Basin map of the Khlong Luang river is shown in Fig. 2, and overall profile in Fig. 3 and Table 1.

2.1.2 Existing Flood Mitigation and Drainage Facilities

There exists Ban Bung dam in the upstream of the Huai Yang river which is a major tributary of the Khlong Luang river. The dam was constructed in 1958 for domestic, industrial and irrigation water supply purposes. The reservoir has a surcharge capacity of 1.0×10^6 m^3 and active storage capacity of 0.4×10^6 m^3.

In the lower reach of the Khlong Luang river, Phan Thong drainage canal was constructed for improvement of drainage condition. It connects the Khlong Nam Khen river with the Bang Pakong river. The canal is 7.8 km is length and two bays of the gate are installed in the lower end as shown in Fig. 4.

Along the highway Route-3, there have been constructed a large number of tidal gates by the RID in order to protect the cultivated land from the salt water intrusion and the backwater effect of the Bang Pakong river.

No other flood mitigation or protection works have been realized in the Khlong Luang river basin.

2.1.3 Channel Capacity

Channel capacity of the Khlong Luang river is calculated for a stretch between the Bang Pakong river and the proposed Khlong Luang damsite under the following conditions.

(a) Channel flow calculation: by non-uniform flow formula using river profile surveyed in November, 1982. Table 2 gives the feature of the Khlong Luang river.

(b) Manning's coefficient of roughness (n):

0.0 to 24.7 km : n = 0.030
24.7 to 46.1 km : n = 0.035

The critical or bankful channel capacity is illustrated in Fig. 5 and is summarized below. It is considerably small compared with the magnitude of flood.

Stretch (km)	Average Capacity (m^3/s)
0 - 10.4	63
10.4 - 24.7	23
24.7 - 46.1	60

2.1.4 Flood Problems

As a results of the above analysis, the causes of flooding in the Khlong Luang river basin are characterized by the following:

(a) In the middle and lower reaches, river courses are braided and channel capacities are thus remarkably reduced as revealed in sub-section 2.1.3.

(b) In the lower reach, the flow is affected by tides through the Bang Pakong river which interfere the smooth gravity drainage of flood run-off of the Khlong Luang river.

(c) Vertical bent of profile is observed near Phanat Nikhom as shown in Fig. 5. Channel capacity of the existing river channel also changes abruptly at this bent from 55 m^3/s in the upstream to 22 m^3/s in the downstream.

2.2 Rayong River

2.2.1 River System

The Rayong river flows southwards gathering its tributaries such as the Khlong Yai, Nong Pla Lai and Khlong Dok Krai rivers in the mountainous area. These rivers originate in Mt. Khao Liang Khwai (El. 179 m), Mt. Khao Chomphu (El. 725 m) and Mt. Khao Chak Kluai (El. 306 m) respectively. The paddy fields extend over the middle and lower reaches. In the lower reach, the Khlong Thap Ma river of which source is Mt. Khao Nang Yong (El. 419 m) joins with the main stream in the vicinity of Rayong city. After passing through Rayong city with meandering, it finally empties into the Gulf of Thailand. The Rayong river has a total length of 90 km from its source to rivermouth. Total drainage area amounts to 1,730 km^2.

The majority of the Rayong river basin lies in Rayong Province and a part of the basin in Chon Buri Province. The basin is bounded by the Prasae river basin in the east, the Khlong Luang river basin in the north and coastal river basins in the west.

About 17% of the basin, that is 295 km^2, is flat alluvial plain. The alluvial plain formed by the Nong Pla Lai, Khlong Dok Krai, and Khlong Yai rivers is approximately 13 m in elevation at Ban Khai weir. The gradient of river is 1/1,200 at the Ban Khai weir site and 1/4,000 near the highway Route-3.

Basin map of the Rayong river is shown in Fig. 6, and overall longitudinal profile of major channels are shown in Table 3 and Fig. 7.

2.2.2 Existing Flood Mitigation and Drainage Facilities

The Dok Krai dam, diversion channels and connecting channel have been constructed by RID as explained below.

Dok Krai Dam

The Dok Krai dam is located in the upper reach of the Khlong Dok Krai river which is one of the major tributaries of the Rayong river. It is situated at about 51 km upstream from the rivermouth of the Rayong river.

