APPENDIX 2 INTRODUCTION OF FLOOD FIGHTING IN OTHER COUNTRIES

1. INTRODUCTION

Flood fighting is an essential and final flood protection measure, which can be made locally during flooding times. This importance of this measure is broadly understood, and it is applied in all countries. It is very much useful to know how flood fighting is carried out in foreign countries. In this sense, flood fighting activities in six countries, Japan, China, USA, the Netherlands, Germany and the United Kingdom are summarized hereinafter and compared in Table 7.4.4 in Vol. 2, Main Report. Because flood fighting is much related to the government framework, social and natural condition of the country, such conditions are also discussed as basic information.

2. FLOOD FIGHTING IN OTHER COUNTRIES

2.1 Japan

2.1.1 Background

Japan is the most developed country in Asia with a population of over 120 million in its 370 thousand km^2 archipelago territory. Japan is a constitutional monarchy like Thailand. Many powers are given to the central government, which gives subsidies and delegates some powers to local governments. Decentralization is now being discussed towards realization of a smaller government.

Japanese people have been fighting against floods for a long time. Due to its archipelago topography, Japanese rivers are so short and steep that a flash flood is likely to be caused by heavy rainfall triggered by a typhoon or a monsoon. Flood inundation is also usually short and localized, but flood damage is significant because flood plains have been developed as urban areas. At present 50% of the national population and 70% of the national total assets are situated in flood plains which occupy only 10% of the national territory.

2.1.2 Flood Fighting Activity

Flood Fighting Law which is a basic law for the flood fighting operation in Japan, stipulates flood fighting organizations and operations, cost allocations and compensation for injuries during flood fighting activities. A flood fighting managing body which is usually a municipal government is primarily responsible for flood fighting. The prefecture government has responsibility to ensure an appropriate flood fighting operation by the managing body.

An actual field operation of flood fighting is done by flood fighting brigades, fire brigades and/or contractors. Flood fighting brigades and fire brigades are organized in local communities voluntarily. If requested by the governor of the prefecture, Self Defense Force participate in the flood fighting operation. The cost of the flood fighting is almost all financed by the flood fighting managing body. According to the 1996 fiscal year revenue for the flood fighting cost in the whole nation, subsidies

from the prefectures and the central government accounted for only 0.9% and 0.4% of the total cost.

2.2 China (Yangtze River)

2.2.1 Background

China is the most populated country in the world with a population of 1.2 billion in its 9.6 million km^2 territory. China is a socialist state and used to close its door to the world for a long time. Since the aftermath of the Great Proletarian Cultural Revolution settled down in 1979, China has been implementing a Reform and Opening Policy towards the establishment of a socialist market economy.

China is still maintaining a strong centralized system in spite of its huge population and vast territory. All activities in local areas are conducted under the command of the central government which operates in one body with the Communist Party.

Yangtze River is the biggest river in China with a catchment area of 1.8 million km^2 extending to 18 provinces. The river basin has been much developed as agricultural areas for a long time. In the middle and downstream areas, manufacture industries are also well developed. Giant cities such as Shanghai, Nanjing, Wuhan and Yichang are also located in the riversides.

Yangtze River Basin has been highly vulnerable to a flood disaster. Particularly the middle and downstream areas have been affected by a flood once in 10 years on an average since the era of Han Dynasty. After the establishment of the People's Republic, the government has been making great efforts to mitigate flood damage in the river basin. Construction and reinforcement of dikes, designation of retarding areas, construction of dam reservoirs have been major works. However, the protection level is still as low as 10 to 20-year return period.

2.2.2 Flood Fighting Activity

In China, participation in a flood fighting operation is a duty. Flood Defense Law stipulates that every individual and body must participate in a flood fighting operation. It is based on the philosophy that a benefit of the whole prevails over that of a part. It is said that flood fighting operation is more vigorously and effectively made in China under this law than the other countries. During the 1998 flood in the Yangtze River Basin, 8 million ordinary people and public servants, 0.27 million soldiers and 5 million militiamen were engaged in flood fighting operations, including reinforcement of dikes, construction of temporary dikes, urgent restoration of breached dikes and guidance of people for evacuation.

Concrete systems necessary for flood fighting operations are stipulated in Flood Fighting Law. Department of State organizes the National Flood Fighting Command Office which is responsible for the leadership for flood fighting in the whole country. People's governments of prefectures and higher levels organize flood fighting command offices which prepare flood fighting plans and supervise field flood fighting operations. Heads of such people's governments are responsible for flood fighting in their jurisdictions. For the Yangtze River Basin, in addition, a river basin flood

fighting command office can also be organized by people's governments of related provinces, cities and the river basin management organization.

The People's Liberation Army and armed police corps play a main role for a field flood fighting operation. On the other hand, local people's governments organize flood fighting brigades mainly composed of militiamen and ordinary people. Costs for flood fighting are generally financed by each local government. In case of a large flood, they are specially dealt with in accordance with related national regulations.

2.3 United States of America (Mississippi River)

2.3.1 Background

USA is one of the most developed countries with a population of 260 million in the 9.4 million km^2 territory. USA is consisting of 50 states and characterized by its diversity of human race, culture, economic situation, natural condition, etc. Decentralization of powers is a basic philosophy for the government structure. Each state functions almost like an independent nation.

Mississippi River is the largest river in North America. The river basin has a catchment areas of 3.2 million km^2 and extends over 31 states and parts of Canada. The Mississippi River and its tributaries form valleys along the river courses. The valleys, namely flood plains are mainly swamp areas and farm lands, but 7.7 million people are living in such flood plains.

Main causes of floods in the Mississippi River Basin are a long duration rainfall in spring and summer, a local thunderstorm, a snow melting flood, and so on. A flood duration of the main course is generally as long as 3 or 4 months. The worst flood in the 20^{th} century took place in 1993 due to an occurrence of three factors, the wet condition of the basin caused by much rainfall and cool summer in the previous year, the snow-melting and heavy rainfall from April to July. The total area of 41,000 km^2 were submerged, and the total flood damage to assets exceeded 15 billion dollars.

Flood mitigation works used to be implemented by local people to protect their own areas by constructing dikes. Large scale works by the federal government began after Flood Control Act was revised in 1928. Since then, dikes, dam reservoirs, diversion channels, retarding basins have been constructed under the Mississippi River & Tributaries Project. Recently flood plain management including flood insurance has been widely introduced.

2.3.2 Flood Fighting Activity

Federal Response Plan, of which concept is that the federal government plays a positive role for the implementation of a disaster response by providing states and municipalities with necessary manpower, equipment, expertise, and other resources was promulgated in 1992. Basically flooding fighting is primarily made by a municipal government with volunteer organizations. If the disaster exceeds its capacity, the municipal government can request supports from the state government. The state governor can further request the President of the United States to declare Emergency Major Disaster if he decides that the disaster is still too big for the state

and the local governments. If declared, the federal government positively participate in the disaster response.

Field flood fighting operations are mainly conducted by municipal governments. Emergency Operation Centers are set up in the municipal governments to collect information and direct the fighting operations by NGOs, police, fire services, civil work organizations, and government staffs. The state government coordinates the flood fighting operations in the state. State police, state soldiers, and civil work sectors of the state government are also incorporated into the operations. U.S. Corps of Engineers supports state and municipal governments by providing equipment and materials for flood fighting operations, protection works of dikes, etc. if Emergency Major Disaster Declaration has been made by the President.

2.4 The Netherlands

2.4.1 Background

Netherlands is a constitutional monarchy and one of the most densely populated countries in Europe with about 15 million inhabitants in the 42 thousand km^2 territory. The administration government structure is divided into three layers, the central, provincial and municipal governments. Administrative powers are decentralized and local autonomy is well ensured.

The country is located in the delta of three major European rivers, the Rhine, Meuse and Schelde. It means that water has always played a dominant role in the course of history. About 25% of the territory is situated below the sea level as a result of land reclamation, polder development and land subsidence. The most important primary measures protecting the country against tidal and river floods are dikes. Dikes have been almost completed with scales of 4000 or 10,000 year return period for sea dikes, and 2,000 or 4,000 year return period for river dikes in tidal areas and 1,250 year return period for river dikes in non-tidal areas.

In 1995 Western Europe, including Netherlands, was hit by the worst flooding of the rivers Rhine and Meuse and their tributaries by heavy rainfall and snow-melting since flood registration began over 100 years ago. High water levels continued for about 10 days along the rivers. Although 250,000 people living in dike-protected areas needed to be evacuated because of the potential threat of dike collapse, fortunately the dikes were protected without any dike breaks by flood fighting operations.

2.4.2 Flood Fighting Activity

The juridical/administrative framework of disaster response in case of national disasters is given in Disaster Act. This law also gives the mayor and alderman of municipalities the main responsibility for disaster management. Fire Service Act stipulates that fire services are the major pivot within the structure of disaster response.

The constitution of the Netherlands gives all levels of government their own responsibilities. The organization of flood fighting is decentralized and starts at the levels of municipalities. In principle the mayor of a municipality is in charge. If a flood is limited, it is handled by the municipalities themselves. If it is larger and

affects more municipalities, it is coordinated on a regional scale. If the flood affect a larger area crossing the borders of the regions, provincial coordination is made with a responsibility of the Royal Commissioner of the Province as the main person. If the flood exceeds the provincial coordination, national level coordination is made with the Minister of Home Affairs as the final person responsible.

Fire services, police, health services, ambulance services and other municipal government services and water boards are involved in flood fighting operation. Water Boards which have been organized for every polder to manage the polder, are engaged in the protection of the dikes. Defense Forces, Red Cross, Ministry of Transport, Public Works and Water Management and Disaster Relief Association are also involved on request from the municipalities. Coordination Centers are set up at the regional, provincial and national levels depending on the magnitude of the floods.

2.5 Germany

2.5.1 Background

Germany is a federal system country with about 77 million inhabitants in the 357 thousand km^2 territory. The administration government structure is divided into four layers, the federal government, 16 provinces and 3 urban provinces, 114 special cities and 426 counties, and 13,031 municipalities. A province functions as a state, and administrative powers are decentralized and local autonomy is well ensured.

Generally the risk of flooding is not so high in Germany mainly due to its hilly topography except for areas along the Rhine River and its tributaries. Flood mitigation has been under the responsibility of local people in the riversides. The Federal Government is not involved in the flood mitigation work.

In the downstream of the Rhine River, dikes have been built and managed by water boards as Netherlands. Movable walls have been provided in Kern against a flood with a magnitude of 40-year return period. In the upstream of the Rhine River a retarding basin project is underway to raise the present safety level of about 50 year return period to 200 year return period. In other areas, a flood warning system is a main facility for flood mitigation.

2.5.2 Flood Fighting Activity

A disaster response council generally headed by the mayor of the municipality is set up to direct flood fighting operations. Concrete operations are undertaken under the name of the head of the fire service. Fire services, police, soldiers and volunteers from non-government rescue associations, Red Cross, fire brigades, church organizations are engaged in the operations. In the downstream of the Rhine where dikes have been provided, water boards are responsible for flood mitigation and protect their dikes during floods.

2.6 United Kingdom

2.6.1 Background

The United Kingdom of Great Britain is composed of four kingdoms, England, Scotland, Wales, and North Ireland with a total population of 57 million in the 244

km^2 territory. 577. Each kingdom has a character as a state but England alone has a legislative power. The four kingdoms have their own local government systems. In England After the Thatcher Government, privatization has been positively promoted towards the realization of a small government.

Generally the risk of flooding is not so high in UK due to its hilly topography. Flood plains are limited to riverside areas which remain mainly as useless wet lands. Land development in the flood plains has just began recently.,

2.5.2 Flood Fighting Activity

In principle, local people is responsible for flood mitigation. Flood fighting operations are undertaken voluntarily by local people under the direction by the municipal government. EA (Environmental Agency) conducts flood forecasting and issues flood warnings.

APPENDIX 3 INTRODUCTION OF LAND USE CONTROL IN OTHER COUNTRIES

In this annex, laws and regulations related to land use control and guidance for flood mitigation in other countries are reviewed. The purpose for the review is to get familiar with what other countries are doing for flood mitigation by means of land use control and guidance and to form the basis to analyze what type of land use control and guidance can be applied to the floodplain in Thailand.

(1) Japan

(a) General View

The whole picture of the overall structure of Japan's land use-related major laws is given in Fig. 3.1.1. The laws related to land use control and guidance are Urban Planning Act, Agricultural Land Act with Act for Agricultural Promotion Areas, Forest Act, Natural Park Act, and Environmental Conservation Act as shown in Fig. 3.1.2. On top of these, there is National Land use Planning Act with which each of them should comply.

Although Fig.3.1.1 shows five laws, excluding National Land use Planning Act, by which land use can be controlled, only three laws such as Urban Planning Act, Agricultural Land Act with Act for Agricultural Promotion Areas, and Forest Act are the ones that are operated in consideration of flood mitigation. In general, Natural Pack Act and Environmental Conservation Act are not concerned about technical aspects on hydrology or floods.

(b) National Land Use Planning Act

In this law, a Prime Minister formulates a national plan that must be approved by the cabinet decision. Then complying with it, governors formulate prefectural plans that must be approved by prefectural assemblies. Governors must ask for consultations and have discussions with regional national development planning councils as well as mayors concerned in the course of formulating prefectural plans. Similarly, mayors formulate their city or town plans as governors do.

After all plans in all territorial levels are formulated, governors are responsible to formulate general land use plans in their prefectures. Again those plans must be approved by a Prime Minister after consultations and discussions with councils and mayors concerned.

In those land use plans, lands are demarcated into five categories: urban area, agricultural area, forest area, natural park area, and natural conservation area. In each of those areas, different land use strategies with different laws are applied.

The rules described above are stipulated by National Land use Planning Act.

(c) Urban Planning Act

This act is enforced in urban areas designated by the general land use plans. When designating urban areas, governors must make hearings with concerned mayors and regional councils of urban planning, then their plans must be approved by a Minister of the Ministry of Construction.

Urban areas are demarcated into three: urbanization areas, controlled urbanization areas, and others. Urban Planning Act stipulates different rules and regulations on each of three areas.

Urbanization areas are the ones that are already urbanized or should be urbanized under good control. Urbanization areas are demarcated into 13 categories in terms of land use, from high quality residential area to commercial to exclusive industrial area. Among them, seven categories are related to residential areas.

For example, in a class one low-rise residential area, a floor space is index should be between 50 to 200% and only those public facilities such as schools and clinics are allowed to build except for residential houses. That is, no large factory or department store is allowed to build so as to keep the residents comfortable for living there. With rules and regulations pertaining to land use types designated, each area of 13 categories is controlled and directed to a desirable shape of land use.

In the urbanization area, any development activity with a size of more than 1,000 square meter should be reported to a prefectural government and approved by a governor. Each prefectural government has a right to change this minimum value between 300 to 1,000 square meter.

A controlled urbanization area is the one where development is to be controlled and contained. One of the criteria to demarcate a urbanization area and a controlled urbanization area is that the area where useful natural functions such as water cultivation function and sediment control function should be preserved is designated as a controlled urbanization area. In this way, mitigating natural disasters is explicitly considered in Urban Planning Act. Development activities are strictly controlled in a controlled urbanization area.

An area that does not belong to either an urbanization area or a controlled urbanization area in an urban area is classified into others. Even in such an area, similar rules and regulations as those in an urbanization area are to be applied and a permission from a governor is required to do any development activities. Basically, any development with a size of more than 3,000 square meter should be reported and permitted by a governor in others.

(d) Agricultural Land Act and Act for Agricultural Promotion Areas

Since the above two acts go along together to control land use in agricultural lands, they are regarded as a single act in this chapter for convenience. In fact, Agricultural Land Act was enforced first, then Act for Agricultural Promotion Areas was enforced to cover such issues that Agricultural Land Act could not handle well.

Agricultural Land Act is to control acquisition and transfer of property rights over agricultural lands; to prevent speculators from acquiring agricultural lands without an intention of cultivating those lands and to promote the efficient use of agricultural lands. Once agricultural lands are converted into other types of land use, it would cost enormously to get them back for agriculture, thus this act is to control disorderly development of agricultural lands by means of a permit system of transactions of property rights.

When an ownership of an agricultural land is transferred or its property rights are changed, such a move should be permitted by a local agricultural committee, even though its type of use, i.e., agricultural use, remains the same.

When an agricultural land is converted into other use, such a move should be permitted by a governor if it is less than or equal to 2 ha, or by a Minister of the Ministry of Agriculture, Forest and Fishery if it is more than 2 ha. However, in case that that agricultural land is located in an urbanization area designated by Urban Planning Act, it is not required to receive a permit, only a reporting to a local agricultural committee is enough to change the land use type from agriculture to other.

