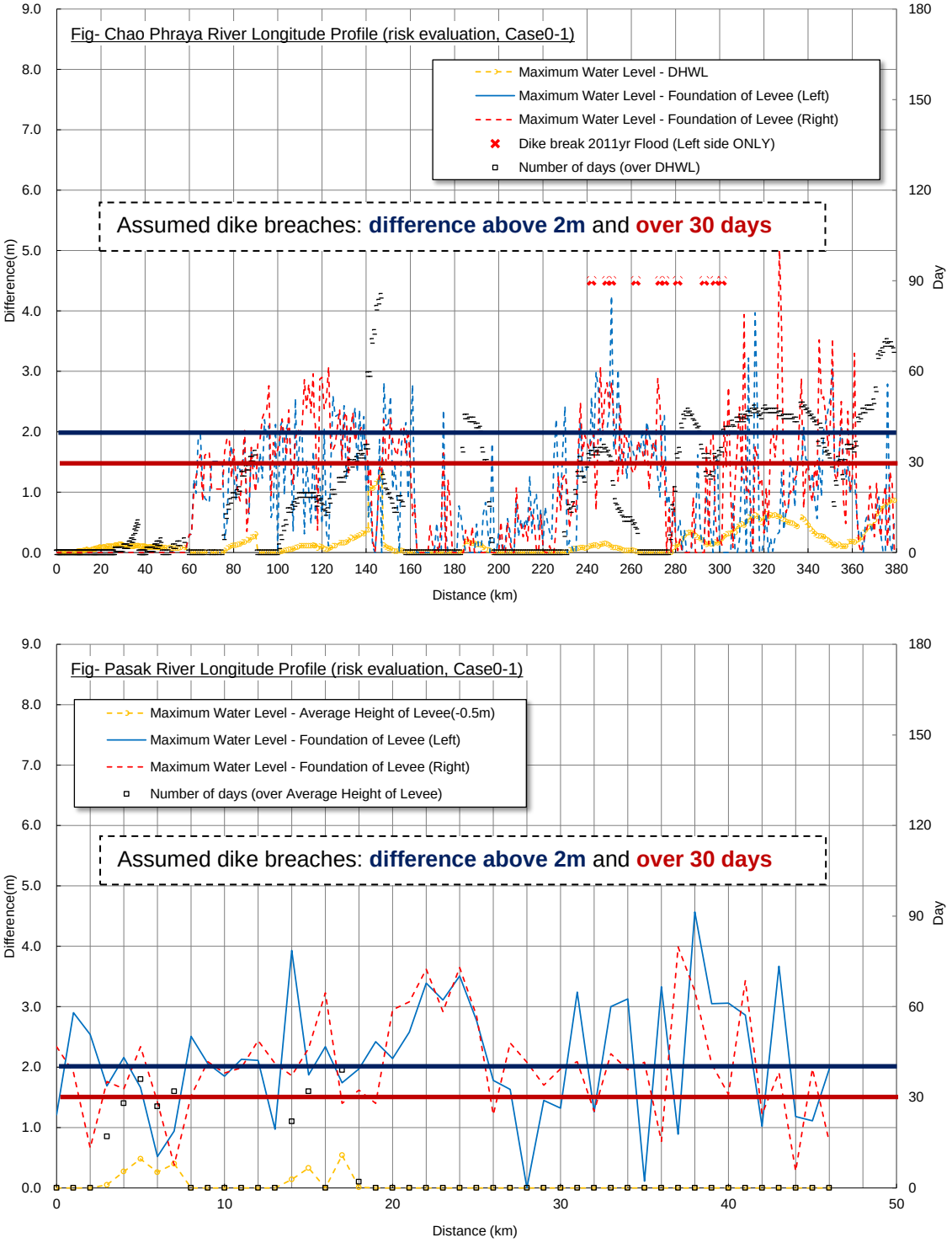
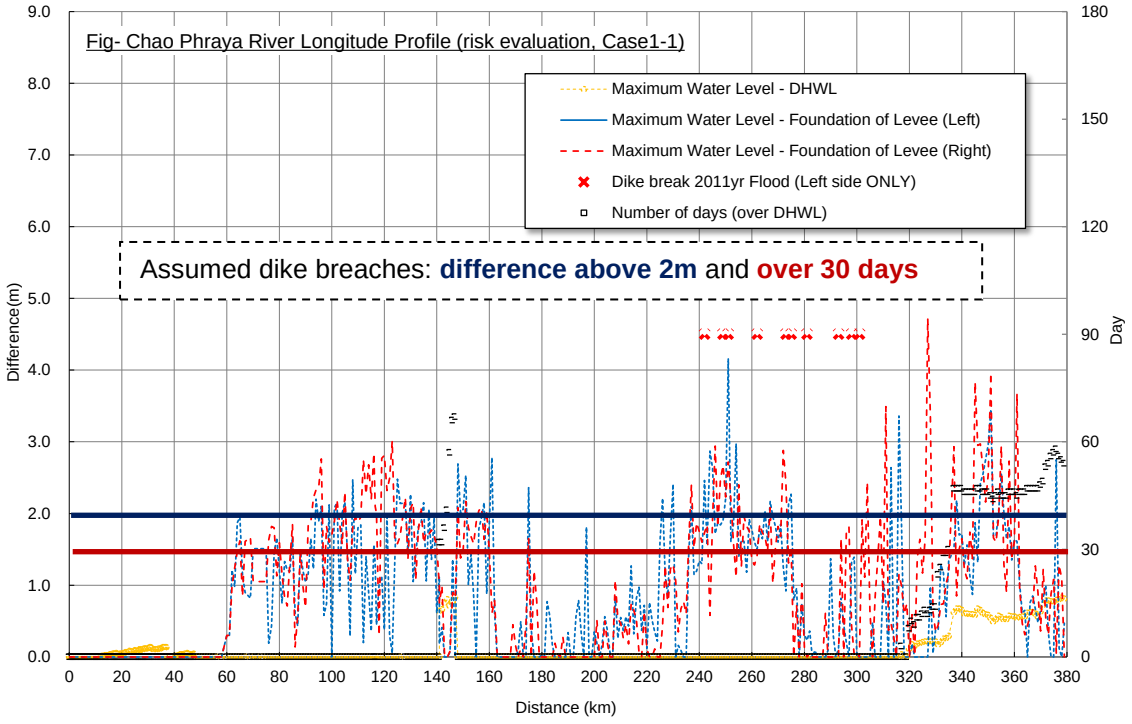


Figure P2.3.21 Selection of Asssumed Dike Breach Points (Case 0-1)



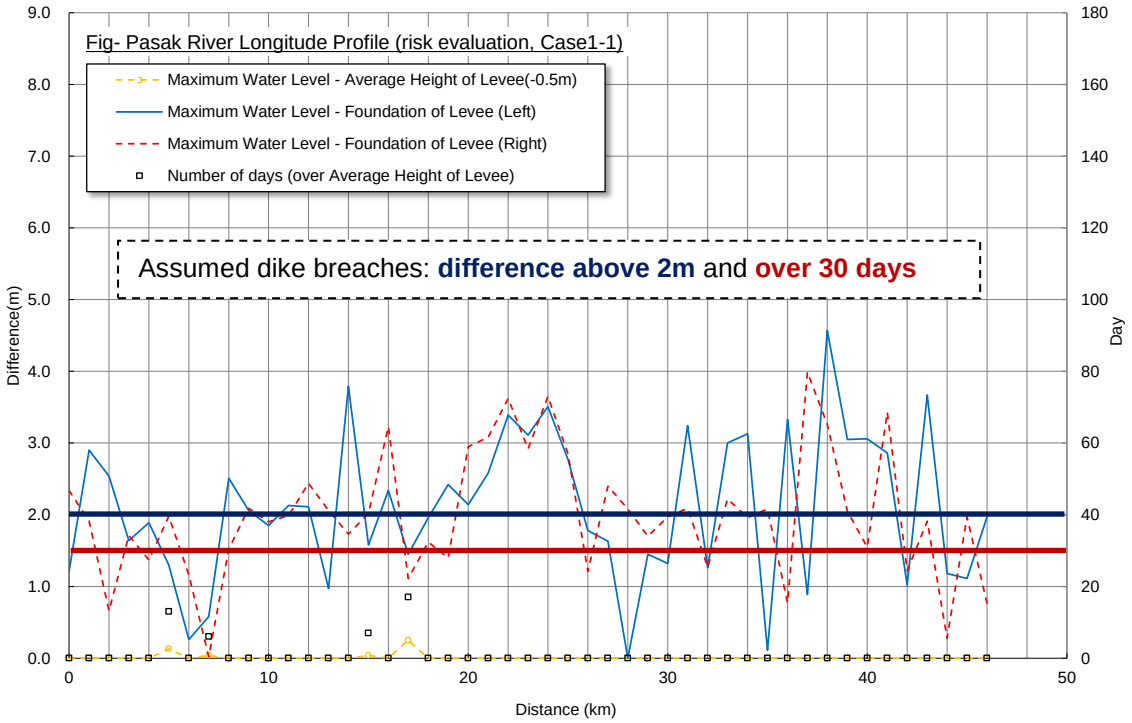


Figure P2.3.22 Selection of Asssumed Dike Breach Points (Case 1-1)

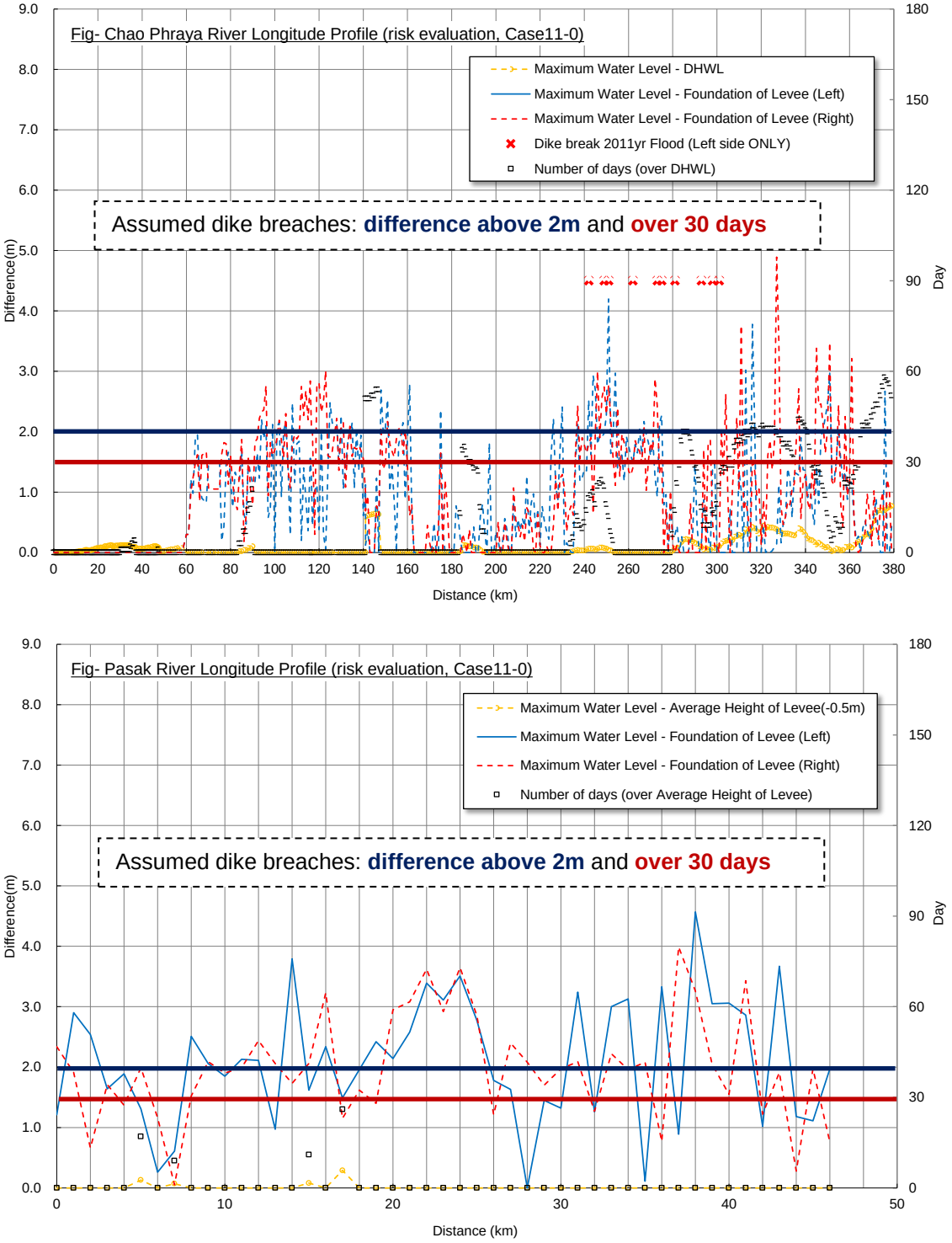
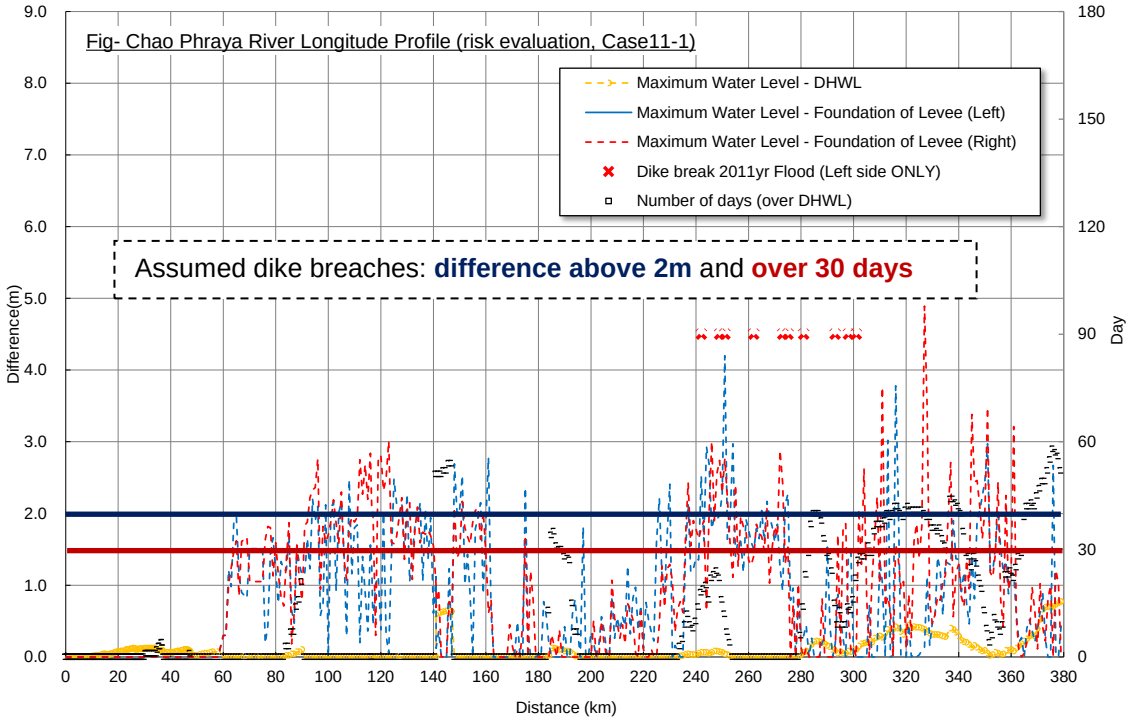


Figure P2.3.23 Selection of Asssumed Dike Breach Points (Case 11-0)



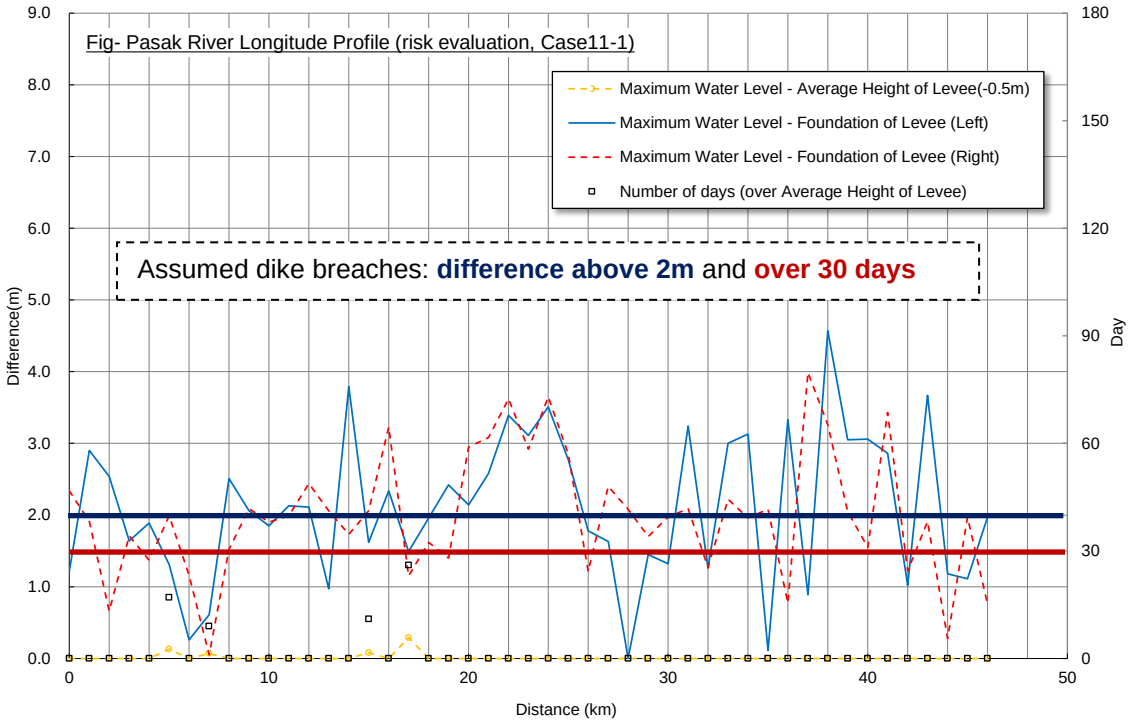


Figure P2.3.24 Selection of Asssumed Dike Breach Points (Case 11-1)

P2.3.3 Manufacturing Sector

(1) Direct Damages

(a) Damageable Values of Manufacturing Sector

Fixed assets (building, machinery, vehicle, office appliances, equipment, etc.) and inventory assets (materials and components, work in progress, finished goods, goods purchased for resale) of factories are considered as the damageable property of the manufacturing sector.

(i) Available Data

"Factory Data 2011" is available from the website of the Department of Industrial Work (DIW), Ministry of Industry. This data include name, type, address, land area, number of employees, etc., of each factory. There are 40,594 factories included in the data for the 24 provinces that are relevant to the potential inundation areas.

The National Statistical Office (NSO) published "The 2007 Industrial Census," which includes the fixed asset data and inventory asset data in book value in addition to the number of persons engaged by industrial division for each province as of December 31, 2006.

Damageable values are calculated as follows:

1. Values of fixed assets and inventory assets per person engaged are calculated by the division for each province using 'The 2007 Industrial Census."
2. Asset values of each factory are calculated by multiplying asset values per person engaged by the number of person engaged in the factory which is included in the "Factory Data 2011."
3. Since factory data in the "Factory Data 2011" have location data, the location of asset values is identified, which can be utilized to the flood simulation results.

Industrial divisions are as follows:

Table P2.3.1 Divisions of Industrial Census Data

No.	NSO Code	Division
1	15	Manufacture of food products and beverages
2	16	Manufacture of tobacco products
3	17	Manufacture of textiles
4	18	Manufacture of wearing apparel; dressing and dyeing of fur
5	19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
6	20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
7	21	Manufacture of paper and paper products
8	22	Publishing, printing and reproduction of recorded media
9	23	Manufacture of coke, refined petroleum products and nuclear fuel
10	24	Manufacture of chemicals and chemical products
11	25	Manufacture of rubber and plastics products
12	26	Manufacture of other non-metallic mineral products
13	27	Manufacture of basic metals
14	28	Manufacture of fabricated metal products, except machinery and equipment
15	29	Manufacture of machinery and equipment n.e.c.
16	30	Manufacture of office, accounting and computing machinery
17	31	Manufacture of electrical machinery and apparatus n.e.c.
18	32	Manufacture of radio, television and communication equipment and apparatus
19	33	Manufacture of medical, precision and optical instruments, and nuclear fuel
20	34	Manufacture of motor vehicles, trailers and semi-trailers
21	35	Manufacture of other transport equipment
22	36	Manufacture of furniture; manufacturing n.e.c.
23	37	Recycling

Value of fixed assets and inventory assets per person engaged is calculated by division for each Province. This value is applied to mesh data calculation.

Table P2.3.2 Fixed Asset Value per Person Engaged of Factory (1/3)

(as of December 31, 2006; Unit: Thousand Baht)

No.	NSO Code	Ang Thong	Uttaradit	Ayutthaya	Bangkok	Chachoen gsao	Chai Nat	Kamphaeng Phet	Lop Buri
1	15	260	437	866	628	1,296	453	5,562	559
2	16								
3	17	330	14	371	736	169	674	71	341
4	18	237	22	73	144	290	24	91	146
5	19	197		55	110	109	38	66	75
6	20	158	82	154	755	203	17	51	163
7	21	3,756	6	586	733	294			1,147
8	22	286	34	848	382	1,140	148	254	511
9	23				6,729	43			1,087
10	24	3,887	79	1,392	395	645	37	108	1,873
11	25	111		462	371	757	448		504
12	26	69	295	240	1,626	587	60	142	360
13	27	126		544	3,398	846			372
14	28	227	73	681	276	803	49	171	405
15	29	231	111	196	521	351	33	179	288
16	30			232	468	423			218
17	31			495	545	808			428
18	32			1,006	753	882			360
19	33			1,548	437	383	8		351
20	34			4,109	1,005	3,243	27		1,023
21	35			214	334	104		404	136
22	36	132	28	163	137	272	64	73	171
23	37			232	571	73			88

Table P2.3.3 Fixed Asset Value per Person Engaged of Factory (2/3)

(as of December 31, 2006; Unit: Thousand Baht)

No.	NSO Code	Nakhon Nayok	Nakhon Pathom	Nakhon Sawan	Nonthaburi	Pathum Thani	Phichit	Phitsanulok	Ratchaburi
1	15	298	559	786	450	1,334	736	929	609
2	16								
3	17	82	341	33	216	604	26	91	932
4	18	85	146	94	235	157	71	100	199
5	19		75	60	119	255	77		97
6	20	87	163	88	191	248	43	106	126
7	21		1,147		247	692	142	681	5,591
8	22	322	511	748	292	527	194	199	761
9	23		1,087						
10	24	241	1,873	276	259	632	93	53	7,534
11	25	196	504	161	324	989			237
12	26	195	360	1,442	3,377	1,144	190	205	391
13	27	78	372	262	198	930	291	157	496
14	28	94	405	253	171	660	146	190	159
15	29	99	288	251	244	3,792	230	192	445
16	30		218		2,271	2,333			
17	31		428		289	491		131	256
18	32		360	30	193	743			398
19	33		351		254	468		140	
20	34		1,023	135	48	2,742		196	308
21	35		136	153	149	1,188			270
22	36	51	171	116	195	378	67	124	230
23	37		88			240	23		

Table P2.3.4 Fixed Asset Value per Person Engaged of Factory (3/3)

(as of December 31, 2006; Unit: Thousand Baht)

No.	NSO Code	Samut Prakan	Samut Sakhon	Samut Songkhram	Saraburi	Sing Buri	Sukhothai	Suphan Buri	Uthai Thani
1	15	483	282	289	555	636	273	605	845
2	16								
3	17	500	500	206	394	45	15	43	45
4	18	196	124	168	155	169	68	82	129
5	19	208	172					79	34
6	20	683	184	190	126	412	12	132	54
7	21	2,141	1,096		1,293		373		
8	22	530	325	563	963	169	196	97	208
9	23	1,897	936					5,541	
10	24	1,554	710		2,183	3,432	317	545	6
11	25	445	393	668	1,740	309	513	225	
12	26	1,067	288	460	805	506	99	363	354
13	27	755	399	371	921	81	0	228	
14	28	421	561	608	735	436	99	100	179
15	29	444	577		512	359	143	82	229
16	30	2,476							
17	31	500	624		1,573			94	87
18	32	551	233						
19	33	309	517					2	
20	34	2,323	535		2,830			203	
21	35	406	285	212					
22	36	142	250	190	137	247	49	141	83
23	37	131	185	89	334			56	

Table P2.3.5 Inventory Asset Value per Person Engaged of Factory (1/3)

(as of December 31, 2006; Unit: Thousand Baht)

No.	NSO Code	Ang Thong	Uttaradit	Ayutthaya	Bangkok	Chachoengsao	Chai Nat	Kamphaeng Phet	Lop Buri
1	15	36	315	157	191	342	234	427	255
2	16								
3	17	6	1	280	284	54	100	1	121
4	18	4	2	76	106	47	55	1	28
5	19	71		105	98	160	53	1	60
6	20	5	126	329	257	800	4	1	285
7	21	738	1	200	176	57			155
8	22	2		112	135	52	1	3	39
9	23				4,008	123			172
10	24	1,096	1	371	279	285	6	5	354
11	25	76		91	153	162	309		155
12	26	20	43	54	232	91	25	15	110
13	27	6		506	1,327	174			184
14	28	9	2	207	138	459	1	8	136
15	29	31	1	171	335	399	65	1	243
16	30			30	1,612	74			35
17	31			186	199	216			151
18	32			208	317	607			143
19	33			387	267	78	2		87
20	34			307	508	1,138	3		177
21	35			18	118	23			28
22	36	6	2	106	167	96	14	9	57
23	37			218	124	4			21

Table P2.3.6 Inventory Asset Value per Person Engaged of Factory (2/3)

(as of December 31, 2006; Unit: Thousand Baht)

No.	NSO Code	Nakhon Nayok	Nakhon Pathom	Nakhon Sawan	Nonthaburi	Pathum Thani	Phichit	Phitsanulok	Ratchaburi
1	15	53	255	294	207	378	477	111	406
2	16								
3	17	26	121	1	153	369	2	4	299
4	18	4	28	18	104	44	4	2	4
5	19		60	4	80	125	1		2
6	20	37	285	4	249	314	11	3	47
7	21		155		59	219	16	133	293
8	22	5	39	12	32	84	1	4	164
9	23		172						
10	24	128	354	6	146	265	387	4	165
11	25	104	155	172	91	229			97
12	26	39	110	101	162	155	20	43	221
13	27	3	184	393	201	1,164	30	10	175
14	28	5	136	19	91	225	5	4	86
15	29	1	243	10	148	767	53	122	424
16	30		35		440	211			
17	31		151		524	184		121	201
18	32		143	15	47	159			57
19	33		87		298	112		2	
20	34		177	11	187	245		63	80
21	35		28	5	165	466			73
22	36	7	57	11	61	343	5	2	41
23	37		21			30	4		

Table P2.3.7 Inventory Asset Value per Person Engaged of Factory (3/3)

(as of December 31, 2006; Unit: Thousand Baht)

No.	NSO Code	Samut Prakan	Samut Sakhon	Samut Songkhram	Saraburi	Sing Buri	Sukhothai	Suphan Buri	Uthai Thani
1	15	552	549	131	326	364	132	209	230
2	16								
3	17	222	188	19	349	1	2	5	1
4	18	98	68	3	15	6	1	31	8
5	19	199	118					92	
6	20	221	216	366	26	1,267	2	37	7
7	21	377	301		118		110		
8	22	158	80	1	8	5	3		2
9	23	626	558					350	
10	24	598	264		874	526	12	178	4
11	25	152	138	123	475	97	389	32	
12	26	183	101	140	234	203	14	80	28
13	27	871	401	251	448	3		60	
14	28	229	228	231	194	62	4	12	5
15	29	336	326		321	658	23	29	2
16	30	280							
17	31	461	187		319			247	2
18	32	144	125						
19	33	162	137					4	
20	34	547	166		211			42	
21	35	212	83	30					
22	36	108	136	186	13	4	26	15	4
23	37	27	2	5	1				

(ii) Modification of Calculation Results

Asset values of factories calculated above are modified for the following reasons:

1. Asset values calculated above are summed up to estimate the total asset value for each Province and compared with the data of "The 2007 Industrial Census" which includes the actual total asset value for each Province, and then the former figures are modified to coincide with the latter data.
2. Since the values are indicated in 2006 price, they are adjusted to the 2011 price by multiplying with 1.288, which is the wholesale price escalation since 2006.

Table P2.3.8 Wholesale Price Index of Thailand

	2005	2006	2007	2008	2009	2010	2011
Wholesale price index (2005 = 100)	100.0	107.1	110.5	124.3	119.6	130.8	137.9
Comparison with 2006 (times)	–	1.00	1.032	1.160	1.116	1.221	1.288

Source: World Bank
Note: Data is available for years up to 2011

(iii) Estimation Result of Damageable Values

Table P2.3.9 presents the damageable values in a potential inundation area of about 35,000 km^2 that is delineated so as to cover inundation areas of past major floods.

Table P2.3.9 Damageable Values of Factories by Province in Potential Inundation Area

Number	Province	Damageable Values (Million Baht)		
		Fixed Assets	Inventory Assets	Total
1	Bangkok	458,158	213,011	671,169
2	Nonthaburi	36,352	15,324	51,676
3	Pathum Thani	365,725	91,629	457,354
4	Ayutthaya	244,642	57,851	302,493
5	Ang Thong	10,192	2,416	12,608
6	Lopburi	12,830	4,413	17,243
7	Singburi	10,144	5,471	15,615
8	Chainat	2,436	1,036	3,472
9	Saraburi	45,169	14,537	59,706
10	Samut Prakarn	440,810	196,883	637,693
11	Chachoengsao	121,789	47,093	168,882
12	Nakhon Nayok	942	359	1,301
13	Ratchaburi	1,231	551	1,782
14	Suphan Buri	7,040	2,296	9,336
15	Nakhon Pathom	57,889	23,067	80,956
16	Samut Sakhon	136,800	102,835	239,635
17	S. Songkhram	334	124	458
18	Uttaradit	2,146	1,058	3,203
19	Nakhon Sawan	9,841	2,569	12,410
20	Uthai Thani	830	160	990
21	Kampaeng Phet	29	10	39
22	Sukhothai	1,607	615	2,222
23	Phitsanu Lok	5,677	1,222	6,899
24	Phichit	2,499	1,244	3,743
	Total	1,975,112	785,774	2,760,886

Source: NSO

(b) Damage Calculation

Direct damages are estimated by multiplying the damageable values by damage rates that vary according to flood inundation depth. The numerical flood simulation gives inundation depth of each 2km x 2km grid cell in the flood plains. Accordingly the damage calculation is also made on the grid cell basis.

(i) Damageable Values for 2km × 2km Grid Cells

Fortunately, the "Factory Data 2011" of DIW includes the address information at tambon level of factories. By assuming that the density of the damageable values in a tambon is uniform, the values in the tambon are distributed uniformly to grid cells in the tambon. Figure P2.3.25 shows the cell-based damageable values obtained in this way.

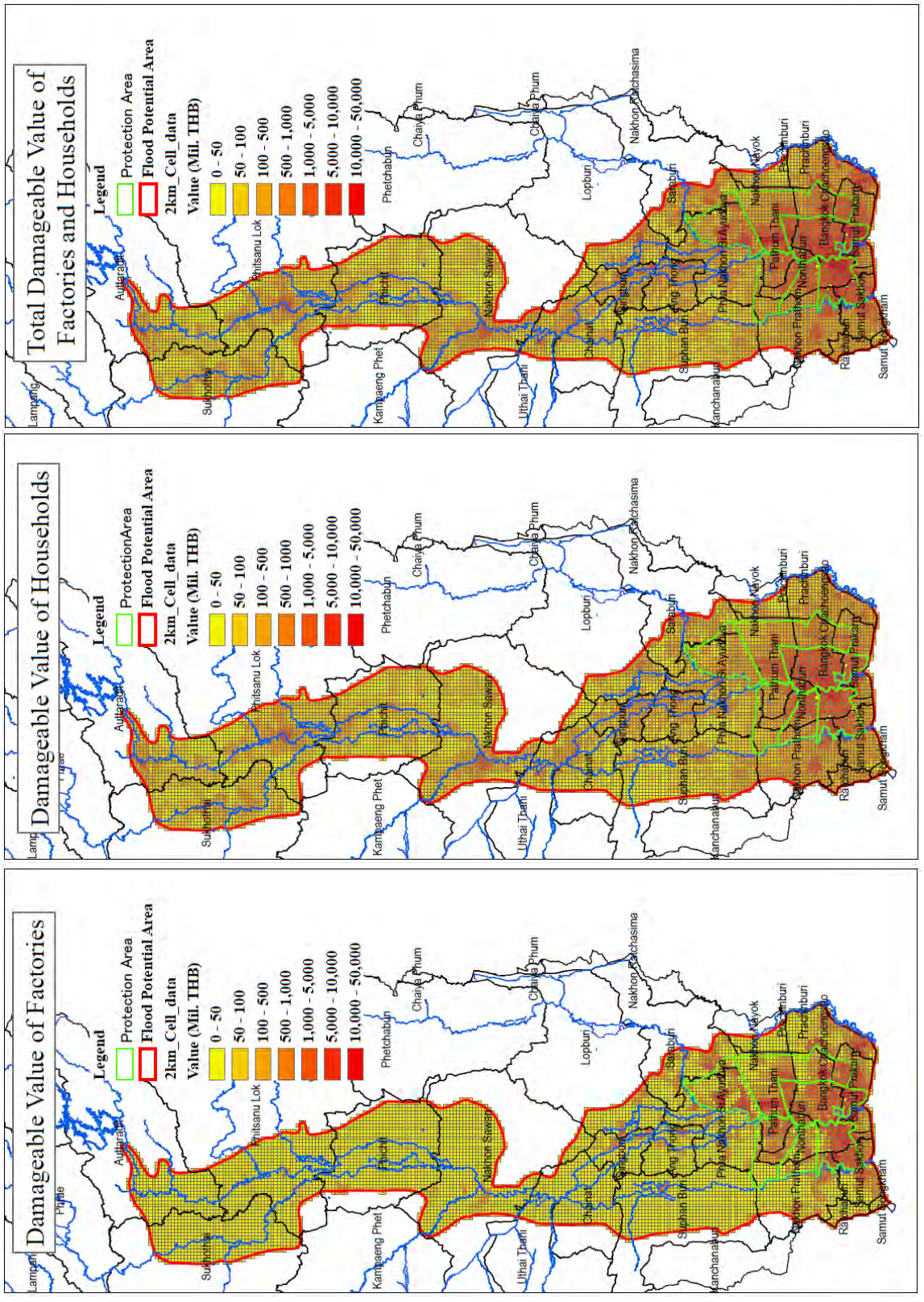


Figure P2.3.25 Distribution of Damageable Values

(ii) Floor Level and Damage Rate

To estimate direct damages to fixed and inventory assets, two parameters, floor level and damage rates have to be determined.

The floor level can be defined as the maximum level that generates no damage to the factory as shown in Figure P2.3.26. Since Thai people are generally familiar with floods, it might be assumed that factory buildings are built with a certain margin above the habitual flood water level, at the 2-year return period inundation water level, at least, for example, based on past experiences. According to the series of site visits, it is also deemed that industrial estates in the protection area (the economic zone of Bangkok and its vicinity) that were badly affected during the 2011 flood are of lower floor level and more vulnerable. Therefore, it is assumed that the floor level is at the 2-year return period inundation water level in the protection area, and that it is 50cm above the 2-year return period inundation water level in the other areas.

Regarding the damage rate, there is no significant relationship found between damage and water depth of the interview survey. Therefore, damage rates used in Japan are applied as presented in Table P2.3.10.

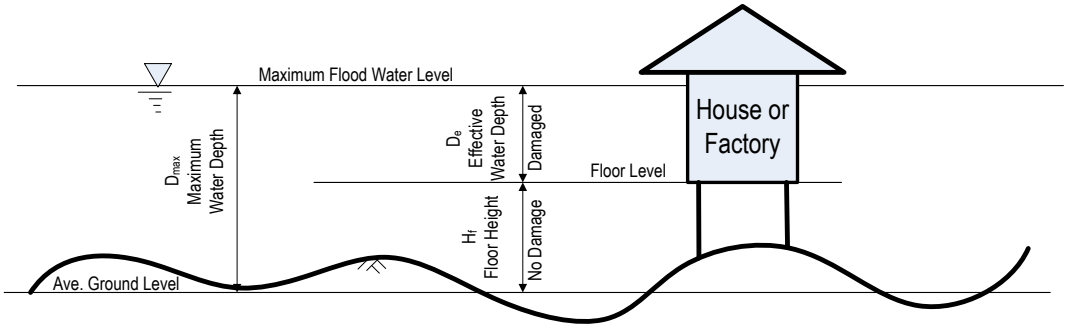


Figure P2.3.26 Floor Level

Table P2.3.10 Floor Level and Damage Rates

Floor Level		Damage Rate*					
Protection Area	Other Areas	Damageable Value	Flood Depth over Floor Level				
			0-0.5m	0.5-1m	1-2m	2-3m	Greater than 3m
Flood inundation level of 2-year return period	Flood inundation level of 2-year return period + 50cm	Fixed Assets	0.232	0.453	0.789	0.966	0.995
		Stocks	0.128	0.267	0.586	0.897	0.982

*Source: "Manual for Economic Analysis for Flood Control Projects in Japanese", Ministry of Infrastructure, Land and Transport, Japan

(iii) Estimation of Direct Damages by 2011 Flood

Using the above damageable values, floor levels and damage rates, direct damages are estimated according to flood inundation depths obtained from the flood simulation.