This dam was constructed in 1975 for domestic water supply, irrigation and flood control. The irrigation service area depending on the dam is about 4,800 ha. Total catchment area of the dam is 291 km^2 and its reservoir has a gross storage capacity of 70.8 x 10^6 m^3. The dam has an effect in reduction of peak flood run-off by surcharge storage capacity of 20.0 x 10^6 m^3.

Diversion Channels

Three diversion channels were constructed in 1962 for the purpose of draining flood water in the northern part of Rayong city. They are equipped with regulating gates to evacuate flood during the flood time and to prevent saline water intrusion during the dry season. Fig. 8 shows the location map of the diversion channels. The total design discharge of three diversion channels is 131 m^3/sec and the cross-section for each channel is described below.

Diversion Channel No.	Discharge (m^3/s)	Length (km)	Cross-section				Remarks
			Width (m)	Height (m)	Nos. of Gate	Gate Sill (El.m)	
1	46	2.0	4.0	4.00	2	-1.0	West Side
2	25	1.6	2.25	2.25	3	0.6	East Side
3	60	1.6	6.0	4.00	2	-1.0	Center

Connecting Channel

In addition to the three diversion channels, another channel of 500 m long was constructed at the same time, which connects the Rayong river with the Khlong Kha river in order to increase the capability of draining.

2.2.3 Channel Capacity

Channel capacity of rivers are calculated along the Rayong, Khlong Yai, Nong Pla Lai and Khlong Thap Ma rivers under the following conditions.

(a) Channel flow calculation: by non-uniform flow formula for the main stem of Rayong river and uniform flow formula for the rest, using river profiles surveyed in 1981 for the Rayong river and in November 1982 for Khlong Yai and Khlong Thap Ma rivers. Tables 4 and 5 shows the features of the Rayong river and Khlong Yai and Khlong Thap Ma rivers respectively.

(b) Manning's coefficient of roughness (n):

- Rayong river
  - 0.0 to 32.6 km : n = 0.030
  - 32.6 to 47.7 km : n = 0.035
- Khlong Yai river : n = 0.035
- Khlong Thap Ma river : n = 0.030

The bankful channel capacity of each river is shown in Fig. 9 thru 11. The channel capacity is outlined as described below.

Stretch (km)	Average Capacity (m^3/s)
(a) Rayong River	
0 - 23.1	50
23.1 - 40.2	161
40.2 - 47.7	29
(b) Khlong Yai River	23
(c) Khlong Thap Ma River	15

2.2.4 Flood Problems

The Rayong river forms a triangular shaped inundated area along the main river, getting wider toward downstream. At the lower end the river meanders considerably. Furthermore the river mouth is clogged by sand spit. The flooding in the lower Rayong river is also worsening the drainage of the tributaries. In order to solve these problems three floodways have been constructed on the meandering channel near the river mouth. The floodway, however, seems not successfully functioned due to clogging of the rivermouth.

2.3 Coastal Rivers

There are a number of small rivers in coastal area as shown in Fig. 12. These rivers are defined herein as coastal rivers. Most of coastal rivers have a catchment area less than 200 km^2 and major rivers in the coastal area are as follows.

River	Catchment Area (km^2)
Khlong Yai Cheng	30.1
Huai Nong Khlong Kohk	20.4
Khlong Bang Prong	27.8
Huai Sukhrip	128.0
Khlong Bang Lamung	301.0
Huai Nong Pru	100.0
Huai Yai	119.0
Khlong Bang Phai	181.0
Khlong Phayun	31.8
Khlong Phala	18.8
Khlong Nam Tok	18.7
Khlong Huai Yai	120.0

There have been constructed four dams in the coastal area. They are Bang Phra, Map Prachan, Khlong Bang Phai and Phluta Luang dams. In addition, Nong Kho dam is under construction.

3. FLOOD DAMAGES

3.1 Historical Flood Events

No official report or information has been issued on the past floods in the Khlong Luang and Rayong river basins.

(1) Khlong Luang River Basin

The annual maximum daily discharges at Ban Mai station are shown in Table 6. The maximum discharge since 1965 was observed in Oct. 19, 1974. Recently, big floods were recorded on Sept. 19, 1978 and Sept. 23, 1981 which fall in the 4th and 5th order of magnitude in a 17-year's hydrological record respectively. The return periods of the 1974- and 1981-floods are estimated approximately at 18.0 and 3.6 years respectively by Thomas' method.