Act for Agricultural Promotion Areas is to designate the lands to be used for agriculture. Such lands are called the agricultural land use areas. Those lands are strategically selected in consideration of securing and conserving clusters of efficient agricultural lands in coordination with other use of lands nearby. Once those lands are designated as the agricultural use, all transactions of rights over them and types of use are strictly restricted. Basically, any change in land use type is not permitted in the agricultural land use area by this act.

(e) Forest Act

The purposes in this act are, by means of setting up forest plans as well as rules and regulations, to conserve forests and to enhance forest productions so as to conserve the national land and contribute to the national economic growth. Basically, forests owned by the country can be controlled at its disposal. The point is how to control private forests.

In the act, a Minister of the Ministry of Agriculture, Forestry and Fishery must formulate a national forest plan every five years. Based on this national plan, governors must formulate regional forest plans in their prefectures every five years. Unlike the national forest plan, regional

plans are formulated only on those private forests that are designated as forest planning areas by a Ministry of Agriculture, Forest, and Fishery. In this way, part of private forests is controlled by Forest Act. Development in such a private forest that belongs to a forest planning area is not allowed unless a governor gives a permit for it.

With regard to national forests, a director at a regional forestry office must formulate a forest plan over national forests in each forest planning area every five year. Thus, national forests are fully controlled by Forest Act.

Most noticeable point in Forest Act in terms of flood mitigation is that the act can designate preserved areas for the purpose of natural disaster mitigation. In case a certain forest area has one of functions of; water cultivation; sediment control; landslide protection; wind damage mitigation; and so on, that forest area can be designated as a preserved forest and all activities there are strictly prohibited except for those activities that are permitted by a governor.

(f) Other Laws and Regulations Related to Land use

There are several others that are able to control and guide land use indirectly. For example, Building Control Act supports Urban Planning Act and contains disorderly construction. In this way, Building Control Act can indirectly control land use.

River Law is a fundamental law for managing rivers. This can, in a sense, control land use in and around rivers where river managers expropriate under River Law. Coast Law can control the land use of coasts and neighbors. Preserved forests are often observed along coastal lines and they are strictly controlled by Coast Law. And there are many other laws and regulations that are supplement to major laws and that are indirectly control land use.

Most of them, however, are in principle not intended to control land use for flood mitigation. Each law has its own purpose; Urban Planning Act is for controlling as well as promoting urban land use developments, Agricultural Land Act is for making efficient use of agricultural lands and controlling buying and selling lands, Act for Agricultural Promotion Areas is for designating productive agricultural lands, Forest Act is for securing public functions of forest, and so on.

Although there is no specific land use law intended to mitigate floods in Japan, concerned agencies in charge of the laws described above cooperate each other and make use of their laws to control land use for flood mitigation.

(g) Problems and Concerns

From the viewpoint of flood mitigation, there are several problems or concerns with respect to land use control and guidance in Japan that are summarized as follows:

- Since technical flood analyses such as flood risk maps are not publicized, there may be some damages unexpected by developers and others when a flood happens.
- Technical flood analyses are done by appointed river managers and river basin committees, not enough communication and cooperation with concerned agencies such as the Urban Planning Division of the Ministry of Construction and with the people are exchanged and provided. Therefore, there is no proof of its rationality and equity about flood mitigation measures formulated by river managers.
- At present, while flood control is taken care of by river managers, land use control is carried out by different agencies on different areas. However, there is no well-established system to coordinate them one another.

(2) Other Countries

(a) France

In France, there is a specific land use law for flood mitigation. France is actively controlling land use in floodplains POS (Le Plan d'Occupation des Sols: in English translation, Land Possession Planning Act) is to plan and control land use. POS is practiced in urban areas in line with SD (Schemas Directeurs: in English translation, Basic Design) and in rural areas in line with CIDA (in English translation, Municipal Union Charter).

POS was merely a law for efficient land use and not originally intended to mitigate flood damage by means of land use control. Based on the recognition that POS was effective to mitigate natural and man-made disasters, the function of mitigating those disasters was stipulated in POS in 1987.

In addition to POS, there are some other laws related to land use control indirectly or supplementary to POS. Before POS has been promulgated, PSS (Le Plan de Surface Submersible: in English translation, Floodplain Plan) existed and still exits now. PSS demarcates areas with high flood potential and clarifies responsibilities about land use. Clause R111-3 in Urban Planning Act is also able to control land use in urban areas for flood mitigation. Flood risk maps are to be open to the public by law, that is, PER (La Plan d'Exposition aux Risque: in English translation, Exposition Plan of Natural Disaster Risks). The relationship among POS, PSS, PER, and Clause R111-3 in Urban Planning Act is shown in Fig. 3.1.2.

(b) USA

In the United States, there is no specific land use control law for flood mitigation. Each local government has a master plan with land use zoning, but in general, there is no land use plan or control law over agricultural lands.

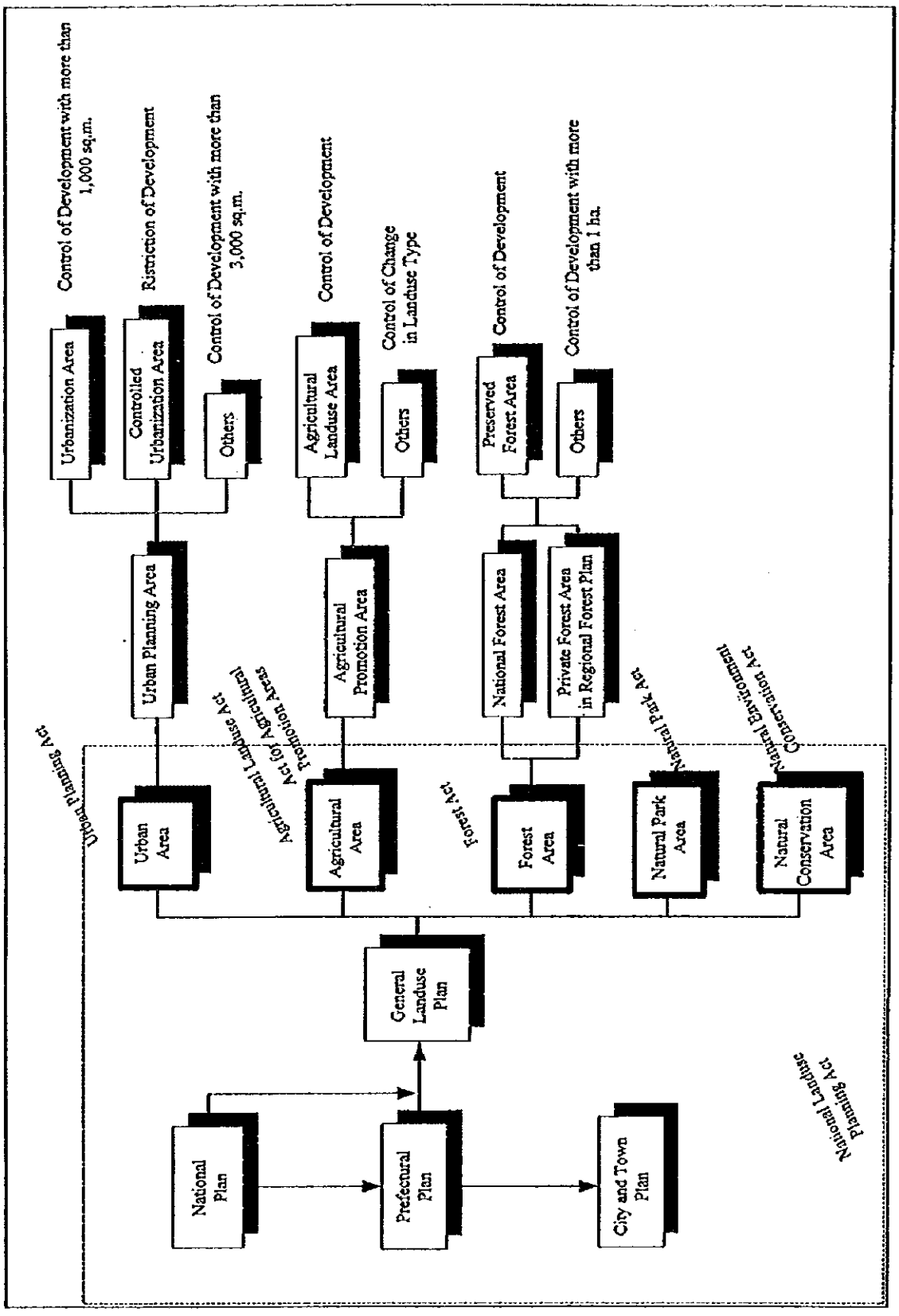
With state laws, urban planning is designated to be done by local government such as counties and districts, they are the ones that make land use plans in urban areas.

The flood insurance can indirectly control land use in floodplains in the United States. For the people to buy the flood insurance supported by the Federal government, a local government where they live must clear some strict rules. Y means of those rules, land use is indirectly guided and become in good shape. A schematic picture of the structure is shown in Fig. 3.1.3.

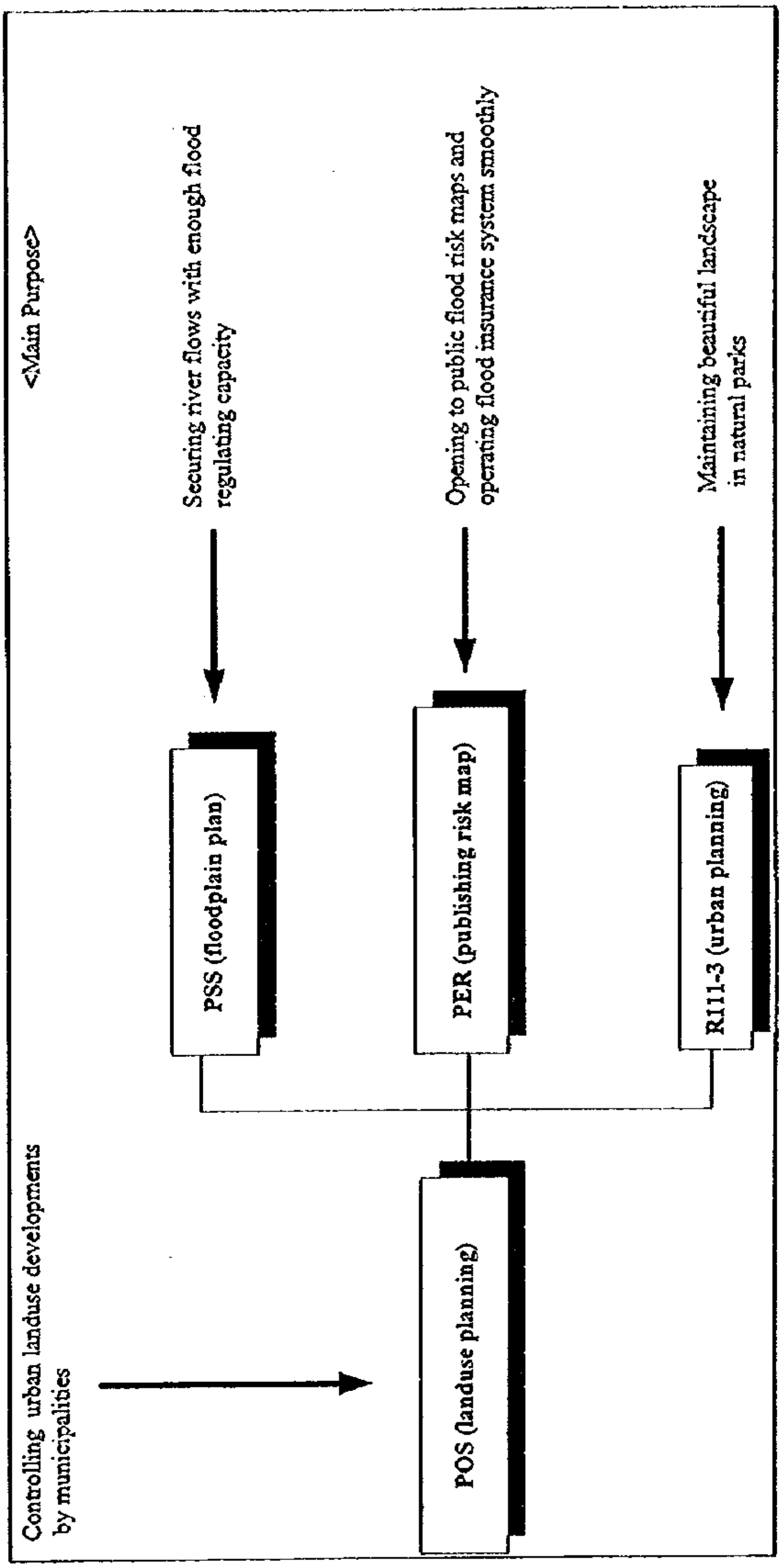
(c) Germany

Based on land use plans (F Plan) detailed area plans (B Plan) are formulated and practiced in Germany. There is no specific land use law for flood mitigation.

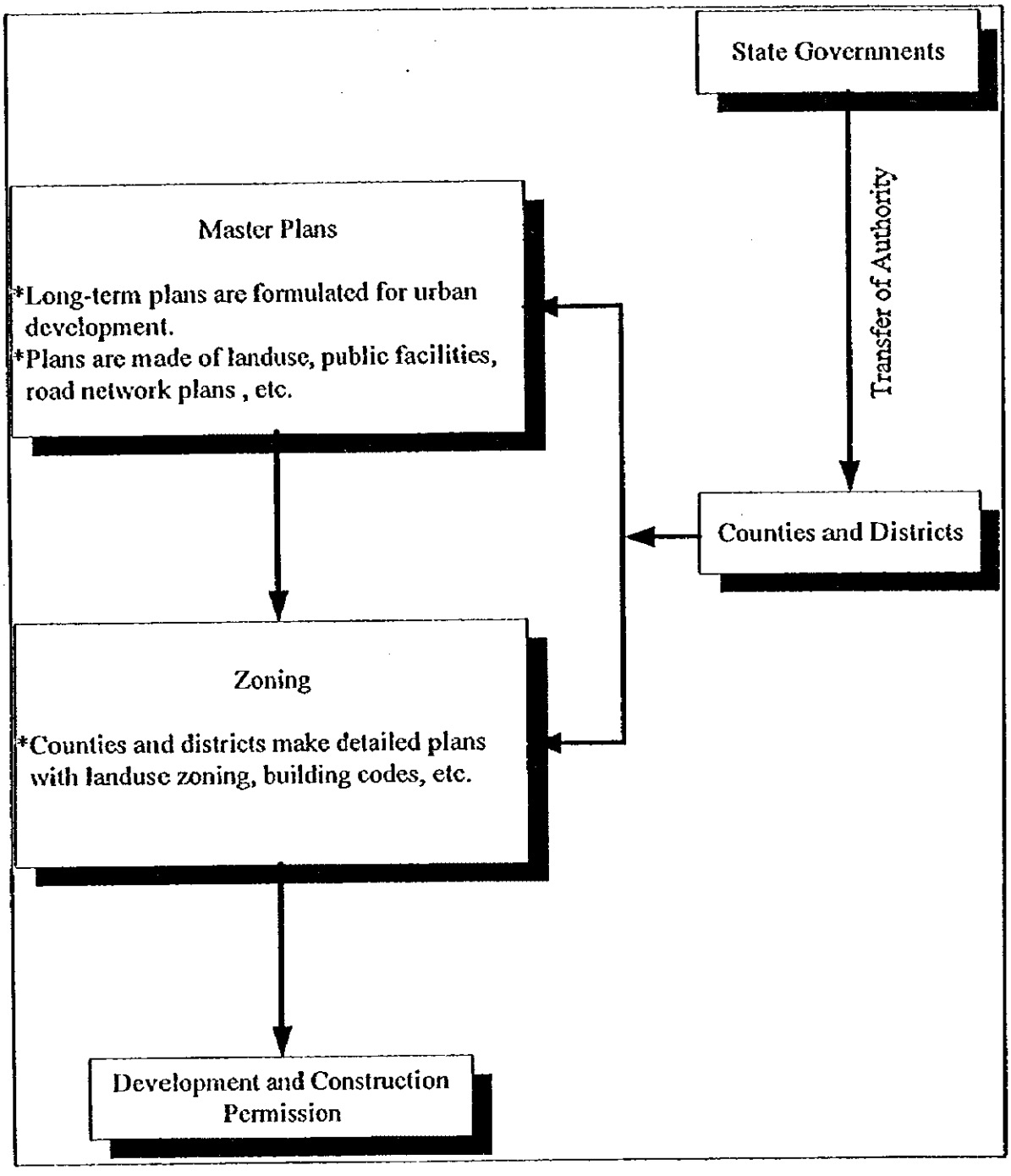
F Plan is formulated by each municipality and approved by a state government. F Plan covers a whole territory of a municipality and basic land use plan is formulated. In conformity with F Plan, detailed land use plans and building codes are specified in B Plan. Thus a structure that will be constructed should conform to B Plan, otherwise the Mayor will not permit the construction of that structure. A schematic picture of the structure is shown in Fig. 3.1.4.