Table P2.3.11 compares the estimated direct damages with those estimated by the Ministry of Industry. The total estimated damage is 644 billion THB, which is very close to 514 billion THB by the Ministry of Industry. Especially, those of Bangkok, Nonthaburi, Pathum Thani, and Ayutthaya provinces in the economic zone (Protection Area) are also close to those by the Ministry of Industry, respectively. Therefore, it might be considered that the values of the floor level and damage rates are set properly.

Table P2.3.11 Estimated Direct Damages of 2011 Flood

No.	Province	Estimated by JICA Study Team (Mil. THB)			Estimated by Ministry of Industry (Mil. THB)		
		Fixed Assets	Inventory Assets	Total	7 industrial estates	Others	Total
1	Bangkok	135,123	40,400	175,523		39,100	39,100
2	Nonthaburi	33,768	8,327	42,096		31,200	31,200
3	Pathum Thani	134,925	19,830	154,756	237,400	62,900	391,600
4	Ayutthaya	80,686	11,063	91,749		91,300	
5	Ang Thong	478	65	543		1,400	1,400
6	Lopburi	3,445	889	4,335		37,500	37,500
7	Singburi	458	129	587			
8	Chainat	383	97	480		4,400	4,400
9	Saraburi	748	143	892			
10	Samut Prakarn	44,908	12,918	57,825			
11	Chachoengsao	15,829	3,419	19,248			
12	Nakhon Nayok	18	2	20			
13	Ratchaburi	0	0	0			
14	Suphan Buri	862	139	1,001			
15	Nakhon Pathom	24,567	6,041	30,609			
16	Samut Sakhon	42,038	18,340	60,378			
17	S. Songkhram	0	0	0			
18	Uttaradit	5	4	9			
19	Nakhon Sawan	1,158	202	1,360		8,300	8,300
20	Uthai Thani	115	26	141		200	200
21	Kampaeng Phet	989	38	1,026			
22	Sukhothai	142	37	179			
23	Phitsanu Lok	601	84	686			
24	Phichit	526	52	578			
	Total	521,772	122,248	644,020	237,400	276,400	513,800

(iv) Estimation of Direct Damage for Future Scenario

Using flood simulation results for several future development scenario cases, direct damage to the manufacture sector of the cases are estimated as presented in Table P2.3.12.

Table P2.3.12 Estimated Direct Damages for Future Scenario Cases

Case No.	Return Period	Direct Damages to Manufacture Sector (Mil. THB)		
		Fixed Assets	Inventory Assets	Total
Reproduction of 2011 Flood		521,772	122,248	644,020
0-1 (Without Project)	2 years	6,327	1,626	7,954
	10 years	155,891	30,764	186,655
	30 years	187,727	36,860	224,587
	50 years	204,844	42,733	247,578
	100 years	303,341	68,661	372,001
1-1 (Master Plan by SCWRM)	2 years	-	-	0
	10 years	138,466	25,952	164,418
	30 years	146,279	28,829	175,108
	50 years	158,943	31,316	190,259
	100 years	183,827	35,441	219,269
11-0 (Proposed Combination-1)	2 years	-	-	0
	10 years	145,928	27,384	173,312
	30 years	170,293	32,722	203,015
	50 years	162,888	32,684	195,572
	100 years	193,114	37,807	230,922
11-1 (Proposed Combination-2)	2 years	-	-	0
	10 years	145,511	27,134	172,645
	30 years	161,781	31,617	193,398
	50 years	163,230	32,441	195,670
	100 years	188,546	36,587	225,133

(2) Indirect Damages

Indirect damages of the manufacturing sector are estimated with the percentages to the total one resulting from the research by the Ministry of Finance and the World Bank in order to get the EIRR and other indicators. Detailed data is shown in **P2.3.5 Other Sectors and Indirect Damages**.

P2.3.4 Household Sector

(1) Direct Damages

(a) Damageable Values of Household Sector

Floods cause damages directly on houses and assets of households. Weighted average value of houses and assets per household are estimated and the total value of households in each area is calculated with household number data in the area issued by Department of Provincial Administration (DOPA).

(i) Weighted Average House Value per Household

Weighted average construction cost of house per household is estimated with the following data:

1) Number of houses by type (debouched house, townhouse, condominium, etc.) and by construction material (wood, brick) for each province in "The 2010 Population and Housing Census" by NSO.
2) Construction cost of house by house type and material for each province published by the Ministry of Finance.
3) Standard total floor size by house type by the Ministry of Interior.
4) Average number of stories of high-rise buildings such as condominiums and apartments by the City Planning Department of related provinces.

It is assumed that high-rise buildings are directly damaged at their first floor. Hence, the house value of high-rise buildings with n stories is reduced to $1/n$.

Finally, the values were depreciated by 50% because it is assumed that the ratios of houses are all the same for ages after the construction.

(ii) Weighted Average Asset Value per Household

Weighted average value of household asset per household is estimated with the following data:

1) Ownership rates of household assets (television, VCD/DVD player, computer, refrigerator, microwave cooker, washing machine, air conditioner, car, motorcycle, etc.) for each province in "The 2010 Population and Housing Census" by NSO.
2) Standard price of commodities published by the Ministry of Commerce.

The asset values of high-rise buildings with n stories are reduced to $1/n$ for the same reason as their house value.

Finally, their value is depreciated by 50% because it is assumed that the ratios of commodities are all the same for ages after the purchase.

Table P2.3.13 Weighted Average Value of House per Household

(Unit: Baht)

Province	Ang Thong	Uttaradit	Ayutthaya	Bangkok	Chachoen gsao	Chai Nat	Kamphaeng Phet	Lop Buri
W.A. Value	272,223	270,634	208,974	241,567	306,785	298,498	271,238	283,401
Province	Nakhon Nayok	Nakhon Pathom	Nakhon Sawan	Nonthaburi	Pathum Thani	Phichit	Phitsanulok	Ratchaburi
W.A. Value	301,697	334,571	295,495	302,959	279,434	242,977	284,258	329,239
Province	Samut Prakan	Samut Sakhon	Samut Songkhram	Saraburi	Sing Buri	Sukhothai	Suphan Buri	Uthai Thani
W.A. Value	265,816	306,432	255,029	321,066	312,585	228,471	291,202	304,990

Table P2.3.14 Weighted Average Value of Household Asset per Household

(Unit: Baht)

Province	Ang Thong	Uttaradit	Ayutthaya	Bangkok	Chachoen gsao	Chai Nat	Kamphaeng Phet	Lop Buri
W.A. Value	197,412	172,523	96,886	163,124	199,436	180,865	176,641	210,785
Province	Nakhon Nayok	Nakhon Pathom	Nakhon Sawan	Nonthaburi	Pathum Thani	Phichit	Phitsanulok	Ratchaburi
W.A. Value	202,037	216,811	181,317	229,299	179,733	175,193	184,398	217,403
Province	Samut Prakan	Samut Sakhon	Samut Songkhram	Saraburi	Sing Buri	Sukhothai	Suphan Buri	Uthai Thani
W.A. Value	164,710	121,983	162,916	213,348	197,657	170,826	207,763	170,765

(iii) Estimation Result of Damageable Values

By using the above average values per household and the household number data, the damageable values of the households are estimated as presented in Table P2.3.15.

Table P2.3.15 Damageable Values of Households by Province in Potential Inundation Area

Number	Province	Number of Households	Damageable Values (Million THB)		
			House Buildings	Household Assets	Total
1	Bangkok	2,337,074	564,559	381,232	945,791
2	Nonthaburi	556,018	168,451	127,497	295,948
3	Pathum Thani	471,813	131,841	84,800	216,641
4	Ayutthaya	286,925	81,280	38,737	120,017
5	Ang Thong	89,282	24,305	17,623	41,928
6	Lopburi	71,178	20,172	15,009	35,181
7	Singburi	70,306	21,977	13,918	35,895
8	Chainat	74,391	22,206	13,457	35,663
9	Saraburi	100,084	32,134	21,353	53,487
10	Samut Prakarn	531,985	141,410	87,606	229,016
11	Chachoengsao	119,656	36,709	23,874	60,583
12	Nakhon Nayok	19,388	5,849	3,907	9,756
13	Ratchaburi	24,719	8,138	5,372	13,510
14	Suphan Buri	134,367	39,128	27,891	67,019
15	Nakhon Pathom	336,977	112,743	73,062	185,804
16	Samut Sakhon	240,518	73,702	29,339	103,041
17	S. Songkhram	7,022	1,791	1,137	2,928
18	Uttaradit	93,758	25,374	16,200	41,574
19	Nakhon Sawan	209,380	61,871	38,000	99,871
20	Uthai Thani	23,773	7,251	4,065	11,315
21	Kampaeng Phet	526	142	95	236
22	Sukhothai	135,815	31,030	23,186	54,216
23	Phitsanu Lok	208,699	59,324	40,568	99,892
24	Phichit	148,104	35,986	25,937	61,923
	Total	6,291,756	1,707,370	1,113,866	2,821,235

(b) Damage Calculation

Direct damages are estimated by multiplying the damageable values by damage rates that vary according to the flood inundation depth. The flood simulation gives inundation depth of each 2km x 2km grid cell in the flood plains. Accordingly, the damage calculation is also made on the grid cell basis.

(i) Damageable Values for 2km x 2km Grid Cells

Household numbers in 2011 at tambon level are available from the Department of Provincial Administration (DOPA). Similar to the industrial sector, by assuming that the density of the damageable values in a tambon is uniform, the values of the tambon are distributed uniformly to grid cells in the tambon. Figure P2.3.25 shows the cell-based damageable values obtained in this way.

(ii) Floor Level and Damage Rate

Similar to the manufacturing sector, two parameters, floor level and damage rates have to be determined. According to site surveys, house owners seem to be more careful than those of factories, probably because of inherited memories of past floods. Houses are generally of higher floor levels. Therefore, it is assumed that the floor level is as high as 50cm above the 5-year return period inundation level, regardless of in or out of the Protection Area.

Regarding the damage rates, there is no significant relationship found between damages and water depths of the interview survey. Therefore, damage rates used in Japan are applied as presented in Table P2.3.16.

Table P2.3.16 Floor Level and Damage Rates

Floor Level	Damage Rate*					
	Damageable Value	Flood Depth over Floor Level				
		0-0.5m	0.5-1m	1-2m	2-3m	Greater than 3m
Flood inundation level of 5-year return period +50cm	House Buildings	0.092	0.119	0.266	0.580	0.834
	Household Assets	0.145	0.326	0.508	0.928	0.991

*) Source: "Manual for Economic Analysis for Flood Control Projects (in Japanese)", Ministry of Land, Infrastructure, Transport and Tourism, Japan

(iii) Estimation of Direct Damages by 2011 Flood

Using the above damageable values, floor level and damage rate, the direct damages are estimated according to flood inundation depths obtained from the flood simulation.

Table P2.3.17 compares the estimated direct damages with those estimated under the Post Disaster Needs Assessment (PDNA) by the World Bank and MoF. According to the table, the estimated number of affected houses is very close to that of PDNA. Therefore, the above assumption of the floor level could be regarded reasonable, at least, while the Japanese damage rates generated larger damages than PDNA.

Table P2.3.17 Estimated Direct Damages of 2011 Flood

No.	Province	Estimated by JICA Study Team				Estimated under PDNA			
		Number of Affected Households	Direct Damages (Mil. THB)			Number of Affected Households	Direct Damages (Mil. THB)		
			House buildings	Household Assets	Total		House buildings	Household Assets	Total
1	Bangkok	994,159	22,302	24,454	46,756	761,725	1,954	14,843	16,797
2	Nonthaburi	509,095	14,190	16,927	31,117	204,920	654	3,974	4,628
3	Pathum Thani	243,902	6,270	6,357	12,627	237,394	1,116	4,616	5,732
4	Ayutthaya	128,323	3,383	2,637	6,020	196,929	1,294	3,835	5,129
5	Ang Thong	5,638	141	161	303	50,579	263	981	1,244
6	Lopburi	38,717	1,564	2,177	3,741	33,280	173	645	818
7	Singburi	5,057	145	145	291	21,078	91	408	499
8	Chainat	17,802	759	810	1,569	20,088	106	389	495
9	Saraburi	5,484	162	169	331	23,459	192	455	647
10	Samut Prakarn	17,088	666	694	1,359	-	-	-	-
11	Chachoengsao	84	2	2	5	61,780	326	1,198	1,524
12	Nakhon Nayok	1,414	39	41	81	19,942	199	386	585
13	Ratchaburi	0	0	0	0	-	-	-	-
14	Suphan Buri	30,113	807	907	1,713	84,841	418	1,645	2,063
15	Nakhon Pathom	132,953	4,097	4,202	8,299	89,571	358	1,737	2,095
16	Samut Sakhon	56,188	1,781	1,520	3,300	19,378	31	378	409
17	S. Songkhram	0	0	0	0	-	-	-	-
18	Uttaradit	3,558	264	273	537	-	-	-	-
19	Nakhon Sawan	86,161	2,357	2,328	4,685	51,411	396	1,005	1,401
20	Uthai Thani	10,646	309	302	611	4,440	23	86	109
21	Kampaeng Phet	9,846	305	412	717	-	-	-	-
22	Sukhothai	6,202	438	436	875	-	-	-	-
23	Phitsanu Lok	22,732	728	1,020	1,748	10,946	44	212	256
24	Phichit	21,197	475	544	1,019	14,826	63	287	350
	Total	2,346,359	61,184	66,518	127,702	1,906,587	7,701	37,080	44,781

(iv) Estimation of Direct Damages for Future Scenarios

Direct damages for several future development scenario cases are estimated as presented in Table P2.3.18.

Table P2.3.18 Estimated Direct Damages of Future Scenario Cases

Case No.	Return Period	Number of Affected Households	Direct Damages to Households (Mil. THB)		
			House buildings	Households Assets	Total
Reproduction of 2011 Flood		2,346,359	61,184	66,518	127,702
0-1 (Without Project)	2 years	-	-	-	0
	10 years	230,469	6,749	6,556	13,305
	30 years	418,839	13,477	16,078	29,555
	50 years	521,828	18,437	22,713	41,150
	100 years	656,637	24,187	28,961	53,148
1-1 (Master Plan by SCWRM)	2 years	-	-	-	0
	10 years	22,969	799	732	1,531
	30 years	197,678	5,891	5,584	11,475
	50 years	292,421	8,718	8,635	17,352
	100 years	383,362	11,405	11,702	23,107
11-0 (Proposed Combination-1)	2 years	-	-	-	0
	10 years	96,435	2,832	2,692	5,524
	30 years	270,240	8,241	8,354	16,594
	50 years	306,706	9,433	9,821	19,255
	100 years	436,994	13,768	15,872	29,640
11-1 (Proposed Combination-2)	2 years	-	-	-	0
	10 years	77,137	2,262	2,148	4,410
	30 years	245,635	7,520	7,598	15,118
	50 years	296,099	9,091	9,436	18,527
	100 years	409,633	12,632	14,238	26,869

(2) Indirect Damages

Indirect damages of the household sector are estimated with the percentages to the total which results from the research by the Ministry of Finance and the World Bank in order to get the EIRR and other indicators. Detailed data is shown in **P2.3.5 Other Sectors and Indirect Damages**.

P2.3.5 Agricultural Sector

Agricultural flood damages, total value of which amounted to about 16,800 million Baht, are classified into crop (annual, perennial), livestock, aquaculture, farmland, and structures. Besides, rehabilitation of irrigation facilities would take time and the terminal beneficiaries have to wait at least couple of years for irrigation water before the completion of recovery works by the government from mud sedimentation and bank breakages.

Value of damages of crop products accounted for 63% or nearly two thirds of the total flood damage value. The damage value of fruit crops has the largest share, around half of the total damage value. Assuming that planted area with these fruit trees were submerged for more than 2 weeks, their roots couldn't aspirate and trees standing amidst inundation were smothered to death. If they are fruiting ones, it requires half a decade to recover their productivity after replanting. Thus, the damage was estimated for 5 years as yield loss of fruit though other farming costs were neglected.

Damage of rice paddy was not included in the record because it was negligible owing to farmer's faithful observation to what MOAC and RID recommend for paddy cropping. On the other hand, fruit trees planted in lowland for crop diversification from rice to fruits affected, causing heavy toll of damages in Southern provinces.

As a result of cracking on embankments, aftermath water leakage would remain in canals and appurtenant structures. Damages on irrigation facilities account for over 50%, followed by drainage ones that mainly took place in central - southern basin where low-lying areas predominate and that's why drainage is more important than irrigation. Farm-road damages are mainly distributed in central - southern basin. Farmland damages were caused by torrential floodwater passing from breakage sites of major streams, accumulation of flood deposits and resulted heavy loss of in land consolidation facilities including farm-roads and modernized water distribution networks.

Inland fish ponds have recently been fast-developing from Bung Boraphet to nearby provinces because MOAC has a large scale fingering production ponds in this lake and many farmers sell each of their farmland to land developing constructors and changing their paddy plots into fish ponds by the reason that fish rearing is far more lucrative than rice production. On the other hand, farmers and local population have enough been prepared for such natural disasters/ calamities by their experiences and distinctive ability. Traditional high-floor residences can avoid loss of human toll as well of livestock, stored harvest/food etc, as the inhabitants can carry all of them to upstairs no sooner than flood over-threatens.

As a conclusion, agricultural damage brought about by the 2011 flood is found as fairly smaller than what had initially been expected from the heaviest disaster with the return period of over 100 years in view of the agricultural policy orientation practiced for years by MOAC and RID before the flood occurrence. However, the population could not get rid of such damages as submergence of their cars, agricultural machinery and cultured fish in their fishponds. Such inevitable damages resulted in per-capita loss of about 1,500 Baht on average.

In this economic context, annual farm income level of farm household is estimated at 249 thousand Baht for north provinces and 381 thousand Baht for southern ones, implying that the flood damage is equivalent to 0.4-0.6% of household income. It follows that such a catastrophic flood actually affected farmers to the same extent as they experience every year as yield fluctuations of their routine crop species. It should be kept in mind that some agricultural damages have not yet been made public, including damages of agricultural machinery, agricultural product-processing units, rice mills, etc. Allowing these invisible damages to additionally count, the actually experienced agricultural damage values would not exceed a few percent of total farm household income.

Table P2.3.19 Total Value of Agricultural Flood Damages

(Unit: Million Baht)

Category / Area	Annual Crop	Fruit Trees	Other Tree Crop	Livestock	Inland Fish Culture	Agri. Prod. Facilities	Farmland Rehabili-tation	Total
Northern CP	488	931	31	44	436	1,445	552	3,927
Central CP	1,465	7,509	254	236	415	2,590	401	12,870
Total	1,953	8,440	285	280	851	4,034	953	16,797
(Share)	(11.6%)	(50.2%)	(1.7%)	(1.7%)	(5.1%)	(24.0%)	(5.7%)	(100.0%)

Source: Ministry of Agriculture and Cooperatives
(Notes)
Annual Crop: maize, cassava, sugar cane, etc.
Fruit Trees: banana, mango, etc.
Other Tree Crop: oil palm, para-rubber, etc.
Livestock: cattle, swine, poultry, etc.

P2.3.6 Other Sectors and Indirect Damages

The summary of the research on the flood in 2011 by the Ministry of Finance and the World Bank is shown below. Since damages of the industrial sector and the household sector amount to 88.8% in direct damage and 76.5% in total, these sectors actually dominated the whole damage by the flood in 2011. Considering other industries, tourism is one of the most important industries in Thailand. Its share of direct damages is just 0.8% while that of indirect damages is 11.3%. Further, the share of direct damages of other industries (excluding manufacturing, household and agriculture) in total is 10.3% while that of indirect damages, 28.8%.

Table P2.3.20 Damage by 2011 Flood

(Unit: Million Baht)

	Direct Damage		Indirect Damage		Total	
Infrastructure						
Water Resources Management	8,715	1.4%	-	-	8,715	0.6%
Transport	23,538	3.7%	6,938	0.9%	30,476	2.1%
Telecommunication	1,290	0.2%	2,558	0.3%	3,848	0.3%
Electricity	3,186	0.5%	5,716	0.7%	8,901	0.6%
Water Supply and Sanitation	3,497	0.6%	1,984	0.2%	5,481	0.4%
Productive						
Agriculture, Livestock and Fishery	5,666	0.9%	34,715	4.4%	40,381	2.8%
Manufacturing	513,881	81.5%	493,258	62.0%	1,007,139	70.6%
Tourism	5,134	0.8%	89,673	11.3%	94,808	6.7%
Finance & Banking	-	-	115,276	14.5%	115,276	8.1%
Social						
Health	1,684	0.3%	2,133	0.3%	3,817	0.3%
Social	-	-	-	-	-	-
Education	13,051	2.1%	1,798	0.2%	14,849	1.0%
Housing	45,908	7.3%	37,889	4.8%	83,797	5.9%
Cultural Heritage	4,429	0.7%	3,076	0.4%	7,505	0.5%
Cross Cutting						
Environment	375	0.1%	176	0.0%	551	0.0%
TOTAL	630,354	100.0%	795,191	100.0%	1,425,544	100.0%

Source: Ministry of Finance, Royal Thai Government and World Bank, "Thailand Flooding 2554 Rapid Assessment for Resilient Recovery and Reconstruction Planning

P2.4 EIRR Calculation

Damages other than direct damages of the manufacturing and household sectors is estimated with the percentages to the total one which resulted from the research by the Ministry of Finance and the World Bank in order to get the EIRR and other indicators. Further, following are assumed in the EIRR calculation:

- Assets are expected to increase with the economic growth. Thus, the benefit is increased in accordance with the forecasted GDP growth rate up to 2022 (end year of GDP forecasting); and
- Benefits of the project will accrue in the construction stage in accordance with its progress after three years of research and design.

As a result of the mesh data calculaiton, annual average benefits of flood direct damage reduction are calculated as follows.

Table P2.4.1 Annual Average Benefit of Flood Direct Damage Reduction (SCWRM M/P)

(Unit: Million Baht)

Factories

Return Period	Flood Damage		Damage Reduction	Average Damage Reduction	Expectation	Benefit
	Without the Project	With the Project				
1	0	0	0			
2	7,954	0	7,954	3,977	0.500	1,988
10	186,655	164,418	22,237	15,095	0.400	6,038
30	224,587	175,108	49,479	35,858	0.067	2,391
50	247,578	190,259	57,319	53,399	0.013	712
100	372,001	219,269	152,732	105,026	0.010	1,050
Annual Average Benefit of Factories						12,179

Households

Return Period	Flood Damage		Damage Reduction	Average Damage Reduction	Expectation	Benefit
	Without the Project	With the Project				
1	0	0	0			
2	0	0	0	0	0.500	0
10	13,305	1,531	11,774	5,887	0.400	2,355
30	29,555	11,475	18,080	14,927	0.067	995
50	41,150	17,352	23,798	20,939	0.013	279
100	53,148	23,107	30,041	26,919	0.010	269
Annual Average Benefit of Households						3,898
AAB Total						16,078

Table P2.4.2 Annual Average Benefit of Flood Direct Damage Reduction (Proposed Component 1)

(Unit: Million Baht)

Factories

Return Period	Flood Damage		Damage Reduction	Average Damage Reduction	Expectation	Benefit
	Without the Project	With the Project				
1	0	0	0			
2	7,954	0	7,954	3,977	0.500	1,988
10	186,655	173,312	13,343	10,648	0.400	4,259
30	224,587	203,015	21,572	17,458	0.067	1,164
50	247,578	195,572	52,006	36,789	0.013	491
100	372,001	230,922	141,080	96,543	0.010	965
Annual Average Benefit of Factories						8,868

Households

Return Period	Flood Damage		Damage Reduction	Average Damage Reduction	Expectation	Benefit
	Without the Project	With the Project				
1	0	0	0			
2	0	0	0	0	0.500	0
10	13,305	5,524	7,781	3,891	0.400	1,556
30	29,555	16,594	12,960	10,371	0.067	691
50	41,150	19,255	21,895	17,428	0.013	232
100	53,148	29,640	23,508	22,701	0.010	227
Annual Average Benefit of Households						2,707
AAB Total						11,575

Table P2.4.3 Annual Average Benefit of Flood Direct Damage Reduction (Proposed Component 2)

(Unit: Million Baht)

Factories

Return Period	Flood Damage		Damage Reduction	Average Damage Reduction	Expectation	Benefit
	Without the Project	With the Project				
1	0	0	0			
2	7,954	0	7,954	3,977	0.500	1,988
10	186,655	172,645	14,010	10,982	0.400	4,393
30	224,587	193,398	31,189	22,599	0.067	1,507
50	247,578	195,670	51,907	41,548	0.013	554
100	372,001	225,133	146,868	99,388	0.010	994
Annual Average Benefit of Factories						9,436

Households

Return Period	Flood Damage		Damage Reduction	Average Damage Reduction	Expectation	Benefit
	Without the Project	With the Project				
1	0	0	0			
2	0	0	0	0	0.500	0
10	13,305	4,410	8,896	4,448	0.400	1,779
30	29,555	15,118	14,437	11,666	0.067	778
50	41,150	18,527	22,623	18,530	0.013	247
100	53,148	26,869	26,279	24,451	0.010	245
Annual Average Benefit of Households						3,048
AAB Total						12,484

Resutls of calculation of EIRR and other idicators are summarized below.

Table P2.4.4 Summary of Results

Case	EIRR	B/C	NPV (Billion Baht)
SCWRM M/P	13.0%	1.08	20.46
Proposed Combination 1	29.3%	2.68	137.21
Proposed Combination 2	24.6%	2.17	127.24

Table P2.4.5 EIRR Calculation (SCWRM M/P)

Price Level: 2012 (Unit: Billion Baht)

	Year	Cost			Benefit			Balance	Discounted (12%)	
		Capital Cost	O&M Cost	Total	Direct Damage	Loss	Total		Cost	Benefit
1	2013	27.41		27.41	0.00	0.00	0.00	-27.41	27.41	0.00
2	2014	27.46		27.46	0.00	0.00	0.00	-27.46	24.52	0.00
3	2015	27.46		27.46	0.00	0.00	0.00	-27.46	21.89	0.00
4	2016	37.39		37.39	3.09	3.81	6.89	-30.50	26.61	4.91
5	2017	37.39		37.39	6.17	7.61	13.78	-23.61	23.76	8.76
6	2018	51.05		51.05	9.26	11.42	20.67	-30.38	28.97	11.73
7	2019	64.71		64.71	12.35	15.22	27.57	-37.14	32.78	13.97
8	2020	44.59		44.59	15.43	19.03	34.46	-10.13	20.17	15.59
9	2021	30.93		30.93	18.52	22.83	41.35	10.42	12.49	16.70
10	2022	30.93		30.93	21.61	26.64	48.24	17.31	11.15	17.40
11	2023	30.93		30.93	24.69	30.44	55.13	24.21	9.96	17.75
12	2024		2.05	2.05	27.78	34.25	62.02	59.97	0.59	17.83
13	2025		2.05	2.05	27.78	34.25	62.02	59.97	0.53	15.92
14	2026		2.05	2.05	27.78	34.25	62.02	59.97	0.47	14.21
15	2027		2.05	2.05	27.78	34.25	62.02	59.97	0.42	12.69
16	2028		2.05	2.05	27.78	34.25	62.02	59.97	0.37	11.33
17	2029		2.05	2.05	27.78	34.25	62.02	59.97	0.33	10.12
18	2030		2.05	2.05	27.78	34.25	62.02	59.97	0.30	9.03
19	2031		2.05	2.05	27.78	34.25	62.02	59.97	0.27	8.07
20	2032		2.05	2.05	27.78	34.25	62.02	59.97	0.24	7.20
21	2033		2.05	2.05	27.78	34.25	62.02	59.97	0.21	6.43
22	2034		2.05	2.05	27.78	34.25	62.02	59.97	0.19	5.74
23	2035		2.05	2.05	27.78	34.25	62.02	59.97	0.17	5.13
24	2036		2.05	2.05	27.78	34.25	62.02	59.97	0.15	4.58
25	2037		2.05	2.05	27.78	34.25	62.02	59.97	0.14	4.09
26	2038		2.05	2.05	27.78	34.25	62.02	59.97	0.12	3.65
27	2039		2.05	2.05	27.78	34.25	62.02	59.97	0.11	3.26
28	2040		2.05	2.05	27.78	34.25	62.02	59.97	0.10	2.91
29	2041		2.05	2.05	27.78	34.25	62.02	59.97	0.09	2.60
30	2042		2.05	2.05	27.78	34.25	62.02	59.97	0.08	2.32
31	2043		2.05	2.05	27.78	34.25	62.02	59.97	0.07	2.07
32	2044		2.05	2.05	27.78	34.25	62.02	59.97	0.06	1.85
33	2045		2.05	2.05	27.78	34.25	62.02	59.97	0.05	1.65
34	2046		2.05	2.05	27.78	34.25	62.02	59.97	0.05	1.47
35	2047		2.05	2.05	27.78	34.25	62.02	59.97	0.04	1.32
36	2048		2.05	2.05	27.78	34.25	62.02	59.97	0.04	1.17
37	2049		2.05	2.05	27.78	34.25	62.02	59.97	0.03	1.05
38	2050		2.05	2.05	27.78	34.25	62.02	59.97	0.03	0.94
	Total	410.24	55.38	465.62			**EIRR:**	**13.0%**	**NPV:**	**20.46**
									B/C ratio:	**1.08**

Table P2.4.6 EIRR Calculation (Proposed Combination 1)

Price Level: 2012 (Unit: Billion Baht)

	Year	Cost			Benefit			Balance	Discounted (12%)	
		Capital Cost	O&M Cost	Total	Direct Damage	Loss	Total		Cost	Benefit
1	2013	9.35		9.35	0.00	0.00	0.00	-9.35	9.35	0.00
2	2014	10.82		10.82	0.00	0.00	0.00	-10.82	9.66	0.00
3	2015	10.82		10.82	0.00	0.00	0.00	-10.82	8.63	0.00
4	2016	11.06		11.06	3.20	3.95	7.14	-3.92	7.87	5.08
5	2017	25.79		25.79	6.39	7.89	14.29	-11.50	16.39	9.08
6	2018	25.79		25.79	9.59	11.84	21.43	-4.36	14.63	12.16
7	2019	18.42		18.42	12.79	15.79	28.57	10.15	9.33	14.48
8	2020	8.34		8.34	15.99	19.73	35.72	27.38	3.77	16.16
9	2021		0.60	0.60	19.18	23.68	42.86	42.26	0.24	17.31
10	2022		0.60	0.60	20.00	24.68	44.68	44.08	0.22	16.11
11	2023		0.60	0.60	20.00	24.68	44.68	44.08	0.19	14.39
12	2024		0.60	0.60	20.00	24.68	44.68	44.08	0.17	12.85
13	2025		0.60	0.60	20.00	24.68	44.68	44.08	0.15	11.47
14	2026		0.60	0.60	20.00	24.68	44.68	44.08	0.14	10.24
15	2027		0.60	0.60	20.00	24.68	44.68	44.08	0.12	9.14
16	2028		0.60	0.60	20.00	24.68	44.68	44.08	0.11	8.16
17	2029		0.60	0.60	20.00	24.68	44.68	44.08	0.10	7.29
18	2030		0.60	0.60	20.00	24.68	44.68	44.08	0.09	6.51
19	2031		0.60	0.60	20.00	24.68	44.68	44.08	0.08	5.81
20	2032		0.60	0.60	20.00	24.68	44.68	44.08	0.07	5.19
21	2033		0.60	0.60	20.00	24.68	44.68	44.08	0.06	4.63
22	2034		0.60	0.60	20.00	24.68	44.68	44.08	0.06	4.14
23	2035		0.60	0.60	20.00	24.68	44.68	44.08	0.05	3.69
24	2036		0.60	0.60	20.00	24.68	44.68	44.08	0.04	3.30
25	2037		0.60	0.60	20.00	24.68	44.68	44.08	0.04	2.94
26	2038		0.60	0.60	20.00	24.68	44.68	44.08	0.04	2.63
27	2039		0.60	0.60	20.00	24.68	44.68	44.08	0.03	2.35
28	2040		0.60	0.60	20.00	24.68	44.68	44.08	0.03	2.10
29	2041		0.60	0.60	20.00	24.68	44.68	44.08	0.03	1.87
30	2042		0.60	0.60	20.00	24.68	44.68	44.08	0.02	1.67
31	2043		0.60	0.60	20.00	24.68	44.68	44.08	0.02	1.49
32	2044		0.60	0.60	20.00	24.68	44.68	44.08	0.02	1.33
33	2045		0.60	0.60	20.00	24.68	44.68	44.08	0.02	1.19
34	2046		0.60	0.60	20.00	24.68	44.68	44.08	0.01	1.06
35	2047		0.60	0.60	20.00	24.68	44.68	44.08	0.01	0.95
36	2048		0.60	0.60	20.00	24.68	44.68	44.08	0.01	0.85
37	2049		0.60	0.60	20.00	24.68	44.68	44.08	0.01	0.76
38	2050		0.60	0.60	20.00	24.68	44.68	44.08	0.01	0.67
	Total	120.39	18.06	138.44			**EIRR:**	**29.3%**	**NPV:**	**137.21**
									B/C ratio:	**2.68**

Table P2.4.7 EIRR Calculation (Proposed Combination 2)

Price Level: 2012 (Unit: Billion Baht)

	Year	Cost			Benefit			Balance	Discounted (12%)	
		Capital Cost	O&M Cost	Total	Direct Damage	Loss	Total		Cost	Benefit
1	2013	12.63		12.63	0.00	0.00	0.00	-12.63	12.63	0.00
2	2014	14.56		14.56	0.00	0.00	0.00	-14.56	13.00	0.00
3	2015	14.56		14.56	0.00	0.00	0.00	-14.56	11.61	0.00
4	2016	14.69		14.69	3.45	4.25	7.70	-6.99	10.46	5.48
5	2017	34.02		34.02	6.90	8.50	15.40	-18.62	21.62	9.79
6	2018	34.02		34.02	10.35	12.75	23.10	-10.92	19.30	13.11
7	2019	24.35		24.35	13.79	17.00	30.79	6.44	12.34	15.60
8	2020	10.94		10.94	17.24	21.25	38.49	27.55	4.95	17.41
9	2021		0.80	0.80	20.69	25.50	46.19	45.39	0.32	18.66
10	2022		0.80	0.80	21.57	26.58	48.15	47.36	0.29	17.36
11	2023		0.80	0.80	21.57	26.58	48.15	47.36	0.26	15.50
12	2024		0.80	0.80	21.57	26.58	48.15	47.36	0.23	13.84
13	2025		0.80	0.80	21.57	26.58	48.15	47.36	0.21	12.36
14	2026		0.80	0.80	21.57	26.58	48.15	47.36	0.18	11.04
15	2027		0.80	0.80	21.57	26.58	48.15	47.36	0.16	9.85
16	2028		0.80	0.80	21.57	26.58	48.15	47.36	0.15	8.80
17	2029		0.80	0.80	21.57	26.58	48.15	47.36	0.13	7.86
18	2030		0.80	0.80	21.57	26.58	48.15	47.36	0.12	7.01
19	2031		0.80	0.80	21.57	26.58	48.15	47.36	0.10	6.26
20	2032		0.80	0.80	21.57	26.58	48.15	47.36	0.09	5.59
21	2033		0.80	0.80	21.57	26.58	48.15	47.36	0.08	4.99
22	2034		0.80	0.80	21.57	26.58	48.15	47.36	0.07	4.46
23	2035		0.80	0.80	21.57	26.58	48.15	47.36	0.07	3.98
24	2036		0.80	0.80	21.57	26.58	48.15	47.36	0.06	3.55
25	2037		0.80	0.80	21.57	26.58	48.15	47.36	0.05	3.17
26	2038		0.80	0.80	21.57	26.58	48.15	47.36	0.05	2.83
27	2039		0.80	0.80	21.57	26.58	48.15	47.36	0.04	2.53
28	2040		0.80	0.80	21.57	26.58	48.15	47.36	0.04	2.26
29	2041		0.80	0.80	21.57	26.58	48.15	47.36	0.03	2.02
30	2042		0.80	0.80	21.57	26.58	48.15	47.36	0.03	1.80
31	2043		0.80	0.80	21.57	26.58	48.15	47.36	0.03	1.61
32	2044		0.80	0.80	21.57	26.58	48.15	47.36	0.02	1.44
33	2045		0.80	0.80	21.57	26.58	48.15	47.36	0.02	1.28
34	2046		0.80	0.80	21.57	26.58	48.15	47.36	0.02	1.14
35	2047		0.80	0.80	21.57	26.58	48.15	47.36	0.02	1.02
36	2048		0.80	0.80	21.57	26.58	48.15	47.36	0.02	0.91
37	2049		0.80	0.80	21.57	26.58	48.15	47.36	0.01	0.81
38	2050		0.80	0.80	21.57	26.58	48.15	47.36	0.01	0.73
	Total	159.77	23.97	183.74			**EIRR:**	**24.6%**	**NPV:**	**127.24**
									B/C ratio:	**2.17**

P2.5 Sensitivity Analysis

Sensitivity analysis is carried out for the project on several cases of changes in the benefit or cost as summarized below. Indicators in original case are so high that they are robust to some extent against unfavorable situations (benefit decrreasing or cost increasing) in principle. More attention should be paid on benefit decreasing cases since they harm the figures more than cost increasing cases.