(2) Rayong River Basin

The annual maximum mean discharges at Ban Khai Weir are shown in Table 7. The maximum discharge since the year 1967 was observed on Oct. 20 in 1974. Recently, big floods were recorded on May 15, 1978, Oct. 24, 1980, and Sept. 23, 1981, respectively. They fall in the 2nd, 3rd and 7th order of magnitude respectively in a 15-year's hydrological record.

The return periods of the 1974- and 1981-floods are estimated approximately at 16.0 and 2.3 years respectively by Thomas' method.

(3) Seasonal Frequency of Floods

Almost all the big floods occurred in the months of September and October. Figs. 13 and 14 present the monthly frequencies of flood run-offs more than 25 m^3/s at Ban Mai stream gauge and more than 70 m^3/s at Ban Khai weir respectively. More than 80 % of floods concentrate in two months, September and October, in the both river basins.

3.2 Flood Damage Survey

In order to grasp the flooding conditions in the basin and gather the data required for the estimate of flood damages, flood damage surveys by the interview were conducted in the Khlong Luang and Rayong river basin by the Study Team.

The surveys were made at 31 sites in the Khlong Luang river basin and 27 sites in the Rayong river basin. Figs. 15 and 16 show the sampling points. Flooding data such as inundated depth and its duration were collected for the 1974-flood and 1981-flood which were the impressive events to the inhabitants.

(1) Khlong Luang River Basin

The results of survey are presented in Table 8 and Figs. 17 and 18. The inundated areas and land use are measured on the topographic maps (1/50,000) and shown in Tables 9 & 10. The inundated areas amounts to 58,300 ha for the 1974-flood and 44,400 ha for the 1981-flood of which breakdowns by land uses are as follows:

Land Use	Inundated Area (ha)	
	1974-flood	1981-flood
Paddy fields	40,100	30,400
Uplands	2,100	1,700
Village areas	1,700	1,500
Other lands	14,400	10,800
Total	58,300	44,400

(2) Rayong River Basin

The results of survey are presented in Table 11 and Figs. 19 & 20. The inundated areas and land use are measured on the topographic maps (1/50,000) and shown in Tables 12 & 13. The inundated area amounts to 21,000 ha for the 1974-flood and 17,000 ha for the 1981-flood of which breakdowns by land uses are as follows:

Land Use	Inundated Area (ha)	
	1974-flood	1981-flood
Paddy fields	11,300	10,400
Uplands	4,000	1,800
Village area	1,600	1,200
Other lands	4,100	3,600
Total	21,000	17,000

3.3 Flood Damage Estimate

3.3.1 Flood Damage Categories

The flood damage is broadly classified into the following 4 categories.

a. Paddy
b. Upland crops
c. House and household effects
d. Livestock

The flood damages of these categories are estimated as a product of damageable value and damage ratio. The damageable value and damage ratio are estimated, in general, for respective inundated depths at every 0.5 m and, if necessary, for respective durations of inundation.

Other tangible damage and indirect damage are counted at 20% of the total values of the above items.

3.3.2 Damageable Value and Rate

The flood damage of each category is estimated based on the damageable value and damage rate as described hereunder.

(1) Damages to Paddy

The flood damage of paddy is the most predominant in the basin, since the paddy field occupies around 70% of the total inundated area.

Damageable Value

Damageable value of paddy is derived based on the agricultural statistics and economic unit price. Ratio between the local and improved varieties is assumed at 60:40. The damageable value is estimated as follows.

Description	Unit	Khlong Luang River Basin	Rayon River Basin
Unit yield	t/ha	1.67	1.72
Unit price	฿/ton		
Local variety		8,430 x 0.6	8,360 x 0.6
Improved variety		8,010 x 0.4	7,940 x 0.4
Damageable value	฿/ha	13,760	14,090

The unit price is indicated in terms of economic price prospected to 1990.

Damage Ratio

Rates of reduction in yield due to inundation are based on the data prepared by Ministry of Agriculture, Forestry and Fishery, Japan which are summarized hereunder.

Depth (m)	Duration (days)			
	0 to 1	1 to 4	4 to 7	More than 7
0 to 0.5	0.08	0.13	0.17	-
0.5 to 1.0	-	0.16	0.23	0.24
1.0 to 1.5	-	0.46	0.65	0.66
1.5 to 2.0	-	-	0.65	0.66

(2) Damages to Upland Crops

According to the agricultural statistical data cropping areas of upland crops are determined as follows.