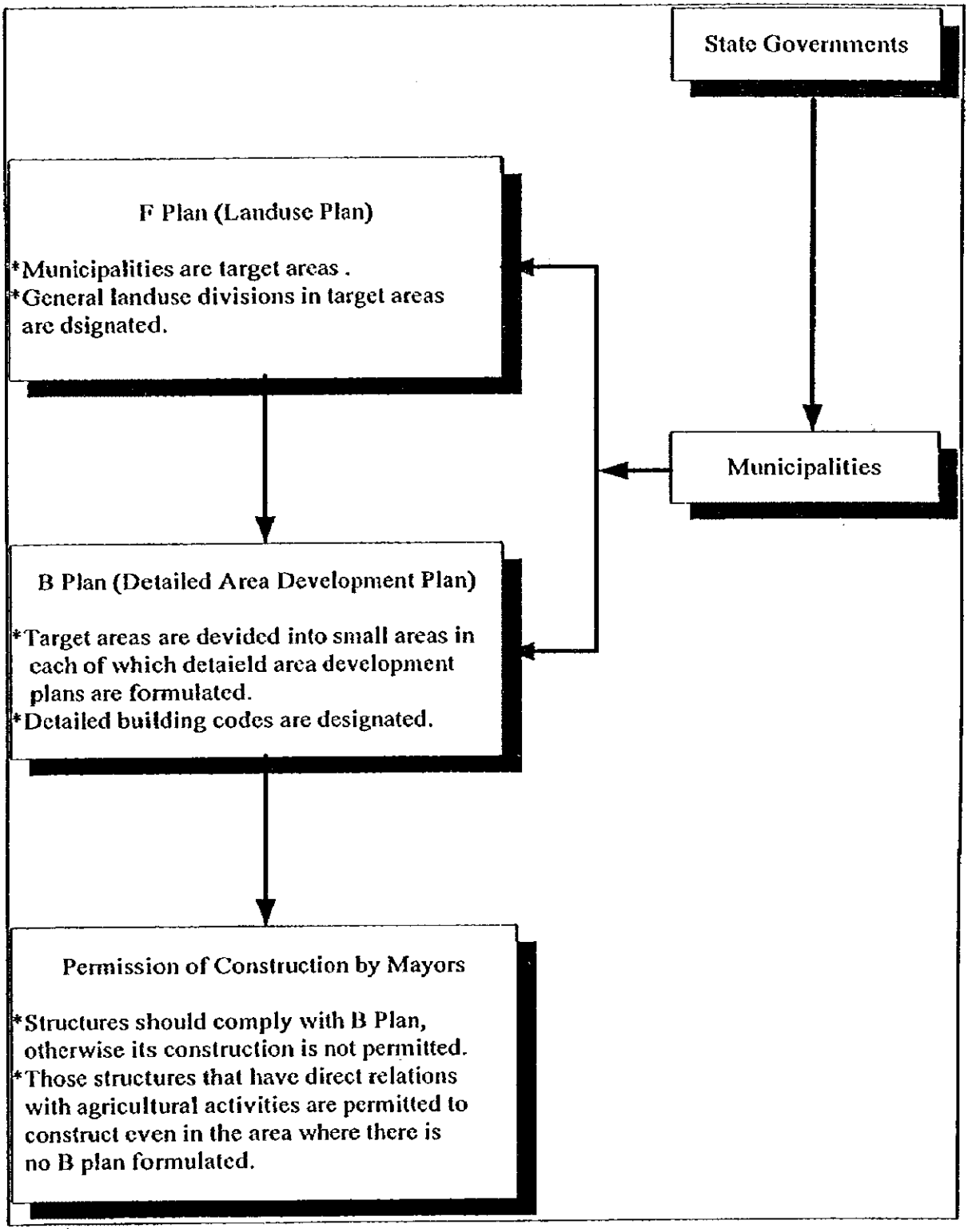
STUDY ON INTEGRATED PLAN FOR FLOOD MITIGATION IN CHAOPHRAYA RIVER BASIN	Fig. 3.1.1 LAWS RELATED TO LANDUSE IN JAPAN
CTI ENGINEERING CO., LTD. AND INA CORPORATION	



STUDY ON INTEGRATED PLAN FOR FLOOD MITIGATION IN CHAOPHRAYA RIVER BASIN CTI ENGINEERING CO., LTD. AND INA CORPORATION	Fig. 3.1.2 LAWS RELATED TO LANDUSE IN FRANCE



STUDY ON INTEGRATED PLAN FOR FLOOD MITIGATION IN CHAOPHRAYA RIVER BASIN CTI ENGINEERING CO., LTD & JNA CORPORATION	Fig. 3.1.3 URBAN PLANNING IN USA



STUDY ON ON INTEGRATED PLAN FOR FLOOD MITIGATION IN CHAOPHRAYA RIVER BASIN CTI ENGINEERING CO., LTD & INA CORPORATION	Fig. 3.1.4 FEDERAL CONSTRUCTION ACT IN GERMANY

SECTOR XII

PRELIMINARY DESIGN, COST ESTIMATE AND CONSTRUCTION PLAN

SECTOR XII
PRELIMINARY DESIGN, COST ESTIMATE AND CONSTRUCTION PLAN

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1. GENERAL

1.1 Contents

This supporting report, Sector XII, Preliminary Design, Cost Estimate and Construction Plan, is divided into three (3) parts. Part 1 deals with the preliminary design (Section 2), Part 2 deals with the construction plan (Section 3 and 4), and Part 3 deals with the cost estimates for the measures in the master plan and the river improvement project in the feasibility study (Section 5).

1.2 Project Components

1.2.1 Structural Measures of the Master Plan

In this study, the Master Plan is formulated in three options: Alternative 1, Partial Protection of Pathum Thani and Nonthaburi; Alternative 2-1, Heightening of Flood Barrier at Bangkok; and Alternative 2-2, Construction of Diversion Channel.

Among the project components, preliminary design, construction plan and cost estimate are prepared for the following measures:

(1) Heightening of Flood Barrier in Bangkok

(2) Diversion Channel

(3) Distribution System Improvement

(4) Drainage Improvement

(5) River Improvement

1.2.2 Structural Measures of the Feasibility Study

In the Master Plan Study, several project components and measures consisting of structural and nonstructural ones are proposed and studied for flood mitigation in the Chao Phraya River Basin. Among several structural measures, the River Improvement for Protection of Agricultural Area, which is selected for the Feasibility Study, is studied in this Sector.

From the economical point of view and the EIA survey, the most suitable measure of river improvement in the Feasibility Study is Alternative 1, Heightening of Existing Dike. Therefore, the construction plan and cost estimate is executed on the objective of Alternative 1 only.

2. PRELIMINARY DESIGN

2.1 Contents

2.1.1 Heightening of Flood Protection Barrier at Bangkok

(1) Conditions

(a) Heightening

As discussed in Sector I, Hydrology and Flood Simulation, the required raising heights of design water level at Memorial Bridge and Samsen are approximately 30 cm and 40 cm, respectively, when Alternative 2-1 is applied as a measure in the Master Plan. Therefore, it is necessary to sustain the safety level in Bangkok by heightening the ongoing flood protection barrier for 30 cm up to 40 cm due to raising of the design water level.

(b) Existing and Future Dike Condition

BMA is undertaking the construction of flood barrier, which is made of concrete. Fig. 2.3.3 in Sector VII, River Improvement Plan shows the typical types of dike in Bangkok.

(2) Study on the Bend of Foundation Pile

Heightening of the existing dike may cause the extreme bending of foundation piles as adverse influence. Therefore, the amount of bending is studied and the results are given below.

Heightening	30 cm	50 cm	100 cm
Amount of Additional Bend	0.5 mm	0.9 mm	1.9 mm

In practice, the heightening of dike is proposed at only about 30 cm. Therefore, it is not necessary to reinforce the foundation.

(3) Measure of Heightening

The structure and design are illustrated in Fig. 2.1.1. The method of heightening is to add concrete on top of the flood barrier. After chipping of the existing concrete dike, it is raised up with reinforced concrete.

(4) Heightening of Existing Regulators

Top of gates of existing regulators are set up according to the former plan. Therefore, it is also necessary to heighten the gates. The improvement of regulators is done with the replacement of gates. However, most of the regulators have a control deck with elevations having enough freeboard for navigation. Hence, it is not necessary to improve the gate pole and deck. (See Fig. 2.1.2.)

2.1.2 Flood Diversion Channel

(1) Conditions

(a) Route and Alignment

The objective route of the diversion channel is the Ayuthaya-East-Sea Diversion Route which has some questionable alignments (refer to Fig. 2.1.3.). One passes through the greenbelt area and the other passes between the greenbelt area and Bang Pa Kong River. Details of alignment of diversion channel are summarized in Table 2.1.1. Hereinafter, alignment of the diversion passing through the greenbelt area is applied and studied because the length of the channel is shorter. (See Fig. 2.1.4 for the detailed alignment of diversion channel.)

(b) Discharge

In Alternative 2-2 of the Master Plan, the flood diversion channel will be constructed with 800 m^3/s in the first stage. In Stage 2, the capacity of the channel will be increased by 300 m^3/s to 1,100 m^3/s.

(c) Water Level at River Mouth

MSL+1.6m is adopted as the water level at the river mouth, which is the high tide in flood season. (Refer to Sector I, Hydrology and Flood Simulation.)

(d) Water Level at Diversion Point

The diversion point is located between Bang Sai and Bang Pa Ing. Considering the 1995's flood water level and the existing dike elevation, water level at the diversion point is set at MSL+3.8m.

(e) Roughness Coefficient

The roughness coefficient of 0.025, which is generally applied to artificial channels in Japan, is adopted.

(2) Longitudinal Profile

Fig. 2.1.5 shows the longitudinal profile of the Ayuthaya-East-Sea Diversion Route.

(3) Standard Cross Section

Fig. 2.1.6 presents the standard cross-section.

2.1.3 Distribution System Improvement

(1) Canal Improvement

Canals in the flood plain are improved to increase the flow capacity by widening of channel, dredging of canal bed and excavation of channel slope, and heightening of canal dike. In addition, new canals are constructed to distribute the floodwater. Fig. 2.1.7 shows the improvement measures for canals. From the irrigation system and hydrological points of view, the most suitable measure is widening of channel.

(2) Installation of Distribution Regulator

Regulators are installed or rehabilitated at suitable points to distribute floodwater. Fig. 2.1.8 illustrates the structural drawing of a typical regulator.

(3) Appurtenant Work

Some facilities, such as siphon, drainage canal and small pumping station, are created for distribution of floodwater.

2.1.4 Drainage Improvement

(1) Conditions

There are about ten (10) drainage canals in the east and west banks of the lower delta which directly drain into the Bangkok Bay. The condition of representative canals are shown in Table 2.1.2.

(2) Measure of Improvement

There are three (3) measures to increase the drainage capacity of existing canals as mentioned below:

- Small Improvement of Existing Canal by Dredging
- Major Improvement of Existing Canal by Dredging and Construction of Retaining Concrete Wall of Canal
- Construction of New Drainage Canal

Figs. 2.1.9 and 2.1.10 show the structural drawings for small and major improvement of drainage in the east and west banks.

2.1.5 River Improvement

(1) Alignment

Fig. 2.1.11 illustrates the alignment of river improvement at 25-year return period with improvement of the distribution system.

(2) Longitudinal Profile

Fig. 2.1.12 shows the longitudinal profile of river improvement.

(3) Cross Section

As an example, a design cross section is drawn in Fig. 2.1.13.

2.2 River Improvement in the Feasibility Study

2.2.1 Basis of Preliminary Design

The numerical value of each material for preliminary structural design is shown in Table 2.2.1.

2.2.2 Structural Design

Standard cross sections for alternatives are shown in Fig. 2.2.1.

(1) Alternative 1

As illustrated in Fig. 2.2.1 (1/3), the existing condition of dike structure is maintained except the elevation of dike crown. When the crown of dike is utilized as asphalt road, the general foundation for roads in Thailand is applied. On the other hand, the surface of slope is covered with sod. For dike material, laterite is mixed with sand for easier compaction and workability.

(2) Alternative 2-1

The structures of dike are presented in Fig. 2.2.1 (2/3). PC pile is utilized for foundation; dike is made of concrete.

(3) Alternative 2-2

Material of dike is the same as Alternative 1. However, the width of crown of dike can be fixed at 3.0 m because new dikes are constructed. The crown of dike is paved as laterite road. [See Fig. 2.2.1 (3/3)]

2.2.3 Detailed Alignment and Cross Section

Fig. 2.2.2 shows the alignment of river improvement. Detail designs of alignment and section are complied in the Data Book. As examples, Figs. 2.2.3 and 2.2.4 show the detail design of alignment and cross-section. The features of river improvement are summarized below.

Location	Length	Heightening	Width of Crown	Type
Chao Phraya Lop Buri Noi Bang Bal Bang Phra Mo	67 km	10 cm ~ 170 cm	6 m ~ 21 m	Asphalt Road

2.2.4 Installation of New Regulators

Fig. 2.2.2 also shows the locations of new regulators. The features of new regulators are tabulated below.

Regulator No.	River	Gate Dimension		
		Width (m)	Number	Height
Reg.-1	Chao Phraya	4	1	4
Reg.-2	Chao Phraya	6	2	5
Reg.-3	Chao Phraya	6	2	5
Reg.-4	Chao Phraya	6	4	6
Reg.-5	Chao Phraya	4	1	4
Reg.-6	Chao Phraya	6	2	5
Reg.-7	Chao Phraya	6	2	5
Reg.-8	Chao Phraya	5	4	6
Reg.-9	Chao Phraya	6	6	6
Reg.-10	Chao Phraya	6	2	5
Reg.-11	Lop Buri	5	2	5
Reg.-12	Lop Buri	6	2	5
Reg.-13	Lop Buri	4	1	4

Typical structural design is drawn in Fig. 2.2.5.

3. CONSTRUCTION PLAN OF STRUCTURAL MEASURES OF THE MASTER PLAN

3.1 Flood Diversion Channel for the Study

As described in Section 2, there are three (3) cases of diversion channel, namely, Case A, 1,500 m^3/s; Case B, 1,000 m^3/s, and Case C, 500 m^3/s. These are also studied in this Section 3.

3.1.1 Work Item

(1) Diversion Channel

The following items of work are necessary for the construction of channel (refer to Fig. 3.1.1):

(a) Dredging/Excavation

(b) Embankment

(c) Smoothing of Channel Slope and Bed

(2) Appurtenant Works

Installation of the following appurtenant structures is necessary for the diversion project:

(a) Diverse Point Weir

(b) Weir with Navigation Lock for Compensation of Irrigation

(c) Small Regulator for Compensation of Irrigation

(d) Bridge for road that channel is intersected

(3) Land Acquisition and House Relocation

Among the major factors to decide the construction plan and the project cost are land acquisition and house relocation.

3.1.2 Work Volume

The volumes of work of each work item for the construction of diversion channel are tabulated below.