Table P2.5.1 Sensitivity Analysis (SCWRM M/P)

	IRR	B/C	NPV (Billion Baht)
Project benefit 10% down	9.1%	0.72	-68.22
Project benefit 20% down	7.3%	0.53	-114.02
Project cost 10% up	11.8%	0.99	-4.04
Project cost 20% up	10.8%	0.90	-28.54

Table P2.5.2 Sensitivity Analysis (Proposed Combination 1)

	IRR	B/C	NPV (Billion Baht)
Project benefit 10% down	21.7%	2.12	91.38
Project benefit 20% down	17.9%	1.71	58.31
Project cost 10% up	27.1%	2.43	129.03
Project cost 20% up	25.2%	2.23	120.84

Table P2.5.3 Sensitivity Analysis (Proposed Combination 2)

	IRR	B/C	NPV (Billion Baht)
Project benefit 10% down	18.7%	1.72	77.84
Project benefit 20% down	15.4%	1.39	42.21
Project cost 10% up	22.6%	1.97	116.35
Project cost 20% up	21.0%	1.81	155.47

Sector Q: Environment

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
VOLUME 3: SUPPORTING REPORT

SECTOR Q: TABLE OF CONTENTS

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CHAPTER Q1 INITIAL ENVIRONMENTAL EXAMINATION

Q1.1 Outline of the Project

Q1.1.1 Project Name

The project works which need the Initial Environmental Examination (IEE) consist of 1) Ayutthaya Bypass Diversion Channel, 2) Outer Ring Road Diversion Channel and 3) Dike Improvement , which are for flood mitigation in the Chao Phraya River Basin.

Q1.1.2 Project Location

The location of the project is illustrated in Figure Q1.1.1. Both planning diversion channels start from the Chao Phraya River in Phra Nakhon Si Ayutthaya southward. The Ayutthaya Bypass Diversion Channel lies in the west side of the Chao Phraya River and the Outer Ring Road Diversion Channel in the east side of the River. Dikes to be improved strech from the estuary to approx. 90km upstream along the Chao Phraya River (those until 60km upstream have been constructed by the BMA).

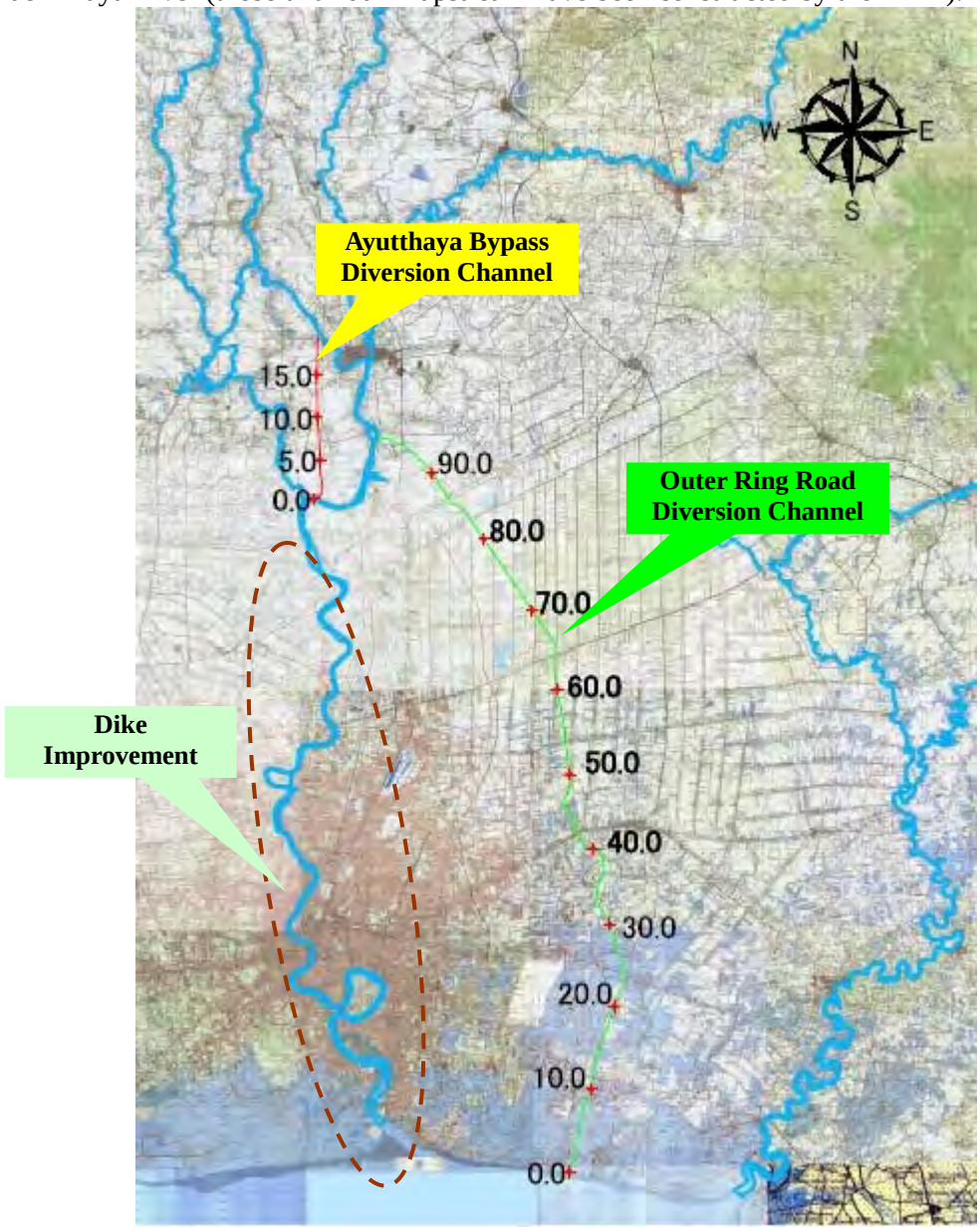


Figure Q1.1.1 Project Location

Q1.1.3 Objectives and Summary of the Project

After several trials to develop an effective countermeasure for flood management in Thailand, establishing two new diversion channels including 1) Ayutthaya Bypass Diversion Channel (19km in length) and 2) Outer Ring Road Diversion Channel (100km in length), and 3) Dike Improvement (90km in length) with other structural/non-structural measures have been selected as the most cost-efficient and significantly effective for protecting the lower Chao Phraya River Basin where the industrial centers are integrated.

Q1.1.4 Activities Requiring Environmental and Social Considerations

In the project regarding the two diversion channels, activities requiring environmental and social considerations are as follows:

1) Canal work (Earth work, road, canal lining, and ground improvement)
2) Facility work (Road Bridge, floodgate)
3) Dike work (Parapet wall, elevation)
4) Material handling (Truck operating)

Outline of the work required is shown in Table Q1.1.1.

Table Q1.1.1 Outline of the Works Related

Work Type	Content of Work	Outline	Main Equipment
Canal	Earthworks	Excavation, Soil disposal, Embankment	Backhoe, Dozer
	Road works	Basement (sub-base and base course), Finishing (asphalt concrete pavement)	Motor grader, Vibratory roller, Tired roller, Asphalt finisher
	Canal lining	Lining with concrete	Concrete mixing vehicle, Crane
Facility	Road bridges	Bridges over the canal to pass	Concrete mixing vehicle, Crane, Pile driver
	Floodgates	With both connecting sites of the River	Crane for truck mount, Backhoe, Dozer, Pile driver, Vibratory hammer
Dike	Wall works	Parapet wall installation	Backhoe, Dozer, Concrete mixing vehicle, Crane
	Elevation works	Elevation of walls for enough wall and dike height	Concrete mixing vehicle, Crane

Q1.1.5 Categories of the Project and Environmental Assessment

According the Thai laws[1], 34 project types and activities require an Environmental Impact Assessment (EIA) and approval through the national approval process. However, the diversion channels are sure to be outside the scope of the EIA category in accordance with the Thai environmental assessment system at present.

On the other hand, impacts on the environment may arise mainly by construction activities for the project. And a case is probable to make the residents or houses resettled in the project area to other location. Taking into account the situation, it is cocluded that conducting an Initial Environmental Examination (IEE) should be essential according to the JICA Guidelines for Environmental and Social Considerations.

[1] The Enhancement and Conservation of National Environmental Quality Act (NEQA) of B.E. 2535 (1992).

Q1.2 Fundamental Environmental and Social Conditions

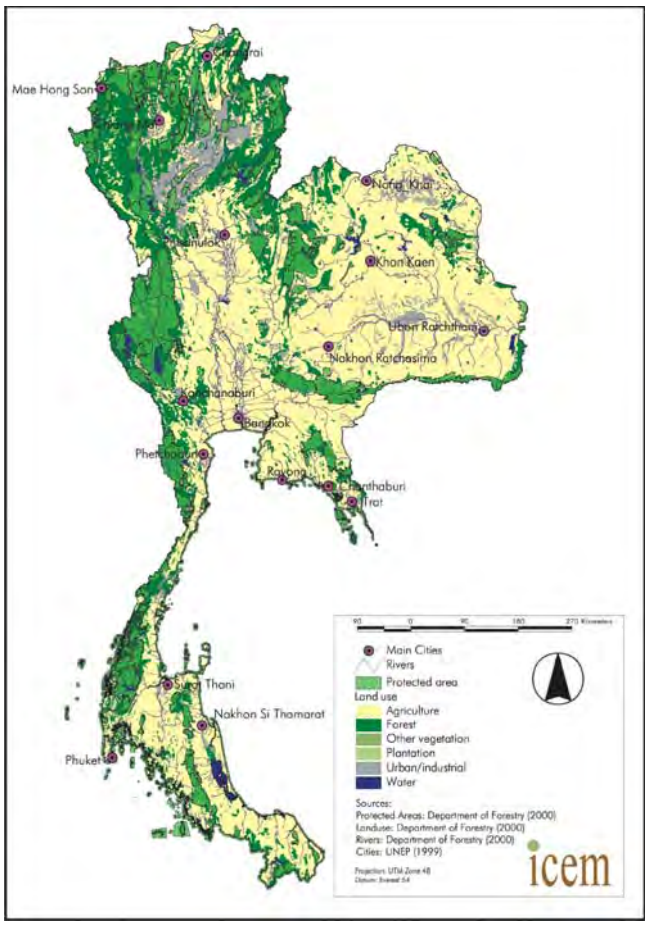
Q1.2.1 Environmental Conditions

(1) Topography and Land Use

Thailand lies in the center of the Indochina, divided mainly into four regions as; mountains in the north, the prairie in the delta of the Chao Phraya River in the center, the Korat Plateau in the Mekong River system in the northeast and the mountainous Malay Peninsula in the south.

The Project area is located in the central prairie and the deltas of the Chao Phraya River Basin. The delta area developing at the estuary of the Chao Phraya River is the alluvial plain widening downstream from Phitsanulok in the Nan River and fairy low and flat. Phra Nakhon Si Ayutthaya, some 100km upstream the estuary, has only five meters of the elevation level with 1/100,000 - 1/50,000 of well-gradual incline. The delta forms an enormous grain belt thanks to its fertile land and irrigation development (see in Figure Q1.2.1).

The Chao Phraya River Basin covers an area of approximately 160,000km^2 - representing 30% of the total country area. It starts at the confluence of the Ping and Nan Rivers at Nakhon Sawan to the Gulf of Thailand and the Pacific Ocean with 372 km of the whole length. Bangkok, the capital and biggest center of the country's activities with more than eight million people, is located near the mouth of the Chao Phraya River. The upper region of the basin is mountainous with agriculturally productive valley, and covers the area of approx. 103,000km^2 occupying 65% of the total basin area. The lower region, however, has alluvial plains with a highly productivity for agriculture as described.



Source: ICEM Website

Figure Q1.2.1 Land Use in Thailand

(2) Climate

Thailand is categorized in the tropical monsoon climate and the season can be divided into dry and rainy seasons. The climate in Phra Nakhon Si Ayutthaya area is almost same as that in Bangkok, with high temperature and humidity and same as the climate in July and August in Japan through a year. The hottest period is during March and May, and in the rainy season from June to October there is a rainfall for a few hours everyday. The dry season lasts in November to May, and cool atmosphere can be felt in the morning and evening from the mid November to February as the best time of the climate ranges in this period. A summary of monthly climate (30-year average) in Phra Nakhon Si Ayutthaya is shown in Table Q1.2.1.

In June 2011, heavy rains attached almost the whole country by south-west monsoons. The 4th Typhoon Haima brought heavy rains in the north region late in June and some areas were damaged by a flash flood or landslide. In July the 8th Typhoon Nock-Ten landed and a south-west monsoon attacked at the north, central and northeast areas through August to September. At the last of the rainy season in October, the northeast monsoon went south and brought a heavy rain in the central area. Flood damages spread from the central area to Bangkok and its vicinities along the Chao Phraya River Basin overlapping high tides on heavy rains and floods downstream the north region.

Table Q1.2.1 Monthly Climate in Phra Nakhon Si Ayutthaya (30-year average, 1960-1990)

Units: ◦C, mm

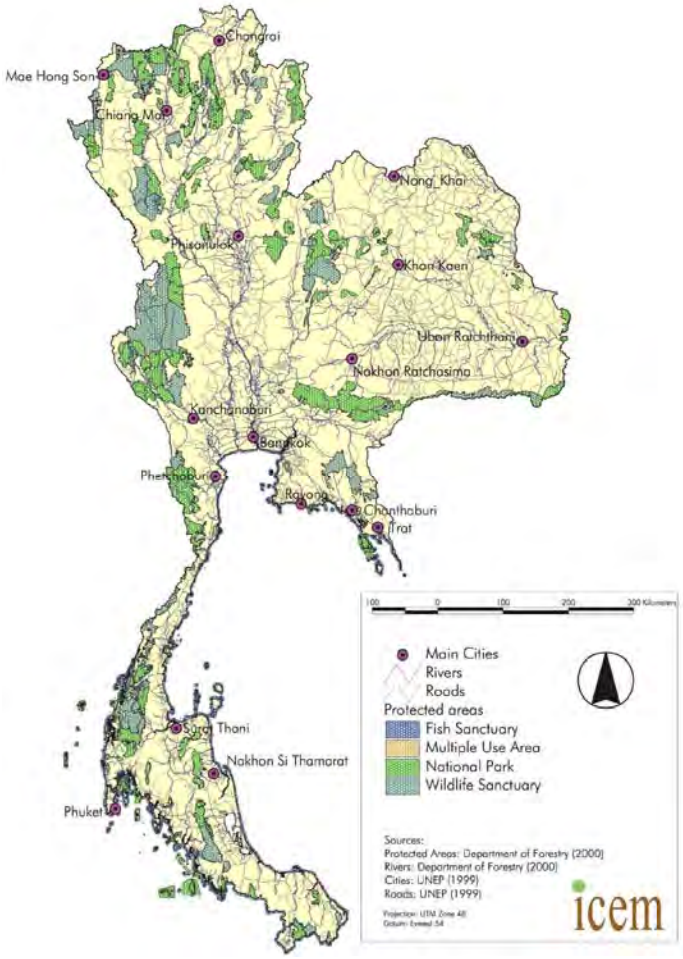
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	Max	31.0	33.3	35.4	35.9	34.3	32.6	32.0	31.4	31.3	31.3	30.7	30.0
	Min	17.0	19.4	22.3	24.3	24.5	24.3	24.0	23.8	23.5	22.5	20.0	17.4
Rain days		0	1	4	6	15	16	17	19	17	12	3	1
Precipitation		2.4	18.8	43.5	67.9	208	223	181	260	214	168	37.1	8.0

Source: Thai Meteorological Department

(3) Ecosystem

Approximately 15,000 plant species are reported to inhabit in Thailand. The figure, however, was derived from knowledge based on 15-30% of estimated vegetation in Thailand, so some 40,000 to 80,000 plant species are estimated to inhabit. About 300 species of mammals (42 families in 14 orders) are reported and 40 species of them are considered as rare or endangered[2]. The number of other species reported is as follows; 982 birds, 4,400 fish (fresh and sea water), 1,610 land vertebrates, 350 reptiles, 137 amphibians. Among these species, the following numbers of species have been designated as the endangered; 60 birds, 14 fish, 14 invertebrates, 20 reptiles and amphibians, respectively. Figure Q1.2.2 indicates preserve areas in Thailand. There is no preservation designation of rare species as the project site is a multiple use area.

[2] Japan Bio-industry Association Website: www.jba.or.jp



Source: ICEM Website

Figure Q1.2.2 Preservation Area Distribution in Thailand

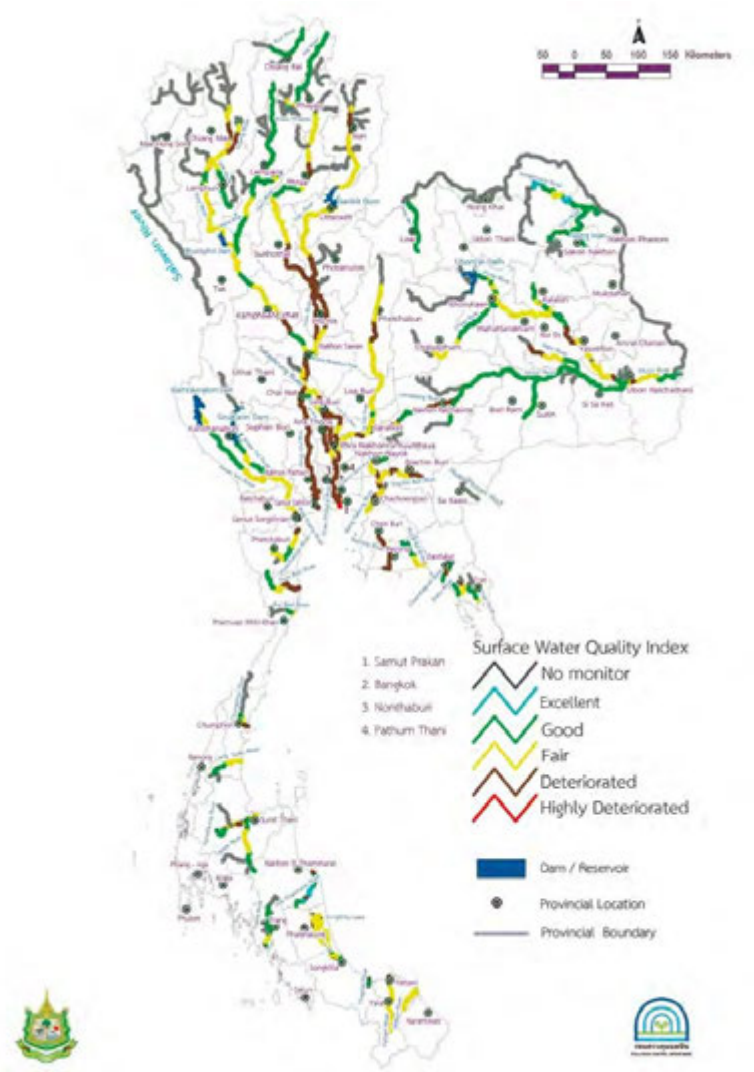
(4) Water Resources

Since 1950s, the Thai Government has constructed approx. 3,000 dams[3] and reservoirs to store water in the rainy season and utilize in the dry season. This has brought enormous rice cropping in the Chao Phraya River Basin and promoted an economical growth in the cities as well.

The first multi-purpose dam in Thailand was Bhumibol Dam, which has 26,400km^2 of catchment area and 713MW of power generation capacity and constructed upstream the Pin River with a support of the World Bank in 1964. The next was Sirikit Dam upstream the Nan River with 13,130km of catchment area and 500MW of power generation capacity in 1972. Both dams are operated by the EGAT and for a main purpose of power generation as well as for irrigation.

The water quality in the water-rich Chao Phraya River by 2011 survey[4] showed "Good" in the upper, "Fair" in the central and "Deteriorated" in the lower streams, respectively[5]. The map of surface water pollution in the main 48 rivers over the nation is shown in Figure Q1.2.3.

[3] The first dam in Thailand was Chao Phraya Dam in 1957.
[4] In accordance with the 2011 survey by the Pollution Control Department (PCD).
[5] Four criteria as "Good", "Fair", "Deteriorated" and "Highly Deteriorated."



Source: Thailand State of Pollution Report 2011 (MNRE)

Figure Q1.2.3 Monitoring Result of Water Quality in the Main Rivers in Thailand (2011)

(5) Air Quality

Followed by the economical growth in 1980s, lots of factories have been established between Phra Nakhon Si Ayutthaya and Bangkok Metropolitan. The number of automobiles has been increasing since 2000 as to motorization advancement (Table Q1.2.2). In addition, air quality in those populated areas has been on the way of increasing because of an increase in the number of motorcycles.

Table Q1.2.2 Motor Vehicle Registrations in Thailand

Unit: thousand vehicles

2005		2006		2007	
Total	PC/T	Total	PC/T	Total	PC/T
7,899	43%	8,822	43%	9,700	39%
2008		2009		2010	
Total	PC/T	Total	PC/T	Total	PC/T
9,772	43%	10,184	44%	10,700	44%

Note: PC/T is the ratio of passenger cars to the total.
Source: "2011 World Automobile Statistical Yearbook", the Japan Automobile Manufacturers Association.

Consistent heavy traffic congestion in the Project area is promoting the air quality. One of critical issues is particle matters (PM) in the exhaust gas, which may induce a health hazard in lungs. Even though the PCD sets the standards on low-emission vehicles in cooperation with other relating authorities, air pollution has been worse by motorcycles which occupy about 75% of road vehicles and diesel trucks or buses with poor maintenance. Gradually, however, increases in new car introduction and development of road systems can realize the alleviation of traffic congestion. Most power generation plants use fossil fuels and the amount of exhausted air pollutants from industrial activities in Bangkok Metropolitan and the central areas accounts for over 60% of all in Thailand.

(6) Solid Waste

In 2009, there were 15.11 million tons of municipal wastes generated throughout the country or 41,410 tons/day (not excluding waste prior to disposal). Bangkok generated about 8,834 tons/day (21%). Municipalities and Pattaya generated about 16,368 tons/day (40%) and Sub-district Administrative Organizations generated about 16,208 tons/day (39%). When compared with the previous year, the amount of waste increased by 0.8%. The amount of waste in municipal areas rose by up to 9.74%. Meanwhile, there was a drop of waste by 6.68% in the areas outside municipalities due to the raising of 378 Sub-district Administrative Organizations status to municipalities. Approximately 16,358 tons of waste/day or 40% of the country's total waste was properly management, up by 2% from 2008.

(7) Natural and Cultural Heritage

Temples and historical ruins in the Ayutthaya Dynasty aggregate in the central area of Phra Nakhon Si Ayutthaya and the area was registered as the UNESCO World Heritage in 1991. More than 3 million tourists from in and outside the country visit the historical area a year. As tourism is a large part of financial income in Phra Nakhon Si Ayutthaya, the 2011 Flood gave damages on the tourism resources and the regional economic activities.

Q1.2.2 Social Conditions

(1) Demography and Local Society

The population in Thailand is approximately 64 million, of which 9.3 million live in Bangkok and its vicinities. Ninety-four (94) percent of the population is Thai-speaking Buddhists. The national population growth rate is 0.68%, according to the 2006 census. About 93% of the people in Thailand are functionally literate.

The Chao Phraya River Basin has some 40 percent of the country's population. The total population of the Basin was 23 million inhabitants according a survey in 1996. About half of the total population (11.5 million) inhabits in the Lower Chao Phraya Basin, including the highly populated areas of Bangkok Metropolitan Area (BMA). Approx. 68 percent of the total population of the Basin lives in rural areas. The average population density is 136 inhabitants per km2, but varies greatly from 44 in the Nan sub-basin to 533 inhabitants per km2 in the Chao Phraya sub-basin. Bangkok and its vicinity have the highest population density, with 1,500 inhabitants per km^2.

Thailand is divided into seven areas in general as; BMA, Central, East, West, North, Northeast and South. The project area is located in the central area. Table Q1.2.3 shows the provinces, their area and population belonging to the BMA and the central region.

Table Q1.2.3 Administrative Units Included in the Project Area

Region	Administrative Units	Area (thousand km^2)	Population (million)
BMA (6 provinces)	Bangkok, Nakhon Pathom, Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon	8.0 (1.5%)*	10.2 (16.1%)*
Central (6 provinces)	Ang Thong, Chainat, Lopburi, Phra Nakhon Si Ayutthaya, Saraburi, Singburi	17 (3.2%)	3.0 (4.7%)
Nationwide (77 provinces)		513 (100%)	63.5 (100%)

*: Ratio of region to the nation. Source: JBIC "Investment Climate in Thailand" (2012)

The central region where includes the project area consists of a part of the Chao Phraya River Basin, and the abundant water resource of the basin has contributed to the local economic activity centered on rice cropping from the long time. However, in modern times the aggregation of both human and financial resources into Bangkok and its surroundings has shifted the core industry from agriculture to manufacturing. In the 1970, the Industrial Estate Authority of Thailand (IEAT) started establishing industrial estates and Japanese companies have begun to rush in the industrial estates near Bangkok and along the Basin since the late 80s, with influence of a strong yen after the Plaza Accord. Thailand has the 4th largest population following Indonesia, Philippines and Vietnam in the ASEAN nations. According to the estimation by a U.S. census, Thailand would have 71.5 million of the demographic peak in 2034 and the volume would turn down thereafter. Moreover, the peak of workforces from the age of 15 to 60 would reach in 2014, indicating Thailand is toward an aging society.

(2) Local Economy

The global recession in 2008 gave Thai economy enormous damages as well. Since the Asian economic crisis in 1997, thanks to an aggressive foreign capital introduction and domestic demand expansion, Thailand kept more than 5% of GDP growth during 2002- 2007. GDP growth largely fell down by -2.3% in 2009 while being kept 2.5% in 2008. Reflecting the result, the Thai Government tried to shore up the actual economy with the economic stimulus measure like large fiscal spending. With a recovery of the overseas export market Thailand attained 7.8% of GDP growth in 2010. The central region where the project area belongs shares 7.6% of the nominal GDP in 2009. The central region produces about 14% of the domestic manufacturing outputs, according to Table Q1.2.4.

Table Q1.2.4 Constituent Ratio by Industry of Nominal GDP by Region

	Nation Wide	BMA	Central	East	North East	South	North	West
All Industries	100	42.0	7.6	15.6	11.5	9.6	9.4	4.3
Primary	11.5	0.5	0.6	1.1	2.5	3.3	2.4	1.0
Secondary	43.3	18.3	5.4	10.9	2.7	2.0	2.6	1.5
Mining	3.4	0.0	0.1	2.3	0.1	0.3	0.5	0.1
Manufacturing	34.2	16.3	4.9	7.4	1.8	1.2	1.6	0.9
Public Utilities	3.1	0.9	0.3	0.9	0.2	0.2	0.2	0.4
Construction	2.7	1.1	0.1	0.3	0.5	0.3	0.3	0.1
Tertiary	45.2	23.1	1.7	3.6	6.4	4.3	4.4	1.8
Others	3.4	1.5	0.2	0.2	0.5	0.4	0.4	0.2

Source: JBIC "Investment Climate in Thailand" (2012)

Having been riding on the wave of constant economic growth, Thailand had an unprecedented damage by the flood in 2011. Estimation by the World Bank revealed that total damages would have counted some THB1.4 trillion in total damages. The 3.7% of forecasted GDP growth rate in 2011 was reset downward 2.4% in accordance with the estimation. The damaged THB1.4 trillion is equivalent to over 10% of Thai GDP and deadly devastated. As mentioned above, the industrial estates aligned from Phra Nakhon Si Ayutthaya to Bangkok were devastated and Japanese corporations which have their factories in the industrial estate had damaged as well. Among these damaged Japanese corporations, nearly 80% of them responded to keep staying the present location and keeping the business[6], according to a survey[7]. Acquiring supply chains is included in the prompt implementation of drastic measures that was one of requests to the Government.

Reviewing the situation, the Prime Minister Ms. Yingluck addressed the implementation of a THB900 billion-scaled "New Thailand Project", in order for the restoration from the flood and long-term countermeasures in the future. In the project, THB100 billion will be allocated for the restoration of industrial estates and the rest THB800 billion for preventive measures against a flood in industrial estates and for an overhaul of the water management.

Q1.3 Legal Framework of Environmental and Social Considerations

Q1.3.1 Outline of the Environmental Legal System

(1) Establishment of the Enhancement and Conservation of National Environmental Quality Act

The first law regarding the environment in Thailand was the Improvement and Conservation of National Environmental Quality Act in 1975, which was established the National Environmental Board (NEB). Later, the Office of National Environmental Board (ONEB), which was in charge to develop environmental policies, embarked on planning of environmental conservation policies and prescription of air and water quality standards as well as establishment of environmental monitoring systems.

After developing the domestic industry and increasing in the people's concern to the pollution in 1980s, the government repealed the 1975 National Environmental Quality Act and replaced it with the Enhancement and Conservation of National Environmental Quality Act in 1992 (NEQA). At the same time, a number of other laws closely relating to environmental policies were substantially revised, including the Factory Act, Public Health Act, Hazardous Substances Act, and Energy Conservation Promotion Act.

[6] Among all 839 factories in the seven devastated industrial estates by the flood, 296 factories (35.3%) had been the same condition before the flood. Nearly 20% had no hopes to restart the operation (JETRO Tsusho Koho Information, on 11 May 2012).

[7] JETRO Bangkok Office "Result of Questionnaire Survey in the Devastated Companies on the 2011 Flood in Thailand", February 2012.

The NEQA contains 7 chapters having 111 sections and another 4 sections as interim provisions, a total of 115 sections. In the act, precautions of pollution problems from activities or projects, which may have impacts on environment, namely the Environmental Impact Assessment (EIA) are required. The EIA requires pollution mitigation measures and pollution monitoring system, which shall be considered by the assessment committee prior to project approval. In case that the EIA does not pass the assessment, the activity or project will not be approved.

(2) Provision under the Constitution

The right that citizens can participate in the procedures of environmental conversation was provided first as "the right of Thai citizen" in Article 56 of the Constitution in 1997. The Constitution was amended in 2007 on providing restriction of a project implementation that could give a serious affection on the environment and obligation reflecting the opinions from an assessment and citizens.

(3) Environmental Standard

The environmental standard was established in Article 32 of the NEQA as bellows:

1. Water Quality (rivers, lakes/ponds, reservoirs)
2. Water Quality (seawater near estuaries)
3. Water Quality (ground water)
4. Air Quality
5. Noise & Vibration
6. Others

Note that the current environmental standard is not always integrated by the NEB standard because the environmental standard is a mixture of ministry ordinances as well as NEB announcements.

Q1.3.2 Environmental Impact Assessment (EIA)

(1) Projects Requiring the EIA

The NEQA prescribes the Environmental Impact Assessment (EIA) in Article 46 to 48. An EIA report is currently required in 34 types or sizes of projects or activities, ranging from public works such as dam or reservoir construction to private-Sector Projects such as petrochemical plant construction. The list of projects or activities that requires an EIA report is as in Table Q1.3.1.

Table Q1.3.1 List of Projects or Activities Subjected to EIA

No.	Type of projects or Activities	Size
1	Mining according to the Minerals Act	All size
2	Development of Petroleum	All size
3	Projects to Transport the Petroleum and Fuel Oil by Pipe	All size
4	Industrial enterprises	All size
5	Petrochemical Industry Projects that Produce Chemicals	More than100 tons per day
6	Petroleum Refining Industry	All size
7	Analyzing or Transmuting Natural Gas	All size
8	Chlor-alkaline Industry using Sodium Chloride (NaCl) as a material in the production of Sodium Carbonate (Na_2CO_3) Sodium Hydroxyl (NaOH) Hydraulic Acid (HCI) Chlorine (CI_2) Sodium Hypo chloride (NaOCI) and Bleaching powder	Each or compound more than 100 tons per day
9	Industry Producing Portland Cement	All size

No.	Type of projects or Activities	Size
10	Industry Producing Paper Pulp	More than 50 tons per day
11	Industry Producing Pesticides	All size
12	Industry Producing Chemical Fertilizers	All size
13	Sugar Industries	All size
14	Iron or Steel Industry	More than100 tons per day
15	Mineral Industry that is not an Iron or Steel Industry	More than50 tons per day
16	Liquor and Alcohol Production Industry	-Liquor and alcohol producer: production capacity of 40,000 liters per month -Wine or beer producer: production capacity of 600,000 liters per month
17	Factories that Recycle Waste Products according to the Factory Law	All size
18	Power Plants	Production capacity of 10 MW per day or more
19	Expressways	All size
20	Highway and Roads according to the Highway Law that Go Through the Following Areas: 20.1 Reserved forest areas 20.2 National parks 20.3 The plain area level 2 according to conclusion of the cabinet 20.4 Mangrove forest 20.5 Fifty meters from beach areas 20.6 Areas 2 kilometers from world heritage sites 20.7 Areas 2 kilometers from ancient remains, antiques, national parks, historical parks and national museums	All size
21	Public Metal Transit System	All size
22	Ports	-Capacity for vessels of 500 gross tons or more -Quay length of 100 m^2 or more -Total port area is amount of 1,000 m^2 or more
23	Marinas for Docking Boats for Sport and Recreational Purposes	Capacity of 50 vessels or more or an area of 1,000 square meters or more
24	Man-made Land Projects	All size
25	Construction or Enlargement of Buildings Close to or in the Sea 25.1 Walls close to the beach 25.2 Dams against sand, surfs and water 25.3 Dam against surfs outside the beach	25.1: Length of 200 m^2 or more Rest: All size
26	Air Transportation Projects 26.1 Construction of or enlargement of commercial water airports. 26.2 Water airports	Runway length of 1,100 m or more
27	Building according to the Building Control Act 27.1 located in an area beside the river, lake, beach or close to or in a national park or historical park 27.2 used for a retail or wholesale business 27.3 used as an office building	Buildings that are 23 m or taller or have all area of 10,000 m^2 or more
28	To Allot the Land for Habitation or Commerce according to the Land Development Law	Projects that have more than 500 plot of land or the area more than 100 Rai (16ha)

No.	Type of projects or Activities	Size
29	Hospitals according to the Medical Premises Law 29.1 Located in an area close to the river, lake, beach within 50 meters 29.2 Out of 29.1	29.1: 30 or more patients beds 29.1: 60 or more patients beds
30	Hotels according to the Hotel Act	80 rooms or more or with a usable area of 4,000 m^2 or more
31	Condominiums according to the Building Control Law	80 rooms or more or with a usable area of 4,000 m^2 or more
32	Dam Projects 32.1 Capacity 32.2 Area	100 million m^3 or more 15 km^2 or more
33	Irrigation Projects	Area of irrigation 80,000 Rai or more
34	All projects that Are Located in the Plain Area Level 1 according to Conclusion of the Cabinet	All size

Source: Thai Law Forum website, www.thailawforum.com

In Article 67 of the Thai Constitution amended in 2007, implementation of projects that may have a serious impact on the environment is restricted and duties are defined to implement environmental and health impact assessment (EHIA) and to reflect the voices from residents into the assessment. Eleven types and sizes of projects that the constitution requires EHIA are shown in Table Q1.3.2.