Crops	Cropping Area (%)	
	Khlong Luang River Basin	Rayong River Basin
Cassava	43.2	69.1
Sugarcane	40.7	14.8

Damageable Value

The damageable value of cassava is estimated by means of the same method as paddy as shown below. Since sugarcane is grown sufficienty high and harvested before September, it damage is thought to be negligible.

Description	Unit	Khlong Luang River Basin	Rayong River Basin
Unit yield	t/ha	13.2	16.8
Unit price	฿/ton	1,250	1,250
Planting area	%	43.2	69.1
Damageable value	฿/ha	7,130	14,510

Damage Ratio

Since the data on damage ratio of cassava are not available, damage ratio of sweet potato prepared by Ministry of Construction, Japan is adopted. It is presented below.

Depth (m)	Duration (days)			
	1 to 2	3 to 4	5 to 6	Above 7
0 to 0.5	0.11	0.30	0.50	0.50
0.5 to 1.0	0.27	0.40	0.75	0.88
Above 1.0	0.38	0.63	0.95	1.00

(3) Damages to House and Household Effects

Damageable Value

The number of house in unit village area is estimated based on the house number in each district and village area measured on the topographic maps of scale 1/50,000. The Phanat Nikhom, Phan Thong and Ban Khai Districts are selected as representative areas for the estimate. The average

On the other hand, the amount of household effects is assumed broadly to be 80% of house (building) value based on the survey results and technical practice in similar countries in Southeast Asia. Accordingly, the unit value of house and household effects is estimated ฿ 39,600/house as follows for both the Khlong Luang and Rayong river basins.

Description	Unit	Amount
Value of house	฿/house	22,000
Value of household effects	฿/house	17,600
Damageable value	฿/house	39,600

Damage Ratio

The following damage ratios were established by adjusting the ratio prepared by Ministry of Construction, Japan, in due consideration that the most houses in the inundated areas are those with high floor about 1.0 m above the natural ground level.

Depth (m)	Damage Ratio
0 to 1.0	0.03
1.0 to 1.5	0.05
1.5 to 2.0	0.07
Above	0.11

(4) Damages to Livestocks

The buffalo, pig, chicken and duck are the major livestocks in the basin. Among these, pig, chicken and duck are presumed to be susceptible to flood damage. The livestock raising rate is as follows, according to the agricultural statistical data.

Livestock	Raising Rate (head/house)	
	Khlong Luang River Basin	Rayong River Basin
Pig	2.26	0.47
Chicken	45.60	2.62
Duck	34.70	0.64

Damageable Value

The damageable is estimated as tabulated below.

Livestock	Unit Price (฿/head)	Damageable Values (฿/house)	
		Khlong Luang River Basin	Rayong River Basin
Pig	2,316	5,230	1,090
Chicken	24.25	1,110	54.8
Duck	30.25	1,050	19.4

Damage Ratio

Since no data on damage ratio of livestocks is available, the following damage ratios are assumed according to the information obtained in the inundated areas:

Depth (m)	Damage Ratio		
	Pig	Chicken	Duck
Below 0.5	0.3	0.5	0.3
0.5 to 1.0	0.8	1.0	0.9
Above 1.0	1.0	1.0	1.0

3.3.3 Flood Damages

The flood damage of each catogory is estimated for the 1974- and 1981- floods based on flood damageable value, rate and inundation area.

The flood inundation areas by land uses are shown in Tables 9 and 10 for the Khlong Luang river basin and Tables 12 and 13 for the Rayong river basin. The flood damages are calculated for each category as shown in Tables 14 to 21 for the Khlong Luang river basin and Tables 22 to 29 for the Rayong river basin. The summary of the flood damage estimate is as follows.

Damage Category	Khlong Luang River Basin		Rayong River Basin	
	1974-flood	1981-flood	1974-flood	1981-flood
Paddy	173.5	95.8	48.6	34.2
Uplands	3.4	1.8	15.1	6.4
House and household effects	25.6	18.6	21.2	15.0
Livestock	109.5	75.1	9.8	7.6
Other tangible	62.4	38.3	18.9	12.6
Total	374.4	229.6	113.6	75.8

3.4 Annual Average Flood Damages

3.4.1 Flood Damage Curve

In order to facilitate the flood mitigation planning, the Khlong Luang and Rayong rivers are divided into 5 blocks and 6 blocks respectively as shown in Table 30. Flood damage curves are prepared for the respective blocks, distributing the flood damage in proportion to the extent of inundated areas of the respective blocks, and according to the return periods of floods as follows by Thomas' method:

River	Return Period (yr)	
	1974-flood	1981-flood
Khlong Luang	18.0	3.6
Rayong	16.0	2.3

The flood damage curves for each blocks are shown in Fig. 21 for the Khlong Luang river and Fig. 22 for the Rayong river.