(1) Diversion Channel

(a) Dredging/Excavation

Summary of Dredging/Excavation Volume of Diversion Channel

Case	Diversion Route	Cost (in million m3)		
		Case-A	Case-B	Case-C
1	Tachin River Diversion (Mouth to 319 km)	344	196	57
2	Chainat-Pasak-Rahpipat-Sea Diversion (Mouth to 260 km)	230	149	69
3	Chainat-Pasak-Rahpipat-Ban Pakong Diversion (Mouth to 362 km)	561	369	191
4	Pasak-Raphipat-Sea Diversion (Mouth to 127 km)	118	80	42
5	Pasak-Raphipat-Ban Pakong Diversion (Mouth to 229 km)	449	299	164
6	Ayutaya-West Bank-Sea Diversion (Mouth to 105 km)	216	148	78
7	Ayuthaya-West Bank–Tha Chin Diversion (Mouth to 160 km)	314	192	94
8	Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	172	117	61
9	Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	193	131	59
10	Chao Phraya II Diversion (Mouth to 57 km)	138	94	50
11	Greenbelt Diversion (Mouth to 78 km)	193	131	68

(b) Embankment

Summary of Embankment Volume of Diversion Channel

Case	Diversion Route	Cost (in million m3)		
		Case-A	Case-B	Case-C
1	Ta Chin River Diversion (Mouth to 319 km)	22	25	28
2	Chainat-Pasak-Raphipat-Sea Diversion (Mouth to 260 km)	24	25	25
3	Chainat-Pasak-Raphipat-Ban Pakong Diversion (Mouth to 362 km)	33	31	31
4	Pasak-Raphipat-Sea Diversion (Mouth to 127 km)	13	13	13
5	Pasak-Raphipat-Ban Pakong Diversion (Mouth to 229 km)	22	19	20
6	Ayuthaya-West Bank-Sea Diversion (Mouth to 105 km)	3	3	3
7	Ayuthaya-West Bank--Tha Chin Diversion (Mouth to 160 km)	13	15	22
8	Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	4	4	4
9	Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	3	3	4
10	Chao Phraya II Diversion (Mouth to 57 km)	1	1	1
11	Greenbelt Diversion (Mouth to 78 km)	3	3	3

(c) Smoothing of Channel Slope and Bed

Summary of Embankment Volume of Diversion Channel

Case	Diversion Route	Cost (in million m2)		
		Case A	Case B	Case C
1	Ta Chin River Diversion (Mouth to 319 km)	65	50	30
2	Chainat-Pasak-Raphipat-Sea Diversion (Mouth to 260 km)	65	45	27
3	Chainat-Pasak-Raphipat-Ban Pakong Diversion (Mouth to 362 km)	122	90	63
4	Pasak-Raphipat-Sea Diversion (Mouth to 127 km)	32	25	17
5	Pasak-Raphipat-Ban Pakong Diversion (Mouth to 229 km)	88	70	53
6	Ayutaya-West Bank-Sea Diversion (Mouth to 105 km)	33	25	15
7	Ayuthaya-West Bank--Tha Chin Diversion (Mouth to 160 km)	53	39	25
8	Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	31	25	16
9	Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	32	24	14
10	Chao Phraya II Diversion (Mouth to 57 km)	20	15	9
11	Greenbelt Diversion (Mouth to 78 km)	32	24	14

(2) Appurtenant Works

The number of appurtenant works for all cases is as follows:

(a) Diverse Point Weir: 1

(b) Weir with Navigation, Small Regulator and Bridge

Number of Work Volume of Appurtenant Work

Case	Diversion Route	Number of Quantity				
		Weir	Regulator	Bridge		
				Large	Medium	Small
1	Tachin River Diversion (Mouth to 319 km)	5	100	3	17	9
2	Chainat-Pasak-Rahpipat-Sea Diversion (Mouth to 260 km)	9	100	7	61	65
3	Chainat-Pasak-Rahpipat-Ban Pakong Diversion (Mouth to 362 km)	7	30	5	67	60
4	Pasak-Rahpipat-Sea Diversion (Mouth to 127 km)	4	50	4	22	62
5	Pasak-Rahpipat-Ban Pakong Diversion (Mouth to 229 km)	3	30	2	28	57
6	Ayutaya-West Bank-Sea Diversion (Mouth to 105 km)	2	40	8	10	63
7	Ayuthaya-West Bank–Tha Chin Diversion (Mouth to 160 km)	2	40	5	11	5
8	Ayuthaya-East Bank-Sea Diversion-1 (Mouth to 96 km)	2	40	7	16	66
9	Ayuthaya-East Bank-Sea Diversion-2 (Mouth to 94 km)	2	40	7	16	66
10	Chao Phraya II Diversion (Mouth to 57 km)	2	30	8	15	35
11	Greenbelt Diversion (Mouth to 78 km)	1	30	4	12	66

(3) Area of Land Acquisition

Area of Land Acquisition

Case	Diversion Route	Area of Land Acquisition (ha)		
		Case-A	Case-B	Case-C
1	Ta Chin River Diversion (Mouth to 319 km)	3077	1883	835
2	Chainat-Pasak-Raphipat-Sea Diversion (Mouth to 260 km)	5484	3682	1886
3	Chainat-Pasak-Raphipat-Ban Pakong Diversion (Mouth to 362 km)	7609	4917	2412
4	Pasak-Raphipat-Sea Diversion (Mouth to 127 km)	2704	1998	1282
5	Pasak-Raphipat-Ban Pakong Diversion (Mouth to 229 km)	4830	3234	1808
6	Ayutaya-West Bank-Sea Diversion (Mouth to 105 km)	3269	2312	1377
7	Ayuthaya-West Bank–Tha Chin Diversion (Mouth to 160 km)	3260	2091	1259
8	Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	2985	2123	1259
9	Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	3024	2129	1213
10	Chao Phraya II Diversion (Mouth to 57 km)	1853	1290	7226
11	Greenbelt Diversion (Mouth to 78 km)	3024	2129	1230

(4) Number of House Relocation

The number of house relocation is summarized in the following table.

Number of House Relocation

Case	Diversion Route	No. of House Relocation		
		Case-A	Case-B	Case-C
1	Ta Chin River Diversion (Mouth to 319 km)	6,500	4,000	1,500
2	Chainat-Pasak-Raphipat-Sea Diversion (Mouth to 260 km)	2,400	2,200	1,700
3	Chainat-Pasak-Raphipat-Ban Pakong Diversion (Mouth to 362 km)	3,000	2,800	2,000
4	Pasak-Raphipat-Sea Diversion (Mouth to 127 km)	1,400	1,200	1,000
5	Pasak-Raphipat-Ban Pakong Diversion (Mouth to 229 km)	2,000	1,900	1,300
6	Ayutaya-West Bank-Sea Diversion (Mouth to 105 km)	3,200	2,900	2,200
7	Ayuthaya-West Bank–Tha Chin Diversion (Mouth to 160 km)	3,600	2,500	1,500
8	Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	1,600	1,500	1,400
9	Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	1,600	1,500	1,400
10	Chao Phraya II Diversion (Mouth to 57 km)	11,000	8,000	5,700
11	Greenbelt Diversion (Mouth to 78 km)	2,500	2,300	2,300

3.2 Flood Diversion Channel in the Master Plan

In the Master Plan, diversion channel, of which Ayuthaya-East-Sea Diversion 1 and Diversion 2 are proposed as the most suitable routes, is considered only in case of Alternative 2-2. In this case, diversion channel is also undertaken in two stages; namely, Stage 1 is implemented to absorb the adverse influence by protection works in the urban areas of Phathum Thani and Nonthaburi, and Stage 2 is to cope with the adverse influence due to river improvement for protection of agricultural areas. In this section, the construction plan of Alternative 2-2 of the Master Plan is studied.

3.2.1 Work Item

Work items are the same as in Section 3.1.

3.2.2 Work Volume

Work volume of each work item is as follows:

(1) Diversion Channel

(a) Dredging/Excavation

Summary of Dredging/Excavation Volume of Diversion Channel

Diversion Route	Volume (in m3)		
	Stage 1 ($800m^3/s$)	Stage 2 (add $300m^3/s$)	Case C (Total $1,100m^3/s$)
Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	65,210,400	24,400,000	89,610,400
Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	63,087,300	23,657,700	86,745,000

(b) Embankment

Summary of Embankment Volume of Diversion Channel

Diversion Route	Volume (in m3)		
	Stage 1 ($800m^3/s$)	Stage 2 (add $300m^3/s$)	Case C (Total $1,100m^3/s$)
Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	2,806,800	0	2,806,800
Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	2,772,000	0	2,772,000

(c) Smoothing of Channel Slope and Bed

Summary of Smoothing of Slope and Bed Volume of Diversion Channel

Diversion Route	Volume (in m^3)		
	Stage 1 ($800m^3/s$)	Stage 2 (add $300m^3/s$)	Case C (Total $1,100m^3/s$)
Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	13,278,200	4,979,300	18,257,500
Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	12,365,800	4,637,200	17.003,000

(2) Appurtenant Works

The number of appurtenant works for all cases is as follows:

(a) Diverse Point Weir: 1

(b) Weir with Navigation, Small Regulator and Bridge

Number of Work Volume of Appurtenant Work

Diversion Route	Number of Works				
	Weir	Regulator	Bridge		
			Large	Medium	Small
Ayuthaya-East Bank-Sea Diversion-1 (Mouth to 96 km)	2	40	7	16	66
Ayuthaya-East Bank-Sea Diversion-2 (Mouth to 94 km)	2	40	7	16	66

(3) Area of Land Acquisition

Area of Land Acquisition of Diversion Channel

Diversion Route	Volume (in ha)		
	Stage 1 ($800m^3/s$)	Stage 2 (add $300m^3/s$)	Case C (Total $1,100m^3/s$)
Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	1,956	0	1,956
Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	1,759	0	1,759

(4) Number of House Relocation

The number of house relocation is summarized in the following table.

House Relocation of Diversion Channel

Diversion Route	Number		
	Stage 1 ($800m^3/s$)	Stage 2 (add $300m^3/s$)	Case C (total $1,100m^3/s$)
Ayuthaya-East Bank-Sea Diversion 1 (Mouth to 96 km)	1,500	0	1,500
Ayuthaya-East Bank-Sea Diversion 2 (Mouth to 94 km)	1,400	0	1,400

3.2.3 Assumed Work Schedule

In the Master Plan Study, the construction stage is divided into two stages. The diversion channel aims at flow capacity of 800 m^3/s in the first stage from 2005 to 2013, which is going to be raised up to 1,100 m^3/s for the protection of agricultural area in the second stage from 2014 to 2016. It takes sixteen (16) years to implement the diversion channel project inclusive of the detail design stage. The integrated implementation schedule is shown in Table 3.2.1.

3.3 Heightening of Flood Protection Barrier at Bangkok

3.3.1 Work Item

(1) Heightening of Concrete Barrier

Fig. 2.1.1 shows the structure and design of heightening of flood barrier. The detail items for heightening of concrete barrier are as follows (see Fig. 2.1.1):

(a) Concrete: σk = more than 210 kgf/cm^2

(b) Reinforced Bar: SD295 D13~D16

(c) Epoxy Injection

(d) Demolition of Concrete

(e) Chipping

(2) Replacement of Gate

Due to raising of elevation of top of all gates at 30 cm to 40 cm, it is necessary to replace all gates of all regulators along the Chao Phraya River in Bangkok. (See Fig. 2.1.2)

3.3.2 Work Volume

(1) Heightening of Flood Barrier

The total length of the flood protection barrier planned by BMA is approximately 60 km.

(2) Replacement of Gate

There are forty-six (46) sets of gates installed in regulators or pumps along the Chao Phraya River in Bangkok. Most of the gates have almost been replaced. The dimensions are assumed as follows:

Height of Gate: 10m; Width of Gate: 10m ; Number of Gates per Set: 2

3.3.3 Assumed Work Schedule

The flood barrier project of BMA in the Bangkok area is ongoing and it is to be completed in the year 2002. Therefore, further heightening (Alternative 2-1 in the Master Plan) should be undertaken considering the progress of the present flood barrier project at Bangkok. The assumed work schedule is shown in Table 3.3.1.

3.4 Distribution System Improvement and Artificial Retarding Basin

Two types of retarding basin are studied in the master plan study. One is the "Distribution System Improvement" which is proposed as one of the projects in the Master Plan and the other is the "Artificial Retarding Basin" which is not suitable for the Master Plan. The study on these two types of retarding basin is as follows.

3.4.1 Work Item

(1) Distribution System Improvement

The following items are necessary for the distribution system improvement:

(a) Connection Canal and Expansion of Main Canal

(b) Construction of New Gate or Rehabilitation of Existing Gate

(c) Construction or Rehabilitation of Regulator

(d) Construction of New Siphon

(2) Artificial Retarding Basin

The items required for construction of artificial retarding basin are as follows:

(a) Enclosure Dike Construction

(b) Construction of Small Sluice Gate

(c) Pumping Station for Drainage in Retarding Basin

(d) Overflow Weir

(e) Road Improvement and Rehabilitation

(f) House Relocation

3.4.2 Work Volume

(1) Distribution System Improvement

The quantity of each item is shown in the table below:

Item	Unit	Quantity
Connection Canal and Expansion of Main Canal	km	40
Gate	place	5
Regulator (Small Sluice Gate)	place	15
Siphon	place	3

(2) Artificial Retarding Basin

In the Master Plan Study stage, three alternatives, namely, Case 1 (3,000 km^2), Case 2 (2,000 km^2) and Case 3 (1,000 km^2) are studied as applicable areas. The work volume of each alternative is estimated and calculated, as given below.

(a) Case 1

Item	Description	Unit	Quantity
Enclosure Dike Construction		Km	220
Pumping Station	5m3/s	Place	10
Small Sluice Gate	B x H = 2 x 2 m	Place	10
Over Flow Weir	2km wide	Place	2
Road Improvement	Heightening of 0.6m	Km	4,700
House Relocation		houses	105,000

(b) Case 2

Item	Description	Unit	Quantity
Enclosure Dike Construction		Km	160
Pumping Station	5m3/s	Place	7
Small Sluice Gate	B x H = 2 x 2 m	Place	7
Over Flow Weir	1km wide	Place	2
Road Improvement	Heightening of 0.6m	Km	2,100
House Relocation		houses	70,000

(c) Case 3

Item	Description	Unit	Quantity
Enclosure Dike Construction		Km	20
Pumping Station	5m3/s	Place	5
Small Sluice Gate	B x H = 2 x 2 m	Place	5
Over Flow Weir	2km wide	Place	1
Road Improvement	Heightening of 0.6m	Km	1,500
House Relocation		houses	35,000

3.4.3 Assumed Work Schedule

In the Master Plan, only the Distribution System Improvement is proposed as one of the structural measures. In addition, the Natural Retarding Basin with distribution system is given high priority for flood mitigation in the agricultural area with less cost. Therefore, this measure should be implemented as soon as possible. (See Table 3.4.1)

3.5 Drainage Improvement

3.5.1 Work Item

Work items for the Drainage Improvement (the Canal Improvement) are as follows:

(1) Earth Work (Dredging, Embankment)

(2) Concrete Work

(3) Foundation Work

3.5.2 Work Volume

Work volumes for the Drainage Improvement Project are as follows:

Case *	Area	Stretch *	Distance (km)	Required Canal Area (m^2)
B1	East Bank	A	25	165
		B	30	240
	West Bank	A	40	135
		B	40	180

* Refer to Supporting Report "Sector I, Hydrology and Flood Simulation."

3.5.3 Work Schedule

As in the Distribution System Improvement, this project will not adversely affect the lower urban area. Therefore, it should be started as soon as possible. (See Table 3.5.1.)

3.6 Tidal Barrage with Pump

As shown in Figs. 3.6.1 and 3.6.2, the tidal barrage with pump project consists of many works to sustain its function and to improve navigation.

3.6.1 Work Item

(1) Weir

(a) Earth Work

(b) Foundation Work: PC Pile

(c) Concrete Work

(d) Gate Manufacture

(c) Electrical and Mechanical Works

(f) Construction Works of Control Building

(2) Pumping Station

(a) Earth Works

(b) Foundation Works: PC Pile

(c) Concrete Works

(d) Manufacture and Installation of Pump with the Appurtenant Facilities

(3) Short Diversion for Discharge of Pump Drainage

(a) Earth Works

(b) Foundation Works

(c) Concrete Works

(4) Navigation Lock

(a) Earth Works

(b) Foundation Works

(c) Concrete Works

(d) Works of Lock

(e) Electrical and Mechanical Works

(5) Construction of Operation Building and Others

(a) Operation Building

(b) Warehouse

(c) Truck for Pump

(d) Boat for Maintenance

(e) Land for Buildings and Truck

(f) Transfer Substation

3.6.2 Work Volume

(1) Weir

Item	Unit	Quantity
Weir	m^2 (ton)	5,400 (12,000)
Motor and Mechanical Facilities	unit (ton)	10 (2,000)
Reinforced Concrete	m^3	300,000
Foundation	m^2	50,000

(2) Pumping Facilities, Warehouse, Automobile (Truck, Sedan and Boat), Offices and Electrical Transfer Substation

Item	Unit	Quantity
Pump with Column	unit	1,500
Cable, Steel Pipe, Screen and Crane	unit	1,500
Control Panel, Gauging System and Other Mechanical Facilities	unit	1,500
Control Office	m^2	300 x 3 stories
Warehouse with Crane	m^2	120,000
Truck, 4t	No.	50
Sedan	No.	10
Boat	No.	2
Transfer Substation + Electrical Wire	L.S.	1
Land Acquisition	m^2	125,000

(3) Pumping Station

Item	Unit	Quantity
Concrete	m^3	360,000
Foundation	m^2	60,000

(4) Short Diversion for Pump

Item	Unit	Quantity
Concrete	m^3	600,000
Foundation	m^2	25,000

(5) Navigation Channel with Lock

1 unit

3.7 River Improvement

3.7.1 Work Item

The works for the River Improvement Project are as follows:

(1) Heightening of Existing Dike

(2) Installation of New Regulator

3.7.2 Work Volume

(1) Heightening of Existing Dike

Location	Length
All Rivers	200 km, Approx.