Table Q1.3.2 Eleven Projects Requiring EHIA in the 2007 Thai Constitution

No	Type of Projects of Activities	Size
1	Land reclamation in the sea or lake in the external existing coastline except it is done for seashore improving purpose.	More than 300 Rai of land
2	Mining with defined by the Mineral Act	All size
3	Industrial Estate in accordance to Industrial Estate Act or Project with identical characteristics of Industrial Estate as: 1) Those which is established to support petrochemical industry described in 4 or ironworks industry that described in 5.1 or 5.2 more than 1 factory, or 2) Those which is expanding area to support petrochemical industry described in 4 or ironworks industry that described in 5.1 or 5.2	All size
4	Petrochemical Industry as: 1) Upstream Petrochemical Industry, or 2) Intermediate Petrochemical Industry	1) All sizes or extensive productivity more than 35% of the existing production. 2) Daily productivity more than 100 ton.
5	Mineral Smelting Industry or Melting Metal Industry	Ironworks, Mineral smelting industry of Cu, Au or Zn, etc.
6	Manufacturing, disposal or modification of radioactive substance	All size
7	Central Waste Treatment Plant or buried garbage or unused material manufacturer as defined by the Factory Act which is burning or buried hazardous waste except burning in cement oven that used hazardous waste as substituted raw material or additional fuel	All size
8	Project of Aviation Transportation System	With the construction or expansion or extension of runway longer than

No	Type of Projects of Activities	Size
		3,000 meters
9	Port	With 300m or more of berth length or 10,000 m^2 or more of port area etc.
10	Dam or Reservoir	With 100M m^3 or more capacity of water storage or 15 km^2 or more area of water storage.
11	Thermal Power Plant, Using Fuel as: 1) Coal 2) Biomass Fertilization 3) Co-thermal System or Co-generation 4) Nuclear Power	1) More than 100MW 2) More than 150MW 3) More than 3,000MW 4) All size

Source: Environmental Impact Assessment in Thailand, ONEP, 2012

(2) Procedures of EIA

< Process of reviewing an EIA report>

For a private-sector development project which requires the EIA, the proponent of the project must prepare two copies of EIA report; submit one copy to the Office of Environmental Policy and Planning (OEPP), and the other copy to the government agency that has jurisdiction over the project.

On receiving an EIA report, the OEPP must examine the documents within 15 days, and then, within the next 15 days, refer the report together with comments based on a preliminary review to an expert review committee. This committee has 45 days to review the referred report and to decide whether to give approval. However, in case the report is judged incomplete, the expert review committee will request the project applicant to submit a revised report. The government agency with jurisdiction over the project considers whether to grant a license after the EIA is approved by the expert review committee.

Regarding government projects requiring the Cabinet approval, the procedure is slightly different from private-Sector Projects mentioned above. In the case, the entity of the project must submit an EIA report to the National Environment Board (NEB), which reviews the report and hears the opinions of the OEPP and expert review committee. The NEB then reports its conclusions to the Cabinet. The Cabinet considers whether to grant approval, having reviewed the project on the basis of the NEB recommendations and experts' opinions. A brief scheme of EIA implementation procedure is indicated in Figure Q1.3.1 about on a government-planning project.

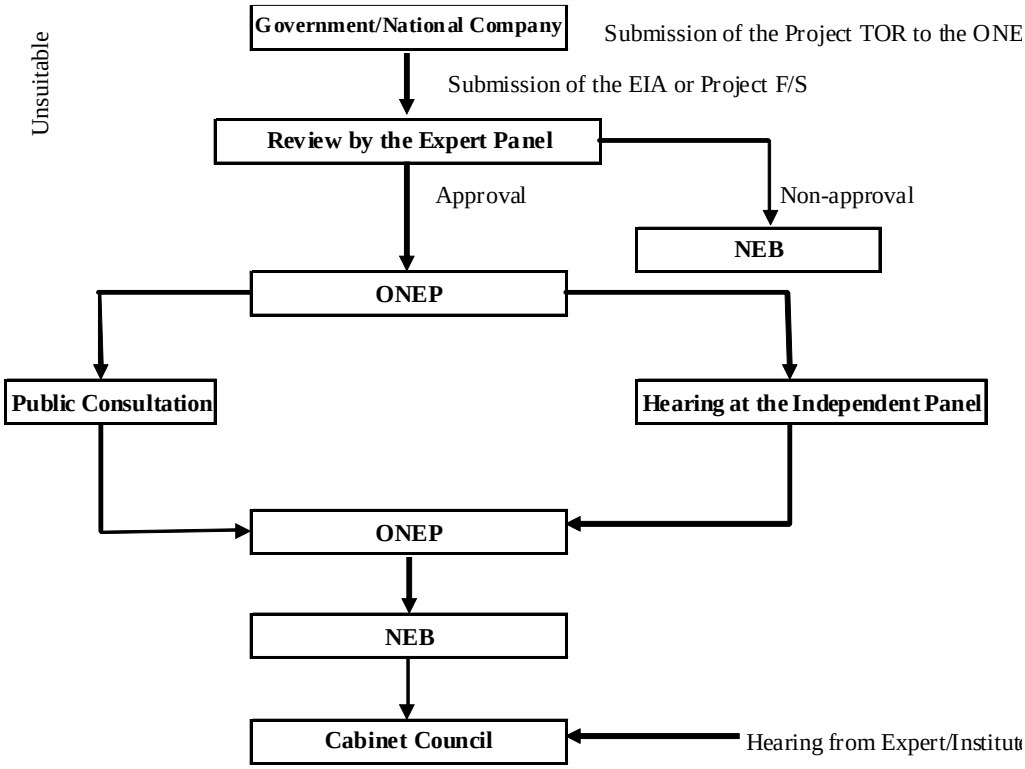


Figure Q1.3.1 Flow of EIA Implementation Procedure (Government-planning Project)

< Content of EIA report>

The EIA report shall contain the five items as follows:

1. Outline of the project including the project contents
2. Latest data on the environment in the project area
3. Environmental impact evaluation by the project implementation
4. Mitigation plan and its expenditures in order to prevent or minimize environmental impacts
5. Monitoring schedule of air and water quality

(3) Stakeholder Participation and Information Disclosure

The Constitution of Thailand in 2007, the latest version, defined the rights of people to participate and get information in environmental issues.

Article 67 - The right of person to participate with State and communities in the preservation and exploitation of natural resources and biological diversity and in the protection, promotion and conservation of the quality of the environment for usual and consistent survival in the environment which is not hazardous to his health and sanitary condition, welfare or quality of life, shall be protected appropriately.

(4) Relative Agencies and Institutions

The main ministry in charge of environmental issues is the Ministry of Natural Resources and Environment (MNRE). The MNRE works for creating the national environmental policies, regulations and standards, monitoring pollutions including water, air, waste, noise and vibration, soil etc., and enhancing motivation among people to protect the environment. Other government entities include the Ministry of Industry (MOI), Ministry of Interior, Ministry of Agriculture and Cooperatives, Ministry of Transport and Communications, Industrial Estate Authority of Thailand (IEAT), and Electricity Generating Authority of Thailand.

Q1.4 Comparative Review of Alternatives

A comparative review of the project and alternatives is shown in Table Q1.4.1, including the without project (zero option).

Table Q1.4.1 Comparative Review of Alternatives

Items	Zero Option (BaU)	Option 1 (SCWRM M/P)	Proposed Project (JICA M/P)
Outline	*No projects are planned.	*East/West Diversion Channels, running from Chao Phraya Dam to the Gulf of Thailand, with 260km long in the East Diversion Channel and 220km in the West Channel. *Both diversion channels run through outside the BMA protected area. *1,500m^3/s of the discharge capacity in together with two channels.	*Proposal of two diversion channels and one dike improvement as follow: 1) Ayutthaya Bypass Diversion Channel: 19km-long channel from the upstream of Ayutthaya to upstream of the confluence of the Noi River and the Chao Phraya River (CPR). 2) Outer Ring Road Diversion Channel: Approx. 100km-long channel from the downstream of Ayutthaya to the Gulf of Thailand running along the outer ring road (east portion). 3) Dike Improvement: new installation and additional elevation for Approx. 100km-long parapet walls and additional elevation for the existing secondary banks. *Discharge capacity 1) Ayutthaya: 1,400m^3/s 2) Outer Ring Road: 500/1,000m^3/s (two options)

Items		Zero Option (BaU)	Option 1 (SCWRM M/P)	Proposed Project (JICA M/P)
Technical & Economical Aspects	Advantages	*Nothing	*The channels have a potential to lower the water level in the Chao Phraya River between Nakhon Sawan and Chai Nat. *The channels can reduce the volume of inundation in the neighboring retention areas.	*Lowering the water level 1) Ayutthaya Bypass Channel: from Ayutthaya to Bang Sai of the CPR, and in the Pasak River. 2) Outer Ring Road Channel: between Ayutthaya and Bangkok of the CPR, and in the downstream Pasak River. 3) Dike Improvement: between Ayutthaya and Bangkok of the CPR. *High B/C value (incl. existing dam operation and river improvement) 5.9 (500m^3/s capacity in Outer Ring Channel) and 4.5 (1,000m^3/s), more than twice compared with the B/C in Op. 1. *Low cost and work period 28-37% of costs in Op.1
	Disadvantages	*Following items are not improved; 1) Damages on properties with citizens and industries. 2) Negative impacts on business activity *The 2011 mega flood resulted in more than 800 deaths and THB1.43 trillion of damages and losses.	*Effect of lowering water levels diminishes as going downstream where the areas to be protected spread out. *Structural ingenuities are required because of intersection with lots of vehicle roads and canals. *B/C value including other projects (existing dam operation and river improvement) is estimated as 2.2, lower than half the B/C values in the proposed project. *The work may need a number of years to complete.	*Effects of flood measures are limited because the measured areas are smaller than those in Op.1. *Structural ingenuities are required because of intersection with existing vehicle roads and canals.
Environmental & Social Aspects	Advantages	*Any human-caused environmental or social impacts will not occur because any projects are not conducted.	*Damages by floods will be reduced over the wider areas downstream Chai Nat.	*Industrial areas at Ayutthaya and southward are intensively protected from a flood. *The number of essential lands and households to be resettled are much smaller than those in Op.1. *Few or no land or resettlement for the dike improvement is needed.
	Disadvantages	* Following items are concerned; 1) Negative impacts on health by pollution or insanitation. 2) Corruption of local morals (looting, illegal settlement)	*A number of land acquisition and house resettlement are inevitable. *The broad project areas need time and effort for negotiations with the project affected persons (PAPs).	*Land acquisition and house resettlement are necessary (The number of affected houses: about 80 for Ayutthaya Bypass and some 600-900 for Outer Ring Road Channel).

Items	Zero Option (BaU)	Option 1 (SCWRM M/P)	Proposed Project (JICA M/P)
Judgment and Verification	**Not Recommended** *No contribution to measures for the flood is expected. *Worst impacts on local economy, environment and society are concerned compared to 'with project' options.	**Not Recommended** *Smaller economic advantage than those in Op.1. *Limited effect to avoid inundation in BMA and its vicinity. *Lots of time and costs are required for the assessment, land acquisition and compensation for the PAPs	**Recommended** *Large economic advantage with the project implementation. *Limited resettlement of the PAPs compared with the Op.1. *To contribute to flood management downstream the CPR and play a huge role in socio-economic security in Thailand.

Q1.5 Scoping

Lists of scoping of the project regarding both environmental and social issues are shown in Table Q1.5.1 for Ayutthaya Bypass Diversion Channel and in Table Q1.5.2 for Outer Ring Road Diversion Channel, respectively. In scoping for the dike improvement in Table Q1.5.3, essential items are listed because impacts on the environment by the construction works are considered limited in comparison with other two channel works.

Table Q1.5.1 Scoping Result of the Project – Ayutthaya Bypass Diversion Channel

Project Entity			Project Operator		
			Evaluation		
Category	No	Impacts	Pre-/ At-work	In-use	Reasons
Pollution	1	Air Pollution	B-	D	**At-work**: Operation of construction equipment may cause air pollution such as exhaust gas or dusts.
	2	Water Pollution	B-	B-	**At-work**: Waste water from the construction site may cause the surface water contamination in the existing canals or waterways. **In-use**: There is little possibility of water pollution inside the channel as the gates are usually opened. But a decrease in DO level is expected when being at high temperature or low water level.
	3	Waste	B-	D	**At-work**: Wastes from construction sites (soil, bottom sediment) or workers are concerned.
	4	Soil Contamination	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	**At-work**: Operation of construction equipment may generate noise and vibration.
	6	Ground Subsidence	B-	D	**At-work**: Ground subsidence during construction should be considered as the project area is on soft grounds in Thai Central Plain
	7	Offensive Odor	B-	B-	**At-work**: Rotten wet excavated soils may induce offensive odor. **In-use**: Rotten inside water may induce offensive odor.
	8	Bottom Sediment	D	D	Non-bottom concrete lining is expected to make little impact on the bottom sediment environment.

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
Natural Environment	9	Sanctuary	D	D	There are no national parks or sanctuaries around the project sites.
	10	Ecosystem	B-	B-	**At-work**: Impacts on aquatic organisms are concerned by excavation work, but the extent is unknown. Construction works may disturb the transportation of land animals. Add that no rare species of animals and plants are found at and around the project area. **In-use**: The new channel may disturb the transportation of land animals. Polluted water in the channel is expected to inhibit the healthy inhabitation of fish.
	11	Hydrological Situation	D	B+	**In-use**: The new channel will help flood mitigation at high water in the Chao Phraya River as a diversion bypass.
	12	Topography and Geographical Features	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: Facility improvement can be helpful against floods.
Social Environment	13	Involuntary Resettlement	A-	B-	**Pre-work**: Some houses are eligible for land expropriation and involuntary resettlement. Such expropriation and resettlement should be done in accordance with relevant laws, and an agreement for compensation will be conducted through an appropriate procedure. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
Social Environment	14	Poverty Group	B-	B-	**Pre-work**: Cautions are needed to avoid that the poverty group only would be a victim of project sub- effects like resettlement, temporal land occupation for stockyard or truck road. Compensation should be done properly if there would be an eligible poverty group associated with the resettlement. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
	15	Indigenous and Ethnic People	D	D	There are no indigenous and ethnic people around the project sites.
	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	**At-work**: Increase of job opportunity is expected with the construction work. **In-use**: Stabilizing local economy is expected with a decrease of flood damages in industrial estates etc.
	17	Land Use and Utilization of Local Resources	B-	B-	**Pre/At-work**: Land use for material storage and the office, or work of riverbank protection is expected. **In-use**: Lower productivity is expected in the arable land divided by the new channel.
	18	Water Usage or Water Rights and Rights of Common	D	D	No impact on the water rights or usage is expected because the new channel will be administrated by the authority in charge.
	19	Existing Social Infrastructures and Services	B-	D	**Pre/At-work**: Traffic for construction work may cause traffic congestion in the area. Coordination with the authorities concerned is required on borrowing/expropriation of junctions with the existing roads/canals.

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	**At-work**: A resident that is out of their benefit by the project could be an opponent against the project.
	21	Misdistribution of Benefit and Damage	D	D	Any unfair benefits or damages are not expected in the project areas because the land providers and the PAPs should take compensation based on a fair assessment.
	22	Local Conflict of Interests	B-	D	**Pre-work**: Local conflict of interests will be revealed in the process of discussion with eligible dwellers as resettlement may be essential in the implementation of the project.
	23	Cultural Heritage	D	D	There is no cultural heritage around the project sites.
	24	Landscape	B-	B-	**At-work**: Construction equipment in the site may spoil the sight. **In-use**: The new structure may change the landscape in the project sites.
	25	Gender	D	D	No impact on gender issues is expected despite occurrence of the resettlement.
	26	Children's Right	D	D	No impact on children's right is expected despite occurrence of the resettlement.
Social Environment	27	Infectious Diseases such as HIV/AIDS	B-	D	**At-work**: Transmission of infectious diseases is considered when infected workers inflow.
	28	Work Environment (incl. Work Safety)	B-	D	**At-work**: Considering work environment is necessary to prevent occupational injury or accidents.
	29	Accident	B-	D	**At-work**: Accidents induced by traffic congestion or construction work are possible.
Other	30	Trans-boundary Impact and Global Warming	B-	D	**At-work**: Operation of construction equipment or vehicles may increase the emission of CO_2, but the impact is expected minor.

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

Table Q1.5.2 Scoping Result of the Project – Outer Ring Road Diversion Channel

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
Pollution	1	Air Pollution	B-	D	**At-work**: Operation of construction equipment may cause air pollution such as exhaust gas or dusts.
	2	Water Pollution	B-	B-	**At-work**: Waste water from the construction site may cause the surface water contamination in the existing canals or waterways. **In-use**: There is a possibility of water pollution inside the channel as the gates are usually closed. Running upstream of the sea water is concerned when opening a gate on flooding or by climate conditions.
	3	Waste	B-	D	**At-work**: Wastes from construction sites (soil, bottom sediment) or workers are concerned.
	4	Soil Contamination	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	**At-work**: Operation of construction equipment may generate noise and vibration.
	6	Ground Subsidence	B-	D	**At-work**: Ground subsidence during construction should be considered as the project area is on soft grounds in Thai Central Plain
	7	Offensive Odor	B-	B-	**At-work**: Rotten wet excavated soils may induce offensive odor. **In-use**: Rotten inside water may induce offensive odor.
	8	Bottom Sediment	D	D	Non-bottom concrete lining is expected to make little impact on the bottom sediment environment.
Natural Environment	9	Sanctuary	D	D	There are no national parks or sanctuaries around the project sites.
	10	Ecosystem	B-	B-	**At-work**: Impacts on aquatic organisms are concerned by excavation work, but the extent is unknown. Construction works may disturb the transportation of land animals. Add that no rare species of animals and plants are found at and around the project area. **In-use**: The new channel may disturb the transportation of land animals. Polluted water in the channel is expected to inhibit the healthy inhabitation of fish.
	11	Hydrological Situation	D	B+	**In-use**: The new channel will help flood mitigation at high water in the Chao Phraya River as a diversion bypass.
	12	Topography and Geographical Features	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: Facility improvement can be helpful against floods.
Social Environment	13	Involuntary Resettlement	A-	B-	**Pre-work**: Some houses and facilities are eligible for land expropriation and involuntary resettlement. Such expropriation and resettlement should be done in accordance with relevant laws, and an agreement for compensation will be conducted through an appropriate procedure. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.

Project Entity			Project Operator		
Category	No	Impacts	Evaluation		Reasons
			Pre-/ At-work	In-use	
	14	Poverty Group	B-	B-	**Pre-work**: Cautions are needed to avoid that the poverty group only would be a victim of project sub- effects like resettlement, temporal land occupation for stockyard or truck road. Compensation should be done properly if there would be an eligible poverty group associated with the resettlement. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
	15	Indigenous and Ethnic People	D	D	There are no indigenous and ethnic people around the project sites.
	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	**At-work**: Increase of job opportunity is expected with the construction work. **In-use**: Stabilizing local economy is expected with a decrease of flood damages in industrial estates etc.
	17	Land Use and Utilization of Local Resources	B-	B-	**Pre/At-work**: Land use for material storage and the office, or work of riverbank protection is expected. **In-use**: Lower productivity is expected in the arable land divided by the new channel.
	18	Water Usage or Water Rights and Rights of Common	D	D	No impact on the water rights or usage is expected because the new channel will be administrated by the authority in charge.
Social Environment	19	Existing Social Infrastructures and Services	B-	D	**Pre/At-work**: Traffic for construction work may cause traffic congestion in the area. Coordination with the authorities concerned is required on borrowing/expropriation of junctions with the existing roads/canals.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	**At-work**: A resident that is out of their benefit by the project could be an opponent against the project.
	21	Misdistribution of Benefit and Damage	D	D	Any unfair benefits or damages are not expected in the project areas because the land providers and the PAPs should take compensation based on a fair assessment.
	22	Local Conflict of Interests	B-	D	**Pre-work**: Local conflict of interests will be revealed in the process of discussion with eligible dwellers as resettlement may be essential in the implementation of the project.
	23	Cultural Heritage	D	D	There is no cultural heritage around the project sites.
	24	Landscape	B-	B-	**At-work**: Construction equipment in the site may spoil the sight. **In-use**: The new structure may change the landscape in the project sites.
	25	Gender	D	D	No impact on gender issues is expected despite occurrence of the resettlement.
	26	Children's Right	D	D	No impact on children's right is expected despite occurrence of the resettlement.
	27	Infectious Diseases such as HIV/AIDS	B-	D	**At-work**: Transmission of infectious diseases is considered when infected workers inflow.
	28	Work Environment (incl. Work Safety)	B-	D	**At-work**: Considering work environment is necessary to prevent occupational injury or accidents.

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
	29	Accident	B-	D	**At-work**: Accidents induced by traffic congestion or construction work are possible.
Other	30	Trans-boundary Impact and Global Warming	B-	D	**At-work**: Operation of construction equipments or vehicles may increase the emission of CO_2, but the impact is expected minor.

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

Table Q1.5.3 Scoping Result of the Project – Dike Improvement

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
Pollution	1	Air Pollution	B-	D	**At-work**: Operation of construction equipment may cause air pollution such as exhaust gas or dusts.
	3	Waste	B-	D	**At-work**: Wastes from construction sites (soil, bottom sediment) or workers are concerned.
	4	Soil Contamination	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	**At-work**: Operation of construction equipment may generate noise and vibration.
	6	Ground Subsidence	B-	D	**At-work**: Ground subsidence during construction should be considered as the project area is on soft grounds in Thai Central Plain
Natural Environment	11	Hydrological Situation	D	B+	**In-use**: The raised dikes will reduce river water outflow outside the Chao Phraya River.
	12	Topography and Geographical Features	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: Facility improvement can be helpful against floods.
Social Environment	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	**At-work**: Increase of job opportunity is expected with the construction work. **In-use**: Stabilizing local economy is expected with a decrease of flood damages in industrial estates etc.
	17	Land Use and Utilization of Local Resources	B-	D	**Pre/At-work**: Land use for material storage and the office, or work of riverbank protection is expected.
	19	Existing Social Infrastructures and Services	B-	D	**Pre/At-work**: Traffic for construction work may cause traffic congestion in the area. Coordination with the authorities concerned is required on borrowing/ expropriation of junctions with the existing roads/canals.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	**At-work**: A resident that is out of their benefit by the project could be an opponent against the project.

Project Entity			Project Operator		
Category	No	Impacts	Evaluation		Reasons
			Pre-/ At-work	In-use	
	24	Landscape	B-	D	**At-work**: Construction equipment in the site may spoil the sight.
	27	Infectious Diseases such as HIV/AIDS	B-	D	**At-work**: Transmission of infectious diseases is considered when infected workers inflow.
	28	Work Environment (incl. Work Safety)	B-	D	**At-work**: Considering work environment is necessary to prevent occupational injury or accidents.
	29	Accident	B-	D	**At-work**: Accidents induced by traffic congestion or construction work are possible.
Other	30	Trans-boundary Impact and Global Warming	B-	D	**At-work**: Operation of construction equipment or vehicles may increase the emission of CO_2, but the impact is expected minor.

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

Q1.6 TOR for Survey on Environmental and Social Considerations

Based on the scoping in Section Q1.5, the TOR is designed and shown in Table Q1.6.1, after selecting the items that were ranked in B or more serious and will be required a survey.

Table Q1.6.1 TOR for Survey on Environmental and Social Considerations

No	Items	Item of Survey	Method of Survey
1	Air Pollution	1.Checking the environmental standards (Comparison of standards between Thailand and Japan) 2.Understanding of actual status of air quality 3.Checking the affected area during construction	1.Research of data & resource 2.Research of data & resource Actual measurement if necessary. 3.Collection and confirmation of the information on the project work -description, method, period, location /area and equipment used
2	Water Pollution	1.Checking the environmental standards (Comparison of standards between Thailand and Japan) 2.Checking the affected range during construction	1.Research of data & resource 2.Collection and confirmation of the information on the project work -description, method, period, location /area, and equipment used
3	Waste	1.Checking process of construction wastes	1.Hearing from relating authorities, collection of similar cases
4	Soil Contamination	1.Confirmation of the source of drinking water in affected areas	1.Hearing from relating authorities, field survey
5	Noise and Vibration	1.Checking the environmental standards (Comparison of standards between Thailand and Japan) 2.Checking the affected area during construction 3.Checking the affected range during construction	1.Research of data & resource 2.Field survey 3.Collection and confirmation of the information on the project work -description, method, period, location /area and equipment used

No	Items	Item of Survey	Method of Survey
6	Subsidence	1. Confirmation of the ground condition	1. Research of data & resource
7	Offensive Odor	1.Checking the environmental standards 2.Understanding of current status of offensive odor	1. Research of data & resource 2. Field survey
8	Bottom Sediment	1.Understanding of the bottom environment	1. Research of data & resource
10	Ecosystem	1.Understanding of the organisms in the area	1. Research of data & resource, hearing from relating authorities, field survey
12	Topography and Geographical Features	1. Checking the original land feature	1. Research of data & resource, field survey
13	Involuntary Resettlement	1.Confirmation of the scale of residents to be resettled 2.Establishing a Resettlement Action Plan - RAP *The RAP will be developed mainly by the operator (RID)	1.Survey of relating regulations Determination of households(houses) to be resettled based on designing and field survey 2.Household budget survey for the interested by field and interview surveys (property appraisal) Establishing a RAP in accordance with Thai regulations, JICA Guideline or WB Operational Policy 4.12
17	Land Use and Utilization of Local Resources	1. Confirmation of land securement regarding the construction (material storage etc.)	1.Hearing survey from the relating organizations
19	Existing Social Infrastructures and Services	1. Confirmation of the condition of existing infrastructures.	1. Research of data & resource, field survey
24	Landscape	1.Confirmation of impact scale by new structures (floodgate, riverbank)	1.Survey by design drawings
27	Infectious Diseases such as HIV/AIDS	1.Efforts against infectious Disease (Domestic legislation, attack in the industry)	1.Research of data & resource
28	Work Environment (incl. Work Safety)	1. Work safety practice (Domestic legislation, attack in the industry)	1. Research of data & resource
29	Accident	1.Road safety practice (Domestic legislation, attack in the industry)	1. Research of data & resource.
30	Trans-boundary Impact and Global Warming	1.Estimation of emission of global warming gas (At-work/In-use)	1.Research of data & resource (Estimation of future traffic volume, etc.).

Q1.7 Survey Results on Environmental and Social Considerations

Table Q1.7.1 and Table Q1.7.2 indicate the survey results of the two diversion channels in accordance with the TOR in previouse section.

Table Q1.7.1 Survey Results on Environmental and Social Considerations -Ayutthaya Bypass Diversion Channel-

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td>Air Pollution</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. The table below indicates the results of ambient air monitored at a station in Ayutthaya.
<table>
<tr><th>Station</th><th>Period</th><th>TPS 24 hr (mg/m^3)</th><th>NO_2 1 hr (ppm)</th><th>CO 1 hr (ppm)</th></tr>
<tr><td>Wittayalai School</td><td>2004.5 - 2007.8</td><td>0.056-0.066</td><td>0.011-0.014</td><td>0.5-0.7</td></tr>
<tr><td colspan="2">Environmental Standards</td><td>0.12</td><td>0.17</td><td>30</td></tr>
</table>
Note: Figures indicate the range from minimum to maximum during the monitoring period.
Source: *JICA (2008) The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.*
It's convenient to consider that the figures represent the air quality in the project sites because of some five km of distance between the sites and the monitoring post.
Although the data indicate the figures observed in 2004-2007, it is expected that the air quality would not drastically change and could be under the standards.
3. The number of vehicles worked and used for the project is under estimation. Trucks are contingent on every construction work. Sulfur dioxide (SO_2) could be listed as an air pollutant caused by the construction equipment operation as well as the substances monitored. These pollutants may diffuse toward the resident area depending on wind directions. Measures are taken like reducing the trip of trucks or strengthening the maintenance of construction equipments etc.</td></tr>
<tr><td>Water Pollution</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. The table below indicates the results of water quality monitored at stations in the middle and lower Chao Phraya River.
<table>
<tr><th>Station</th><th>Period</th><th>DO (mg/l)</th><th>BOD (mg/l)</th><th>TCB (MPN/100ml)</th></tr>
<tr><td>Middle CPR</td><td rowspan="2">2011</td><td>3.8-4.7</td><td>1.3-1.6</td><td>2,700-14,000</td></tr>
<tr><td>Lower CPR</td><td>3.0-3.7</td><td>1.4-3.6</td><td>9,700-65,000</td></tr>
<tr><td rowspan="2">Environmental Standards</td><td>Class 3</td><td>>4</td><td><2</td><td><20,000</td></tr>
<tr><td>Class 4</td><td>>2</td><td><4</td><td>-</td></tr>
</table>
Source: :*RID (2013) : Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management (in Thai)*
The water quality near the project sites seems to be classified in Class 4 despite seasonal changes.
3 Contents regarding the project are indicated in Table Q1.1.1. The project entity recommends minimum earthwork, work to secure water flow, maintenance of construction equipments to contractors in order to avoid surface water pollution.</td></tr>
<tr><td>Waste</td><td>1. Possible wastes generated by the construction work consist of dredged soil (approx. 17M m^3). Recyclable materials should be recycled or reused as much as possible, but concrete measures have not been determined. Note that wastes from a construction activity are classified as general waste in Thailand. Treatment will be conducted in accordance with the way that the local authority in charge determines.</td></tr>
<tr><td>Soil Contamination</td><td>1. Public water system generally develops for drinking and industrial use in housing communities. However, an isolated house may use groundwater. Soil contamination by work equipment should be considered in case the groundwater is used after a detailed survey.</td></tr>
<tr><td>Noise and Vibration</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.</td></tr>
</table>

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td></td><td>2. Monitoring records of noise and vibration in Ayutthaya have not been found yet. Here's the outputs obtained in Thai provincial cities by PCD. These data can provide a similar tendency of noise status in Ayutthaya
<table>
<tr><th>Location</th><th>L_{eq} 24h (dB(A))</th></tr>
<tr><td>Roadside</td><td>63 (54-77)</td></tr>
<tr><td>Residential Area</td><td>57 (44-74)</td></tr>
<tr><td>Environmental Standards</td><td>70</td></tr>
</table>
Note: Figures indicate average values. The range from minimum to maximum during monitoring period are provided in brackets.
Source: *JICA (2008) The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.*
The predictable value at the project sites is thought similar to those of roadside as most of the project sites locate along the main road.
For the estimation of noise generated by operating construction equipment, an assumption can explain as follow: Provided that a hydraulic hammer (8t) that is one of main noisy equipment is operated, the estimated noise level from the equipment would mark 90dB (A) at a site 15m from the work place. The result supports the noise by the project does not exceed the environmental standard of L_{max} (115dB (A)), and it is expected that the noise would not exceed the standard if operating a couple of equipments at the same time.
Instead, no standards have not been defined regarding vibration, nor obtained monitoring outputs. Evaluation is impossible by this reason.
3. Same as No.3 in Air Pollution. The works that would be required considering noise and vibration are 'earth work' and 'road construction'.</td></tr>
<tr><td>Subsidence</td><td>1. Unequal settlement seems ongoing in the Chao Phraya Plain constructed with soft ground layers by excess pumping-up of groundwater with the economic development and population concentration. Approx. 30cm of subsidence was reported near the project area during 1978-1987.
Reference: *Phienwej, N. et al. (2005) 'Land Subsidence Caused by Groundwater Pumpage in Bangkok', J. the Jpn. Geotechnical Society (in Japanese)*</td></tr>
<tr><td>Offensive Odor</td><td>1. There are no laws and regulations on offensive odor in Thailand.
2. Main perceptible type of odor in the project site derives from exhaust gas of vehicle. It is concerned about the generation of more offensive odor in the period with high ambient temperature.</td></tr>
<tr><td>Bottom Sediment</td><td>1. Document surveys reveal there are no rare species and organisms to be protected in/around the project sites. In the bottom sediment of canals, there is little possibility to inhabit rare species as the water quality in the new channel is full of highly polluted water (Class 4 or equivalent) from the Chao Phraya River.
References: *ONEP (2005) 'Thailand Red Data Book Series', JICA (2008) 'The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.', RID (2013) : 'Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management' (in Thai)*</td></tr>
<tr><td>Ecosystem</td><td>1. Document surveys reveal there are no rare species and organisms to be protected in/around the project sites. Main plants growing in the project area consist of weeds and miscellaneous trees. Plants to be protected have not been found by the field survey. In addition, most occupying animals are human-friendly and species such as birds to be protected are not determined.
References: *ONEP (2005) 'Thailand Red Data Book Series', JICA (2008) 'The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.', RID (2013) : 'Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management' (in Thai)*</td></tr>
<tr><td>Topography and Geographical Features Resettlement</td><td>1. The project area is located in the arable land of the Chao Phraya Plain and mostly is not used for houses or industrial activities. However, a proper ground treatment will be necessary to avoid a geographical change in the construction are as well as its surrounding because the blue-gray marine clay layer distributes under 30m from the ground level.
Reference: *Phienwej, N. et al. (2005) 'Land Subsidence Caused by Groundwater Pumpage in Bangkok', J. the Jpn. Geotechnical Society (in Japanese)*</td></tr>
</table>

Impact	Result
Involuntary Resettlement	1. Refer to the section of 'Land Expropriation and Resettlement' for further information. 2. About 82 households are expected for resettlement by the project. The project entity will develop the Resettlement Action Plan (RAP) reflecting the desires of persons or households involved. Repeating dialogues with the stakeholders and establishing a decision-making are essential in order that the eligible persons and its content will not be one-sided in accordance with conditions of the project entity.
Land Use and Utilization of Local Resources	1. Land for the project will be acquired in accordance with the Thai laws and regulations. In addition, the space for a local office, material stockyard and temporary area that are needed during the project will be prepared to the contractor with the support of the project entity.
Existing Social Infrastructures and Services	1. The project channel will cross two vehicle roads (10-32m width) and 18 canals (4-21m width). Negotiations are required regarding land use and deformation of the existing structures with the managers in charge of road (DOH, DOR) and canal (RID) as well as the local authorities in the project site.
Landscape	1. The new channel will provide protection fences and affiliated facilities that are considered to disturb the area's landscape. As a main driveway runs east side of the project channel and most lands to be acquired are in the arable land, a surprising impression is not expected to provide. In order to obtain consent from the stakeholders regarding the landscape, activities are required on showing the final design at the planning stage and laying out the design taking into account the opinions obtained in public consultations.
Infectious Diseases such as HIV/AIDS	1. There are no national laws or regulations relating to infectious diseases against construction workers. However, with the existing Labor Protection Law and Social Security Law under the Labor Protection Act 1998, construction workers are entitled to social security in which their health and welfare are covered. Any case of illness and infectious disease would be examined by medical professional provided according to the Social Security Law. Discharge of workers with infectious disease may entail compensation. In the past, Thailand launched an indoctrination program against infectious diseases such as HIV/AIDS for construction workers and local people with a help of JBIC and other organizations (The Second Mekong International Bridge Construction Project).
Work Environment (including Work Safety)	1. One of the laws for work environment in Thailand is Labor Protection Act in 1998. As for a guideline regarding construction work includes the Ministerial Ordinance for Determining the Standards of Operation and Administration on Work Safety, Sanitation and Environment Regarding Construction Work in 2008. The ordinance stipulates points of concern every construction works.
Accident	1. The Road Traffic Act in 1979 is the dominant law to regulate the road traffic in Thailand. In Thailand, concrete actions to avoid a traffic accident include: to notice the construction section using digital billboards or message boards, to lead cars to the roundabout way by barriers or a guide etc.
Trans-boundary Impact and Global Warming	1. Estimation of CO_2 by construction works is possible at the time when information is available including operating situation of work equipment and trucks, types and quantity of materials used. Taking account of the current condition of the estimation in process, the future precise data set can produce more reliable estimation of the emission.