3.4.2 Annual Average Flood Damage

By use of the damage curves and flood frequency curves of each blocks, the annual average flood damages are estimated as follows:

(Unit: ฿ 10^6)

Inundation Block	Khlong Luang River Basin	Rayong River Basin
A	20.9	5.7
B	13.4	5.6
C	48.9	9.2
D	79.6/1	16.9
E	157.7	36.2
F	-	16.9
G	-	56.6
Total	240.9	147.1

/1 : Excluded from total because of interior inundation

The flood frequency curves are constructed as shown in Fig. 23 for the Khlong Luang river basin and Fig. 24 for the Rayong river basin, based on the flood run-off analysis presented in Sectoral Report VII, Meteorology and Hydrology.

4. BASIC CRITERIA FOR FLOOD MITIGATION PLANNING

4.1 Approach to Planning

4.1.1 General Description

The flood damage situations in both the Khlong Luang and Rayong river basins are revealed through the analyses of channel capacity and flood damage survey as explained in Chapters 2 and 3 respectively. It could be expected that flood hazards to life and health will increase as population increase, and intesified use and occupancy of flood plain lands will result in increased property damage from future floods.

An appropriate flood protection measure will be essential for enhancement and prosperity of economic activity, conservation of land, increase of agricultural productivity and assurance of human life and health. Such protective measure, however, should be established in view of long-term perspective.

In order to regulate and drain the flood run-off without causing damages, the following measures are taken in general:

(1) Channel improvement

The channel improvement which mainly aims at increasing flow capacity of channel is the principal and substantial flood mitigation measures. The followings are the major works included in the channel improvement:

a. Widening and deepening of low water channel.

b. Diking system to confine the flood run-off in the river area. Another function of the diking system is to clarify the river area to be conserved for flood control.

c. Revetment, groyne and consolidation works to protect and maintain the river facilities like river channel and dikes.

(2) Cutoff channel

The cutoff channel in the meandering river is planned aiming at generally;

a. Shortening the stretches subject to the channel improvement and, accordingly, to save the construction cost,

b. Increasing channel capacity by steepening the river slope, and

c. Preventing local scouring due to channel bent by transfering the channel course.

(3) Floodway or flood diversion channel

The floodway or flood diversion channel is planned generally in the case that;

a. Channel improvement works and land acquisition are difficult in the lower reaches due to urban area, river port, etc.

b. Construction cost of floodway gets lower than that of improvement of existing channel, and

c. Improvement of existing channel is not technically and economically effective enough from the topographic features such as in low-lying areas.

(4) Dam reservoir and retarding basin

Function of these measures is to reduce the peak run-off, regulating and retarding the flood run-off artificially.

(5) Basin management

Regulating and guiding the land use in the basin, flood damages are mitigated in the following manners:

a. Conservation of natural flood retarding functions such as in swampy area and forest in the upper watershed.

b. Reduction of the damageable properties in the flood prone area.

4.1.2 Methodology

A new water resources development is being contemplated to be carried out in both the Khlong Luang and Rayong river basins in order to cope with the domestic and industrial water demand and irrigation water demand.

In the Rayong river basin, Dok Krai dam has been constructed and Nong Pla Lai dam is being contemplated to be implemented within several years. The Khlong Yai dam is situated in the Khlong Yai river, which joins with the main stem of the Rayong river at about 3.5 km downstream from the proposed damsite and is expected to be implemented after Nong Pla Lai dam.

Also in the Khlong Luang river basin, New Ban Bung and Khlong Luang dams are being planned to be constructed in near future.

These dams will evidently contribute to flood damage reduction in the respective basin.

A basic flood control plan was initially elaborated. The plan aims at protecting the entire riparian lands for a standard project flood. The standard project flood has a recurrence interval of 50 years. The plan is formed by a combination of dams and river improvement works.