(2) Installation of New Regulator

Location	Number of Regulators
All Rivers	20

4. CONSTRUCTION PLAN OF STRUCTURAL MEASURES OF THE FEASIBILITY STUDY

4.1 River Improvement

4.1.1 Work Item

The following items are necessary for the river improvement project:

(1) Heightening of Road

(a) Prime Coat

(b) Asphalt, 0.1m thick

(c) Cap Seal

(d) Aggregate

(e) Embankment

(f) Removing existing A.C. Surface

(g) Sodding

(2) Installation of Regulator

(a) Earth Works

(b) Pile Works

(c) (Reinforced) Concrete Works

(d) Steel Works

(e) Revetment

(f) Mechanical Works

4.1.2 Work Volume

Details of work volume for each work item of the river improvement project are given in Tables 4.1.1 and 4.1.2. Work volumes are summarized below.

Summarization of River Improvement Project

	Improved Length (km)	Installation of Regulator (No.)	House Relocation (No.)	Land Acquisition (m^2)
Chao Phraya	41.8	10	4	12,590
Noi	6.6	0	0	0
Lop Buri	14.0	3	1	6,100
Bang Bal	2.5	0	0	0
Bang Phra Mo	2.1	0	0	0
Total	67.0	13	5	18,690

4.2 Construction Schedule

4.2.1 General

In the Master Plan Study, it is proposed to complete the river improvement by the year 2005. It is assumed that the river improvement project will start within 1999 as soon as this study is completed. In this connection, it is possible to execute the aforementioned work volume within approximately six (6) years.

4.2.2 Construction Plan and Schedule

(1) Detail Design and Procurement Stage

Immediately after the completion of this study in 1999, detail design of the project is to be implemented. It will take about one (1) year for the detail design. Especially, investment and survey work will take the longest time in this stage. After the detail design stage, the project will move to the procurement stage. Firstly, the responsible agency will procure consulting firm(s) and begin to negotiate purchasing of land with residents. Secondly, the agency and the consultant will prepare for procurement of contractor(s) for the project, including tendering and contracting.

(2) Construction Stage

(a) Order of Construction

Heightening of existing dike is undertaken from the lower portion.

(b) Construction Period

Construction period is six (6) years. However, the net duration will be three (3) years due to impossibility of compaction of dike in the rainy season from the beginning of June to the end of December. Hence, it is difficult for one work group to complete the river improvement within the target year. Therefore, after completion of the Chao Phraya River improvement, the construction of upper parts will overlap with each other. The tentative progress of construction is to be the improvement of 25 m in one week by one group. Basically, two work groups are required for the construction.

(c) Construction Schedule

Fig. 4.2.1 shows the construction schedule of river improvement.

(3) Special Considerations for the Construction Plan

(a) Borrow Pit

Canals along the heightened road or areas in the right of way are generally utilized as borrow pit. In addition, swampy areas near the construction sites are also utilized as borrow pit. Swampy areas play the role of retarding area in flood time and the excavation of swampy areas will increase the retarding effect. The price of soil is free. Table 4.2.1 shows the considered locations of swampy areas.

(b) Heightening Method

Most of the heightened roads are 2-lane and utilized as main roads in the local areas. Therefore, construction is to be implemented one-way, and for the whole width when detour near the road is constructed.

4.2.3 Integrated Construction Schedule including the Master Plan

Table 4.2.2 shows the integrated construction schedule of alternatives in the Master Plan.

4.2.4 Organization of Construction

The river improvement is to be undertaken by RID. For RID projects, two implementation methods are followed. One method is to carry out the construction through a firm contracted by RID. The other method is for RID to carry out the construction entirely by RID personnel without a private contractor.

Many project offices of RID, such as Rangsit Tai and Phrapimol, have been established to carry out construction works. If RID will decide to undertake construction by itself, a new project office is to be established to carry out the river improvement project.

The project field office will generally comprise the following personnel:

- Project Engineer
- Assistant Project Engineer
- Structural Engineer / Civil Engineer
- Hydraulic Engineer
- Irrigation Engineer
- Survey Technician
- Hydrogeologist
- Environmentalist
- Project Economist
- Public Relations Officer
- Procurement Officer
- Finance Officer
- Mechanical Engineer
- General Service and Administrative Officer
- Storekeeper
- Earth Moving Equipment Operators
- Dredging Crew
- Drivers
- Boat Operators
- Secretary
- Office Clerks and Typists
- Skilled labour of various disciplines
- Unskilled Labour

The total number of staff varies depending on the size of the project. It may be from a few hundred to several thousand. The other factor governing the number of staff is the time frame of the project. The shorter is the time for project implementation, the greater is the number of staff required.

If the construction works are done with the supervision of RID, the staffing of the Project Field Office will be less than the above. Normally, the number of staff may be around 20 to 35 persons. However, the number also depends on size of the project. There is no rigid rule on this arrangement.

Table 4.2.3 is an example of setting up of project personnel in the Chaochet-Bang Yihon Project Office.

5. COST ESTIMATE

5.1 General

5.1.1 Basis of Cost Estimate

To estimate the cost of the project, the work volume for the major items is obtained from the preliminary or feasibility design of main structures and major appurtenant structures, and minor items are counted as a percentage of major items, as discussed below (see Fig. 5.1.1).

(1) Major Items

(a) Construction Cost of Main Structures and Major Appurtenant Works in Each Project (Major Works)

The major works of main structures include earth works, concrete works, foundation works, steel works and pavement works. The quantities of major works are calculated from the preliminary or feasibility design drawings for which results of cross-section data and topographical map with a scale of 1:50,000 or 1:10,000 are utilized. The costs of major works are obtained by summing-up of the costs derived by multiplying the unit cost of each work item with the total quantity. (Refer to Subsection 5.1.2, Unit Price, Rate and Cost.)

(b) Purchase of Land

For the purchase of land required for river improvements and so on, work volume is obtained from the results of cross-section survey and topographic map with a scale of 1/10,000 or others. Unit land price is based on the survey results in the field through the EIA study or the data books of the land department in each agency concerned.

(2) Minor Items

(a) Preparatory Works

The building including office, residence, warehouse, laboratory, etc. for the supervisory body of RID or other agencies, the Consultant and the Contractor will be constructed by the Contractor at the beginning stage of construction and maintained during the construction period by the Contractor. The costs of preparatory works are estimated as 5% of the major works in the feasibility study and as 5~10% of the major works in the master plan study.

(b) Temporary Works

Contractor's camp and office, access road, stripping at the borrow area, temporary transmission line for electricity, water supply system, etc., will be constructed or provided by the Contractor at his own expense. The costs of temporary works are estimated as 10% of the major works

in the feasibility study and as 10~20% of the major works in the master plan study.

(c) Survey and Investigation

The cost of survey and geological investigation works are estimated as 2% of the construction cost of the major works in the feasibility study and as 2~10 % of construction cost in the master plan study.

(d) Engineering Services for Detailed Design and Supervision

The cost of consulting services for the detailed design is estimated as 5% of the construction cost of the major works, and the cost of construction supervision by RID and the Consultant is estimated as 5% of the construction cost of the major works in the feasibility study. The cost of consulting services for the detailed design with construction supervision is estimated as 5~10% of the construction cost of the major works in the master plan study.

(e) Administration/Miscellaneous Cost

The administration cost consists of allowances, salaries for temporary personnel, costs for transportation, and miscellaneous costs, except the cost of building, project office and residence. It is estimated as 5% of the construction cost of the major works.

(3) Base Cost

The base cost is the sum of costs of major works and the costs of the above-listed items (a) to (e).

(4) Physical Contingency

In both the feasibility and master plan studies, the physical contingency is estimated as 10% of the base cost considering that the preliminary design is based only on the topographical map with scale of less than 1/10,000.

(5) Price Contingency

All costs and prices are estimated as of 1998. Therefore, the price contingency is estimated by assuming that the annual price escalation rate is 3% and the weighted disbursement period is 3 years. $[(1+0.03)^3 - 1 = 0.093$; namely, 10% of price contingency is applied in the project of the Feasibility Study.]

(6) O/M Cost

The cost of equipment, administration and O/M is estimated as 4% of the construction cost of major works after the completion of the project.

5.1.2 Unit Price, Rate and Cost

The unit rates used for costing the river improvement project are given in Tables 5.1.1 to 5.1.6. These rates are based on recently constructed projects of RID, some projects of similar scale of agencies concerned, and questionnaire with private firms, with adjustments to reflect escalation of costs of construction materials and of wages. The segregation of cost into Local Currency Component (L/C) and Foreign Currency Component (F/C) is also based on recent projects of RID and agencies concerned. F/C costs for the river improvement project are made up primarily from direct foreign costs for plant and fuel. Indirect F/C costs in items such as cement, aggregate and transport, which include fuel cost, make up a smaller part of the total foreign exchange cost.

Assuming that local contractors are employed, it is estimated that the overall F/C component for the project will be about 40% to about 60%.

5.2 Cost Estimate in the Master Plan Study

5.2.1 Flood Diversion Channel

Tables 5.2.1, 5.2.2 and 5.2.3 show the financial construction/project cost of the diversion channel project at three capacities, 1,500 m^3/s, 1,000 m^3/s and 500 m^3/s. In the Master Plan, the capacity of the diversion channel is proposed at 800 m^3/s in the first stage and 300 m^3/s will be added in the second stage. Therefore, the capacity will be increased to 1,100 m^3/s. Table 5.2.4 shows the project cost of the proposed diversion in the Master Plan.

5.2.2 Heightening of Flood Protection Barrier at Bangkok

Table 5.2.5 presents the construction cost of the heightening of flood barrier at Bangkok. This cost is in addition to the previous flood protection project of BMA (BMA Project). Hence, the total cost of the BMA project is 13,573.4 million baht.

5.2.3 Distribution System Improvement

The project cost of Distribution System Improvement has been roughly estimated due to the large area for the study. The cost is given in Table 5.2.6.

5.2.4 Drainage Improvement

Table 5.2.7 shows the project cost of Drainage Improvement in the lower delta in accordance with work volume and construction plan.

5.2.5 Retarding Basin for Reference

The project cost of artificial retarding basin has been very roughly estimated due to huge area for the study. The project cost of "Artificial Retarding Basin" is given in Table 5.2.8.

5.2.6 Tidal Barrage with Pump for Reference

The project cost of the tidal barrage with pump is estimated at 131,020 million baht as itemized in Table 5.2.9.

5.3 Cost Estimate of River Improvement in the Feasibility Study

From the preliminary design, construction plan including calculation of work volume and unit cost, the financial cost of river improvement project is estimated. Table 5.3.1 gives the financial project cost, and the cost of the project is summarized below.

Summary of Financial Cost of River Improvement Project

Unit: million baht

Item	Chao Phraya	Lop Buri	Noi	Bang Bal	Bang Phra Mo	Total
Total Length of Dike Heightening Stretches (km)	41.8	14.0	6.6	2.5	2.1	67.0
Regulators (places)	10	3	-	-	-	13
Land Acquisition (m^2)	15,500	6,200	2,000	800	300	24,800
House Relocation (houses)	4	1	-	-	-	5
Financial Cost (mil. Baht)	1,052	284	55	23	11	1,425

5.4 Integrated Cost of River Improvement Project

Table 5.4.1 shows the integrated cost of the river improvement project, including improvement at 25-year return period in the Master Plan.

Tables

Table 2.1.1 THE OUTLINE OF THE ALTERNATIVE ROUTES OF DIVERSION

Diversion	Area passed through	Distance (km)	Water level at Diversion Point (MSL+m)	Bed Elevation at the Mouth (MSL+m)	Bed Slope (i=1/I)
Ayutthaya-East Bank-sea (1) Div.	Bang-Pa-Ing ~ RangSit ~ Khlong Phra-ong Chaiyanuchit ~ Khlong Dan	Mouth to 96	3.8	-6	1/ 46,000
Ayutthaya-East Bank-sea (2) Div.	Bang-Pa-Ing ~ RangSit ~ Khlong Bang Chalong ~ Khlong Bang Pla	Mouth to 93	3.8	-6	1/ 45,000

Table 2.1.2 FEATURES OF MAIN CANAL IN THE EAST BANK

Name	Width (m)	Depth (m)
K. Bang Rhu	8~10	1.3~1.5
K. Bang Phra	20	2.0~3.0
K. Chareonrathi	10~12	1.5~1.8
K. Dan	35~40	2.8~3.2
K. Konbueng	10~15	0.5~0.8
K. Phraya Visutr	8~10	1.5~1.6

Table 2.2.1 NUMERICAL VALUES OF MATERIAL FOR DESIGN CRITERIA

Material	Unit Weight (tf/m3)	Application	Remarks
Sand	1.8	wet	
	2.0	saturation	
Laterite	1.6	wet	
	1.8	saturation	
Reinforced Concrete	2.5		
Material	Angle of shearing resistance (ϕ) (deg.)	Cohesion (tf/m2)	N-value
Sand	30.0	0.0	
Laterite	value will be estimated based on results of test near locations (See Table. in "Geology" of Supporting Report)		
Other Soils			
Material	Allowable Stress (kgf/cm2)	Application	Remarks
Reinforced Concrete	70	Compression	fca=210kgf/cm2
Reinforced Bar	1800	Tension (Genaral)	SD295
	1600	Tension (wet)	
PC-pile	see Table.		
Material	Slope Stability (1:N)=(Vert.:Horiz.)	Application	Remarks
Embankment	Gentler than 1:2.0	Mixed Soil	

Table 3.2.1 IMPLEMENTATION SCHEDULE OF FLOOD DIVERSION CHANNEL

Diversion 800m3/s~1,100m3/s

Year		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Structual Measures																						
Diversion Channel																						
Detailed Design	100%				5%	30%	30%	10%							12%	13%						
					0.011%	0.069%	0.069%	0.023%							0.028%	0.030%						
Land Acquicisior	100%								5%	5%	5%	5%	10%	10%	20%	20%	20%					
									1.794%	1.794%	1.794%	1.794%	3.588%	3.588%	7.175%	7.175%	7.175%					
Super Vision and Administration	100%								5%	5%	5%	5%	10%	10%	10%	10%	10%	10%	10%	10%		
									0.205%	0.205%	0.205%	0.205%	0.409%	0.409%	0.409%	0.409%	0.409%	0.409%	0.409%	0.409%		
Construction	100%								2%	2%	2%	2%	5%	6%	9%	20%	20%	12%	10%	10%		
	42.328								1.196%	1.196%	1.196%	1.196%	2.990%	3.588%	5.382%	11.961%	11.961%	7%	6%	6%		
Project Total		0%	0%	0%	0.011%	0.069%	0.069%	0.023%	3.194%	3.194%	3.194%	3.194%	6.987%	7.585%	12.994%	19.575%	19.545%	7.586%	6.389%	6.389%		
Total %	42.329	0%	0%	0%	0.011%	0.080%	0.149%	0.172%	3.367%	6.561%	9.755%	12.950%	19.937%	27.52%	40.52%	60.09%	79.64%	87.22%	93.61%	100.00%		

Table 3.3.1 IMPLEMENTATION SCHEDULE OF HEIGHTING OF FLOOD PROTECTION BARRIER AT BANGKOK PROJECT

Heightening

Project Components		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Structual Measures																						
BKK Dike Heighteing																						
Detailed Design	100%				10%	40%	50%															
					0.220%	0.880%	1.100%															
Land Acquicision	100%							30%	40%	30%												
								0.330%	0.440%	0.330%												
Super Vision and Administration	100%							20%	30%	30%	20%											
								1.210%	1.815%	1.815%	1.210%											
Construction	100%							10%	35%	35%	20%											
	1.839							9.064%	31.724%	31.724%	18.128%											
Financial Total		0%	0%	0%	0.220%	0.880%	1.100%	10.604%	33.979%	33.869%	19.338%											
Total %	1.840	0%	0%	0%	0.220%	1.100%	2.200%	12.804%	46.783%	80.652%	99.990%											

Table 3.4.1 IMPLEMENTATION SCHEDULE OF DISTRIBUTION SYSTEM IMPROVEMENT PROJECT

Distribution System Improvement

Project Components		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Structual Measures																						
Natural Retarding Basin																						
Detailed Design	100%	10%	50%	40%																		
		0.220%	1.100%	0.880%																		
Land Acquicision	100%				20%	40%	40%															
					0.220%	0.440%	0.440%															
Super Vision and Administration	100%				20%	20%	30%	30%														
					1.210%	1.210%	1.815%	1.815%														
Construction	100%				20%	20%	30%	30%														
	284				18.128%	18.128%	27.192%	27.192%														
Project Total		0.220%	1.100%	0.880%	19.558%	19.778%	29.447%	29.007%														
Total %	285	0.220%	1.320%	2.200%	21.758%	41.536%	70.983%	99.990%														