Table Q1.7.2 Survey Results on Environmental and Social Considerations -Outer Ring Road Diversion Channel-

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td>Air Pollution</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. The table below indicates the results of ambient air monitored along the outer ring road by the DOH.
<table>
<tr><th>Site (STA.)</th><th>Period</th><th>TSP 24 hr (mg/m^3)</th><th>NO_2 1 hr (ppm)</th><th>CO 1 hr (ppm)</th></tr>
<tr><td rowspan="2">0km</td><td>Dry</td><td>0.061
(0.048-0.093)</td><td>0.014
(0.0067-0.036)</td><td>0.27
(0.14-0.95)</td></tr>
<tr><td>Rainy</td><td>0.060
(0.047-0.078)</td><td>0.011
(0.0054-0.0025)</td><td>0.33
(0.18-0.91)</td></tr>
<tr><td rowspan="2">22km</td><td>Dry</td><td>0.050
(0.040-0.059)</td><td>0.0068
(0.0040-0.015)</td><td>0.28
(0.15-0.99)</td></tr>
<tr><td>Rainy</td><td>0.039
(0.032-0.045)</td><td>0.0092
(0.0042-0.019)</td><td>0.43
(0.20-0.81)</td></tr>
<tr><td rowspan="2">40km</td><td>Dry</td><td>0.065
(0.050-0.097)</td><td>0.0103
(0.0048-0.0257)</td><td>0.41
(0.21-1.11)</td></tr>
<tr><td>Rainy</td><td>0.045
(0.041-0.052)</td><td>0.0091
(0.0045-0.0192)</td><td>0.59
(0.22-1.18)</td></tr>
<tr><td rowspan="2">51km</td><td>Dry</td><td>0.055
(0.050-0.060)</td><td>0.0095
(0.0058-0.0256)</td><td>0.85
(0.50-2.42)</td></tr>
<tr><td>Rainy</td><td>0.048
(0.042-0.059)</td><td>0.0152
(0.0064-0.0289)</td><td>0.66
(0.40-1.44)</td></tr>
<tr><td rowspan="2">60km</td><td>Dry</td><td>0.103
(0.078-0.119)</td><td>0.0068
(0.0044-0.0187)</td><td>0.24
(0.14-0.57)</td></tr>
<tr><td>Rainy</td><td>0.079
(0.069-0.091)</td><td>0.0144
(0.0061-0.0282)</td><td>0.60
(0.27-1.16)</td></tr>
<tr><td colspan="2">Environmental Standards</td><td>0.12</td><td>0.17</td><td>30</td></tr>
</table>
Note: Upper figures show periodical average, and the lower show min-max range during the period.
For Site (STA), 0km is at the north start point (junction with R1) and the others show distances from 0km point. The measurement was done in May 2011 for dry season and in October 2011 for rainy season.
Source: *DOH (2012) 'Monitoring of the Environmental Quality, Interstate Motorway Bangkok Outer Ring Road Eastern Side' (in Thai)*
All these values were under each standard. The project area is considered to have little impact on the polluted air from these heavy traffics though the area locates in the east side of the outer ring road. There are no sources generating serious air pollutants, either. Thus, it's convenient to consider that the figures could represent the air quality in the project sites
3. The number of vehicles worked and used for the project is under estimation. Trucks are contingent on every construction work. Sulfur dioxide (SO_2) could be listed as an air pollutant caused by the construction equipment operation as well as the substances monitored. These pollutants may diffuse toward the resident area depending on wind directions. Measures are taken like reducing the trip of trucks or strengthening the maintenance of construction equipments etc.</td></tr>
<tr><td>Water Pollution</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. The table below indicates the results of water quality monitored at stations in the middle and lower Chao Phraya River.
<table>
<tr><th>Station</th><th>Period</th><th>DO (mg/l)</th><th>BOD (mg/l)</th><th>TCB (MPN/100ml)</th></tr>
<tr><td>Middle CPR</td><td rowspan="2">2011</td><td>3.8-4.7</td><td>1.3-1.6</td><td>2,700-14,000</td></tr>
<tr><td>Lower CPR</td><td>3.0-3.7</td><td>1.4-3.6</td><td>9,700-65,000</td></tr>
<tr><td rowspan="2">Environmental Standards</td><td>Class 3</td><td>>4</td><td><2</td><td><20,000</td></tr>
<tr><td>Class 4</td><td>>2</td><td><4</td><td>-</td></tr>
</table>
Source: :*RID (2013) : Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management (in Thai)*
The water quality near the project sites seems to be classified in Class 4 despite seasonal changes. In addition, the water quality of some 85 of crossing canals and</td></tr>
</table>

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td></td><td>waterways was reported as Class 4 in general.
Source: DOH (2012) 'Monitoring of the Environmental Quality, Interstate Motorway Bangkok Outer Ring Road Eastern Side' (in Thai)
The area at 0-4m MSL is considered to have an influence by the sea water runup from the Gulf of Thailand. The tidal cycle twice a day produces 2m of average tidal variation (-0.5 to 1.5m). Sea level rise by the global warming or high tide by typhoons may have a negative impact on the sea water runup in the streams including the Chao Phraya River with the mouth at the Gulf
Reference: APN (2007) Climate Perturbation and Coastal Zone Systems in Asia Pacific Region: Holistic Approaches and Tools for Vulnerability Assessment and Sustainable Management Strategy.
3 Contents regarding the project are indicated in Table Q1.1.1. The project entity recommends minimum earthwork, work to secure water flow, maintenance of construction equipments to contractors in order to avoid surface water pollution.</td></tr>
<tr><td>Waste</td><td>1. Possible wastes generated by the construction work consist of dredged soil (approx. 43-53M m^3 at 500m^3/s capacity, 89-109M m^3 at 1,000m^3/s). Recyclable materials should be recycled or reused as much as possible, but concrete measures have not been determined. Note that wastes from a construction activity are classified as general waste in Thailand. Treatment will be conducted in accordance with the way that the local authority in charge determines.</td></tr>
<tr><td>Soil Contamination</td><td>1. Public water system generally develops for drinking and industrial use in housing communities. However, an isolated house may use groundwater. Soil contamination by work equipment should be considered in case the groundwater is used after a detailed survey.</td></tr>
<tr><td>Noise and Vibration</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. The table below indicates the results of noise monitored along the outer ring road by the DOH.
<table>
<tr><th>Site (STA.)</th><th>Period</th><th>Leq 24hr (dB(A))</th><th>Lmax (dB(A))</th><th>Distance from the Border</th></tr>
<tr><td rowspan="2">0km</td><td>Dry</td><td>64
(63-64)</td><td>95
(83-95)</td><td rowspan="2">20.0m</td></tr>
<tr><td>Rainy</td><td>63
(62-64)</td><td>91
(85-91)</td></tr>
<tr><td rowspan="2">22km</td><td>Dry</td><td>64
(59-66)</td><td>101
(83-101)</td><td rowspan="2">18.0m</td></tr>
<tr><td>Rainy</td><td>60
(58-64)</td><td>100
(82-100)</td></tr>
<tr><td rowspan="2">40km</td><td>Dry</td><td>66
(65-67)</td><td>96
(93-96)</td><td rowspan="2">34.0m</td></tr>
<tr><td>Rainy</td><td>64
(62-65)</td><td>101
(94-101)</td></tr>
<tr><td rowspan="2">51km</td><td>Dry</td><td>67
(66-67)</td><td>109
(97-109)</td><td rowspan="2">30.0m</td></tr>
<tr><td>Rainy</td><td>67
(66-67)</td><td>102
(94-102)</td></tr>
<tr><td rowspan="2">60km</td><td>Dry</td><td>66
(64-68)</td><td>100
(92-100)</td><td rowspan="2">53.0m</td></tr>
<tr><td>Rainy</td><td>64
(62-65)</td><td>101
(83-101)</td></tr>
<tr><td colspan="2">Environmental Standards</td><td>70</td><td>115</td><td></td></tr>
</table>
Note: Figures in the upper row show 24h average for Leq and the minimum for Lmax. Those in lower raw show min-max range during the monitoring period.
For Site (STA), 0km is at the north start point (junction with R1) and the others show distances from 0km point. The measurement was done in May 2011 for dry season and in October 2011 for rainy season.
Source: DOH (2012) 'Monitoring of the Environmental Quality, Interstate Motorway Bangkok Outer Ring Road Eastern Side' (in Thai)
All the values monitored did not exceed the standards at each point. It is expected the actual values would be under the standards alike the case of air pollution.
The predictable value at the project sites is thought similar to those of roadside as most of the project sites locate along the main road.</td></tr>
</table>

Impact	Result
	For the estimation of noise generated by operating construction equipment, an assumption can explain as follow: Provided that a hydraulic hammer (8t) that is one of main noisy equipment is operated, the estimated noise level from the equipment would mark 90dB (A) at a site 15m from the work place. The result supports the noise by the project does not exceed the environmental standard of L_{max} (115dB (A)), and it is expected that the noise would not exceed the standard if operating a couple of equipments at the same time. Instead, no standards have not been defined regarding vibration, nor obtained monitoring outputs. Evaluation is impossible by this reason. 3. Same as No.3 in Air Pollution. The works that would be required considering noise and vibration are 'earth work' and 'road construction'.
Subsidence	1. Unequal settlement seems ongoing in the Chao Phraya Plain constructed with soft ground layers by excess pumping-up of groundwater with the economic development and population concentration. Approx. 30cm of subsidence was reported near the project area during 1978-1987. Reference: *Phienwej, N. et al. (2005) 'Land Subsidence Caused by Groundwater Pumpage in Bangkok', J. the Jpn. Geotechnical Society (in Japanese)*
Offensive Odor	1. There are no laws and regulations on offensive odor in Thailand. 2. Main perceptible types of odor in the project site derive from exhaust gas of vehicle, sewage or polluted water and festering wastes. It is concerned about the generation of more offensive odor in the period with high ambient temperature.
Bottom Sediment	1. Document surveys reveal there are no rare species and organisms to be protected in/around the project sites. In the bottom sediment of canals, there is little possibility to inhabit rare species as the water quality in the new channel is full of highly polluted water (Class 4 or equivalent) from the Chao Phraya River. References: *ONEP (2005) 'Thailand Red Data Book Series', JICA (2008) 'The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.', RID (2013) : 'Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management' (in Thai)*
Ecosystem	1. Document surveys reveal there are no rare species and organisms to be protected in/around the project sites. Main plants growing in the project area consist of weeds and miscellaneous trees. Plants to be protected have not been found by the field survey. In addition, most occupying animals are human-friendly and species such as birds to be protected are not determined. References: *ONEP (2005) 'Thailand Red Data Book Series', JICA (2008) 'The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.', RID (2013) : 'Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management' (in Thai)*
Topography and Geographical Features Resettlement	1. The project area is located in the arable land of the Chao Phraya Plain and mostly is not used for houses or industrial activities. However, a proper ground treatment will be necessary to avoid a geographical change in the construction are as well as its surrounding because the blue-gray marine clay layer distributes under 30m from the ground level. Reference: *Phienwej, N. et al. (2005) 'Land Subsidence Caused by Groundwater Pumpage in Bangkok', J. the Jpn. Geotechnical Society (in Japanese)*
Involuntary Resettlement	1. Refer to the section of 'Land Expropriation and Resettlement' for further information. 2. About 540-570 households ($500m^3/s$ capacity) or 810-920 ($1,000m^3/s$) are expected for resettlement by the project. The project entity will develop the Resettlement Action Plan (RAP) reflecting the desires of persons or households involved. Repeating dialogues with the stakeholders and establishing a decision-making are essential in order that the eligible persons and its content will not be one-sided in accordance with conditions of the project entity.
Land Use and Utilization of Local Resources	1. Land for the project will be acquired in accordance with the Thai laws and regulations. In addition, the space for a local office, material stockyard and temporary area that are needed during the project will be prepared to the contractor with the support of the project entity.
Existing Social Infrastructures and	1. The project channel will cross 14 vehicle roads (8-90m width), 85 canals (2-63m width) and two railways. Negotiations are required regarding land use and deformation

Impact	Result
Services	of the existing structures with the managers in charge of road (DOH, DOR), canal (RID) and railway (SRT) as well as the local authorities in the project site.
Landscape	1. The new channel will provide protection fences and affiliated facilities that are considered to disturb the area's landscape. As a main driveway runs east side of the project channel and most lands to be acquired are in the arable land, a surprising impression is not expected to provide. In order to obtain consent from the stakeholders regarding the landscape, activities are required on showing the final design at the planning stage and laying out the design taking into account the opinions obtained in public consultations.
Infectious Diseases such as HIV/AIDS	1. There are no national laws or regulations relating to infectious diseases against construction workers. However, with the existing Labor Protection Law and Social Security Law under the Labor Protection Act 1998, construction workers are entitled to social security in which their health and welfare are covered. Any case of illness and infectious disease would be examined by medical professional provided according to the Social Security Law. Discharge of workers with infectious disease may entail compensation. In the past, Thailand launched an indoctrination program against infectious diseases such as HIV/AIDS for construction workers and local people with a help of JBIC and other organizations (The Second Mekong International Bridge Construction Project).
Work Environment (including Work Safety)	1. One of the laws for work environment in Thailand is Labor Protection Act in 1998. As for a guideline regarding construction work includes the Ministerial Ordinance for Determining the Standards of Operation and Administration on Work Safety, Sanitation and Environment Regarding Construction Work in 2008. The ordinance stipulates points of concern every construction works.
Accident	1. The Road Traffic Act in 1979 is the dominant law to regulate the road traffic in Thailand. In Thailand, concrete actions to avoid a traffic accident include: to notice the construction section using digital billboards or message boards, to lead cars to the roundabout way by barriers or a guide etc.
Trans-boundary Impact and Global Warming	1. Estimation of CO_2 by construction works is possible at the time when information is available including operating situation of work equipment and trucks, types and quantity of materials used. Taking account of the current condition of the estimation in process, the future precise data set can produce more reliable estimation of the emission.

Table Q1.7.3 Survey Results on Environmental and Social Considerations – Dike Improvement-

Impact	Result
Air Pollution	1., 2. and 3. Results are same as those in Table Q1.7.2.
Waste	1. Wastes to be generated are mostly soil, wed mud or river sediment. The total amount is unknown but it is expected the volume is minor. Like the channel project, recyclable materials should be recycled or reused as much as possible, but concrete measures have not been determined. Note that wastes from a construction activity are classified as general waste in Thailand. Treatment will be conducted in accordance with the way that the local authority in charge determines.
Soil Contamination	1. Public water system generally develops for drinking and industrial use in housing communities. However, an isolated house may use groundwater. Soil contamination by work equipment should be considered in case the groundwater is used after a detailed survey.
Noise and Vibration	1. and 2. Results are similar to those in Table Q1.7.2. 3. Same as No.3 in Air Pollution. The work that would be required considering noise and vibration is 'elevation'.
Ground Subsidence	1. Results are same as those in Table Q1.7.2.
Topography and Geographical Features	1. Results are same as those in Table Q1.7.2.
Land Use and Utilization of Local Resources	1. Results are same as those in Table Q1.7.2.

Impact	Result
Existing Social Infrastructures and Services	1. Most of the existing river banks were built by other authorities (BMA, DOH). For elevation of walls and banks, coordination with these authorities is essential in order to facilitate the work.
Landscape	1. This work is expected to give a minor impact on landscape because most construction works are for the existing parapet walls and secondary riverbanks. Additional wall elevation of 0.5m seems little influence on the river landscape as well. However, it is important to show the final picture of the work to people surrounding to mitigate a trouble during / after the construction.
Infectious Diseases such as HIV/AIDS	1. Results are same as those in Table Q1.7.2.
Work Environment (including Work Safety)	1. Results are same as those in Table Q1.7.2.
Accident	1. Results are same as those in Table Q1.7.2.
Trans-boundary Impact and Global Warming	1. Results are same as those in Table Q1.7.2.

Table Q1.7.4 Comparison of the Environmental Standards between Thailand and Japan

	Unit	Environmental Standard				Note
		Thailand[*1]		Japan		
Ambient Air Quality						
TSP	mg/m^3	0.33		-		24-hr average
PM10	mg/m^3	0.12		0.10		24-hr average *Categorized in SPM in Japan
SO_2	ppm	0.12		0.04		24-hr average
NO_2	ppm	0.17		0.06		1-hr average
CO	ppm	30		10		1-hr average
O_3	ppm	0.10		0.06		1-hr average
Surface Water Quality		**Class 3**	**Class 4**	**Type B**	**Type C**	Refer to the legend for classification of Class (Thailand) and Type (Japan)[*2]
pH	-	5-9	5-9	6.5-8.5	6.5-8.5	
SS	mg/l	-	-	<25	<50	
DO	mg/l	>4	>2	>5	>5	
BOD	mg/l	<2	<4	<3	<5	
TCB	MPN/100ml	<20,000	-	<5,000	-	
Noise		**L_{eq}**	**L_{max}**	**L_{eq}**	**Specified Construc-tion Work**	
	dB(A)	70	115	45-55 (60-65)	85	L_{eq} applicable to resident areas. Values in ( ) for an area facing the road with two lanes or more.
Vibration				**Specified Factory**	**Specified Construc-tion Work**	
	dB	No environmental standard determined.		55-65	75	

*1 Thai environmental standard is defined in Section 32 of the Enhancement and Conservation of National Environmental Quality Act in 1992

*2 Class 3: Water quality is classified in middle-class, mainly for irrigation use. Water processing is needed with a standard water processor before use.
Class 4: Water quality is less than that in Class 3, mainly for industrial use. Water processing is needed with a special processor before use.
Type B: Equivalent to water level 3 and fishery level 2, and to Class 3 in Thailand.
Type C: Equivalent to fishery level 3 and industry water level 1, and to Class 4 in Thailand.

Q1.8 Impact Evaluation

Table Q1.8.1 and Table Q1.8.2 how the re-evaluations of the scoping, based on the survey results on environmental and social considerations in Section Q1.7.

Table Q1.8.1 Impact Evaluation Based on the Survey Results - Ayutthaya Bypass Diversion Channel -

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	B-	D	**At-work**: Concrete impact areas were undetermined because the operating plan of construction equipment was not fixed. However, negative impacts to exceed the air quality standard are not expected because the current air quality meets the respective standards and works to produce serious air pollution are not planned.
	2	Water Pollution	B-	B-	B-	B-	**At-work**: Water quality in the canals in the project site is expected as Class 4(need a special treatment for use) because the water quality near the project sites in the Chao Phraya River is classified in the same class. Impacts on water quality by construction equipment operation like oil leakage are probable. **In-use**: Decrease of DO or TCB increment of the inner water in the new channel is possible in case of a high temperature or low water level.
	3	Waste	B-	D	B-	D	**At-work**: The project operator will secure a disposal site and properly process the wastes.
	4	Soil Contamination	B-	D	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	B-	D	**At-work**: The Survey revealed little impact on the ambient environment by noises from construction work. But impacts by change of work plan should be considered.
	6	Ground Subsidence	B-	D	B-	D	**At-work**: Measures to prevent subsidence should be needed for the construction work in the soft ground.
	7	Offensive Odor	B-	B-	B-	B-	**At-work**: Rotten wet excavated soils can be a cause of offensive odor. **In-use**: Rotten inner water of the channel can be a cause of offensive odor.
	8	Bottom Sediment	D	D	N/A	N/A	Same evaluation as the scoping.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Natural Environment	9	Sanctuary	D	D	N/A	N/A	Same evaluation as the scoping.
	10	Ecosystem	B-	B-	B-	B-	**At-work**: Even though no rare species have been found in the project area, traveling limitation of existing animals or resettlement of habitat is expected by the construction. **In-use**: Settling bridges over the channel will help animals to move around. However polluted inner water of the channel is concerned to give an impact on fish habitation.
	11	Hydrological Situation	D	B+	D	B+	**In-use**: Floodwater from the Chao Phraya River at high level will be mitigated or prevented.
	12	Topography and Geographical Features	B-	B+	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: The new channel can be helpful against the flood.
Social Environment	13	Involuntary Resettlement	A-	B-	A-	B-	**Pre-work**: The project entity is in charge of establishing a plan for land expropriation and resettlement of residents in accordance with relating laws. In the process of planning resettlement, living survey is conducted on the interested residents and compensation will be estimated later. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
	14	Poverty Group	B-	B-	B-	B-	**Pre-work**: Cautions are needed to avoid that the poverty group only would be a victim of project sub- effects like resettlement, temporal land occupation for stockyard or truck road. Compensation should be done properly if there would be an eligible poverty group associated with the resettlement. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location. For a temporary land use, returning the land as the original condition is needed.
	15	Indigenous and Ethnic People	D	D	N/A	N/A	Same evaluation as the scoping.
	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	B+	B+	**At-work**: Construction demands may provide a positive effect on regional employment and relating works as well. **In-use**: Stabilizing local economy is expected with a decrease of flood damages.
	17	Land Use and Utilization of Local Resources	B-	D	B-	D	**Pre-/At-work**: The site for a stockyard and the office will be prepared by the project entity cooperating with the government in the project area.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
	18	Water Usage or Water Rights and Rights of Common	D	D	N/A	N/A	Same evaluation as the scoping.
	19	Existing Social Infrastructures and Services	B-	D	B-	D	**Pre-/At-work**: Traffic for construction work may cause traffic congestion in the area.
Social Environment	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	B-	D	**At-work**: Extent of impact is still vague at present because opponents would come to the surface around the inauguration of the project.
	21	Misdistribution of Benefit and Damage	D	D	N/A	N/A	Same evaluation as the scoping.
	22	Local Conflict of Interests	B-	D	B-	D	**Pre-work**: Though any local conflict of interests has not been confirmed, the impact is expected minor because of improving the existing road.
	23	Cultural Heritage	D	D	N/A	N/A	Same evaluation as the scoping.
	24	Landscape	B-	B-	B-	B-	**At-work**: Construction equipment in the project area may spoil the landscape. **In-use**: The new structures may change the regional landscape, but the extent is expected minor.
	25	Gender	D	D	N/A	N/A	Same evaluation as the scoping.
	26	Children's Right	D	D	N/A	N/A	Same as above.
	27	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**At-work**: Now investigation concrete actions by RID. However, Thailand has experienced to do with an anti-AIDS activity in an int'l project.
	28	Work Environment (incl. Work Safety)	B-	D	B-	D	**At-work**: National regulations or guidelines regarding management of work safety in construction are available. Complying with these rules will assure a better work environment.
	29	Accident	B-	D	B-	D	**At-work**: Accidents can be reduced if information on roundabout roads and the direction for safe driving are sufficient.
Other	30	Trans-boundary Impact and Global Warming	B-	D	B-	D	**At-work**: Estimating CO_2 emission from construction equipments will be available after determination of the work plan. However, the impact on the environment is expected minor taking account of the project scale.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C+/-: Extend of positive (+)/negative (-) impact is unknown (A further examination is needed, and the impact could be clarified as the survey progresses).
D : No impact is expected.
N/A: Not Applicable.

Table Q1.8.2 Impact Evaluation Based on the Survey Results
-Outer Ring Road Diversion Channel-

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	B-	D	**At-work**: Concrete impact areas were undetermined because the operating plan of construction equipment was not fixed. However, negative impacts to exceed the air quality standard are not expected because the current air quality meets the respective standards and works to produce serious air pollution are not planned.
	2	Water Pollution	B-	B-	B-	B-	**At-work**: Water quality both in the canals and the Chao Phraya River near the project site is classified as Class 4(need a special treatment for use). Impacts on water quality by construction equipment operation like oil leakage are probable. **In-use**: Decrease of DO or TCB increment of the inner water in the new channel is possible in case of a high temperature or low water level. Salt damages by sea water runup when opening the sluice.
	3	Waste	B-	D	B-	D	**At-work**: The project operator will secure a disposal site and properly process the wastes.
	4	Soil Contamination	B-	D	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	B-	D	**At-work**: The Survey revealed little impact on the ambient environment by noises from construction work. But impacts by change of work plan should be considered.
	6	Ground Subsidence	B-	D	B-	D	**At-work**: Measures to prevent subsidence should be needed for the construction work in the soft ground.
	7	Offensive Odor	B-	B-	B-	B-	**At-work**: Rotten wet excavated soils can be a cause of offensive odor. **In-use**: Rotten inner water of the channel can be a cause of offensive odor.
	8	Bottom Sediment	D	D	N/A	N/A	Same evaluation as the scoping.
Natural Environment	9	Sanctuary	D	D	N/A	N/A	Same evaluation as the scoping.
	10	Ecosystem	B-	B-	B-	B-	**At-work**: Even though no rare species have been found in the project area, travel limitation of existing animals or resettlement of habitat is expected by the construction.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
							In-use: Settling bridges over the channel will help animals to move around. However polluted inner water of the channel is concerned to give an impact on fish habitation.
	11	Hydrological Situation	D	B+	D	B+	**In-use**: Floodwater from the Chao Phraya River at high level will be mitigated or prevented.
	12	Topography and Geographical Features	B-	B+	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: The new channel can be helpful against the flood.
Social Environment	13	Involuntary Resettlement	A-	B-	A-	B-	**Pre-work**: The project entity is in charge of establishing a plan for land expropriation and resettlement of residents in accordance with relating laws. In the process of planning resettlement, living survey is conducted on the interested residents and compensation will be estimated later. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
	14	Poverty Group	B-	B-	B-	B-	**Pre-work**: Cautions are needed to avoid that the poverty group only would be a victim of project sub- effects like resettlement, temporal land occupation for stockyard or truck road. Compensation should be done properly if there would be an eligible poverty group associated with the resettlement. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location. For a temporary land use, returning the land as the original condition is needed.
	15	Indigenous and Ethnic People	D	D	N/A	N/A	Same evaluation as the scoping.
	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	B+	B+	**At-work**: Construction demands may provide a positive effect on regional employment and relating works as well. **In-use**: Stabilizing local economy is expected with a decrease of flood damages.
	17	Land Use and Utilization of Local Resources	B-	D	B-	D	**Pre-/At-work**: The site for a stockyard and the office will be prepared by the project entity cooperating with the government in the project area.
	18	Water Usage or Water Rights and Rights of Common	D	D	N/A	N/A	Same evaluation as the scoping.
	19	Existing Social Infrastructures and Services	B-	D	B-	D	**Pre-/At-work**: Traffic for construction work may cause traffic congestion in the area.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	B-	D	**At-work**: Extent of impact is still vague at present because opponents would come to the surface around the inauguration of the project.
	21	Misdistribution of Benefit and Damage	D	D	N/A	N/A	Same evaluation as the scoping.
	22	Local Conflict of Interests	B-	D	B-	D	**Pre-work**: Though any local conflict of interests has not been confirmed, the impact is expected minor because of improving the existing road.
	23	Cultural Heritage	D	D	N/A	N/A	Same evaluation as the scoping.
	24	Landscape	B-	B-	B-	B-	**At-work**: Construction equipment in the project area may spoil the landscape. **In-use**: The new structures may change the regional landscape, but the extent is expected minor.
	25	Gender	D	D	N/A	N/A	Same evaluation as the scoping.
Social Environment	26	Children's Right	D	D	N/A	N/A	Same as above.
	27	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**At-work**: Now investigation concrete actions by RID. However, Thailand has experienced to do with an anti-AIDS activity in an int'l project.
	28	Work Environment (incl. Work Safety)	B-	D	B-	D	**At-work**: National regulations or guidelines regarding management of work safety in construction are available. Complying with these rules will assure a better work environment.
	29	Accident	B-	D	B-	D	**At-work**: Accidents can be reduced if information on roundabout roads and the direction for safe driving are sufficient.
Other	30	Trans-boundary Impact and Global Warming	B-	D	B-	D	**At-work**: Estimating CO_2 emission from construction equipments will be available after determination of the work plan. However, the impact on the environment is expected minor taking account of the project scale.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C+/-: Extend of positive (+)/negative (-) impact is unknown (A further examination is needed, and the impact could be clarified as the survey progresses).
D : No impact is expected.
N/A: Not Applicable.

Table Q1.8.3 Impact Evaluation Based on the Survey Results – Dike Improvement-

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	B-	D	**At-work**: Negative impacts to exceed the air quality standard are not expected because the current air quality meets the respective standards and works to produce serious air pollution are not planned.
	3	Waste	B-	D	B-	D	**At-work**: The project operator will secure a disposal site and properly process the wastes.
	4	Soil Contamination	B-	D	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	B-	D	**At-work**: The Survey revealed little impact on the ambient environment by noises from construction work. But impacts by change of work plan should be considered.
	6	Ground Subsidence	B-	D	B-	D	**At-work**: Measures to prevent subsidence should be needed for the construction work in the soft ground.
Natural Environment	11	Hydrological Situation	D	B+	D	B+	**In-use**: Overflowing the water from the Chao Phraya River at high level will be mitigated or prevented.
	12	Topography and Geographical Features	B-	B+	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: The wall elevation work can be helpful against the flood.
Social Environment	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	B+	B+	**At-work**: Construction demands may provide a positive effect on regional employment and relating works as well. **In-use**: Stabilizing local economy is expected with a decrease of flood damages.
	17	Land Use and Utilization of Local Resources	B-	D	B-	D	**Pre-/At-work**: The site for a stockyard and the office will be prepared by the project entity cooperating with the government in the project area.
	19	Existing Social Infrastructures and Services	B-	D	B-	D	**Pre-/At-work**: Traffic for construction work may cause traffic congestion in the area.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	B-	D	**At-work**: Extent of impact is still vague at present because opponents would come to the surface around the inauguration of the project.
	24	Landscape	B-	D	B-	D	**At-work**: Construction equipment in the project area may spoil the landscape.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
	27	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**At-work**: Now investigation concrete actions by RID. However, Thailand has experienced to do with an anti-AIDS activity in an int'l project.
	28	Work Environment (incl. Work Safety)	B-	D	B-	D	**At-work**: National regulations or guidelines regarding management of work safety in construction are available. Complying with these rules will assure a better work environment.
	29	Accident	B-	D	B-	D	**At-work**: Accidents can be reduced if information on roundabout roads and the direction for safe driving are sufficient.
Other	30	Trans-boundary Impact and Global Warming	B-	D	B-	D	**At-work**: Estimating CO_2 emission from construction equipments will be available after determination of the work plan. However, the impact on the environment is expected minor taking account of the project scale.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C+/-: Extend of positive (+)/negative (-) impact is unknown (A further examination is needed, and the impact could be clarified as the survey progresses).
D : No impact is expected.
N/A: Not Applicable.

Q1.9 Mitigation Plan

Table Q1.9.1 shows a possible mitigation plan for mitigating or minimizing the impacts on environmental and social concerns that were argued with.

Table Q1.9.1 Mitigation Plan

No.	Impacts	Mitigation Plan
Pre-/At-work		
1	Air Pollution	1. Conduct maintenance of construction equipment in order to keep good conditions. Take construction management to reduce unnecessary operation of the equipment. 2. Do watering on a proper area to prevent from disturbing dust. 3. Manage and direct to use trucks and vehicles complying with the national requirements for the emission criteria. In case of carrying sands or wastes, drive on the shortest route to minimize both CO_2 emission and fly of sand and dust covered with sheets. 4. Set monitoring items and monitor them at proper intervals according to the standards in Table Q1.7.4.
2	Water Pollution	1. Provide thorough instruction in routine maintenance and checkout to avoid a leakage of oil or hazardous materials from the construction equipment. 2. In order to avoid salinization of the river, construct a barrage at the estuary and discharge fresh water downstream for excluding the salted water. 3. Set monitoring items and monitor them at proper intervals according to the standards in Table Q1.7.4.
3	Waste	1. Construction debris: Convey the debris to the station specified by the operator or local authority and process them properly. 2. Garbage from workers: Pile up at the designated place inside the project area,

No.	Impacts	Mitigation Plan
		and process them under control by the contractor. At the same time, get across keeping the work site and its circumstance clean usually.
4	Soil Contamination	1. Provide thorough instruction in routine maintenance and checkout to avoid a leakage of oil or hazardous materials from the construction equipment.
5	Noise and Vibration	1. Use a noise-proof sheet covering a loudly construction equipment to reduce the noise generation as much as possible. With piling work, apply the method not using a hammer-typed pile driver. 2. Make a work plan to avoid the work during the night time. In case that the work at night is compelled to, make consideration not to cause a trouble to the residents around the project site. 3. When complained by residents, stop the work and take measures by the operator and contractor. 4. Set monitoring items and monitor them at proper intervals according to the standards in Table Q1.7.4.
6	Subsidence	1. Improve the soft ground condition to prevent the subsidence if required.
7	Offensive Odor	1. Dehydrate wet excavated soils or dredged sludge as much as possible and convey the treated soil or sludge to the deposit station promptly. On the way to the station, cover the truck carrier with sheets in order not to scatter these soils on the route. 2. When complained by residents, stop the work and take measures by the operator and contractor.
10	Ecosystem	1. Minimize to cut local trees and plants for the construction as many as possible. 2. In case that a precious/rare species of animal or plant is found in the project area, stop the work and take measures to protect the species in cooperation with the operator and an expert of the issue. 3. Preferably establish an alternative route for animal traffic.
12	Topography and Geographical Features	1. Conduct an engineering treatment within the affected area in order to avoid land deformation (e.g. landslide, subsidence etc.) by the construction.
13	Involuntary Resettlement	1. Establish the Resettlement Action Plan (RAP) reflecting the regional conditions such as livelihood of the affected persons, local culture or customs etc. Conduct public consultations to study and incorporate the voice of stakeholders into the RAP. 2. Take care of the resettled people not to receive inconvenience for their livelihood by the construction work (ex. Follow-up by interviewing).
14	Poverty Group	1. Take care of the group to prevent poverty from a cause of discrimination for compensation.
17	Land Use and Utilization of Local Resources	1. In case of requiring the ground outside the project site for material storage or an office, the project operator shall be responsible to prepare the ground and the contractor shall manage it without troubles.
19	Existing Social Infrastructures and Services	1. Collaborate with the authorities which administrate the infrastructure crossing the project channel in order to minimize the impact on these existing structures by the construction.
20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	1. The project operator shall explain the objectives and advantages of the project to the opponent, and try to obtain consent and agreement.
22	Local Conflict of Interests	1. The project operator shall play reconciliatory role with the conflict and support to solve.
24	Landscape	1. The operator shall manage to arrange the layout of equipment in the work site and enhance cleaning in order to maintain good landscape. 2. At the public consultation before starting the project, show the future feature after the construction to the residents and obtain understanding and consensus. 3. If needed, design the riverbank protection well-assorted with the surrounding landscape using woods or stones.
27	Infectious Diseases	1. Organize regular training sections to learn the correct knowledge about the

No.	Impacts	Mitigation Plan
	such as HIV/AIDS	diseases. 2. The project manager shall oversee workers to prevent risk activities.
28	Work Environment (incl. Work Safety)	1. Observe the working conditions according to the Thai related regulations (working time, wage etc.). 2. Make putting on a work wear and a helmet obligatory. 3. Practice educational activity regarding work safety utilizing morning meetings or training sessions. 4. Establish an emergency response system in case of an accident.
29	Accident	1. Allocate traffic controllers and arrange the passing vehicles properly on the roads around the project area. 2. In order to mitigate the traffic congestion, the project operator shall take measures through advance consultation with the operator and the local police 3. Set the speed limitation for construction vehicles, place signs or protective facilities in order for accident avoidance
30	Trans-boundary Impact and Global Warming	1. Estimate the emission of global warming gases generated during the project. 2. Specify a potential factor to reduce emission based on the estimated values, and strive to reduce the emission as much as possible (vehicles, work equipment etc.).
In-use		
2	Water Pollution	1. Channel off the river water with a regular gate opening to avoid the retention of rotten inner water (during low water level at high temperature, in particular). 2. Monitor or check the water quality condition not to exceed the criteria settled.
7	Offensive Odor	1. Same as No.1
10	Ecosystem	1. Same as No.1 2. In case a number of dead fish found in the new channel, conduct the water quality test to determine the cause and take appropriate measures by the operator.
13	Involuntary Resettlement	1. Secure the life of resettled people in accordance with the follow-up program of RAP.
14	Poverty Group	1. Same as No.13
24	Landscape	1. In case that a stakeholder or a community concerned makes any complains about the landscape regarding the new channel, the operator shall obtain opinions from whom complains and examine whether the requests could be resolved. Public involvement is one of measures in order to solve the questions.

Q1.10 Evaluation for the Project in Tha Chin River

Q1.10.1 Outline of the Project

Measures like dike road elevation (secondary dike) in the midstream of the Chao Phraya River basin are likely to contribute to mitigating floods in the Bangkok upstream and increasing the water inflowing into the Tha Chin River. Although the outer ring road diversion channel in the Master Plan may play a role in buffering water inflow into the Tha Chin River, an increase in water level in the Tha Chin River and inundations in the basin are inevitable with these measures. In order to mitigate the disaster, the following improvement plans for the Tha Chin River are examined.

1) Short cut channels in meandering parts of the lower basin
2) River channel improvement
3) Embankment

Q1.10.2 Project Location

The location of the project is illustrated in Figure Q1.10.1. Four short cut channels are to be installed in the lower basin of the Tha Chin River (21 – 87km). River channel improvement ranges 90 to 141km points to elevate the existing dike roads. The new embankment is to be established from 0 to 90km points, except parapet walls in the estuary area.

Q1.10.3 Activities Requiring Environmental and Social Considerations

When conducting the construction works in the project, the following activities should be taken into account for the environmental and social considereations.

1) Canal work (Earth work, road, canal lining and ground improvement)
2) Facility work (Road bridge, floodgate)
3) Riverbank work (Embankment)
4) Dike work (Parapet wall, elevation)
5) Material handling (Truck operating)

Outline of the work required is shown in Table Q1.10.1.