The magnitude of the river improvement works is dominated by flood control effect by reservoir. The flood control capability of reservoir varies with surcharge volume and spillway discharge capacity. A set of alternatives are therefore set up by employing the width of spillway as a parameter. An alternative with minimum cost is selected as the proposed basic flood control plan.

Economic viability of river improvement works is testified under condition that all contemplated dams should have been constructed. It is worked out for three different risk levels, namely, 10-year, 30-year and 50-year floods.

4.2 Run-off Simulation Model

The flood run-off along the river course is calculated by applying the run-off simulation model, which is explained in detail in Sectoral Report VII, Meteorology and Hydrology. The run-off simulation models are formulated for the Khlong Luang and Rayong river basins respectively as shown in Figs. 25 and 26.

The same models are adopted in evaluating the flood regulation effects by dams.

4.3 Criteria for Channel Design

The following criteria is employed for design of channels.

(1) Channel section

Compound section is adopted in principle, which is composed of low water channel and high water channel confined by dikes on the existing river banks.

(2) River width

The river width between both dikes is decided based on the following criteria recommended by Ministry of Contruction, Japan:

Design Discharge (m^3/s)	River Width (m)
300	40 to 60
500	60 to 80
1,000	90 to 120
2,000	160 to 220
5,000	350 to 450

(3) Design river bed profile

The design river bed profile is set based on the average river bed of the existing channel.

(4) Low water channel section

The low water channel is excavated above the design river bed so as to get materials for dikes as well as to increase channel capacity. The excacation volume is thus nearly equivalent to embankment volume considering the swelling factor and some loss. The side slope of the channel is 1 on 3.

(5) Design high water level

The design high water level is decided based on the channel flow calculation for the designed section. Manning's coefficient of roughness for designed channel is taken at 0.03 to 0.035 for low water channel and 0.05 to 0.06 for high water channel depending on the river conditions.

(6) Dike section

The elevation of dike crown is decided above the design high water level adding some freeboard. The standard dike section based on the criteria by Ministry of Construction, Japan illustrated in Fig. 27.

5. PRELIMINARY FLOOD MITIGATION PLANNING FOR KHLONG LUANG RIVER

5.1 Formulation of Basic Flood Control Plan

5.1.1 Alternatives

In the Khlong Luang river basin, New Ban Bung and Khlong Luang multiple-purpose dams are being contemplated to be developed in near future. The basic flood control plan of the basin is constituted by a combination of these dams and river improvement works.

It is being anticipated that New Ban Bung dam is to be implemented within a couple of years. Its feasibility study has already been completed and its development scale has also been determined. The basic flood control plan is thus subject to flood regulation effect of Khlong Luang dam. Three alternatives are established as shown below for comparision.

Structures	Unit	Alternatives		
		1	2	3
New Ban Bung Dam				
High water level	El.m	82.1	82.1	82.1
Flood water level	El.m	84.3	84.3	84.3
Surcharge volume	$10^6 m^3$	7.8	7.8	7.8
Spillway width	m	20.0	20.0	20.0
Dam crest	El.m	86.3	86.3	86.3
Khlong Luang Dam				
High water level	El.m	39.5	39.5	39.5
Flood water level	El.m	40.6	40.5	40.4
Surcharge volume	$10^6 m^3$	39.2	34.3	31.4
Spillway width	m	50.0	70.0	90.0
Dam crest	El.m	42.6	42.5	42.4
River Improvement Work				
Length	km	47.0	47.0	47.0
Earthwork	$10^3 m^3$	5,712	5,720	5,725

The high water level of Khlong Luang reservoir has been determined from the viewpoint of conservation use as explained in Sectoral Report XI, Water Resources Engineering. The spillway and surcharge volume have been designed for a design flood with recurrence interval of 500-year.

The quantity of the river improvement works is resulted from preliminary design of channel improvement as explained in subsection 5.1.3.

5.1.2 Flood Regulation by Dams

The proposed reservoirs retain temporarily a substantial portion of flood run-off, resulting in reduction in a rate of peak discharge in the downstream reach from the damsites. The flood regulations by reservoirs were worked out for various probable floods based on the run-off simulation model. Tables 31 to 33 show the probable food run-offs under the present, with New Ban Bung and with Khlong Luang dam respectively.