Table 3.5.1 IMPLEMENTATION SCHEDULE OF DRAINAGE IMPROVEMENT PROJECT

Drainage Improvement

Year		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Structual Measures																						
Drainage Improvement																						
Detailed Design	100%	10%	30%	40%	20%																	
		0.227%	0.682%	0.909%	0.455%																	
Land Acquicision	100%					10%	25%	30%	25%	10%												
						0.909%	2.273%	2.727%	2.273%	0.909%												
Super Vision and Administration	100%					5%	15%	30%	25%	15%	10%											
						0.318%	0.955%	1.909%	1.591%	0.955%	0.636%											
Construction	100%					5%	15%	30%	25%	15%	10%											
	6,734					4.114%	12.341%	24.682%	20.568%	12.341%	8.227%											
Project Total		0.227%	0.682%	0.909%	0.455%	5.341%	15.568%	29.318%	24.432%	14.205%	8.864%											
Total %	6,735	0.227%	0.909%	1.818%	2.273%	7.614%	23.182%	52.500%	76.932%	91.136%	100.000%											

Table 4.1.1 (1/3) QUANTITY OF HEIHGTENING WORK OF EXISTING ROAD

	Heightening (cm)	With of road (m)	Length (m)	Type	Prime coat (m2)	Asphalt 0.1m. thk. (m2)	Cap seal (m2)	Agg. Base 0.20mm. Thick (m2)	Soil agg. Surface 0.30m. thk. layer 1 (m2)	Soil agg. Surface 0.30m. thk. layer 2 (m2)	Embankment (m3)	Removing existing A.C. surface (m2)	Sodding (m2)
CP-R-1	50	9	1900	Asphalt	9	6	3	10	11	0	2.0	6	8.0
CP-R-2	80	6	1100	Asphalt	6	3	3	7	8	0	2.6	3	9.2
CP-R-3	30	6	300	Asphalt	6	3	3	7	0	0	1.1	3	6.9
CP-R-4	90	6	2000	Asphalt	6	3	3	7	8	9	3.2	3	9.6
CP-R-5	170	21	2200	Asphalt	21	18	3	22	23	24	28.2	18	13.2
CP-R-6	100	6	800	Asphalt	6	3	3	7	8	9	4.2	3	9.8
CP-R-7	30	6	1000	Asphalt	6	3	3	7	0	0	1.1	3	6.9
CP-R-8	10	6	400	Asphalt	6	3	3	1.6	0	0	0.0	3	6.0
CP-R-9	80	6	3800	Asphalt	6	3	3	7	8	0	2.6	3	9.2
CP-R-10	110	6	700	Asphalt	6	3	3	7	8	9	5.3	3	10.1
CP-R-11	30	9	3400	Asphalt	9	6	3	10	0	0	1.1	6	6.9
CP-R-12	80	6	2900	Asphalt	6	3	3	7	8	0	2.6	3	9.2
CP-R-13	50	6	900	Asphalt	6	3	3	7	0	0	1.7	3	7.9
CP-R-14	40	6	800	Asphalt	6	3	3	7	0	0	1.4	3	7.3
Right sub total			**22200**		**105**	**63**	**42**	**113.6**	**82**	**51**	**57.1**	**63**	**120.4**
CP-L-1	70	9	800	Asphalt	9	6	3	10	11	0	2.5	6	8.6
CP-L-2	80	9	1500	Asphalt	9	6	3	10	11	0	2.9	6	9.2
CP-L-3	80	9	2600	Asphalt	9	6	3	10	11	0	2.9	6	9.2
CP-L-4	60	9	700	Asphalt	9	6	3	10	11	0	2.3	6	8.3
CP-L-5	30	9	1300	Asphalt	9	6	3	10	0	0	1.1	6	6.9
CP-L-6	50	9	1800	Asphalt	9	6	3	10	11	0	2.0	6	8.0
CP-L-7	20	9	400	Asphalt	9	6	3	1.6	0	0	0.0	3	6.5
CP-L-8	40	21	1700	Asphalt	21	18	3	22	0	0	1.4	18	7.4
CP-L-9	50	21	1300	Asphalt	21	18	3	22	0	0	1.8	18	7.9
CP-L-10	50	12	6400	Asphalt	12	9	3	13	0	0	1.7	9	7.8
CP-L-11	60	12	1100	Asphalt	12	9	3	13	14	0	2.1	9	8.3
Left sub total			**19600**		**129**	**96**	**33**	**131.6**	**69**	**0**	**20.7**	**93**	**88.1**
CP total			**41800**		**234**	**159**	**75**	**245.2**	**151**	**51**	**77.8**	**156**	**208.5**

Table 4.1.1 (2/3) QUANTITY OF HEIHGTENING WORK OF EXISTING ROAD

	Heightening (cm)	With of road (m)	Length (m)	Type	Prime coat (m2)	Asphalt 0.1m. thk. (m2)	Cap seal (m2)	Agg. Base 0.20mm. Thick (m2)	Soil agg. Surface 0.30m. thk. layer 1 (m2)	Soil agg. Surface 0.30m. thk. layer 2 (m2)	Embankment (m3)	Removing existing A.C. surface (m2)	Sodding (m2)
Noi-R-1	20	6	600	Asphalt	6	3	3	1.6	0	0	0.5	3	6.5
Noi-R-2	40	6	600	Asphalt	6	3	3	7	0	0	1.4	3	7.3
Right sub total			**1200**		**12**	**6**	**6**	**8.6**	**0**	**0**	**1.9**	**6**	**13.8**
Noi-L-1	110	6	700	Asphalt	6	3	3	7	8	9	5.3	3	10.1
Noi-L-2	40	6	2700	Asphalt	6	3	3	7	0	0	1.4	3	7.3
Noi-L-3	20	6	400	Asphalt	6	3	3	1.6	0	0	0.5	3	6.5
Noi-L-4	80	6	300	Asphalt	6	3	3	7	8	0	2.6	3	9.2
Noi-L-5	50	21	1300	Asphalt	21	18	3	22	0	0	1.8	18	7.9
Left sub total			**5400**		**45**	**30**	**15**	**44.6**	**16**	**9**	**11.6**	**30**	**41.0**
Noi total			**6600**		**57**	**36**	**21**	**53.2**	**16**	**9**	**13.5**	**36**	**54.8**
BPM-R-1	30	6	900	Asphalt	6	3	3	7	0	0	1.1	3	6.9
BPM-R-2	30	6	1200	Asphalt	6	3	3	7	0	0	1.1	3	6.9
Right sub total			**2100**		**12**	**6**	**6**	**14**	**0**	**0**	**2.1**	**6**	**13.9**
BPM total			**2100**		**12**	**6**	**6**	**14**	**0**	**0**	**2.1**	**6**	**13.9**
BB-R-1	80	21	400	Asphalt	21	18	3	22	23	0	2.9	18	9.1
Right sub total			**400**		**21**	**18**	**3**	**22**	**23**	**0**	**2.9**	**18**	**9.1**
BB-L-1	70	6	1300	Asphalt	6	3	3	7	8	0	2.7	3	7.8
BB-L-2	40	6	800	Asphalt	6	3	3	7	0	0	1.4	3	7.3
Left sub total			**2100**		**12**	**6**	**6**	**14**	**8**	**0**	**4.1**	**6**	**15.1**
BB total			**2500**		**33**	**24**	**9**	**36**	**31**	**0**	**7.0**	**24**	**24.2**
L-R-1	120	21	1300	Asphalt	21	18	3	22	23	24	15.1	18	11.3
L-R-2	70	9	3700	Asphalt	9	6	3	10	11	0	2.5	6	8.6
L-R-3	40	9	1100	Asphalt	9	6	3	10	0	0	1.5	6	7.3
L-R-4	30	6	1300	Asphalt	6	3	3	7	0	0	1.1	3	6.9
L-R-5	80	6	1300	Asphalt	6	3	3	7	8	0	2.6	3	9.2
L-R-6	80	6	1400	Asphalt	6	3	3	7	8	0	2.6	3	9.2
Right sub total			**10100**		**57**	**39**	**18**	**63**	**50**	**24**	**25.4**	**39**	**52.5**

Table 4.1.1 (3/3) QUANTITY OF HEIHGTENING WORK OF EXISTING ROAD

	Heightening (cm)	With of road (m)	Length (m)	Type	Prime coat (m2)	Asphalt 0.1m. thk. (m2)	Cap seal (m2)	Agg. Base 0.20mm. Thick (m2)	Soil agg. Surface 0.30m. thk. layer 1 (m2)	Soil agg. Surface 0.30m. thk. layer 2 (m2)	Embankment (m3)	Removing existing A.C. surface (m2)	Sodding (m2)
L-L-1	30	9	1300	Asphalt	9	6	3	10	0	0	1.1	6	6.9
L-L-2	100	12	1500	Asphalt	12	9	3	13	14	15	4.1	9	10.5
L-L-3	30	12	200	Asphalt	12	9	3	13	0	0	1.1	9	6.9
L-L-4	50	12	900	Asphalt	12	9	3	13	0	0	1.7	9	7.8
Left sub total			**3900**		**45**	**33**	**12**	**49**	**14**	**15**	**7.9**	**33**	**32.2**
L total			**14000**		**102**	**72**	**30**	**112**	**64**	**39**	**33.4**	**72**	**84.7**

Table 4.1.2 FEATURES OF NEW REGULATORS

Regulator Code	River	Gate Dimension (m)			Land Acquisition (m2)	House Relocation	No. of Drawing	
		Width	Number	Height			*1	*2
Reg.-1	Chao Phraya Left Dike	4	1	4	20			No.44
Reg.-2	Chao Phraya Left Dike	6	2	5	40			No.43
Reg.-3	Chao Phraya Left Dike	6	2	5	40			No.43
Reg.-4	Chao Phraya Left Dike	6	4	6	100			No.43
Reg.-5	Chao Phraya Left Dike	4	1	4	20			No.41
Reg.-6	Chao Phraya Left Dike	6	2	5	40			No.41
Reg.-7	Chao Phraya Left Dike	6	2	5	40			No.41
Reg.-8	Chao Phraya Left Dike	5	4	6	100	1		No.41
Reg.-9	Chao Phraya Left Dike	6	6	6	150	2		No.41
Reg.-10	Chao Phraya Right Dike	6	2	5	40			No.39
Reg.-11	Lop Buri Right Dike	5	2	5	40			No.28
Reg.-12	Lop Buri Right Dike	6	2	5	40	1		No.28
Reg.-13	Lop Buri Right Dike	4	1	4	20			No.14

Note *1 : See Fig.3.4.2 in Sector VII "River Improvement Plan"
*2 : See "Data Book"

Table 4.2.1 SWAMPY AREAS WHICH HAVE POSSIBILITY OF BORROW PIT FOR HEIGHTENING MATERIAL

No.	Name	Location	
1	Nong Chorakhe	Khlong Noi Sub-district	Maharaj district
2	Nong Lad Sa Uen	Khlong Noi Sub-district	Maharaj district
3	Nong E-Vit	Phit Phian sub-district	Maharaj district
4	Nong Khluk	Phit Phian sub-district	Maharaj district
5	Nong Lad Sa Kaeo	Ban Na sub-district	Maharaj district
6	Nong Long	Ban Khwang sub-district	Maharaj district
7	Nong Hang Sing	Rong Chang sub-district	Maharaj district
8	Nong E-Pi	Bang Phloeng sub-district	Ban Pa Han district
9	Nong Lad	Ban Khlo sub-district	Ban Pa Han district
10	Nong Wong Phat	Ban Pa Han sub-district	Ban Pa Han district
11	Bung Wang Daeng	Wang Daeng sub-district	Tha Rua district
12	Bung Suan Phrik	Tha Chao Sanuk sub-district	Tha Rua district
13	Bung Ban Chung	Nakhon Luang sub-district	Nakhon Luang district
14	Bung Oo	Bang Sung sub-district	Nakhon Luang district
15	Nong Lad Chang	Wat Yom sub-district	Ban Bat district

Table 4.2.2 IMPLEMENTATION SCHEDULE OF RIVER IMPROVEMENT PROJECT IN THE MASTERPLAN

River Improvement 10-year~25-year for Alter-2-2

Project Components		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Structual Measures																						
River Training																						
Detailed Design	100%		30%	30%														20%	20%			
			1.394%	1.394%														0.929%	0.929%			
Land Acquicision	100%				25%	25%												10%	20%	20%		
					0.364%	0.364%												0.145%	0.291%	0.291%		
Super Vision and	100%				5%	10%	10%	10%	10%											15%	25%	15%
					0.293%	0.587%	0.587%	0.587%	0.587%											0.880%	1.466%	0.880%
Construction	100%				5%	10%	10%	10%	10%											15%	25%	15%
	3.260				4.405%	8.810%	8.810%	8.810%	8.810%											13.214%	22.024%	13.214%
Ecnomic Total		0.000%	1.394%	1.394%	5.062%	9.760%	9.396%	9.396%	9.396%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	1.075%	1.220%	14.385%	23.490%	14.094%
Total %	3.259	0.000%	1.394%	2.788%	7.850%	17.610%	27.006%	36.402%	45.798%	45.798%	45.798%	45.798%	45.798%	45.80%	45.80%	45.80%	45.80%	46.87%	48.09%	62.48%	85.97%	100.06%

Table 4.2.3 EXAMPLE OF SETUP OF PROJECT PERSONNEL

Name of Project Office: Chaochet-Bang-Yihon Project Office

No.	Organization and Designation	Number of Personnel		
		Official	Employee	Total
1	Chief of Project Office	1		1
2	Administrative Section			
	Support Staff	1	24	25
3	Engineering Section			
	Engineer (Irrigation and Civil)	3		3
	Surveying Technician		2	2
	Construction Technician		1	1
	Support Staff		25	25
4	Management and Maintenance Section			
	Irrigation Engineer	1		1
	Agricultural Engineer	1		1
	Support Staff		7	7
5	Mechanical Section			
	Mechanical Engineer	1		1
	Support Staff		17	17
6	Operation and Maintenance Section1			
	(Site at Amphoe Sena)			
	Irrigation Engineer	2		2
	Support Staff	1	80	81
7	Operation and Maintenance Section2			
	(Site at Amphoe Bang Sai - Lad Bua Luang)			
	Irrigation Engineer	2		2
	Construction Technician		1	1
	Support Staff		59	59
8	Operation and Maintenance Section3			
	(Site at Amphoe Bang Pla Ma - Song Pi Nong)			
	Irrigation Engineer	2		2
	Support Staff		62	62
	Total	15	278	293

Note: 1 Support Staff including Financial Clerk, Typist, Store Keeper, Driver, Boat Operator, Skilled Labour, Unskilled Labour etc.