Table Q1.10.1 Outline of the Works Related

Work Type	Content of Work	Outline	Main Equipment
Canal	Earth work	Excavation, Soil disposal, Embankment	Backhoe, Dozer
	Road work	Basement (sub-base and base course), Finishing (asphalt concrete pavement)	Motor grader, Vibratory roller, Tired roller, Asphalt finisher
	Canal lining	Lining with concrete	Concrete mixing vehicle, Crane
Facility	Road bridge	Bridges over the canal to pass	Concrete mixing vehicle, Crane, Pile driver
	Floodgate	With both connecting sites of the River	Crane for truck mount, Backhoe, Dozer, Pile driver, Vibratory hammer
River bank	Embankment	Earthfill to build riverbanks	Backhoe, Dozer, Scraper
Dike	Wall work	Parapet wall installation	Backhoe, Dozer, Concrete mixing vehicle, Crane
	Elevation work	Elevation walls for enough wall and dyke height	Concrete mixing vehicle, Crane

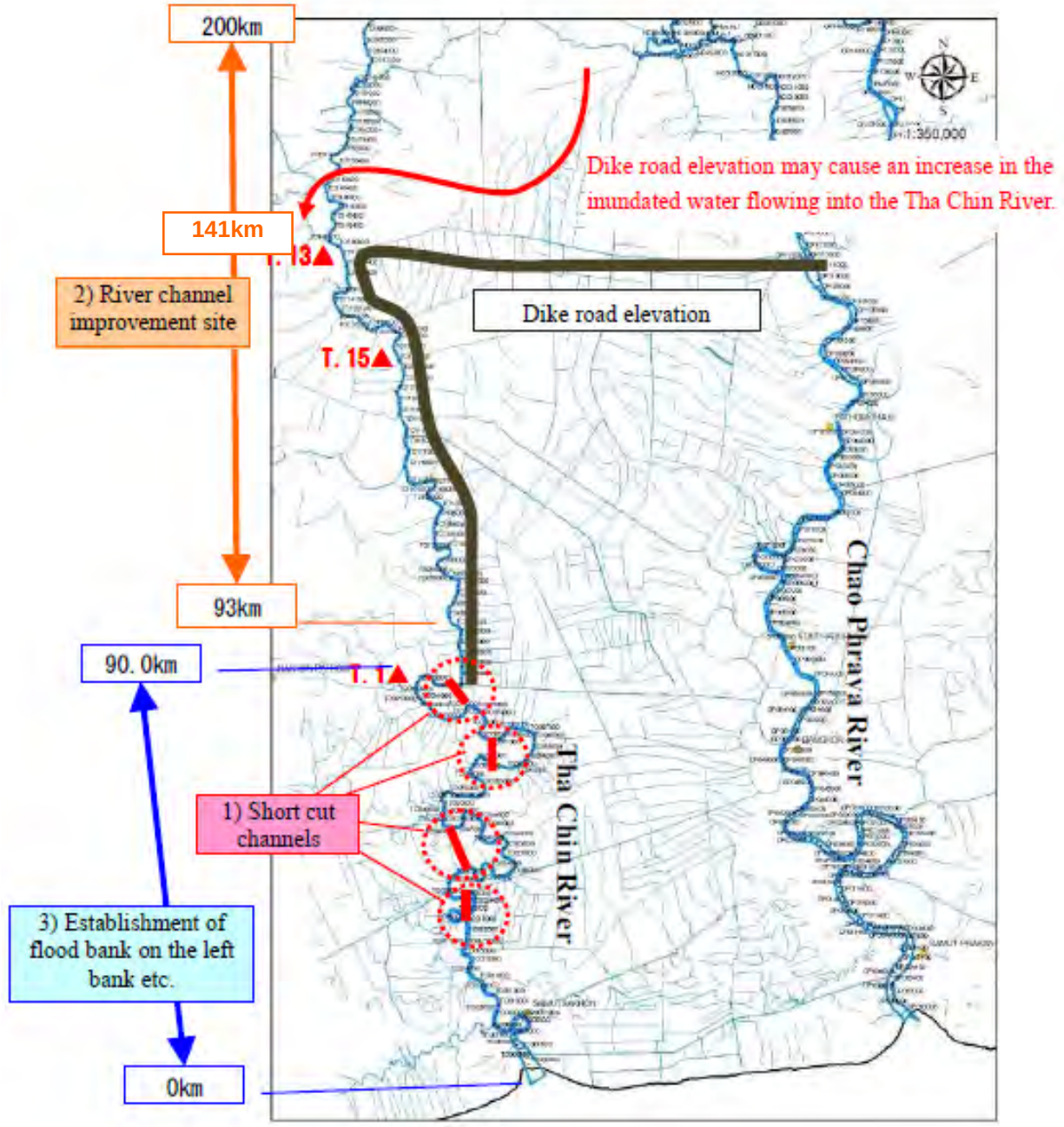


Figure Q1.10.1 Project Location – Tha Chin River

Q1.10.4 Fundamental Environmental and Social Conditions

Typical conditions in the Tha Chin River and the basin are as follows. See Section Q1.2 for the common conditions.

(1) Topography and Land Use

Located in Thailand's central plain, the Tha Chin River is a distributary of the Chao Phraya River, Thailand's largest river system. The river covers an area of approx. 14,000km^2 and begins at Makham Thao Subdistrict, Wat Sing District of Chainat. It flows through Suphan Buri, Nakhon Pathom and drains to the Gulf of Thailand at Samut Sakhon, with 439km of the whole length. The lower river basin connects to the Mae Klong River basin.

Ninety percent of the basin is used for agriculture - paddy field, field crop, perennial. Forests

(7%) are located in the northwest of the catchment. The slope of the river becomes smooth downwards: 1/10,200 (200-180km), 1/32,000 (180-100km) and 1/54,000 (100-0km).

(2) Water Resources

The water quality in the Tha Chin River by a PCD survey in 2011 showed "Deteriorated". The Tha Chin River is recognized as one of the most polluted rivers in Thailand because runoff from agricultural and livestock activities, notably wastewater discharges from intensive agriculture, are significant sources of pollution in the watershed.

(3) Social Conditions

The Tha Chin River basin covers most parts of Suphan Buri Province. Assumed by the condition, the population of the Basin is estimated 850,000 at most, occupying 1.2% of the country's population.

For local economy, the western area where Suphan Buri Province belongs produces 4.3% of the country's GDP in 2009. The area is dominant in agriculture compared with other regions. In secondary industry, public works mainly support the industry but the growth of private sector has been still on a delay. The tendency is common in service sector as well.

Q1.10.5 Scoping

Scoping result of the Tha Chin River Project is shown in Table Q1.10.2.

Table Q1.10.2 Scoping Result of the Project – Tha Chin River Project

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
Pollution	1	Air Pollution	B-	D	**At-work**: Operation of construction equipment may cause air pollution such as exhaust gas or dusts.
Pollution	2	Water Pollution	B-	B-	**At-work**: Waste water from the construction site may cause the surface water contamination in the existing canals or waterways. **In-use**: There is little possibility of water pollution inside the channel as the gates are usually opened. But a decrease in DO level is expected when being at high temperature or low water level in the bypass channels. Short cut channel construction may cause salt water intrusion toward more upstream from the Gulf of Thailand because of shrinking the river length.
Pollution	3	Waste	B-	D	**At-work**: Wastes from construction sites (soil, bottom sediment) or workers are concerned.
Pollution	4	Soil Contamination	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
Pollution	5	Noise and Vibration	B-	D	**At-work**: Operation of construction equipment may generate noise and vibration.
Pollution	6	Ground Subsidence	B-	D	**At-work**: Ground subsidence during construction should be considered as the project area is on soft grounds in Thai Central Plain
Pollution	7	Offensive Odor	B-	B-	**At-work**: Rotten wet excavated soils may induce offensive odor. **In-use**: Rotten inside water may induce offensive odor.
Pollution	8	Bottom Sediment	D	D	Non-bottom concrete lining is expected to make little impact on the bottom sediment environment.
al Envir onme	9	Sanctuary	D	D	There are no national parks or sanctuaries around the project sites.

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
	10	Ecosystem	B-	B-	**At-work**: Impacts on aquatic organisms are concerned by excavation work, but the extent is unknown. Construction works may disturb the transportation of land animals. Add that no rare species of animals and plants are found at and around the project area. **In-use**: The new channels may give some impacts on the transportation of land animals. Polluted water in the channel is expected to inhibit the healthy inhabitation of fish.
	11	Hydrological Situation	D	B+	**In-use**: The new channels and riverbanks will help flood mitigation at high water in the Tha Chin River as a diversion bypass.
	12	Topography and Geographical Features	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: Facility improvement can be helpful against floods.
Social Environment	13	Involuntary Resettlement	B-	B-	**Pre-work**: Some houses may have an impact by the bypass channel and embankment but the extent is expected minor because most construction works will be planned in non-residential parts of the basin. If land acquisition and resettlement are required, they should be done in accordance with relevant laws, and an agreement for compensation will be conducted through an appropriate procedure. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location if the case occurs.
	14	Poverty Group	B-	B-	**Pre-work**: Cautions are needed to avoid that the poverty group only would be a victim of project sub- effects like resettlement, temporal land occupation for stockyard or truck road. Compensation should be done properly if there would be an eligible poverty group associated with the resettlement. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
	15	Indigenous and Ethnic People	D	D	There are no indigenous and ethnic people around the project sites.
Social Environment	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	**At-work**: Increase of job opportunity is expected with the construction work. **In-use**: Stabilizing local economy is expected with a decrease of flood damages in industrial estates etc.
	17	Land Use and Utilization of Local Resources	B-	B-	**Pre/At-work**: Land use for material storage and the office, or other work is expected. **In-use**: Lower productivity is expected in the arable land divided by the new channels but the extent seems minor.
	18	Water Usage or Water Rights and Rights of Common	D	D	No impact on the water rights or usage is expected because the new channel will be administrated by the authority in charge.
	19	Existing Social Infrastructures and	B-	D	**Pre/At-work**: Traffic for construction work may cause traffic congestion in the area. Coordination with the

Project Entity			Project Operator		
Category	No	Impacts	Evaluation: Pre-/ At-work	Evaluation: In-use	Reasons
		Services			authorities concerned is required on borrowing/expropriation of junctions with the existing roads/canals.
	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	**At-work**: A resident that is out of their benefit by the project could be an opponent against the project.
	21	Misdistribution of Benefit and Damage	D	D	Any unfair benefits or damages are not expected in the project areas because the land providers and the PAPs should take compensation based on a fair assessment.
	22	Local Conflict of Interests	B-	D	**Pre-work**: Local conflict of interests will be revealed in the process of discussion with eligible dwellers as resettlement may be essential in the implementation of the project.
	23	Cultural Heritage	D	D	There is no cultural heritage around the project sites.
	24	Landscape	B-	B-	**At-work**: Construction equipment in the site may spoil the sight. **In-use**: The new structure may change the landscape in the project sites.
	25	Gender	D	D	No impact on gender issues is expected despite occurrence of the resettlement.
	26	Children's Right	D	D	No impact on children's right is expected despite occurrence of the resettlement.
	27	Infectious Diseases such as HIV/AIDS	B-	D	**At-work**: Transmission of infectious diseases is considered when infected workers inflow.
	28	Work Environment (incl. Work Safety)	B-	D	**At-work**: Considering work environment is necessary to prevent occupational injury or accidents.
	29	Accident	B-	D	**At-work**: Accidents induced by traffic congestion or construction work are possible.
Other	30	Trans-boundary Impact and Global Warming	B-	D	**At-work**: Operation of construction equipment or vehicles may increase the emission of CO_2, but the impact is expected minor.

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

Q1.10.6 Survey Results on Environmental and Social Considerations

Based on the result in Section Q1.10.5 referring to the TOR for survey in Section Q1.6, the survey results in the Tha Chin River project is indicated in Table xxx.

Table Q1.10.3 Survey Results on Environmental and Social Considerations - Tha Chin Project-

Impact	Result
Air Pollution	1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4. 2. Although the data on air quality in the area was not obtained, it is assumed the extent of air quality is not far away from those in Ayutthaya area because of magnitude of industry and population. Already mentioned in Table Q1.7.1, it could

<table>
<tr><th>Impact</th><th>Result</th></tr>
<tr><td></td><td>be certain few air problems in the project area as a background status.
3. The number of vehicles worked and used for the project is under estimation. Trucks are contingent on every construction work. Sulfur dioxide (SO_2) could be listed as an air pollutant caused by the construction equipment operation as well as the substances monitored. These pollutants may diffuse toward the resident area depending on wind directions. Measures are taken like reducing the trip of trucks or strengthening the maintenance of construction equipments etc.</td></tr>
<tr><td>Water Pollution</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. As mentioned before, the water quality in the Tha Chin River is not good. According to the sequential monitoring data by PCD in July 2013, the value of DO is below the Class 3 standard (>4 mg/l) even in the upper stream (3.4 mg/l). On the other hand, in the midstream (0.2 mg/l) and lower stream (0.1 mg/l), DOs are quite lower than the Class 4 standard (>2 mg/l). Unfortunately other parameters are unknown but it is not hard to consider they would not have good quality.
3. Contents regarding the project are indicated in Table Q1.1.1. The project entity recommends minimum earthwork, work to secure water flow, maintenance of construction equipments to contractors in order to avoid surface water pollution.</td></tr>
<tr><td>Waste</td><td>1. The work for short cut channels will produce dredged soil as wastes but the volume is under estimation. Recyclable materials should be recycled or reused as much as possible, but concrete measures have not been determined. Note that wastes from a construction activity are classified as general waste in Thailand. Treatment will be conducted in accordance with the way that the local authority in charge determines.</td></tr>
<tr><td>Soil Contamination</td><td>1. Public water system generally develops for drinking and industrial use in housing communities. However, an isolated house may use groundwater. Soil contamination by work equipment should be considered in case the groundwater is used after a detailed survey.</td></tr>
<tr><td>Noise and Vibration</td><td>1. A summary of environmental standards in Thailand and Japan is shown in Table Q1.7.4.
2. Monitoring records of noise and vibration in the project area have not been found yet. Here's the outputs obtained in Thai provincial cities by PCD. These data can provide a similar tendency of noise status in the project sites.
<table><tr><th>Location</th><th>L_{eq} 24h (dB(A))</th></tr><tr><td>Roadside</td><td>63 (54-77)</td></tr><tr><td>Residential Area</td><td>57 (44-74)</td></tr><tr><td>Environmental Standards</td><td>70</td></tr></table>Note: Figures indicate average values. The range from minimum to maximum during monitoring period are provided in brackets.
Source: *JICA (2008) The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.*
The predictable value at the project sites is thought similar to those of roadside as most of the project sites locate along the main road.
For the estimation of noise generated by operating construction equipment, an assumption can explain as follow: Provided that a hydraulic hammer (8t) that is one of main noisy equipment is operated, the estimated noise level from the equipment would mark 90dB (A) at a site 15m from the work place. The result supports the noise by the project does not exceed the environmental standard of L_{max} (115dB (A)), and it is expected that the noise would not exceed the standard if operating a couple of equipments at the same time.
Instead, no standards have not been defined regarding vibration, nor obtained monitoring outputs. Evaluation is impossible by this reason.
3. Same as No.3 in Air Pollution. The works that would be required considering noise and vibration are 'earth work' and 'road construction'.</td></tr>
<tr><td>Ground Subsidence</td><td>1. Unequal settlement seems ongoing in the Chao Phraya Plain constructed with soft ground layers by excess pumping-up of groundwater with the economic development</td></tr>
</table>

Impact	Result
	and population concentration. Approx. 30cm of subsidence was reported near the project area during 1978-1987. Reference: *Phienwej, N. et al. (2005) 'Land Subsidence Caused by Groundwater Pumpage in Bangkok', J. the Jpn. Geotechnical Society (in Japanese)*
Offensive Odor	1. There are no laws and regulations on offensive odor in Thailand. 2. Main perceptible type of odor in the project site derives from exhaust gas of vehicle. It is concerned about the generation of more offensive odor in the period with high ambient temperature.
Ecosystem	1. Document surveys reveal there are no rare species and organisms to be protected in/around the project sites. Main plants growing in the project area consist of weeds and miscellaneous trees. Plants to be protected have not been found by the field survey. In addition, most occupying animals are human-friendly and species such as birds to be protected are not determined. References: *ONEP (2005) 'Thailand Red Data Book Series', JICA (2008) 'The Study on Supporting System for Local Administrations on Natural Resources and Environmental Management in the Kingdom of Thailand.', RID (2013) : 'Feasibility and Environmental Impact study Project- West Chao Phraya River Area Water Management' (in Thai)*
Topography and Geographical Features Resettlement	1. The project area is located in the arable land of a part of the Chao Phraya Plain and mostly is not used for houses or industrial activities. However, a proper ground treatment will be necessary to avoid a geographical change in the construction are as well as its surrounding because the blue-gray marine clay layer distributes under 30m from the ground level. Reference: *Phienwej, N. et al. (2005) 'Land Subsidence Caused by Groundwater Pumpage in Bangkok', J. the Jpn. Geotechnical Society (in Japanese)*
Involuntary Resettlement	1. Refer to the section of 'Land Expropriation and Resettlement' for further information. 2. Some people may be affected by the construction of parapet walls around the estuary but the amount is uncertain. As the scale of work is small, the influence is considered to be limited. The project entity will develop the Resettlement Action Plan (RAP) reflecting the desires of persons or households involved. Repeating dialogues with the stakeholders and establishing a decision-making are essential in order that the eligible persons and its content will not be one-sided in accordance with conditions of the project entity.
Land Use and Utilization of Local Resources	1. Land for the project will be acquired in accordance with the Thai laws and regulations. In addition, the space for a local office, material stockyard and temporary area that are needed during the project will be prepared to the contractor with the support of the project entity.
Existing Social Infrastructures and Services	1. The project area in the Tha Chin River crosses six main vehicle roads and one railway. Negotiations are required regarding land use and deformation of the existing structures with the managers in charge of road (DOH, DOR) and railway (SRT) as well as the local authorities in the project site.
Landscape	1. The new short cut channel and embankment will provide a bit strange view and affiliated facilities that are considered to disturb the area's landscape. However the most construction will give minor modification on the land so people will feel little difference after the completion. In order to obtain consent from the stakeholders regarding the landscape, activities are required on showing the final design at the planning stage and laying out the design taking into account the opinions obtained in public consultations.
Infectious Diseases such as HIV/AIDS	1. There are no national laws or regulations relating to infectious diseases against construction workers. However, with the existing Labor Protection Law and Social Security Law under the Labor Protection Act 1998, construction workers are entitled to social security in which their health and welfare are covered. Any case of illness and infectious disease would be examined by medical professional provided according to the Social Security Law. Discharge of workers with infectious disease may entail compensation. In the past, Thailand launched an indoctrination program against infectious diseases such as HIV/AIDS for construction workers and local people with a help of JBIC and other organizations (The Second Mekong International Bridge Construction Project).
Work Environment	1. One of the laws for work environment in Thailand is Labor Protection Act in 1998.

Impact	Result
(including Work Safety)	As for a guideline regarding construction work includes the Ministerial Ordinance for Determining the Standards of Operation and Administration on Work Safety, Sanitation and Environment Regarding Construction Work in 2008. The ordinance stipulates points of concern every construction works.
Accident	1. The Road Traffic Act in 1979 is the dominant law to regulate the road traffic in Thailand. In Thailand, concrete actions to avoid a traffic accident include: to notice the construction section using digital billboards or message boards, to lead cars to the roundabout way by barriers or a guide etc.
Trans-boundary Impact and Global Warming	1. Estimation of CO_2 by construction works is possible at the time when information is available including operating situation of work equipment and trucks, types and quantity of materials used. Taking account of the current condition of the estimation in process, the future precise data set can produce more reliable estimation of the emission.

Q1.10.7 Impact Evaluation

The impact evaluation in accordance with the survey is provided in Table Q1.10.4.

Table Q1.10.4 Impact Evaluation Based on the Survey Results – Tha Chin Project-

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
Pollution	1	Air Pollution	B-	D	B-	D	**At-work**: Detailed impact areas were undetermined because the operating plan of construction equipment was not fixed. However, negative impacts to exceed the air quality standard are not expected because the current air quality meets the respective standards and works to produce serious air pollution are not planned.
	2	Water Pollution	B-	B-	B-	B-	**At-work**: Water quality in the new channels is expected below Class 4(need a special treatment for use) because the water quality in the Tha Chin River is classified in the same class. Impacts on water quality by construction equipment operation like oil leakage are probable. **In-use**: Decrease of DO or TCB increment of the inner water in the new channel is possible in case of a high temperature or low water level.
	3	Waste	B-	D	B-	D	**At-work**: The project operator will secure a disposal site and properly process the wastes.
	4	Soil Contamination	B-	D	B-	D	**At-work**: Oil from the construction equipment may cause soil contamination.
	5	Noise and Vibration	B-	D	B-	D	**At-work**: The Survey revealed little impact on the ambient environment by noises from construction work. But impacts by change of work plan should be considered.
	6	Ground Subsidence	B-	D	B-	D	**At-work**: Measures to prevent subsidence should be needed for the construction work in the soft ground.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
	7	Offensive Odor	B-	B-	B-	B-	**At-work**: Rotten wet excavated soils can be a cause of offensive odor. **In-use**: Rotten inner water of the channel can be a cause of offensive odor.
	8	Bottom Sediment	D	D	N/A	N/A	Same evaluation as the scoping.
Natural Environment	9	Sanctuary	D	D	N/A	N/A	Same evaluation as the scoping.
	10	Ecosystem	B-	B-	B-	B-	**At-work**: Even though no rare species have been found in the project area, traveling limitation of existing animals or resettlement of habitat is expected by the construction. **In-use**: Settling bridges over the channel will help animals to move around. However polluted inner water of the channel is concerned to give an impact on fish habitation.
	11	Hydrological Situation	D	B+	D	B+	**In-use**: Floodwater from the Tha Chin River at high level will be mitigated or prevented.
	12	Topography and Geographical Features	B-	B+	B-	B+	**At-work**: Dredging work may deform the original land form. **In-use**: The new channel can be helpful against the flood.
Social Environment	13	Involuntary Resettlement	B-	B-	B-	B-	**Pre-work**: Even though the number of PAPs is small, the project entity is in charge of establishing a plan for land expropriation and resettlement of residents in accordance with relating laws. In the process of planning resettlement, living survey is conducted on the interested residents and compensation will be estimated later. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location.
	14	Poverty Group	B-	B-	B-	B-	**Pre-work**: Cautions are needed to avoid that the poverty group only would be a victim of project sub- effects like resettlement, temporal land occupation for stockyard or truck road. Compensation should be done properly if there would be an eligible poverty group associated with the resettlement. **In-use**: Follow-up should be required to ensure that the resettled people can spend a normal life at the new location. For a temporary land use, returning the land as the original condition is needed.
	15	Indigenous and Ethnic People	D	D	N/A	N/A	Same evaluation as the scoping.
	16	Local Economy such as Employment and Livelihood, etc.	B+	B+	B+	B+	**At-work**: Construction demands may provide a positive effect on regional employment and relating works as well.

Category	No	Impacts	Evaluation in Scoping		Evaluation on surveys		Reasons
			Pre-/ At-work	In-use	Pre-/ At-work	In-use	
							In-use: Stabilizing local economy is expected with a decrease of flood damages.
	17	Land Use and Utilization of Local Resources	B-	B-	B-	D	**Pre-/At-work**: The site for a stockyard and the office will be prepared by the project entity cooperating with the government in the project area. **In-use**: Land use constraint for production will be limited after the project.
	18	Water Usage or Water Rights and Rights of Common	D	D	N/A	N/A	Same evaluation as the scoping.
	19	Existing Social Infrastructures and Services	B-	D	B-	D	**Pre-/At-work**: Traffic for construction work may cause traffic congestion in the area.
Social Environment	20	Social Institutions such as Social Infrastructures and Local Decision-making Institutions	B-	D	B-	D	**At-work**: Extent of impact is still vague at present because opponents would come to the surface around the inauguration of the project.
	21	Misdistribution of Benefit and Damage	D	D	N/A	N/A	Same evaluation as the scoping.
	22	Local Conflict of Interests	B-	D	B-	D	**Pre-work**: Though any local conflict of interests has not been confirmed, the impact is expected minor because of improving the existing road.
	23	Cultural Heritage	D	D	N/A	N/A	Same evaluation as the scoping.
	24	Landscape	B-	B-	B-	B-	**At-work**: Construction equipment in the project area may spoil the landscape. **In-use**: The new structures may change the regional landscape, but the extent is expected minor.
	25	Gender	D	D	N/A	N/A	Same evaluation as the scoping.
	26	Children's Right	D	D	N/A	N/A	Same as above.
	27	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**At-work**: Now investigation concrete actions by RID. However, Thailand has experienced to do with an anti-AIDS activity in an int'l project.
	28	Work Environment (incl. Work Safety)	B-	D	B-	D	**At-work**: National regulations or guidelines regarding management of work safety in construction are available. Complying with these rules will assure a better work environment.
	29	Accident	B-	D	B-	D	**At-work**: Accidents can be reduced if information on roundabout roads and the direction for safe driving are sufficient.
Other	30	Trans-boundary Impact and Global Warming	B-	D	B-	D	**At-work**: Estimating CO_2 emission from construction equipments will be available after determination of the work plan. However, the impact on the environment is expected minor taking account of the project scale.

A+/-: Serious positive (+)/negative (-) impact is expected.
B+/-: Some positive (+)/negative (-) impact is expected.
C+/-: Extend of positive (+)/negative (-) impact is unknown (A further examination is needed, and the impact could be clarified as the survey progresses).
D : No impact is expected.
N/A: Not Applicable.

Q1.10.8 Mitigation Plan

The mitigation plan for the Tha Chin Project is almost the same as other projects in the Master Plan. See Section Q1.9 for detailed measures.

CHAPTER Q2 LAND EXPROPRIATION AND RESETTLEMENT

Q2.1 Necessity of Land Expropriation and Resettlement

The project activity that will lead to land expropriated or to people resettled is the construction of flood diversion channel, together with the construction of ancillary facilities and dike improvement in the Chao Phraya River basin as well as construction of short cut channels and dike improvement along the Tha Chin River. As already described, the affected areas lie on 1) the west side of the Chao Phraya River from upstream Ayutthaya to the confluence of the Noi River (19km in length, called as "Ayutthaya Bypass Diversion Channel"), 2) the east side of the Chao Phraya River along the Outer Ring Road from downstream Ayutthaya to the Gulf of Thailand (100km in length, called as "Outer Ring Road Diversion Channel"), 3) the lower basin of the Chao Phraya River (90km in length, called as "Dike Improvement of the Lower Chao Phraya River") and 4) the midstream and lower basin of the Tha Chin River (approx. 180km in length, called as "Dike Improvement and Short Cut Channels in the Tha Chin River Basin"), respectively. Estimated numbers of possible buildings that would be affected by the project are 82 in the west side and 550-920 in the east side, even though being entitled legally or not. For the lower Chao Phraya and Tha Chin River projects, the number of affected people is undetermined but the magnitude is estimated smaller compared with the two diversion channel projects.

As described in Section Q1.4 of the sector, alternative plans including "Zero option" which is not to conduct any project, have been evaluated. Table Q1.4.1 has already shown the result of the evaluation regarding land expropriation and resettlement. Both diversion channel plans required middle-scale resettlement.

Q2.2 Legal Framework of Land Expropriation and Resettlement

Q2.2.1 Basic Concept of Laws and Regulations

As for land expropriation and resettlement of inhabitants relating to a project planned by a national or local authority in Thailand, four (4) legislations mainly relate to the processes as:

i) Constitution of the Kingdom of Thailand, B.E. 2540 (1997)
ii) Land Expropriation Act, B.E. 2530 (1987)
iii) Regulations of the Office of the Prime Minister on Procurement
iv) Ministerial Minutes of Meeting on July 11, 1989

The Constitution states that the expropriation of immovable property shall not be made except by virtue of the law specifically enacted for the purpose of public interest.

The Land Expropriation Act in 1987 is the general law to acquire private lands and buildings to carry on a public purpose. The public purposes include such as defense, natural resources, town planning, agriculture development, industrial, land consolidation and other projects.

In the Regulation of the Office of the Prime Minister Regulation on Procurement, Director General of the project organization should sign an order of land acquisition to proceed with land expropriation. The chairman of committee may appoint a working group or assign a professional grader to prepare the evaluation report.

The Ministerial Minutes of Meeting on July 11, 1989 shows that the government policy has overcome the problems of illegal occupants in public land for the projects of the Royal Irrigation Department (RID).

Q2.2.2 Definition of Estimation of Compensation

(1) Land Expropriation Act, B.E. 2530 (1987)

A person who has interest in land can claim for money compensation as follows:

1) owners or occupants of land by law, 2) owners of permanent buildings or improvement on land, 3) lessees of land, buildings or other improvements with rent contracts, 4) owners of trees and 5) owners of moveable buildings.

In these five cases, compensation should be assessed for demolition costs, moving costs and reconstruction costs. The amount of compensation should be assessed by comparison of 1) sales price of similar property, 2) the medium land price list for land tax, 3) the assessed value of real estate for registration act, 4) the adjustment between comparable sales and subject property and 5) the reason and purpose of expropriation. Compensation on such act should be paid to a person who holds legal right and interest on land, buildings and trees. A schematic flow of land expropriation procedure based on the Land Expropriation Act is presented in Figure Q2.2.1.

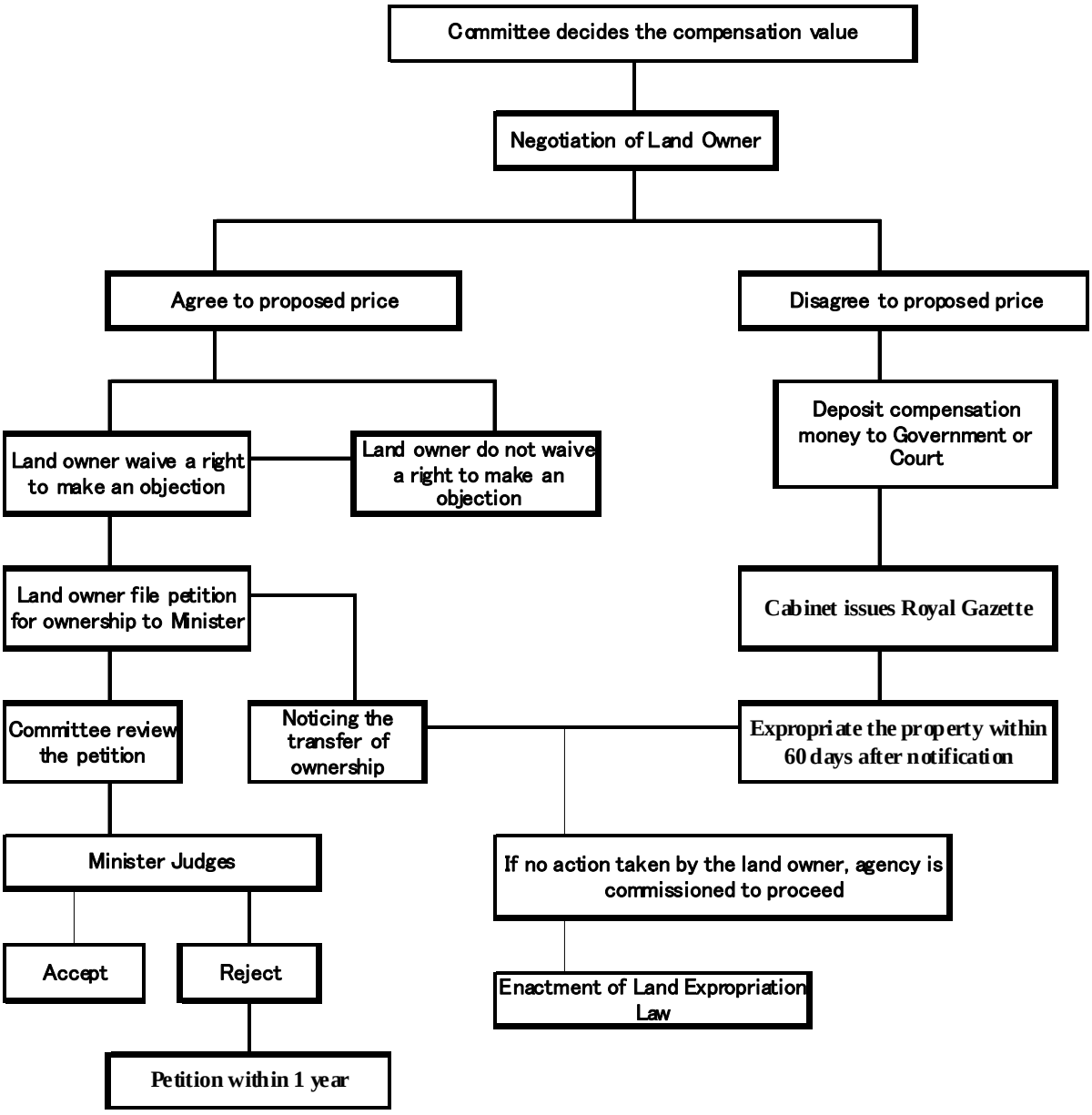


Figure Q2.2.1 Flow of Land Expropriation Procedure

(2) Regulations of the Office of the Prime Minister on Procurement

The evaluation report should include comparable sales not less than three sales, and an evaluation report on a basic market comparison approach is also needed. The committee use market value to negotiate with the land owner. If the final price is obtained, the two parties will go to the Land Office to register for transfer and pay compensation to the dispossessed owner. The ways for negotiation and compensation according to the regulations are on a friendly-process basis.

In practice, the sale from the contract price is usually lower than the market value or some sale is not comparable, the working group can refer to the assessed value for transfer fee but the price to purchase is not more than 50 percent (Agriculture Land Reform Purchase Manual).

(3) Ministerial Minutes of Meeting on July 11, 1989

The compensation will not be paid for land taken but will be paid for relocation costs. The relocation costs should be assessed by compensation with lowest assessed land value for transfer fee under the land code. The compensation committee can adjust by reason of public land so relocation cost should be 2/3 or 3/5 of the assessed land value. If the project area covers more than one Tambon (sub-district), the lowest land price unit should be an average.

(4) Proceeding on Land Expropriation and Resettlement

Proceeding on land expropriation and resettlement of inhabitants has three alternatives that acquire by 1) friendly negotiation, 2) Royal Decree or compulsory acquisition and 3) expropriation.

Friendly negotiation procedure is the most efficient for timeline. It is an appropriate alternative for a small project opposite to second and third alternatives, which take time and have to initiate special law and regulation for the Project. Under compulsory acquisition and expropriation, the land owner has right to appeal the amount of compensation to the minister. In case of no settlement, the landowner can present the dispute to the political court. The total timeline for appeal does not exceed one year, but the political court is about 5-10 years.

Q2.3 Method of Calculation of the Property and Compensation

In the laws of Thailand, the heads of compensations are land taken, severance damage, disturbance and betterment. Land taken consists of compensations for land, building/house and trees. The calculation methods include market comparison, cost and income methods. The valuation is fixed at the date of acquisition for friendly negotiation, at the date of the Royal Decree for compulsory acquisition and the date of enforcement for expropriation. Severance damage is loss of land part, calculated by difference of value before and after acquisition. The result is to be the difference calculated. Disturbance is any losses occurring when the owner has to move from the residential or commercial area such as transportation cost, location goodwill, law service or valuation service, cost of cure, advertising cost. Disturbance loss is calculated by comparing with the criteria of other departments

Q2.4 Timing for Payment of Compensation

In case that a negotiation is settled, the offer should pay compensation within 120 days from the date of signing the contract, in accordance with the Land Expropriation Act.

Q2.5 Scale of the Land Expropriation and Resettlement

The general view of the project sites are shown in the following Figures, respectively.

Q2.5.1 Ayutthaya Bypass Diversion Channel

In Figure Q2.5.1 and Figure Q2.5.2, The project area runs along the west side of Route 347 southward from the upstream Ayutthaya to Bang Sai at the confluence of the Noi River. The area is mostly occupied with plain arable fields, and houses are found in a few sites such as the intersection with Route 3263. Major industrial centers including an industrial estate develop along the left bank of the Chao Phraya River. The 19km-long planning channel needs land for its structure and affiliated facilities as well as tentative spaces for construction work. The construction will need at least 290 hectares (ha) of areas. Though 82 houses and no factories are expected to have an influence by the project at present, the extent and volume can be changed in accordance with a modification of the project. Two vehicle roads (10-32m width) and 18 canals (4-21m width) are to intersect with the channel.