Due to flood control effects by reservoirs, flood frequency curves naturally change. The modified flood frequency curves are constructed as a result of reservoir regulation effect. The modified curve is shown in Fig. 23 for the selected plan which has a spillway width of 70 m in Khlong Luang dam.

5.1.3 River Improvement Works

The distribution of flood discharge is determined for each alternative taking into account the flood regulation effects of New Ban Bung and Khlong Luang reservoirs and execution of river improvement works. It is shown in Table 34 and is illustrated in Fig. 28.

The preliminary layout design of river imprvement works was carried out in accordance with the criteria set forth in Section 4.3. The main stem of the Khlong Luang river is divided into 6 reaches as shown in Fig. 29. Channel factors applied for design of channel improvement works are shown in Table 35.

Based on the preliminary design, construction cost of the river imprvement works was estimated for the respective alternative as shown in Tables 36 to 38. The quantity of earth work, practically dike embankment work indicates only slight difference among the alternatives, since flood run-offs from the downstream area is so large compared to critical channel capacity.

5.1.4 Comparison of Construction Cost

The construction cost of the flood control measure is expressed as the sum of cost of Khlong Luang dam and cost of river improvement works. The construction cost of Khlong Luang dam attributable to flood control is assumed to be equivalent to the dam embankment cost above normal high water level and spillway cost. The comparison of construction cost is tabulated hereunder.

(Unit: ฿ 10^6)

Structures	Alternatives		
	1	2	3
Khlong Luang Dam (incremental only)	307.7	302.9	303.9
River improvement work	1,086.6	1,087.4	1,088.2
Total	1,394.3	1,390.3	1,392.1

The construction costs of three alternative are almost even. The Alternative 2 however, indicates the minimum cost. Further comparison was made from the view point of total construction cost of Khlong Luang dam as presented below.

Alternative	Spillway Width(m)	Construction Cost (฿ 10^6)		
		Dam	Spillway	Total
1	50	824.8	26.9	851.7
2	70	815.8	31.1	846.9
3	90	812.2	35.7	847.9

The total construction cost is the lowest for spillway width of 70 m. Therefore, the Alternative 2 is adopted as the basic flood control plan.

5.1.5 Preliminary Design of Channel

The basic flood control plan for a 50-year probable flood is preliminarily formulated as described in the above. The outlines of the river improvement works are described herein.

The alignment of dikes is designed as smooth as possible confining the existing river channel with specified river width at minimum. The designed plan, profile and typical sections are shown in Figs. 30 through 32.

The revetment for low water channel is placed on the slope from the lowest river bed of the existing channel and high-water revetment on the dike slope up to design high water level.

As for the countermeasures to the tributaries and local drainage behind the dike, backwater levee or drainage sluices are considered. The backwater levees are provided for the tributaries. For the drainage of the area other than the tributaries, the drainage sluices are provied at the rate of one sluice (1.5 m x 1.5 m) for 2.0 km^2 of drainage area.

The land areas to be acquired for channel improvement are those confined by the dikes excluding the existing channel areas.

5.2 Flood Regulation Effects by Dams

Although both the New Ban Bung and Khlong Luang dams have no specific flood control space other than surcharge volume in their reservoirs, they incidentally reduce flood stage in the downstream as indicated by the modified flood frequency curves in Fig. 23. The flood control benefits due to dam was measured as the difference between the annual damages under unregulated conditions of flooding and those with the reservoir in operation.

The flood control benefits are calculated block by block in accordance with development sequence of dam and based on the flood damage curves and modified flood frequency curves as shown in Tables 39 and 42. The summary is given below.

(Unit: ฿ 10^6)

Condition	Residual Damages by Block				Total
	Block A	Block B	Block C	Block E	
1. Unregulated	20.9	13.4	48.9	157.7	240.9
2. N. Ban Bung	20.9	13.4	44.3	151.7	230.3
3. N. Ban Bung + Khlong Luang	0.3	1.1	30.3	148.7	180.4

The annual flood control benefit of the Khlong Luang dam is assessed to be ฿ 49.9 x 10^6.

5.3 Appraisal of River Improvement Works

5.3.1 General Description

The basic flood control plan has been established for the main stem of the Khlong Luang river by means of a combination of New Ban Bung and Khlong Luang dams and river improvement works. The river improvement plan involved in the basic flood control plan is for a long-range objective and would be realized as a mean of final flood control resort, since existing channel capacity is not capable of flow down safely the flood discharge. It, however, would be planned to be executed progressively in due consideration of flood damage severities.