2 The above example is just to give some idea how RID organizes the Field Office.

Table 5.1.1 UNIT COST OF BASIC WORK

Excavation

Item	Unit	Local					Foreign			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Backhoe Excavation	m3	1.38	0.23	0.69	5.52	7.82	2.53	12.65	15.18	23	
Driving Dump Truck	m3	0	2.96	7.4	14.8	25.16	14.8	34.04	48.84	74	5.0 km
Total	**m3**	**1.38**	**3.19**	**8.09**	**20.32**	**32.98**	**17.33**	**46.69**	**64.02**	**97**	**Baht**
Percentage	**%**	**1.42**	**3.29**	**8.34**	**20.95**	**34**	**17.87**	**48.13**	**66**	**100**	

Embankment

Item	Unit	Local					Foreign			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Bulldozer Embankment	m3	1.38	0.23	0.69	5.52	7.82	2.53	12.65	15.18	23	
Total		**1.38**	**0.23**	**0.69**	**5.52**	**7.82**	**2.53**	**12.65**	**15.18**	**23**	**Baht**
Percentage	**%**	**6**	**1**	**3**	**24**	**34**	**11**	**55**	**66**	**100**	

Land Smoothing in Excavation

Item	Unit	Local					Foreign			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Backhoe Smoothing	m2	2.79	0.93	0.93	7.13	11.78	3.1	16.12	19.22	31	0.6 m3
Total		**2.79**	**0.93**	**0.93**	**7.13**	**11.78**	**3.1**	**16.12**	**19.22**	**31**	**Baht**

Land Smoothing in Embankment

Item	Unit	Local					Foreign			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Backhoe Smoothing	m2	1.87	1.3	0.78	5.98	9.93	2.6	13.52	16.12	26.05	0.6 m3
Sodding	m2	3.2	9	4.8	0.8	17.8	0.8	1.4	2.2	20	
Total	**m2**	**5.07**	**10.3**	**5.58**	**6.78**	**27.73**	**3.4**	**14.92**	**18.32**	**46.05**	**Baht**
Percentage	**%**	**11.01**	**22.37**	**12.12**	**14.72**	**60.22**	**7.38**	**32.4**	**39.78**	**100**	

Table 5.1.2 UNIT COST OF CONSTRUCTION OF STRUCTURES

Bridge

Item	Unit	Local (%)					Foreign (%)			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Total	%/place	2	1	42	3	48	30	22	52	100	Assumption

Steel Gate Diversion (Large Size)

Item	Unit	Local (%)					Foreign (%)			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Total	%/place	1	1	24	2	28	48	24	72	100	Assumption

Steel Gate Diversion (Small Size)

Item	Unit	Local (%)					Foreign (%)			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Total	%/place	2	2	43	4	51	28	21	49	100	Assumption

Rubber Gate Diversion

Item	Unit	Local (%)					Foreign (%)			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Total	%/place	1	1	32	3	37	40	23	63	100	Assumption

Concrete Structure

Unit Baht

Item	Unit	Local					Foreign			Grand Total	Remarks
		Skilled	Unskilled	Material	Machine	Total	Material	Machine	Total		
Concrete	10m3	183	183	10,974	549	11,889	4,573	1,829	6,402	18,291	
Frame Work	30m2	1,500	600	1,020	0	3,120	2,880	0	2,880	6,000	
Reinforced-bar Work	500kg	556	209	1,669	139	2,573	3,964	417	4,381	6,954	5.0 km
Total	10m3	2239	992	13663	688	17582	11417	2246	13663	31245	Baht
Percentage	%	7	3	44	2	56	37	7	44	100	

Table 5.1.3 UNIT COST OF LAND ACQUISITION

Sample of Land Price

Unit : Baht/m2

Location	Province	Surveyed Land Cost		Estimated Land Cost				
				Urban		Rural		
		Max	Min	Built-up	Others	Residential	Agricultural	Others
A. Manorom	Chainat	3,750	8	3,000	1,000	500	50	50
A. Taclee	Chainat	3,750	8	3,000	1,000	500	50	50
A. Banmii	Lopburi	1,250	5	1,000	500	500	50	50
M. Lopbiru		2,500	5	2,000	1,000	500	50	50
A. Banmohr	Saraburi	1,500	8	1,000	500	500	50	50
A. Tha rua	Ayyuthaya	2,000	10	1,500	1,000	500	50	50
A. Nongkae	Saraburi	2,250	10	2,000	1,000	500	50	50
A. Nang. Sua	Nakon Nayok	1,500	8	1,000	500	500	50	50
M. Nakornnayok		16,500	25	10,000	5,000	1,000	50	50
A. Nongchot	BKK	5,000	250	3,500	2,000	1,000	250	250
M. Samutprakarn		37,500	125	20,000	10,000	1,000	200	200

Table 5.1.4 PRICE AND CHARACTERISTICS OF PC-PILE

Diameter (mm)		ϕ 250	ϕ 300	ϕ 400	ϕ 500	ϕ 600	ϕ 800
Length (m)		7~15					
Price (baht/m)	M+T *1	183	248	418	633	878	1,466
	D *2	44	59	100	151	204	433
	Total	227	307	518	784	1,082	1,899
Moment of Inertia (cm4)		17.293	34.617	106.516	255.390	510.640	1,528.262
Effective Prestress (kgf/cm2)		40	42	41	42	40	43
Design Compressive Strength of Concrete (kgf/cm2)		$f_{cu} = 500$					
Allowable Bending Compressive Unit Stress (kgf/cm2)		$f_{ca} = 0.45 \times f_{cu} = 225$					
Allowable Bending Tensile Unit Stress (kgf/cm2)		$f_{ta} = -1.59 \sqrt{f_{cu}} = -35.5$					
Module Ratio		$n = E_p/E_c = 2{,}000 kgf/cm2 \div 400{,}000 kgf/cm2 = 5$					

Note * : 1. M+T = (Material + Transportation) Expenses per Meter
2. D = Driving Expense per Meter
3. Aforementioned Prices are inclusive of Profit for Pile Firm.

Source : Quetionnaire to Pile Maker's Firm & Data of Reports by Thai Consultant

Table 5.1.5 UNIT COST IN HIGHWAY DEPARTMENT IN 1993

No	Subject	Unit	Price of Labor	Price of Material	Total Price	Note	
1	Forest Way						
	Field	m2	0.80				
	Forest	m2	1.10				
	Thick Forest, Mountain	m2	2.20				
2	Surveying for Design						
	Plain	km	21,300				
	Mountain	km	38,200				
3	Surveying for Construction						
	Plain	km	10,600				
	Mountain	km	16,900				
4	Road						
	Plain	km	22,700				
	Mountain	km	24,900				
5	Earth Work						
	Excavation	m3	31.50				
5	Compacted						
	Side Borrow	m3	30.00				
	Other Compacted by Track Roller	m3				1.8m3/t	
6	Lateritic by Dig	m3				1.7m3/t	
7	Spread and Compaction						
	Sand	m3	22.00				
	Lateritic Soil	m3	25.00				
	Mix	m3	31.50				
8	Stripping Old Surface						
	Thickness 5cm	m2	2.70				
	Thickness 10cm	m2	6.00				
	Thickness more than 10cm	m2	9.00				
9	Soft Rock	m3	97.00				
10	Hard Rock						
	Sand Stone	m3	120.00				
	Lime Stone	m3	150.00				
	Granit	m3	170.00				
11	Prime Coat	m2	5.00	10.00	15	Proceeding	
		m2			16	Wage	
12	Tack Coat	m2	2.50	5.50	8	Proceeding	
		m2			8	Wage	
13	Surface						
	S.S.T.	m2	9.50	19.50	29	Stone1/2"	Proceeding
		m2			35		Wage
	D.S.T.	m2	18.00	35.00	53	Stone3/4~3/8"	Proceeding
		m2			56		Wage
	P.M.	m2	44.00	86.00	130		Proceeding
		m2			135		Wage
	Asphaltic Concrete (Hot Mix)	m2			2,550		
	Asphaltic Concrete (Cold Mix)	m2			2,250		
	Slurry Seal Type2	m2			34		
	Slurry Seal Type4	m2			56		
	Cap Seal	m2			65		
14	Laying Concrete Pipes						
	0.30	m	135~200				
	0.40	m	170~255				
	0.60	m	225~345				
	0.80	m	285~435				
	1.00	m	435~620				
	1.20	m	745				
	1.50	m	870				
15	Temporary Trafic Sign	km			7,900		
16	Slope Protection						
	Strip	m2			8		
	Block	m2			12.50		
	Ferro Cement	m2			630		
	Concrete	m2			525		
	Motar Rip Rap	m2			470		
17	Drainage 2 sides						
	Concrete	m2			420		
	Motar Rip Rap	m2			370		
18	Construction of Temporary Office	Place			1,050,000	50km/place	
					1,570,000		
19	Analysis and Reserch						
20	Maintenance Work						
	Lateritic	km			18,000		
	Asphalt	km			15,000		
	Asphalt	km			30,000		
21	Traffic Commodity						
	Termo Plastic Color 1	m2			250		
	Termo Plastic Color 1	m2			350		
	Bond of Landmark	unit			315		
	Highway Landmark	unit			160		
	Kilometer Landmark	unit			1,400		
	Dangerous Line	m			1,200		
	Chatter Bar	unit			1,600		
	Traffic Sign without Frame	m2			2,200		
	Traffic Sign with Frame	m2			2,400		

Table 5.1.6 SAMPLE UNIT COST FOR HEIGHTENING OF EXISTING ROAD

Calculating unit cost of construction raised pavement. (Calculation quantity for 1 m. length)

ITEM NO	DESCRIPTION OF WORKS	QUANTITY	UNIT	Material		Labour		Total Cost per unit (Baht)	Total Cost (Baht)	REMARKS
				Unit Rate	Total	Unit Rate	Total			
	Raised pavement W = 6 m., Raise = 0.60 m.									
	shoulder work = 1.5 m.									
1	Prime Cost	3.00	m^2					13.00	39.00	
2	Cap seal	3.00	m^2					50.00	150.00	
3	Agg . Base 0.20 m m. Thick	4.00	m^2					78.00	312.00	
4	Soil agg .surbase 0.30 m. thk.	5.00	m^2					103.00	515.00	
5	Soil agg .surbase 0.30 m. thk. layer 2		m^2					103.00	-	
6	Embankment sand	2.13	m^3					315.00	670.95	
	Surface coarse									
1	Prime Cost	6.00	m^2					13.00	78.00	
2	Cap seal	6.00	m^2					228.00	1,368.00	
3	Agg . Base 0.20 m m. Thick	6.00	m^2					78.00	468.00	
4	Soil agg .surbase 0.30 m. thk.	6.00	m^2					103.00	618.00	
5	Soil agg .surbase 0.30 m. thk. layer 2		m^2					103.00	-	
6	Embankment laterite		m^3					100.00	-	
7	Removing existing A.C. surface	6.00	m^2					5.00	30.00	
		2.40	m^2					100.00	240.00	
	Total (1) / lin.m.								4,489	
	Total direct cost + Profit and etc.								6,554	
	(Cost per lin.m.)									

Table 5.2.1 (1/2) FINANCIAL CONSTRUCTION COST IN CASE OF 1,500M3/S

Ayutthaya-East-Sea-Diversion 1 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	7	10	79	57	107	159
Excavation		m3	120,699,948	167	385	976	2,453	2,092	5,635
Embankment		m3	2,806,780	4	1	2	15	7	36
Land Surface Smoothing		m2	19,997,250	56	19	19	143	62	322
Land Surface Smoothing		m2	1,828,313	9	19	10	12	6	27
Diversion Point Weir		piece	1	26	26	624	52	1,248	624
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	18	18	588	55	734	422
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	7						
	Medium	piece	16						
	Small	piece	33	72	36	1,520	109	1,086	796
OTHERS									
Miscellaneous	2%	L.S.	1	7	10	80	58	109	162
Temporary Work	10%	L.S.	1	38	53	409	297	558	828
Subtotal				413	586	4,496	3,269	6,133	9,105
Resettlement			1,600	628					
Land Price		m2	29,850,588	17,061					
Total (1)				26,453				15,238	
Tax (VAT) 10%				2,645				1,524	
Total (2)				29,098				16,761	
Sale of Soil			29,473,292						
Grand Total				29,098				16,761	

Table 5.2.1 (2/2) FINANCIAL CONSTRUCTION COST IN CASE OF 1,500M3/S

Ayutthaya-East-Sea-Diversion 2 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	7	10	79	56	106	158
Excavation		m3	116,856,660	161	373	945	2,375	2,025	5,456
Embankment		m3	2,772,420	4	1	2	15	7	35
Land Surface Smoothing		m2	19,486,600	54	18	18	139	60	314
Land Surface Smoothing		m2	2,176,300	11	22	12	15	7	32
Diversion Point Weir		piece	1	26	26	616	51	1,232	616
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	18	18	580	54	725	529
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	8						
	Medium	piece	17						
	Small	piece	29	75	38	1,580	113	1,128	827
OTHERS									
Miscellaneous	2%	L.S.	1	7	10	80	57	108	161
Temporary Work	10%	L.S.	1	37	52	410	289	552	822
Subtotal				410	577	4,512	3,181	6,075	9,044
Resettlement			1,480	570					
Land Price		m2	22,278,640	16,041					
Total (1)				25,291				15,119	
Tax (VAT) 10%				2,529				1,512	
Total (2)				27,820				16,631	
Sale of Soil			29,473,292						
Grand Total				27,820				16,631	

Table 5.2.2 (1/2) FINANCIAL CONSTRUCTION COST IN CASE OF 1,000M3/S

Ayutthaya-East-Sea-Diversion 1 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	5	7	56	39	75	111
Excavation		m3	81,837,983	113	261	662	1,663	1,418	3,821
Embankment		m3	2,806,780	4	1	2	15	7	36
Land Surface Smoothing		m2	15,343,125	43	14	14	109	48	247
Land Surface Smoothing		m2	2,022,313	10	21	11	14	7	30
Diversion Point Weir		piece	1	18	18	441	37	881	441
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	13	13	415	39	518	298
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	7						
	Medium	piece	16						
	Small	piece	33	51	26	1,073	77	766	562
OTHERS									
Miscellaneous	2%	L.S.	1	5	7	57	40	77	113
Temporary Work	10%	L.S.	1	27	38	292	205	392	575
Subtotal				299	415	3,212	2,256	4,313	6,325
Resettlement			1,490	588					
Land Price		m2	16,986,390	12,066					
Total (1)				18,836				10,639	
Tax (VAT) 10%				1,884				1,064	
Total (2)				20,720				11,702	
Sale of Soil			21,169,094						
Grand Total				20,720				11,702	

Table 5.2.2 (2/2) FINANCIAL CONSTRUCTION COST IN CASE OF 1,000M3/S

Ayutthaya-East-Sea-Diversion 2 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	5	7	56	38	75	108
Excavation		m3	79,217,560	109	253	641	1,610	1,373	3,699
Embankment		m3	2,772,420	4	1	2	15	7	35
Land Surface Smoothing		m2	13,661,900	38	13	13	97	42	220
Land Surface Smoothing		m2	2,176,300	11	22	12	15	7	32
Diversion Point Weir		piece	1	18	18	435	36	869	435
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	13	13	409	38	511	294
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	8						
	Medium	piece	17						
	Small	piece	29	53	27	1,115	80	797	584
OTHERS									
Miscellaneous	2%	L.S.	1	5	7	57	39	76	110
Temporary Work	10%	L.S.	1	27	37	293	199	388	561
Subtotal				292	406	3,222	2,185	4,268	6,170
Resettlement			1,397	539					
Land Price		m2	16,413,520	11,785					
Total (1)				18,429				10,438	
Tax (VAT) 10%				1,843				1,044	
Total (2)				20,271				11,482	
Sale of Soil			21,169,094						
Grand Total				20,271				11,482	

Table 5.2.3 (1/2) FINANCIAL CONSTRUCTION COST IN CASE OF 500M3/S

Ayutthaya-East-Sea-Diversion 1 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	3	4	34	21	43	61
Excavation		m3	42,891,265	59	137	347	872	743	2,003
Embankment		m3	2,806,780	4	1	2	15	7	36
Land Surface Smoothing		m2	9,398,375	26	9	9	67	29	152
Land Surface Smoothing		m2	1,828,313	9	19	10	12	6	27
Diversion Point Weir		piece	1	11	11	257	21	514	257
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	8	8	242	23	302	174
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	7						
	Medium	piece	16						
	Small	piece	33	30	15	625	45	446	327
OTHERS									
Miscellaneous	2%	L.S.	1	3	4	34	22	44	63
Temporary Work	10%	L.S.	1	16	22	175	112	226	319
Subtotal				178	237	1,923	1,228	2,485	3,510
Resettlement			1,380	547					
Land Price		m2	10,070,230	7,055					
Total (1)				11,168				5,996	
Tax (VAT) 10%				1,117				600	
Total (2)				12,285				6,595	
Sale of Soil			11,452,686						
Grand Total				12,285				6,595	

Table 5.2.3 (2/2) FINANCIAL CONSTRUCTION COST IN CASE OF 500M3/S

Ayutthaya-East-Sea-Diversion 2 As a sample for cost estimation

Item		Unit	Quantity	Cost(Local) (Million Baht)				Cost(Forign) (Million Baht)	
				Skilled	Unskilled	Material	Machine	Material	Machine
DIRECT CONSTRUCTION COST									
Preparation Work	2%	L.S.	1	3	4	34	21	43	149
Excavation		m3	41,456,960	57	132	335	842	718	1,936
Embankment		m3	2,772,420	4	1	2	15	7	35
Land Surface Smoothing		m2	7,785,400	22	7	7	56	24	126
Land Surface Smoothing		m2	2,176,300	11	22	12	15	7	32
Diversion Point Weir		piece	1	11	11	255	21	510	255
INDIRECT CONSTRUCTION COST									
Irrigation Weir with Lock		piece	2	8	8	240	23	300	173
Small Irrigation Regulator		piece	40	9	9	189	18	123	92
Bridge	Large	piece	8						
	Medium	piece	17						
	Small	piece	29	31	15	651	46	465	341
OTHERS									
Miscellaneous	2%	L.S.	1	3	4	35	21	44	63
Temporary Work	10%	L.S.	1	16	21	176	108	224	320
Subtotal				173	235	1,936	1,185	2,466	3,522
Resettlement			1,310	510					
Land Price		m2	9,704,720	6,895					
Total (1)				10,933				5,988	
Tax (VAT) 10%				1,093				599	
Total (2)				12,027				6,587	
Sale of Soil			11,452,686						
Grand Total				12,027				6,587	