Figure Q2.5.1 Planning Area (Overall) - Ayutthaya Bypass Diversion Channel -

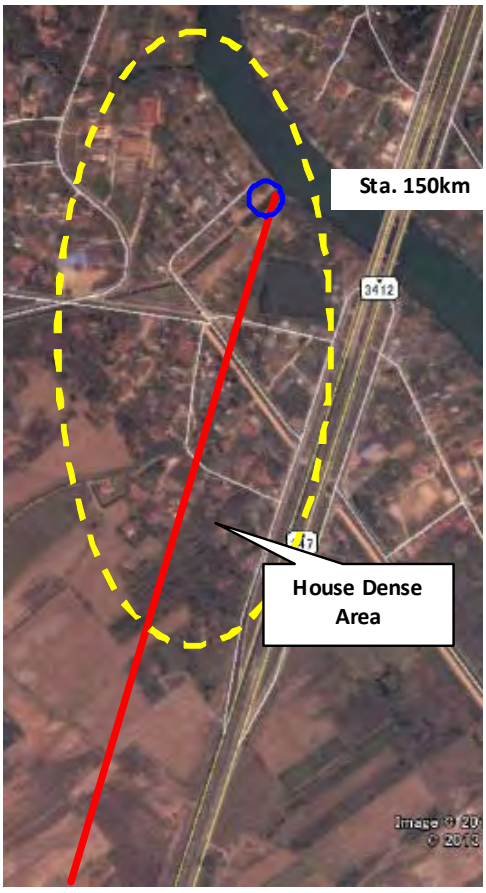


Figure Q2.5.2 Planning Area (House Dense Area) - Ayutthaya Bypass Diversion Channel -

Q2.5.2 Outer Ring Road Diversion Channel

According to Figure Q2.5.3 and Figure Q2.5.4, the area which the project needs spreads southward from the left bank of the Chao Phraya River in the south part of Bang Pa-in Industrial Estate until the Gulf of Thailand at Klong Dan mostly along the east side of the Outer Ring Road (Route 9), through the east area of Suvarnabhumi International Airport. The 100km-long planning channel lies on wet and low land used as paddy fields and socio-relating activities (houses, commercial facilities, schools, temples etc.). In general, such socio-relating activities are dominant in the upper area and paddies or swamps in the lower area, respectively. However, the lower area has been developing into socio-relating areas thanks to recent development plans in East Bangkok. Swamps that develop some ponds and canals spreading out around the area contribute mainly to the area's ecosystem with small-scale shrubs. Total area required for the construction ranges 2,000-2,320 hectares at least, based on the design planning. The planning channel is to intersect with 14 vehicle roads (8-90 width), two railways and 85 canals or waterways (2-63m width).

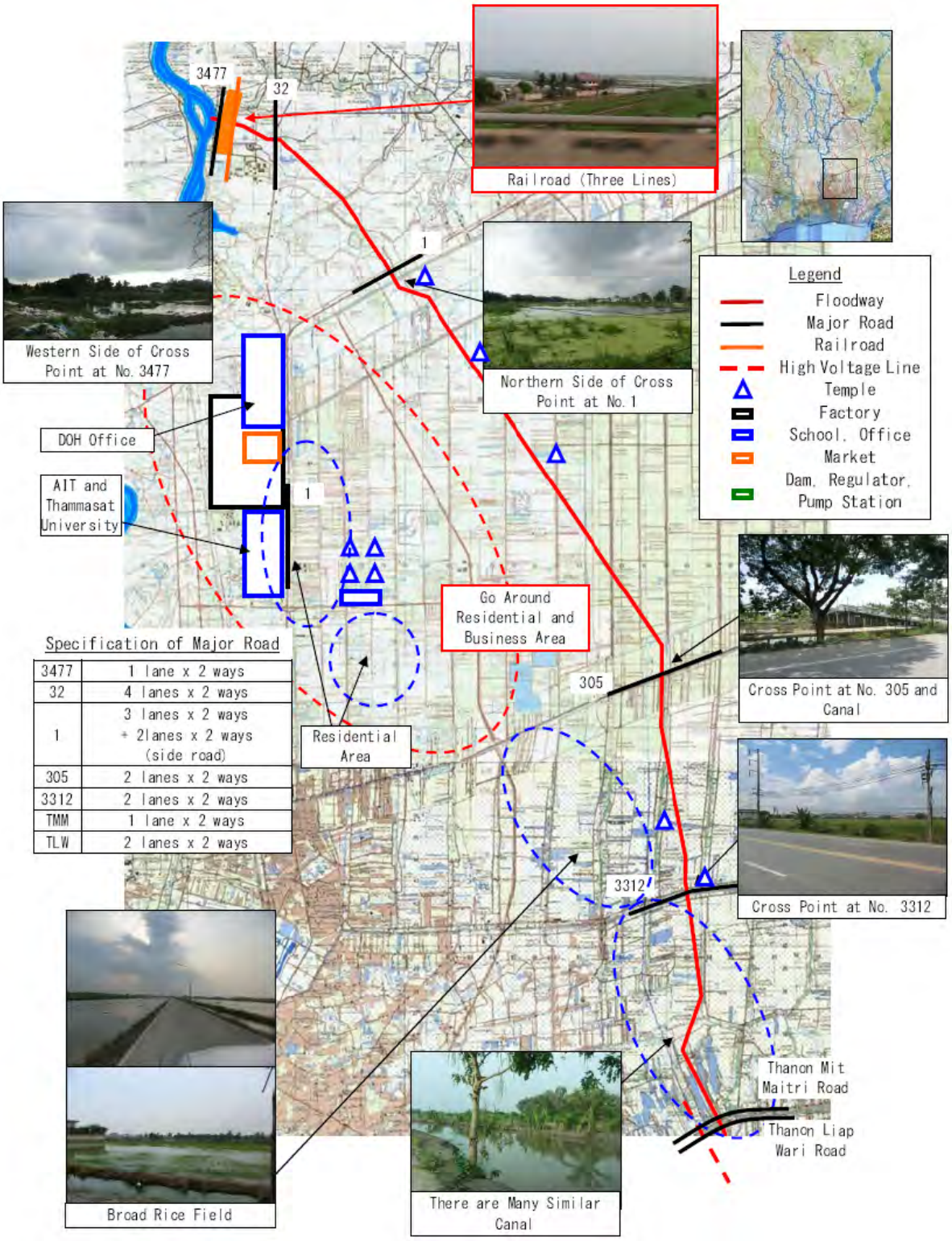


Figure Q2.5.3 Planning Area (Inlet to R304 (58.5km in length))
-Outer Ring Road Diversion Channel-

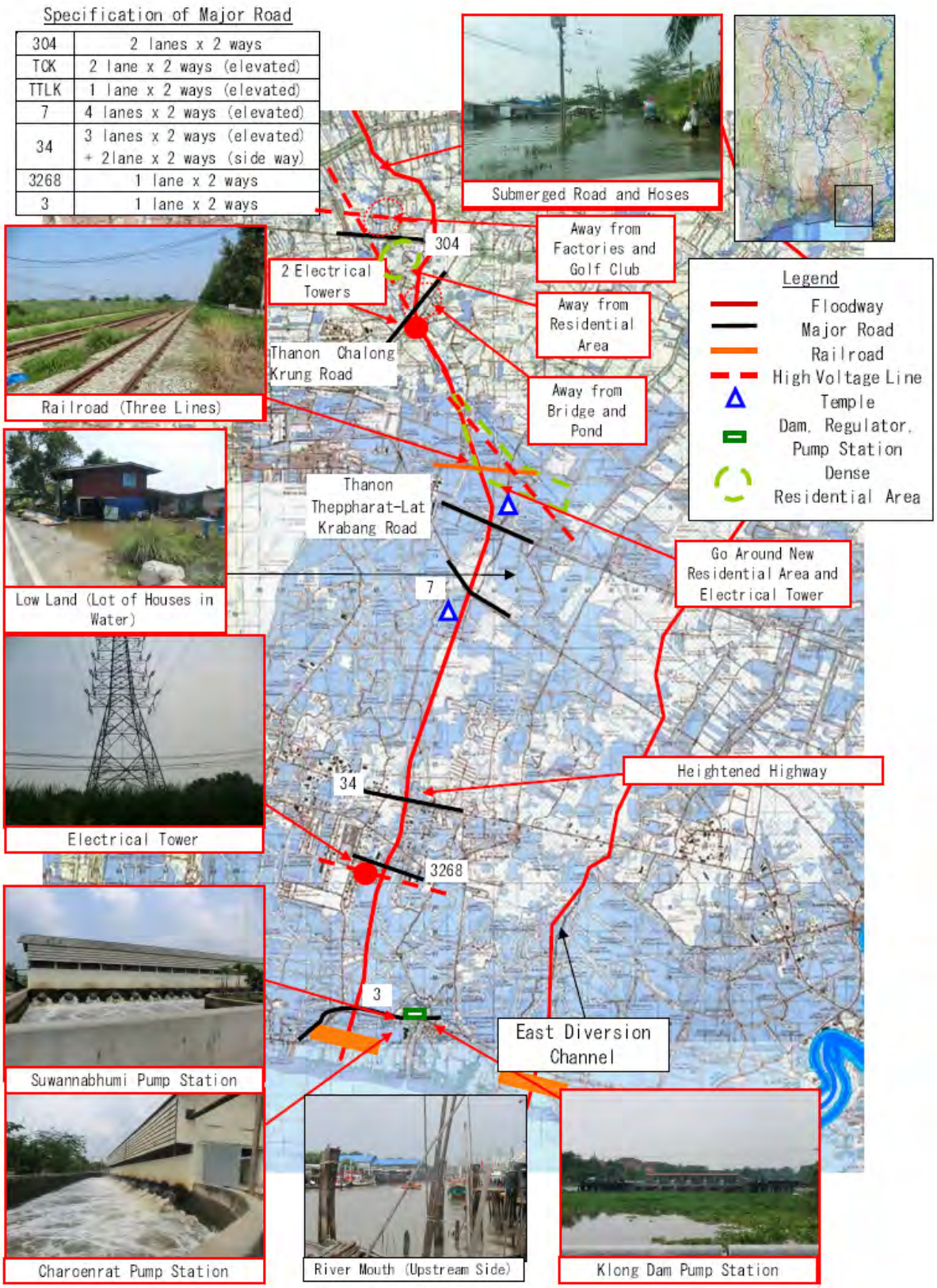


Figure Q2.5.4 Planning Area (R304 to the Gulf of Thailand (39.2km in length))
-Outer Ring Road Diversion Channel-

Q2.5.3 Dike Improvement of the Lower Chao Phraya River

The target lower Chao Phraya goes through central Bangkok where important facilities and business activities are focusing and its vicinities with houses, factories and paddy fields upstream. The project is mainly a supplemental work to the existing parapet walls and secondary dikes of the Chao Phraya River to add height. From 0 to 60km point, the parapet walls have been already established by BMA but additional 40km-long walls will be newly installed. The secondary dike, which is a road constructed by DOH and the existing parapet walls have insufficient height to prevent from flowing out of high water in the River. Taking account of the condition, all the project area is within the Right-of-way then special land acquisition and involuntary resettlement will be out of scope (See Figure Q2.5.5).

Figure Q2.5.5 Planning Area - Dike Improvement of the Lower Chao Phraya River

Q2.5.4 Dike Improvement and Short Cut Channels in the Tha Chin River Basin

Like the case of the dike improvement of the lower Chao Phraya River, one main part of the project consists of the existing dike improvement (elevation). This means few new lands required for the project implementation. In addition, new dike introduction with embankment requires minimum arable land because the location lies within the Right-of-way of the authority. However, another portion of the project - four short cut channels needs approx. 1.7km^2 of areas in total. The candidate area is low, wet and arable land and vulnerable to inundation. People and houses allocate along the River for residence and commercial activity. In the channel project, the necessary lands are selected to avoid the residential and commercial zones. This indicates little or no involuntary resettlement for the land acquisition is required. In contrast, installing parapet wall at the estuary needs some resettlement as the area is a densely populated section where belongs to the Bangkok Metropolitan Area (See Figure Q2.5.6 and Figure Q2.5.7).

Figure Q2.5.6 Planning Area (Gulf of Thailand to Route 346, Approx. 119km long)
-Dike Improvement and Short Cut Channels in the Tha Chin River Basin-

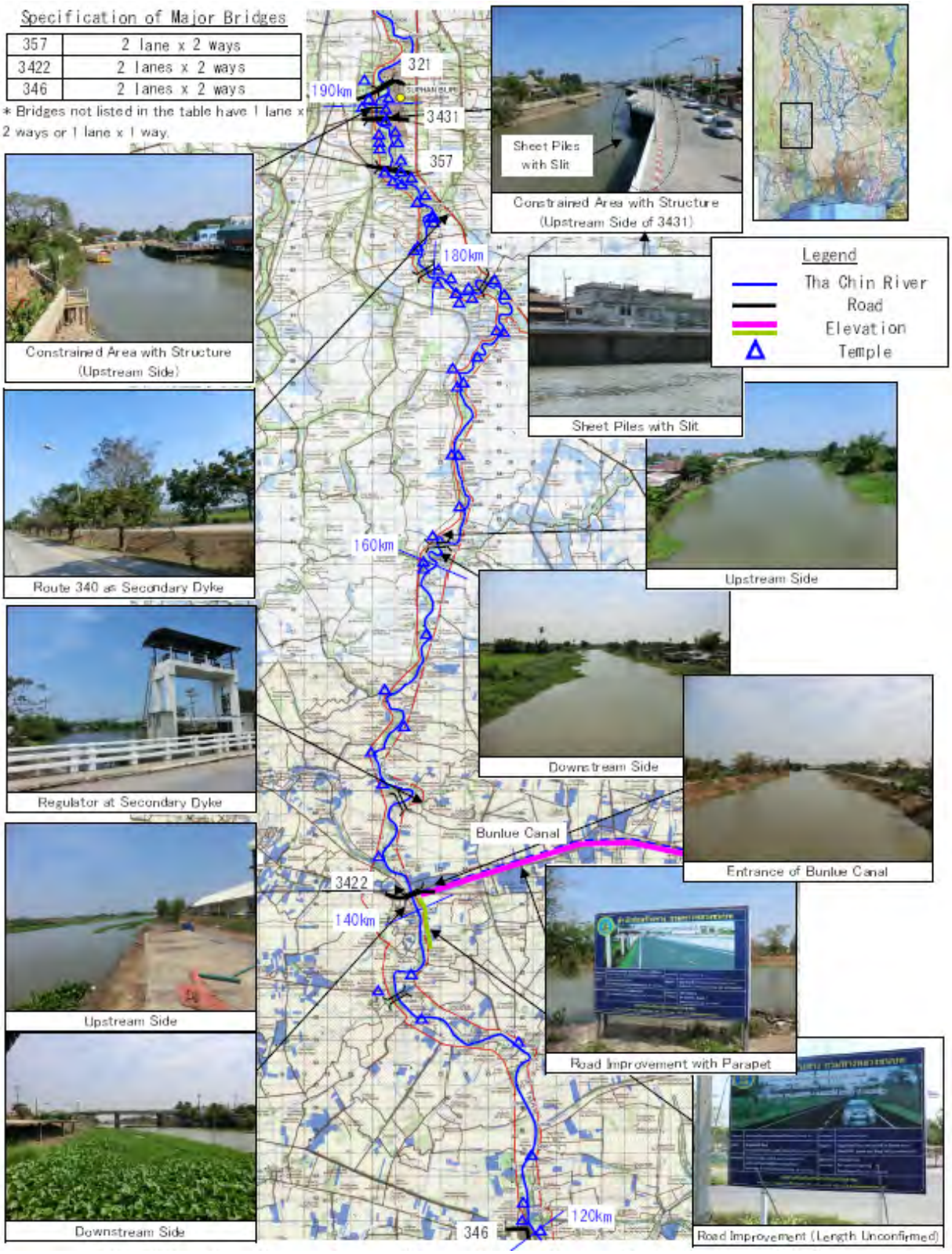


Figure Q2.5.7 Planning Area (Route 346, to Suphan Buri Approx. 71km long)
-Dike Improvement and Short Cut Channels in the Tha Chin River Basin-

Q2.6 Public Relations and Public Participation

Public relations (PR) and public participation (PP) are inevitable in a project involving people and social entities concerned. The aims of PR and PP are 1) to disseminate information about the project, 2) to enhance the understanding of target groups and 3) to provide the groups with opportunities to express/share the opinions in order to ensure the demands from project affected persons (PAPs) with satisfaction.

For securing transparency and fair implementation of the project as well as consistent public involvement, target groups for PP activities should include all stakeholders who can give affection to the emotion or ideas of the PAPs. Eight classifications below are employed for these target groups in general.

1) Public organization at district and provincial level, 2) State enterprise agencies, 3) NGOs, 4) Private businesses, 5) Community leaders, 6) Local people who are directly affected, 7) Educational institutions and 8) The media.

Among the classifications, NGOs often play an important role on the direction of the project. In order to obtain a better solution with an NGO, the project facilitator should keep in mind the following tips: 1) to ask for cooperation through all processes in project development, 2) to establish an NGO consortium incorporating some proven NGOs with balance and request to be the representative for broader interests of the PAPs, 3) to support the system that the consortium can ensure accountability to the PAPs, 4) to assign maximum value to the independence of NGO regarding the ways of cooperation and 5) to secure rooms for discussion with the entity which is involved in the top-down plan of the implementing agency or relating organizations.

Particularly in the Outer Ring Road Diversion Channel project, the area required is vast and then the interests of the stakeholders vary by region or lifestyle. The important point is to divide the PAPs into a few groups by area: upper-, middle- and lower-stream for example.

Sector R: Climate Change

PROJECT FOR THE COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN

FINAL REPORT
VOLUME 3: SUPPORTING REPORT

SECTOR R: TABLE OF CONTENTS

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CHAPTER R1 ISSUES ON CLIMATE CHANGE

R1.1 How is Climate Change Incorporated into Flood Mitigation Plan?

Although studies on increase of runoff discharge have been carried out for major rivers in Japan, the discharge increase have not been reflected in the design discharge of the rivers probably because of uncertainty of the phenomena. The discharge increase is regarded as one of future flood risk, and non-structure measures are mainly adopted rather than structure measures.

This master plan study focuses on the estimation of change of runoff discharge due to climate change. Judgment whether to change design discharges according to the projected impacts is left to the Thai side.

R1.2 Adaptation Measures in Consideration of Characteristics of River Basin

If characteristics of the Chao Phraya River Basin are taken into consideration, countermeasures should be sought separately for the upper basin (upstream of Nakhon Sawan), the middle basin (Ayutthaya to Nakhon Sawan) and the lower basin (the river mouth to Ayutthaya).

The upper basin, in which frequency of large floods will increase, will not be affected since planned structural measures will be changed. On the other hand, the lower basin, which is under the tidal effects, will likely be affected by flood inundation risk augmented by sea level rise and storm surges in addition to rainfall increase. If the impact is very much, the basic specifications of the structural countermeasures including DHWL (Design High Water Level) should be modified.

CHAPTER R2 PREVIOUS STUDIES ON CLIMATE CHANGE

R2.1 Study in Thailand

There are three available study reports on Climate Change in Thailand as shown in Table R2.1.1. The first and second reports are the same in terms of contents. Projection results of the WB (The World Bank) Study[1] and the START Study[2] are summarized in Table R2.1.2 and Table R2.1.3.

Table R2.1.1 Study Report in Thailand on Climate Change

No.	Report	Outline
1	Climate Risks and Adaptation in Asian Coastal Megacities, A Synthesis Report	Released in 2010, this report provided impact projection data to the 2009 WB study published in March 2009.
2	Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region (Final Report)	This is the 2009 WB study by Panya Consultant.
3	Preparation of climate Change Scenarios for Climate Change Impact Assessment in Thailand, Southeast Asia START Regional Center, 2010 (START Study)	Projection of 4 variables, maximum and minimum temperature, annual precipitation and sea level rise

Table R2.1.2 Climate Change Impact Projection in 2050 (WB Study)

IPCC Scenario	Temperature increase (ºC)	Mean Seasonal Precipitation Increase (%)	Sea Level Rise (m)	Storm Surge (m)
B1	1.2	2	0.19	0.61
A1FI	1.9	3	0.29	0.61

Table R2.1.3 Summary of Climate Change Impact Projection by START

Scenario		Prediction	Note
Maximum Temperature	SRES A1B (2045-2065)	Rise by 3-4 degrees	In the Chao Phraya River Basin, 3-month estimated temperature, esp. March to May was largely out of the median.
	SRES A2 (21st Century)	Upward tendency	Current temperature (33-35 degrees) may rise up to 37-39 degrees in the end of 21st Century.
	SRES B2 (21st Century)	Upward tendency	Upward tendency in temperature, but without large changes.
Minimum Temperature	SRES A1B (2045-2065)	Rise by 4 degrees	In the Chao Phraya River Basin, 23.74 deg. of current temperature may rise up to 27.76 deg.
	SRES A2 (21st Century)	Upward tendency	Current temperature (22-26 deg.) may rise up to 26-28 deg. in the end of 21st Century.
	SRES B2 (21st Century)	Upward tendency	Upward tendency in temperature, but without large changes.

1 Climate Change Impact and Adaptation Study for Bangkok Metropolitan Region, Panya Consultants Co., Ltd. March 2009

2 Preparation of Climate Change Scenarios for Climate Change Impact Assessment in Thailand, Southeast Asia START Regional Center, January 2010

Scenario		Prediction	Note
Precipitation	SRES A1B (2045-2065)	Rise by 10 %	Upward tendency in the rainy season, namely 1,095 to 1,210mm/y.
	SRES A2 (21st Century)	Upward tendency	A remarkable rise in precipitation to be observed in the Gulf of Thailand in later 21st Century.
	SRES B2 (21st Century)	Upward tendency	Upward tendency in precipitation, but without large changes.
Sea Level Rise	DIVA & POM (2010-2029)	Rise by 5-10 cm	The coastal area of the Gulf of Thailand including the estuary of Chao Phraya River may be affected most. Effects on the sea level rise vary by season because of affection of monsoon seasons.
	DIVA & POM (2030-2049)	Rise by 10-20 cm	

R2.2 Projection of Rainfall

It is very important for flood mitigation planners to know how precipitation will change due to climate change. In the Chao Phraya River Basin where evaporation is much, evaporation is also very important.

According to the WB report, precipitation will increase by 2 to 3%. Since the design rainfall duration is assumed to be 6 months in this JICA Study, it is desirable that impact projection results for monthly rainfall are available, at least. However, they have not been found yet as of January 201). Neither have been projection results of evaporation.

According to the START Study in Table R2.1.3, future trends in precipitation are predicted as follows:

- The Central Plain and the Chao Phraya River Basin: There will be higher precipitation throughout the rainy season. Annual precipitation in the future may increase from the present level by approximately 10%, from 1,095mm to 1,210mm.

- The Gulf of Thailand Coastal Zone: There will be significantly higher precipitation throughout the year. Total annual precipitation could change from 1,857mm to 2,603mm, approximately 40% up. Results from climate models show that precipitation will be significantly increased during the north-east monsoon season during November to February.

R2.3 Projection of Sea Level Rise

For the Chao Phraya River Basin which has the capital, Bangkok in the lowest tidal area, sea level rise is a very serious issue. According to the WB report, the sea level rise of the Gulf of Thailand will be 19 to 29 cm in 2050. The sea level rise in the global level was presented with a map in the IPCC Fourth Assessment Report (AR4) in 2007 as shown in Figure R2.3.1. The adopted scenario is A1B, and a rise of 21 to 48cm is projected all over the globe. However, there is no information (Blank) in the Gulf of Thailand (probably the gulf was excluded for the simulation area).

It is generally said that the sea level rise is significant where an ocean current is strong. In the Gulf of Thailand where no strong current is flowing the sea level rise might be not so large.

The IPCC Fifth Assessment Report (AR5) will be released in 2013 or later. According to JAMSTEC (Japan Agency for Marine-Earth Science and Technology), there is a report in AR5 that the sea level rise will be greater than the projection in AR4.

On the other hand, the Southeast Asia START Regional Center developed the sea level rise scenario for the Gulf of Thailand, which was projected by combining the effects of sea level rise and changing sea surface fluctuations. Changes in sea level in the Inner Gulf of Thailand were predicted for two periods (2010-2029 and 2030-2049) in comparison to average sea level of 1985-2000.

- 2010-2029: Ranging from 6.8 to 12.2 cm rise. Maximum sea level rise will be marked in June and minimum in August instead.
- 2030-2049: Ranging from 17.8 to 22.4 cm rise. Maximum sea level rise will be marked in August and minimum in December. This trend is different from those to be predicted during 2010-2029.

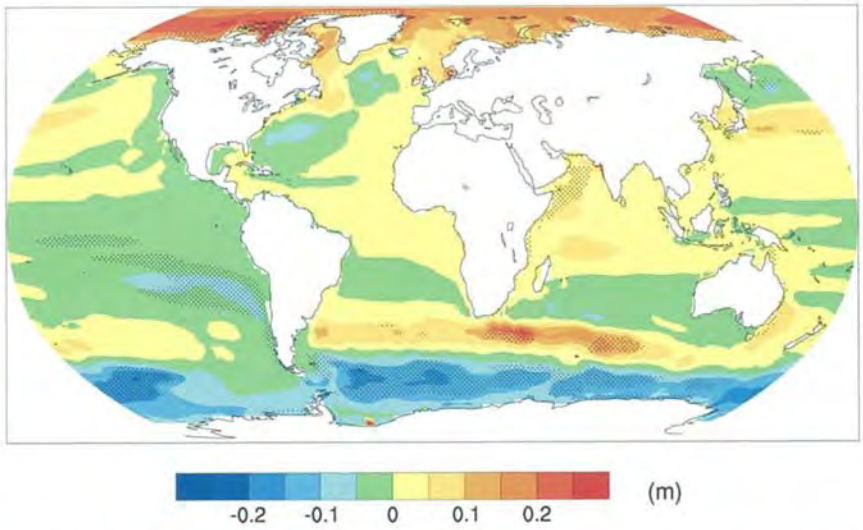


Figure 10.32. *Local sea level change (m) due to ocean density and circulation change relative to the global average (i.e., positive values indicate greater local sea level change than global) during the 21st century, calculated as the difference between averages for 2080 to 2099 and 1980 to 1999, as an ensemble mean over 16 AOGCMs forced with the SRES A1B scenario. Stippling denotes regions where the magnitude of the multi-model ensemble mean divided by the multi-model standard deviation exceeds 1.0.*

Figure R2.3.1 Projection of Sea Level Rise (Global Model)

R2.4 Projection of Storm Surge

Since storm surge is a short-term phenomenon as short as one day, its influence on the flood of the Chao Phraya River that continues a few months is very limited. However, the rise of the sea level by storm surge is very important to determine the level of the dikes in the downstream stretches.

In Thailand 61cm of the sea level rise by storm surge that was estimated for Typhoon Linda (1997) has been adopted. It is necessary to ask experts if typhoon paths and atmospheric pressure will be changed due to climate change. In this JICA Study it is possible to preliminarily examine the influence of climate change on storm surge by using a storm surge simulation model.

JICA conducted interviews to JAMSTEC (Japan Agency for Marine-Earth Science and Technology) and MRI, JMA (Meteorological Research Institute, Japan Meteorological Agency) about typhoons and cyclones in November 2012. Results are summarized as follows:

- According to results of ensemble average of various simulation models, the global tendency is that the number of typhoons and cyclones will decrease but their strength will increase.
- Many simulation results show a unique tendency but the range of values is very wide. Even for specific areas like the east or west pacific, differences among the simulation models are big.
- If the smaller area like the Gulf of Thailand is focused, the bigger is uncertainty. Information is too scarce to determine concrete measures.
- The number of typhoons and cyclones will decrease by 20 to 30% in the north pacific, and decrease by 15 to 20% at the global level. Although uncertainty is still large for local areas as mentioned in the above, followings could be said at least:
- The number of typhoons will not change or decrease by as little as one or two in 25 years.
- The strength of typhoons will hardly change.

CHAPTER R3 PROJECTION OF IMPACT ON RAINFALL BY CLIMATE CHANGE

In this JICA Study the duration of the design rainfall is 6 months. Therefore, monthly projection data of rainfall and evaporation are necessary, at least, although monthly evaporation might be estimated from temperature data. The monthly data will also make it possible to examine influence on drought. Following are conditions of the impact projection and method of data arrangement:

R3.1 Green House Gas Emissions Scenario

There are emission scenarios, A1 (very rapid economic growth scenario: A1FI, A1T, A1B); A2 (very heterogeneous world scenario); B1 (convergent world scenario with an emphasis on global solutions to economic, social, and environmental sustainability); and B2 (world scenario with an emphasis on local solutions to economic, social, and environmental sustainability). Generally, an average scenario, A1B is adopted. There are also cases that adopt both of the most conservative scenarios (A1FI) and the most optimistic scenario (B1).

R3.2 Climate Change Simulation Model

There are available data of GCM (Global Climate Model) and AGCM (Atmospheric General Circulation Models by MRI, JMA). The Calculation grid sizes are $100km^2$ for GCM and $20km^2$ for AGCM, respectively.

R3.3 Method for Projection Data Arrangement

A method to arrange projection data is proposed as follows:

- Arrangement of change quantity: extent of change is assessed by statistical analysis. For example, there are available 20C3M (reproduction data for 20 years from 1981 to 2000), mid-term projection data for 20 years from 2046 to 2065 and long-term projection data for 20 years from 2081 to 2100. Statistical analysis will be made for each data set to extract significant changes among them.
- Seasonal characteristics: In order to examine seasonal characteristics (for example rainfall of April to June will increase, that of July to September will increase, etc.) projection data will be treated separately for every 3 months.
- Regional characteristics: Since the Chao Phraya River Basin is very wide, regional characteristics will be also examined. For example, 2-division case (upstream and downstream of Nakhon Sawan) or 5-division case (downstream of Nakhon Sawan, Ping, Wang, Yom and Nam River Basins)

R3.4 Effect of Sea Level Rise in H-Q

The comparisons of H-Q Plotting (10 km pitch) of Chao Phraya River with and without sea level rise by 30cm are shown from Figure R3.4.1 to Figure R3.4.5.

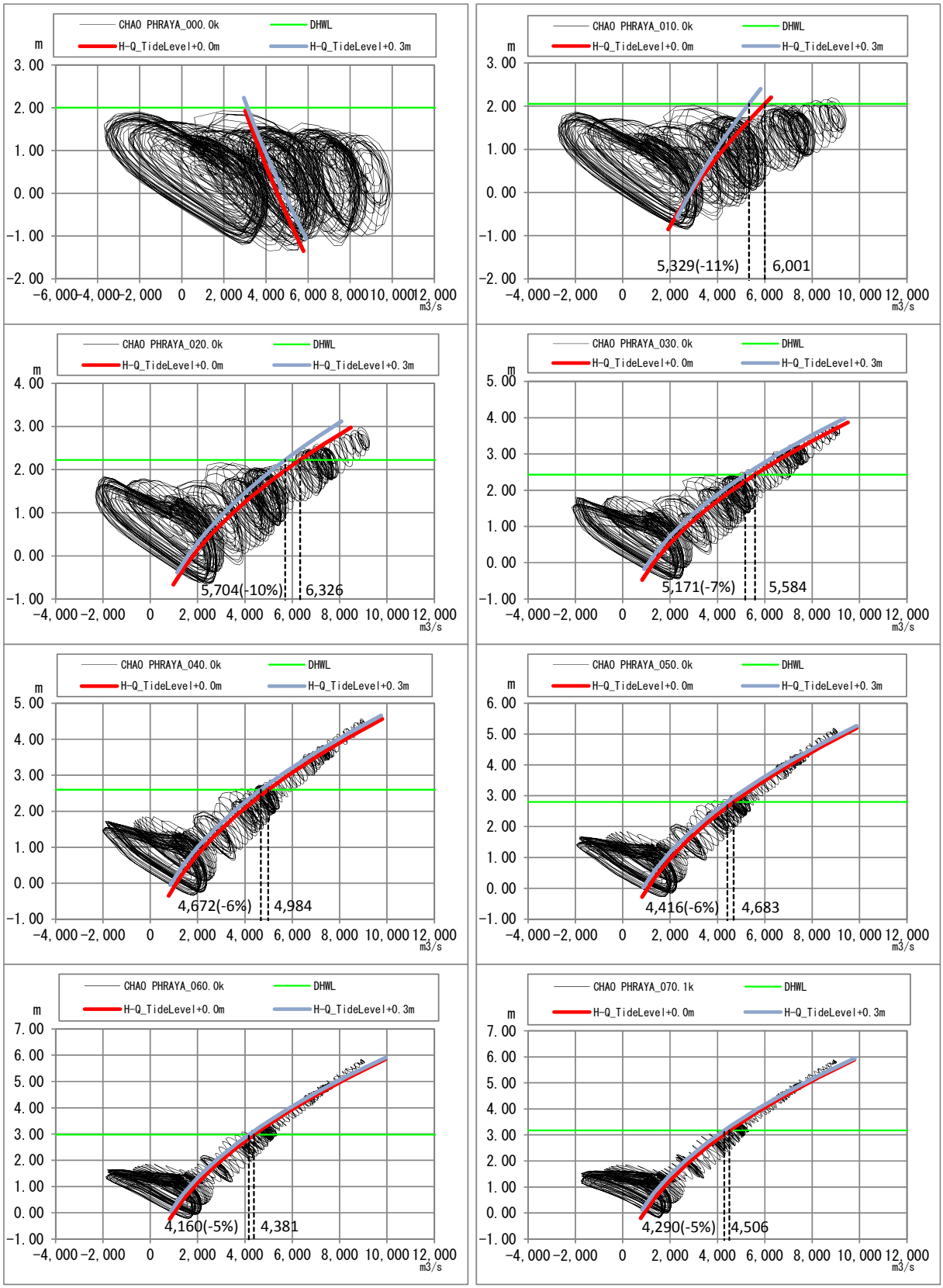


Figure R3.4.1 H-Q of Chao Phraya River (from 0 km to 70 km)

CTI Engineering International Co., Ltd.
Oriental Consultants Co., Ltd.
Nippon Koei Co., Ltd.
CTI Engineering Co., Ltd.

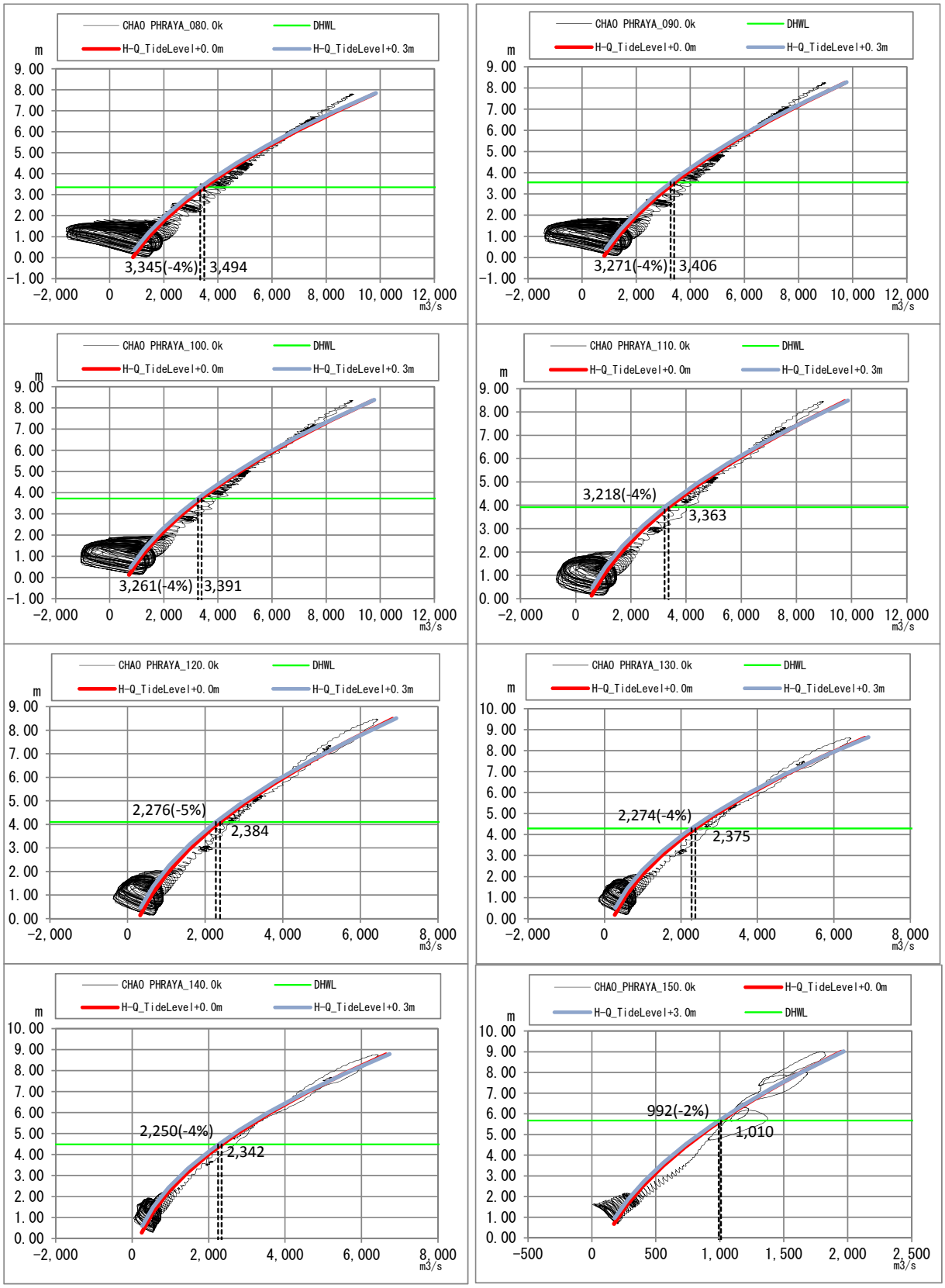


Figure R3.4.2 H-Q of Chao Phraya River (from 80 km to 150 km)

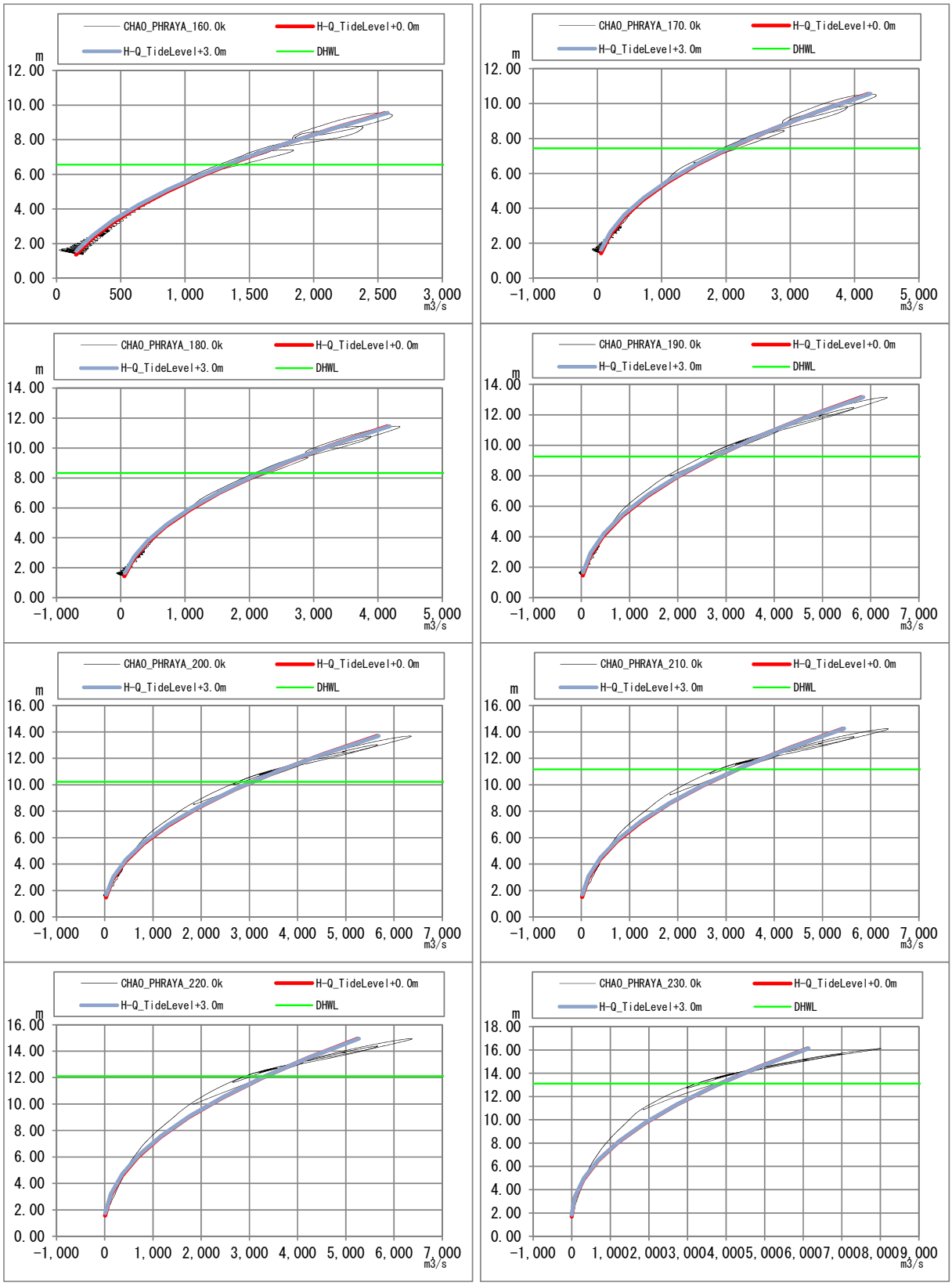


Figure R3.4.3 H-Q of Chao Phraya River (from 160 km to 230 km)

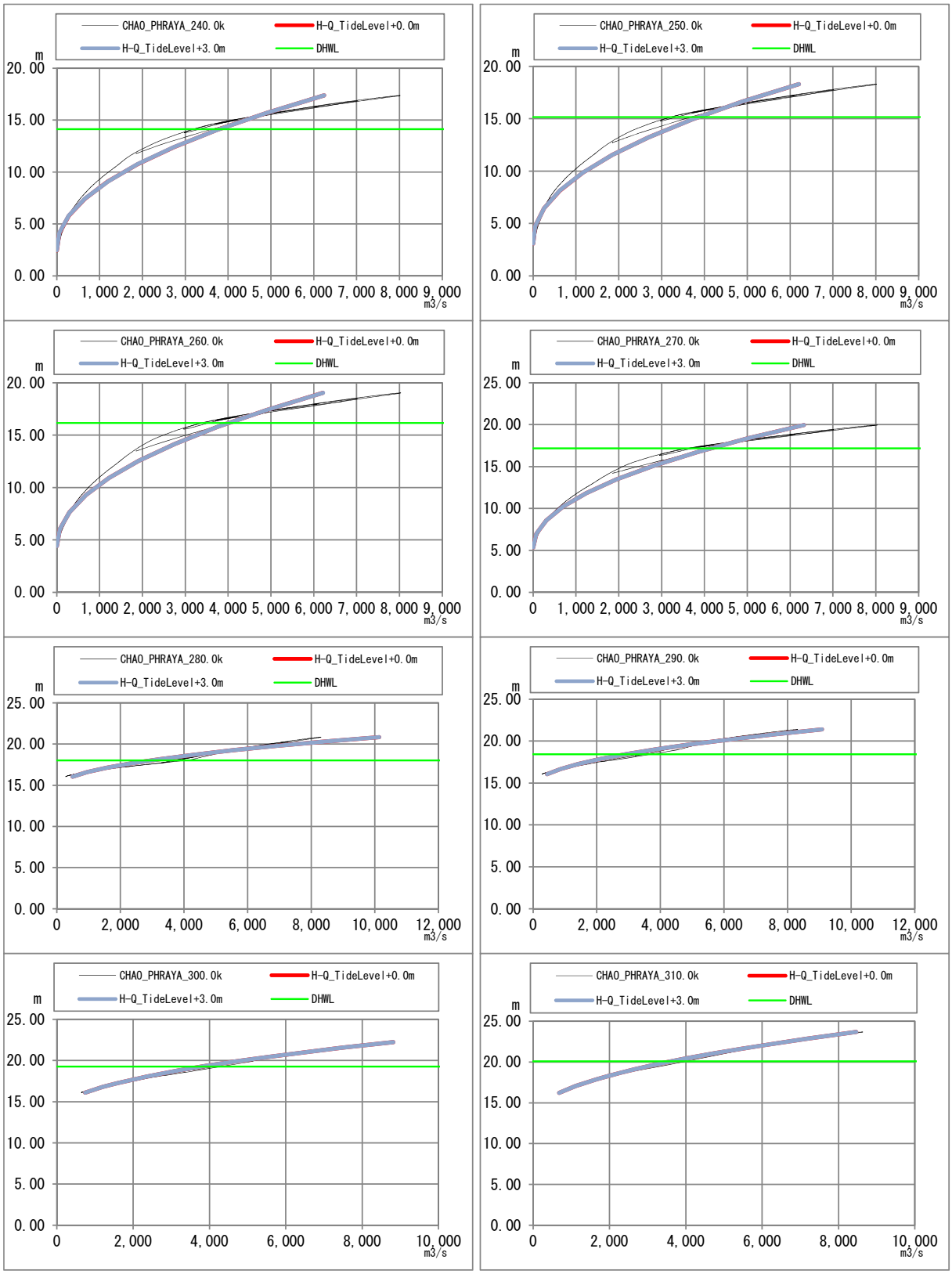


Figure R3.4.4 H-Q of Chao Phraya River (from 240 km to 310 km)

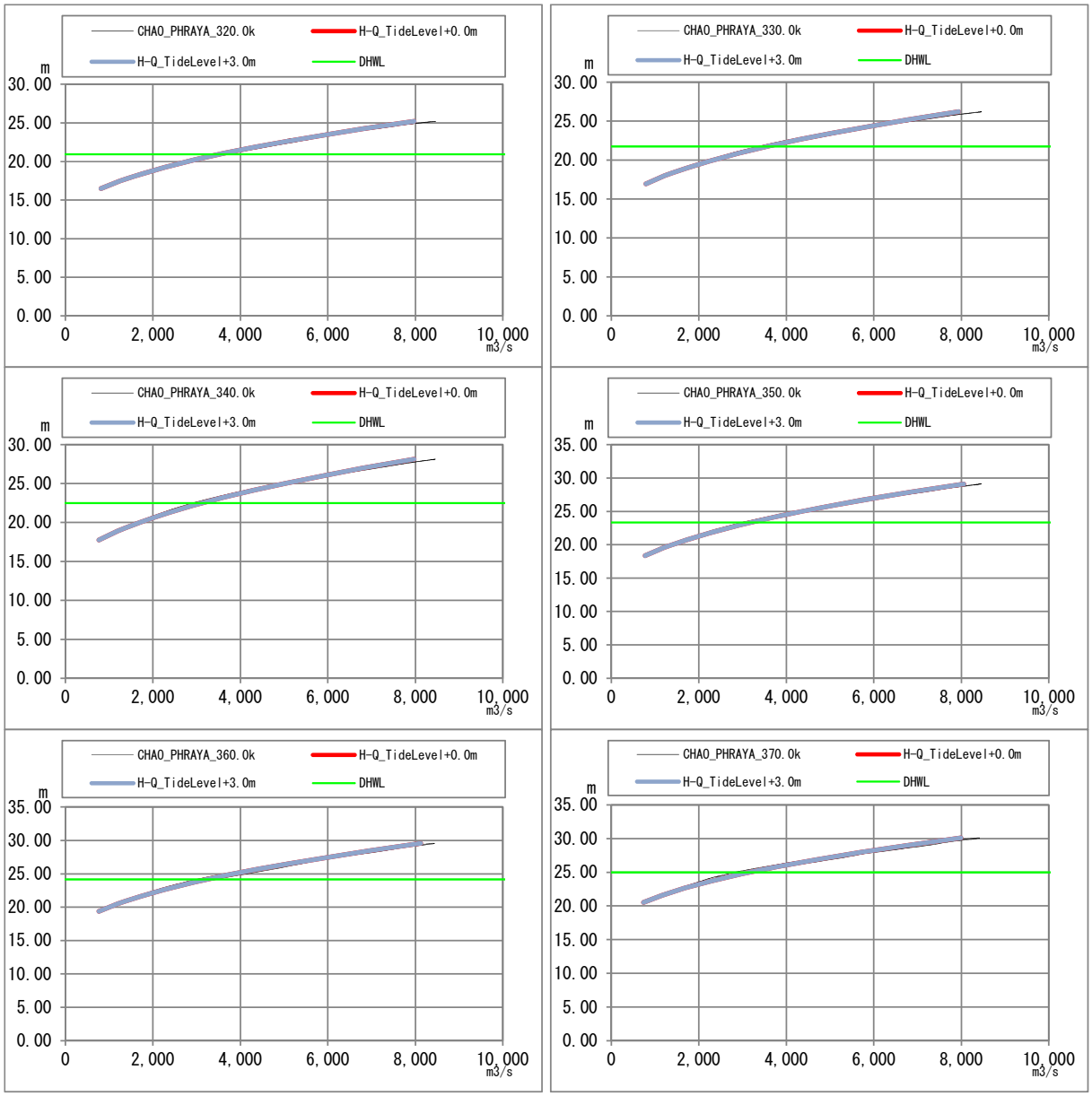


Figure R3.4.5 H-Q of Chao Phraya River (from 320 km to 370 km)

SECTOR R: ANNEX-1 Recent Trend of Climate in Thailand

1. Temperature and Evaporation

Based on TMD Data, yearly mean temperature and monthly mean temperature of 32 years from 1980 to 2011 are arranged in following figures: There is no clear change of temperature seen in the figures.

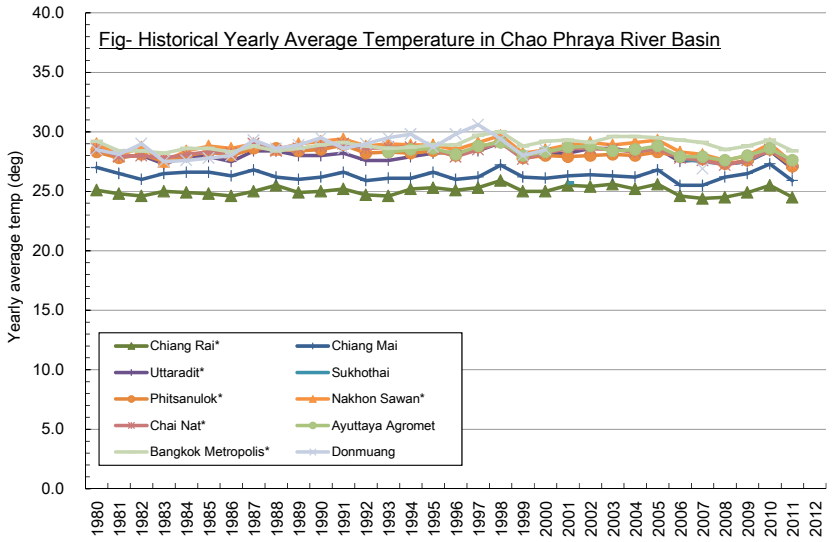


Figure 1.1 Yearly Mean Temperatures (Major Stations)

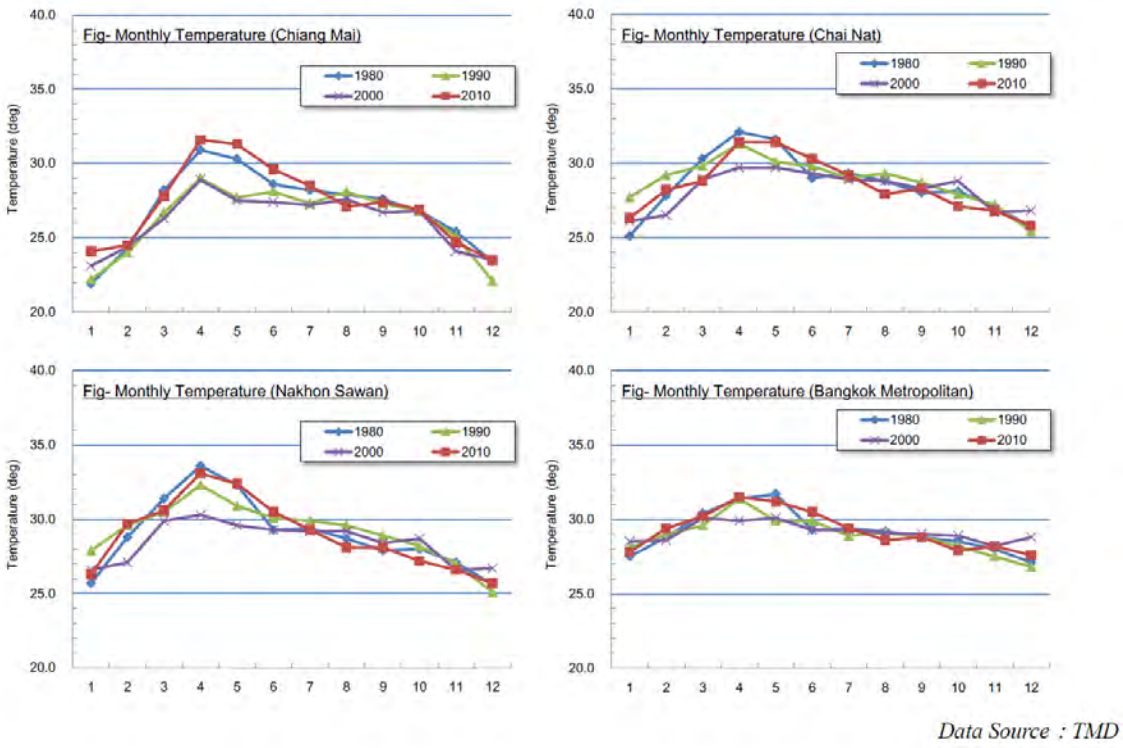
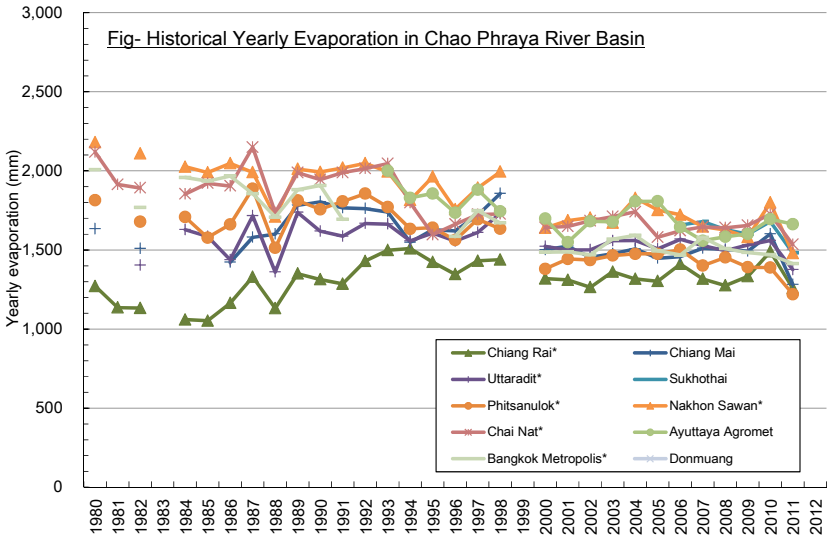


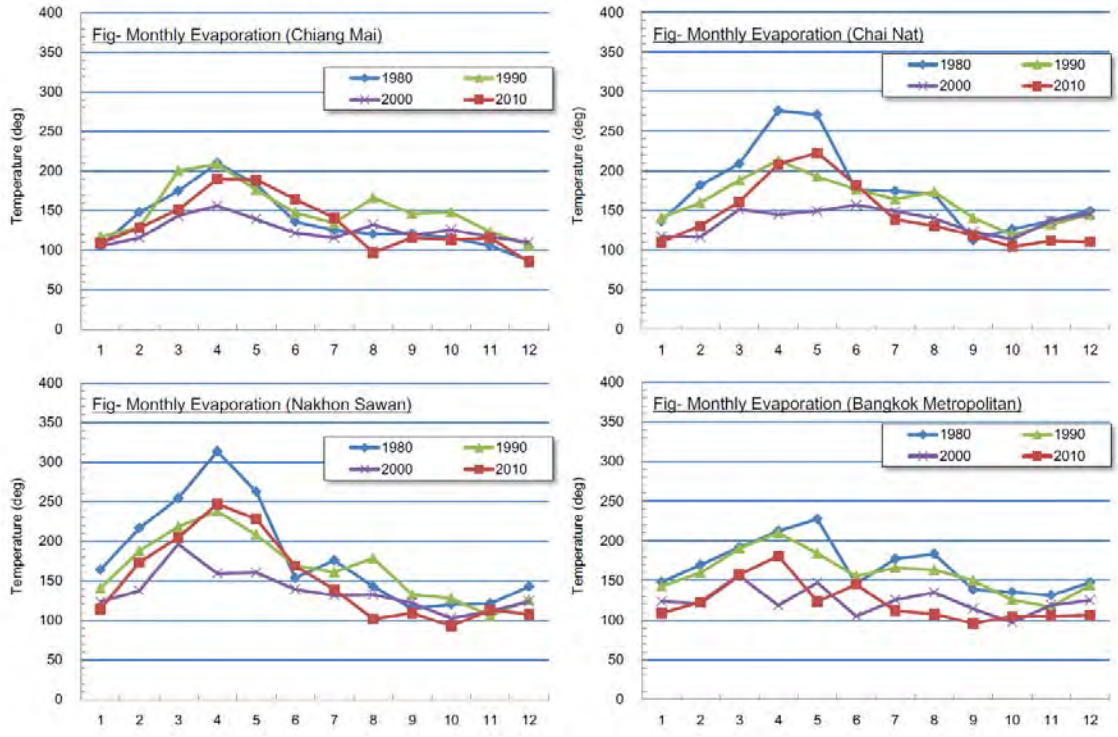
Figure 1.2 Monthly Mean Temperatures (Major Stations)

On the other hand, evaporation is decreasing as shown in Figure 1.3. Regarding the causes of the decrease of evaporation, change of vegetative covers, radiation, saturation condition, wind velocity are considered.



Data source: TMD

Figure 1.3 Yearly Evaporation (Major Stations)

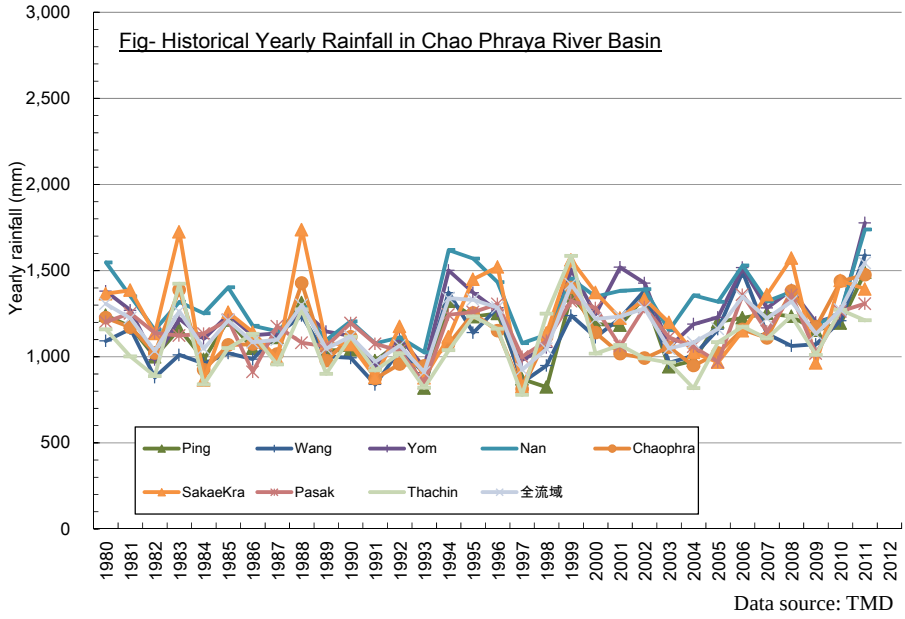


Data source: TMD

Figure 1.4 Monthly Evaporation (Major Stations)

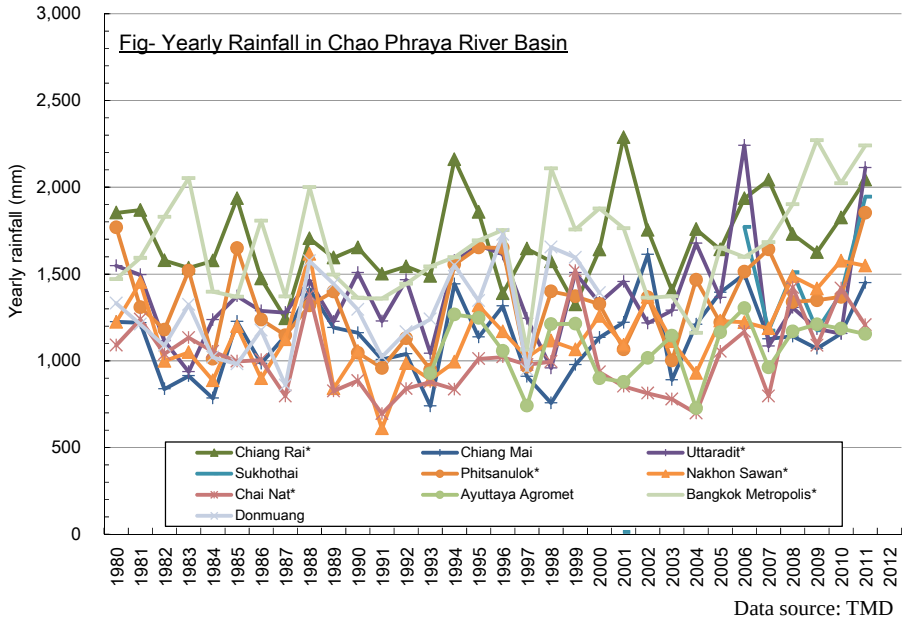
2. Rainfall

In the following figures, yearly rainfall in the Chao Phraya River Basin is presented. A slight increase trend can be seen in the figures, although an additional detail study is necessary for the whole river basin.



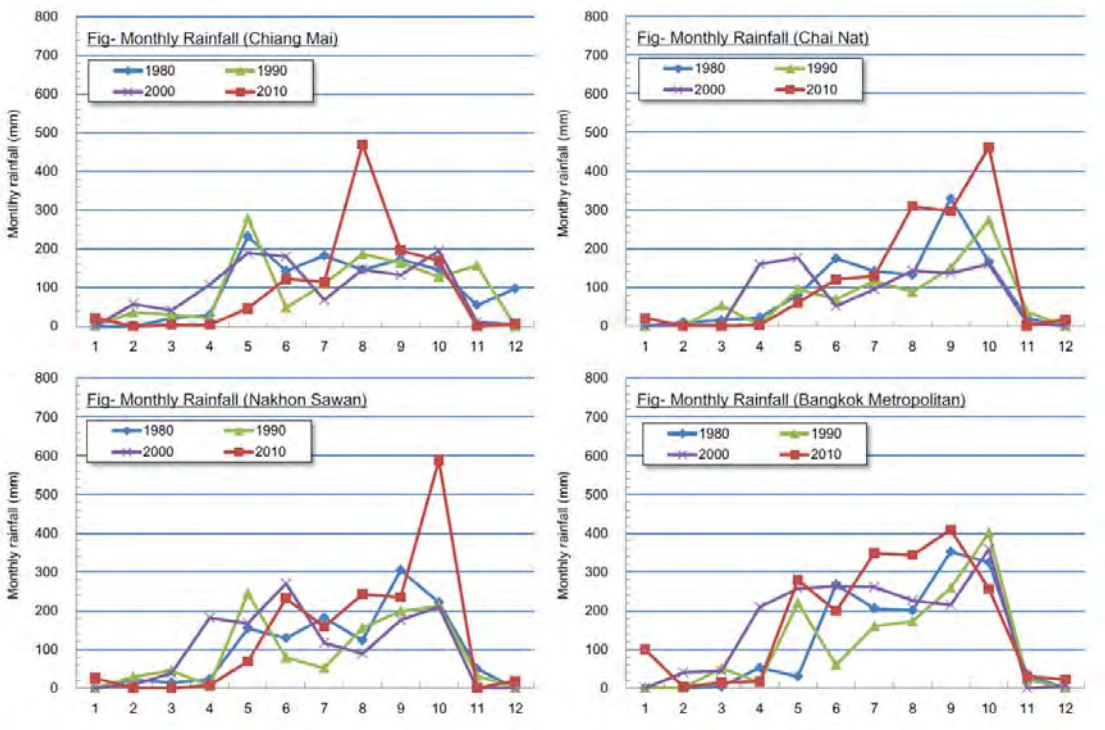
Data source: TMD

Figure 2.1 Yearly Rainfalls (Basin Mean Rainfall)



Data source: TMD

Figure 2.2 Yearly Rainfalls (Major Stations)

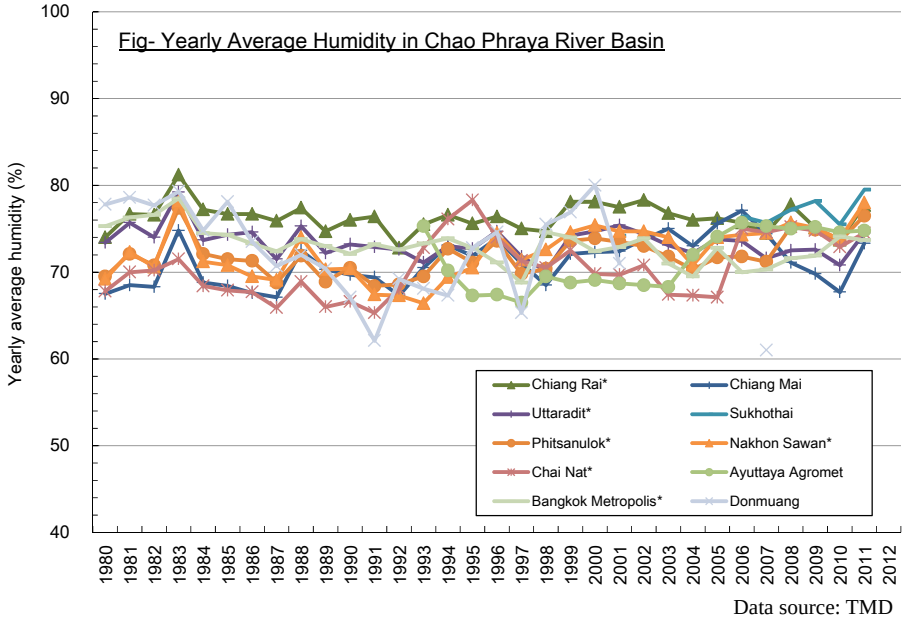


Data source: TMD

Figure 2.3 Monthly Rainfalls (Major Stations)

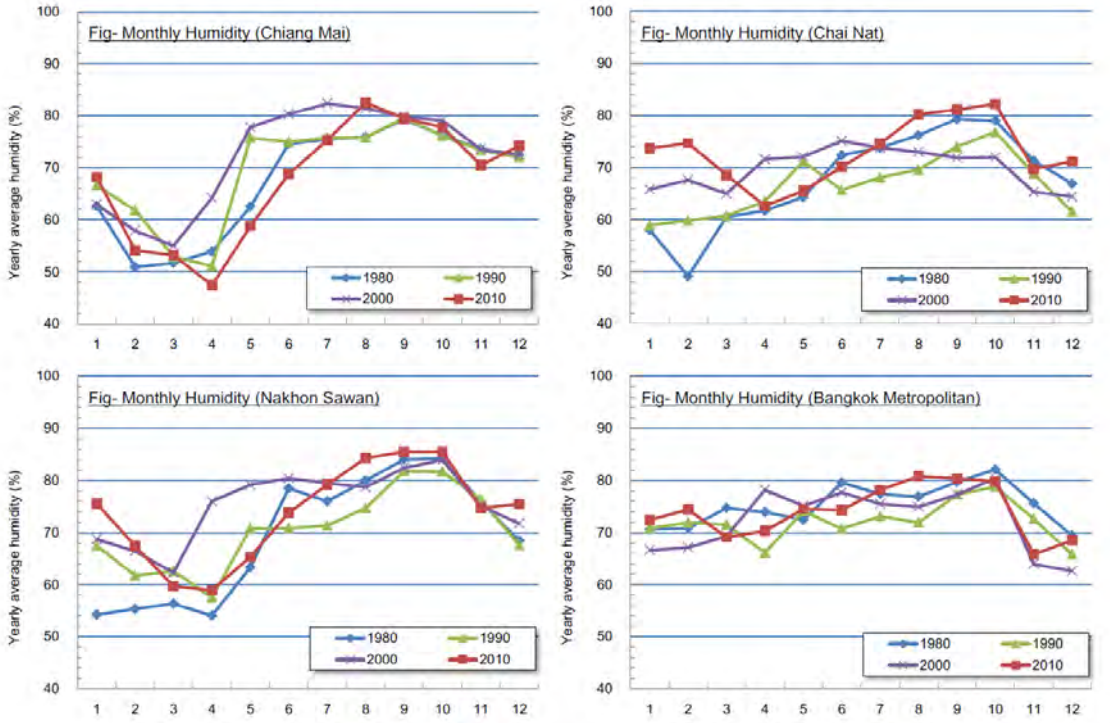
3. Humidity

In the following figures yearly and monthly mean humidity in the Chao Phraya River Basin is presented.



Data source: TMD

Figure 3.1 early Mean Humidity (Major Stations)

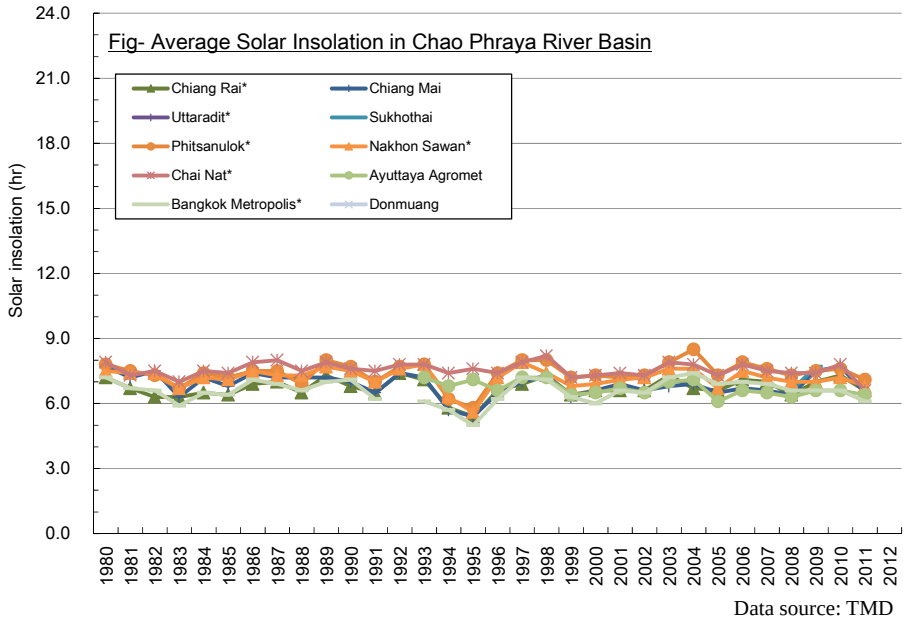


Data source: TMD

Figure 3.2 Monthly Mean Humidity (Major Stations)

4. Solar Radiation

In the following figures, yearly and monthly solar radiation in the Chao Phraya River Basin is presented.



Data source: TMD

Figure 4.1 Monthly Mean Humidity (Major Stations)

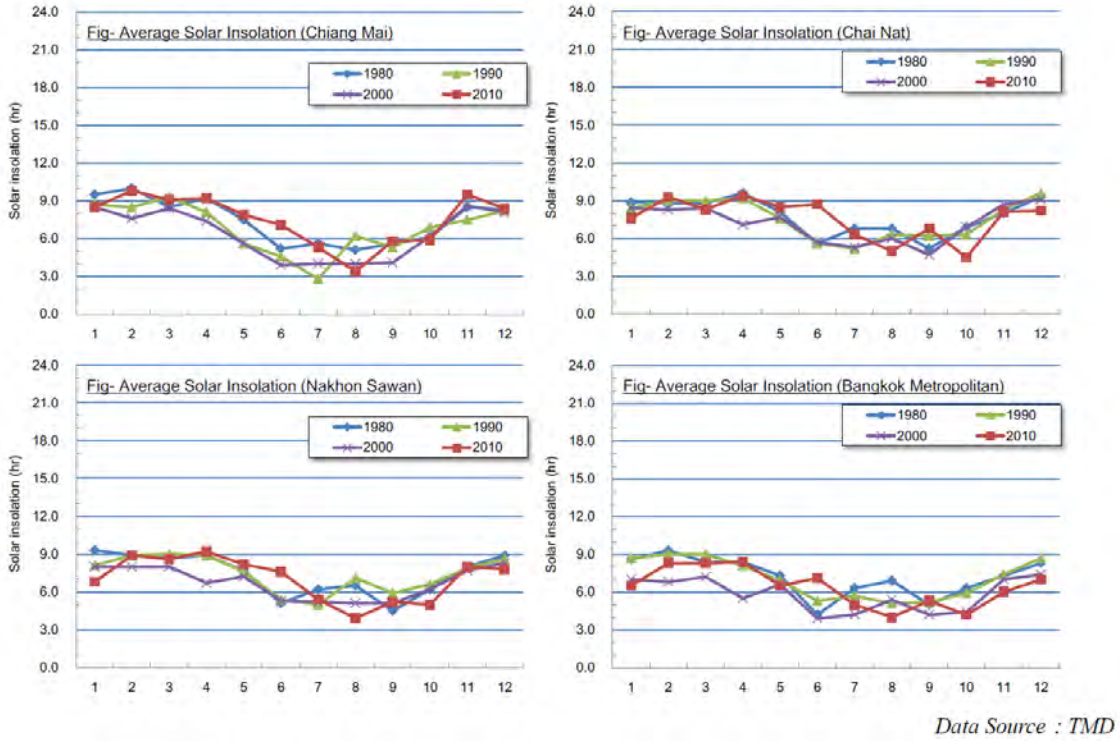


Figure 4.2 Monthly Mean Humidity (Major Stations)