Table 5.2.4 CONSTRUCTION COST OF AYUTHAYA-EAST-SEA DIVERSION-2

800 m3/s

No.		Local Cost	Foreign Cost	Total
1	Construction Cost	4,983.94	8,503.85	13,488
	1) Material	2,659.29	3,484.17	6,143
	2) Machine & Equipment Rental or Depriciation	1,753.16	5,019.68	6,773
	3) Labor	571.48	-	571
	a. Skilled Labor	240.12	-	240
	b. Unskilled Labor	331.37	-	331
2	Land Acquisition	9,828.72	0	9,829
3	House Relocation	527.35	0	527
4	Administration	517.80	0	518
5	Engineering D/D	6.74	60.70	67
	S/V	67.44	606.95	674
6	Physical Contingency	90.45	154.33	245
7	Sub-Total	16,022	9,326	25,348
8	Price Contingency	2,403	1,399	3,802
9	Tax	1,843	1,072	2,915
10	Grand Total	20,268	11,797	32,066
11	O & M Cost	44	85	129

1,100 m3/s

No.		Local Cost	Foreign Cost	Total
1	Construction Cost	6,501.56	11,171.68	17,673
	1) Material	3,417.97	4,547.10	7,965
	2) Machine & Equipment Rental or Depriciation	2,341.50	6,624.58	8,966
	3) Labor	742.10	-	742
	a. Skilled Labor	309.80	-	310
	b. Unskilled Labor	432.29	-	432
2	Land Acquisition	12,636.08	-	12,636
3	House Relocation	545.40	-	545
4	Administration	659.07	-	659
5	Engineering D/D	8.84	79.53	88
	S/V	88.37	795.30	884
6	Physical Contingency	118.00	202.75	321
7	Sub-Total	20,557	12,249	32,807
8	Price Contingency	3,084	1,837	4,921
9	Tax	2,364	1,409	3,773
10	Grand Total	26,005	15,495	41,500
11	O & M Cost	58	112	169

Table 5.2.5 FINANCIAL COST OF HEIGHTENING OF FLOOD WALL IN BANGKOK

Cost Estimation of Extension of existing cap beam wall (Type B1) ; 0.30 m. heightening

Item No.	Description of Works	Quantity	Unit	Material		Labor		Total Cost	REMARKS
				Unit Rate	Total	Unit Rate	Total	(Baht)	
	Flood barrier type " B1 "								
1	Chipping existing concrete surface	0.20	m^2		-	30	6	6	
	width 0.20 m.								
2	Hilti HIT C100 epoxy injection	7.00	hole	100	700	50	350	1,050	
	Dia. 0.16* 0.30 m.								
3	Concrete grade 280 ksc. cylinder strenght	0.06	m^3	1,560	94	300	18	112	
4	Form work	0.60	m^2	320	192	80	48	240	
5	Steel reinforcement								
	Y12 Grade SD 295	9.18	kg	13	119	3	28	147	
	Tied wire 1.50 % of Steel reinforce bar	0.14	kg	19	3		-	3	
6	Nonshrink grout mortar	1.00	m	100	100	10	10	110	
7	Access for working	2.00	m^2	140	280	105	210	490	=2 m^2 / lin.m.
	Total direct cost per lin.m.				1,488		670	2,157	

Cost Estimation of Installation of New Gate

Item No.	Description of Works	Quantity	Unit	Material		Labor		Total Cost	REMARKS
				Unit Rate	Total	Unit Rate	Total	(Baht)	
1	Installation of New Gate	160	ton	200,000	32,000,000	1,000	160,000	32,160,000	Including
	80 ton/gate x 2 gates								temporary works,
2	Sale of Old Gate								etc.
	70 ton/gate x 2 gates	140	ton	-12,000	-1,680,000			-1,680,000	
	Total direct cost per gate				30,320,000		160,000	30,480,000	

Total Cost of Heightening Project

Item No.	Description of Works	Quantity	Unit	Material		Labor		Total Cost	REMARKS
				Unit Rate	Total	Unit Rate	Total	(Baht)	
T-1	Heightening of Concrete Wall	60	km	1.49	89.25	0.67	40.17	129	
T-2	Installation of Gates	40	gate	30.32	1,212.80	0.16	6.40	1,219	
T-3	Engineering Service	1	L.S			100.00	100.00	100	
	Subtotal				1,302.05		146.57	1,449	
T-4	Physical Contingency	10	%		130.21		14.66	145	
T-5	Price Contingency	5	%		71.61		8.06	80	
T-6	Tax (VAT)	10	%		150.39		16.93	167	
	Grand Total				1,654.26		186.22	1,840	

Table 5.2.6 CONSTURUCTION COST OF DISTRIBUTION OF INUNDATION WATER

Item	unit	Quantity	unit cost (million baht)	Cost (million baht)
Connection Canal Expansion of Main Canal	km	40	0.8	32
Gate	place	5	18	90
Regulator (Small Sluice)	place	15	3	45
Siphon	place	3	20	60
Administration	L.S.			3
Engineering	L.S.			18
Physical Contingency	L.S.			11
Price Contingency	%			26
Total				285

Table 5.2.7 PROJECT COST OF DRAINAGE IMPROVEMENT

UNIT of PROJECT COST

Range		Method	Unit Cost	Unit
East Bank	0 ~ 120 m2	Minor	0.1	million baht/m2/km
	120 ~ 300m2	Major	0.5	including all.
	over 300 m2	New Canal	0.7	(tax, profit, etc.)
Lower of West Bank	0 ~ 120 m2	Minor	0.1	
	80 ~ 300m2	Major	0.5	
	over 300 m2	New Canal	0.7	

Note : Unit costs are quoted from similar projects of agency concerned.

CONSTRUCTION COST

Case	Area	Stretch *1	Distance (km)	Reqired Canal Area Minor (m2)	Major (m2)	Minor Improvement (miilion baht)	Major Improvement (miilion baht)	Total (miilion baht)
B1	East Bank	A	25	120	45	300	563	863
		B	30	120	120	360	1,800	2,160
	Subtotal(1)							3,023
	West Bank	A	40	80	55	320	1,100	1,420
		B	40	120	60	480	1,200	1,680
	Subtotal(2)							3,100
Total								6,123
Price Contingency								612
Grand Total								6,735

Note: *1 Refer to Sector I "Hydrology" regarding A and B

Table 5.2.8 CONSTRUCTION COST OF ARTIFICIAL RETARDING BASIN

Case-1 3,000km2

Enclosure Dike Construction						
No.	Distance (m)	Improvement Length (m)	Type	Heightening Height (m)	Unit Cost (Bart / m)	Cost (million baht)
1	40,000	2,500	A1	3	15,700	39
2	10,000	10,000	A2	1	6,000	60
3	25,500	25,500	A1	3	15,700	400
4	7,500	7,500	C1	1	5,200	39
5	29,000	29,000	C1	1	5,200	151
6	54,000	54,000	C1	1	5,200	281
7	27,500	27,500	C1	1	5,200	143
8	13,500	13,500	C1	1	5,200	70
9	8,500	8,500	C1	1	5,200	44
Total	215,500					1,228
Small Sluice Gate		2m x2m x2 x 10		1.0	million baht/m2	80
Pumping Station		5m3/s x 10		12	million baht/m3	600
Over Flow Weir		2km wide x 2m high x 2places				6,400
Road Improvement		42km x 112 x 0.6m heightening x 6m wide				22,109
House Relocation		3,000km2 x 35 house/km2		0.25	mill. baht/house	26,250
Total						56,666 million baht
Running Cost					million baht / year	620

Case-2 2,000km2

Enclosure Dike Construction						
No.	Distance (m)	Improvement Length (m)	Type	Heightening Height (m)	Unit Cost (Bart / m)	Cost (million baht)
1	9,000	9,000	C1	1	5,200	47
2	7,500	7,500	C1	1	5,200	39
3	29,000	29,000	C1	1	5,200	151
4	54,000	54,000	C1	1	5,200	281
5	27,500	27,500	C1	1	5,200	143
6	11,500	11,500	C1	1	5,200	60
7	19,000	19,000	C1	1	5,200	99
Total	157,500					819
Small Sluice Gate		2m x2m x2 x 7		1.0 million baht/m2		56 million baht
Pumping Station		5m3/s x 7		12 million baht / m3		420
Overflow Weir		1km wide x 2m high x 2 places				3,200
Road Improvement		42km x 50 x 0.6m heightening x 6m wide				9,870
House Relocation		2,000km2 x 35 house/km2		0.25	mill. baht/house	17,500
Total						31,865 million baht
Running Cost					million baht / year	290

Case-3 1,000km2

Enclosure Dike Construction						
No.	Distance (m)	Improvement Length (m)	Type	Heightening Height (m)	Unit Cost (Bart / m)	Cost (million baht)
1	20,500	20,500	C1	0.5	3,100	64
Total	20,500					64
Small Sluice Gate		2m x2m x2 x 5		1.0 million baht/m2		40 million baht
Pumping Station		5m3/s x 5		12 million baht / m3		300
Overflow Weir		1km wide x 2m high x 1 places				1,600
Road Improvement		42km x 35 x 0.6m heightening x 6m wide				6,909
House Relocation		1,000km2 x 35 house/km2		0.25	mill. baht/house	8,750
Total						17,663 million baht
Running Cost					million baht / year	150

Note 1 : Aforementioned Cost is Financial Cost.
2 : Exclusive of Price Contingency

Table 5.2.9 PROJECT COST OF TIDAL BARRAGE WITH PUMP

Item	Unit	Quantity	Unit Cost (mil. Baht)	Cost (mil. Baht)
Pump	unit	1500	20	30,000
Pump				
Pump Column				
Cable				
Steel Pipe				
Screen				
Crane				
Mechanical & Electrical Facility	unit	1500	10	15,000
Control Panel				
Gauging System				
Others				
Offices				
Control Office	m2	300x3stories	0.1	90
Truck Space (land)	m2	2700	0.0005	1
Warehouse				
Warehouse with Crane	m2	120000	0.1	12,000
Land	m2	120000	0.0005	60
Vehicle				
Truck	cars	50	1	50
Sedan	cars	10	1	10
Boat	boat	2	50	100
Electrical Transformer & Electrical Wire	L.S	1	20000	20,000
Pumping Station				
Concrete Work	m3	360000	0.008	2,880
Foundation Work	L.S	1	1440	1,440
Short Diversion				
Concrete Work	m3	600000	0.006	3,600
Foundation Work	L.S	1	720	720
Weir				
Gate (Steel)	ton	1200x10unit	0.5	6,000
		200x2set		
Winch in general (steel)	ton	x10units	0.5	2,000
Concrete Work	m3	300000	0.008	2,400
Foundation Work	L.S	1	1200	1,200
Navigation Channel with Lock	L.S	1	5000	5,000
Concrete Work				
Foundation Work				
Others				
Temporary and Additional Work	L.S	1	3000	3,000
Land acquisition excluding offices and warehouse and House Relocation	L.S	1	4200	4,200
Sub-total				109,751
Price Contingency	%	10		10,975
Tax	%	15		18,109
Total Cost				**127,860**
O&M Cost	%	2		**2,557**

Table 5.3.1 FINANCIAL COST OF HEIGHTENING
FOR RIVER IMPROVEMENT PROJECT

Item	Unit	Quantity	Cost (million baht)						
			Local				Foreign		
			Skilled	Unskilled	Material	Machine	Skilled	Material	Machine
Direct Cost									
Preparatory Work	%	5	1	0.8	2	4.3		1.8	9.8
ChaoPraya	L.S.	1	12.1	9.68	24.2	53.24		21.78	121
Noi	L.S.	1	1.63	1.3	3.25	7.16		2.93	16.27
LopBuri	L.S.	1	4.82	3.85	9.63	21.19		8.67	48.16
Bang Bal	L.S.	1	0.67	0.54	1.35	2.96		1.21	6.74
Bang Phra Mo	L.S.	1	0.32	0.26	0.64	1.41		0.58	3.21
Other Conc.St.	m2	140	0.007	0.006	0.015	0.033		0.013	0.075
Indirect Cost									
Temporary Work	%	10	2	1.6	3.9	8.6		3.5	19.5
Miscellaneous	%	5	1	0.8	2	4.3		1.8	9.8
Physical Contingency	%	10	2.4	1.9	4.7	10.3		4.2	23.5
Subtotal (1)			25.947	20.736	51.685	113.493		46.483	258.055
House Relocation	nos.	1			0.07				
Land Acquisition	m2	24100			16.5				
Subtotal (2)					228.431			304.538	
Engineering Service									
D/D Investigation	%	2	0.02	0.01	0.16	0.26		0.16	1.37
D/D Engineering	%	5	2.6				23.2		
S/V Stage	%	5	2.6				23.2		
Subtotal (3)					234.081			352.468	
Price Contingency	%	3			7			10.6	
Subtotal (4)					241.081			363.068	
Tax	%	10			24.1			36.3	
					265.181			399.368	
Grand Total					664.549				
O&M Cost	%	4			15.6			million baht/year	

Table 5.3.2 FINANCIAL COST OF REGULATOR
FOR RIVER IMPROVEMENT PROJECT

Item	Unit	Quantity	Cost (million baht)						
			Local				Foreign		
			Skilled	Unskilled	Material	Machine	Skilled	Material	Machine
Direct Cost									
Preparatory Work	%	5	0.5	0.5	9.9	0.9		6.4	4.8
Reg.-1	L.S.	1	0.3	0.3	6.45	0.6		4.2	3.15
Reg.-2	L.S.	1	0.7	0.7	15.05	1.4		9.8	7.35
Reg.-3	L.S.	1	0.7	0.7	15.05	1.4		9.8	7.35
Reg.-4	L.S.	1	1.1	1.1	23.65	2.2		15.4	11.55
Reg.-5	L.S.	1	0.3	0.3	6.45	0.6		4.2	3.15
Reg.-6	L.S.	1	0.7	0.7	15.05	1.4		9.8	7.35
Reg.-7	L.S.	1	0.7	0.7	15.05	1.4		9.8	7.35
Reg.-8	L.S.	1	1	1	21.5	2		14	10.5
Reg.-9	L.S.	1	1.5	1.5	32.25	3		21	15.75
Reg.-10	L.S.	1	0.7	0.7	15.05	1.4		9.8	7.35
Reg.-11	L.S.	1	0.6	0.6	12.9	1.2		8.4	6.3
Reg.-12	L.S.	1	0.7	0.7	15.05	1.4		9.8	7.35
Reg.-13	L.S.	1	0.2	0.2	4.3	0.4		2.8	2.1
Indirect Cost									
Temporary Work	%	10	0.9	0.9	19.8	1.8		12.9	9.7
Miscellaneous	%	5	0.5	0.5	9.9	0.9		6.4	4.8
Physical Contingency	%	10	1.1	1.1	23.7	2.2		15.5	11.6
Subtotal (1)			12.2	12.2	261.1	24.2		170	127.5
House Relocation	nos.	4			0.8				
Land Acquisition	m2	700			0.656				
Subtotal (2)					311.156			297.5	
Engineering Service									
D/D Investigation	%	2	0.01	0	0.79	0.06		0.59	0.68
D/D Engineering	%	5	3				27.3		
S/V Stage	%	5	3				27.3		
Subtotal (3)					318.016			353.37	
Price Contingency	%	3			9.5			10.6	
Subtotal (4)					327.516			363.97	
Tax	%	10			32.8			36.4	
					360.316			400.37	
Grand Total					760.686				
O&M Cost	%	4			18.4			million baht/year	

Table 5.4.1 COST ESTIMATION OF RIVER IMPROVEMENT PROJECT IN THE MASTER PLAN

River Improvement 10-year (Chainat~Pathum Thani : Thai (Financial)

	Classification of cost	L.C.	F.C	Total
1	Constructioin cost	507	602	1,109
	1) Material and Equipment	432	602	1,034
	2)(a) Skilled Labor	40		40
	(b) Unskilled Labor	35		35
2	Land acquisition	20		20
3	Administration	22		22
4	1)Engineering service D/D	8	59	66
	2)Engineering service S/V	6	56	62
5	Physical contingency	45	60	105
	Sub-total	607	776	1,384
6	Price Contingency	18	23	41
	Grand total	625	800	1,425
	OM Cost			34

River Improvement 25-year (Chainat~Pathum Thani : Thai (Financial)

	Classification of cost	L.C.	F.C	Total
1	Constructioin cost	652	775	1,427
	1) Material and Equipment	556	775	1,330
	2)(a) Skilled Labor	52	0	52
	(b) Unskilled Labor	45	0	45
2	Land acquisition	26	0	26
3	Administration	28	0	28
4	1)Engineering service D/D	10	75	85
	2)Engineering service S/V	8	71	79
5	Physical contingency	58	78	135
	Sub-total	782	999	1,781
6	Price Contingency	23	30	53
	Grand total	805	1,029	1,834
	OM Cost			44