Taking the above circumstance into consideration, economic viability of river improvement works was examined. In the study, the river improvement works are assumed to be taken place upon completion of New Ban Bung and Khlong Luang dams and its economic viability is testified for three risk levels as follows.

Risk Level	Recurrence Interval of Flood (year)
1	10
2	30
3	50

5.3.2 Channel Design and Construction Cost Estimate

The design of the channel improvement is followed to the design criteria set forth in Section 4.3 and is based on the channel factors shown in Table 43 and discharge distribution shown in Fig. 33. The channel factors for Risk Level "3" are the same as those shown in Table 35.

The work quantity and construction cost are estimated for Risk Levels "1" and "2" as shown in Tables 44 and 45. Those for Risk Level "1" are the same as Table 37.

5.3.3 Economic Comparison

The residual damages after construction of New Ban Bung and Khlong Luang dams are counted as benefit of river improvement works. They are quoted from Tables 39 to 42 and are summarized below.

(Unit: ฿ 10^6/yr)

Blocks	Risk Levels		
	1	2	3
A	0.279	0.308	0.315
B	0.933	1.037	1.063
C	25.115	28.158	28.890
E	132.146	143.227	145.423
Total	158.473	172.730	175.691

The construction cost including an interest during construction is converted into the annual equivalent cost at assumed discount rate of 8 % per annum. The interest during construction is calculated assuming construction period of 7 years. The useful life is assumed to be 50 years. The annual O & M cost is also assumed to be 0.5 % of the initial construction cost. The annual equivalent cost, O & M cost and benefit are tabulated below.

(Unit: ฿ 10^6/yr)

Description	Risk Levels		
	1	2	3
Construction Cost	1,192.2	1,268.9	1,331.0
Annual Equivalent Cost	97.4	103.7	108.7
Annual OM Cost	4.87	5.18	5.44
Annual Benefit	158.47	172.73	175.69
Annual Net Benefit	+56.20	+63.93	+61.55

As shown in the above, the river improvement works induce a positive economic return for all cases and appears to be most attractive for Risk Level "2".

It is expected, therefore, that the river improvement works would firstly be proceeded aiming at protecting the flood with the recurrence interval of 30 years. It is recommendable to carry out systematic statistical survey on flood damages so that economic and financial losses in the basin will realistically be clarified. Then the economic viability of the river improvement works should be reviewed.

6. PRELIMINARY FLOOD MITIGATION PLANNING FOR RAYONG RIVER

6.1 Formulation of Basic Flood Control Plan

6.1.1 Alternatives

There are one dam in operation, one dam under planning and two dams under study in the Rayong river basin as listed below.

Dams	Rivers	Catchment Area (km^2)	Status
Dok Krai	Khlong Dok Krai	291	Existing
Nong Pla Lai	Nong Pla Lai	408	Under planning
Khlong Yai	Khlong Yai	218	Under study
Khlong Thap Ma	Khlong Thap Ma	158	Under study

Upon completion of the above-listed 4 dams, out of 1,730 km^2 of the entire Rayong river basin, about 1,075 km^2 or 62 % would be kept under control. Thus these four dams certainly result in reduction in flood damage in the basin.

At present it is being expected that the three dams would be implemented in order of (i) Nong Pla Lai dam, (ii) Khlong Yai dam and (iii) Khlong Thap Ma dam, in compliance with the proposed development sequence in the long-term water supply.

The basic flood control plan of the Rayong river was established through two steps. The first step is directed to lay out the optimum plan with a combination of three dams (Dok Krai, Nong Pla Lai and Khlong Yai dams) and river improvement works. The second step is to work out the appropriate flood control plan for the Khlong Thap Ma river by a combination of Khlong Thap Ma dam and river improvement. The overall basic flood control plan of the Rayong river is given by the results of Steps "1" and "2".

For Step "1", three alternatives are established for their cost comparison as tabulated below.

Structures	Unit	Alternatives		
		1	2	3
Dok Krai Dam				
Surcharge volume	$10^6 m^3$	20.0	20.0	20.0
Spillway width	m	ø10.0	ø10.0	ø10.0
Nong Pla Lai Dam				
Surcharge volume	$10^6 m^3$	43.5	43.5	43.5
Spillway width	m	120.0	120.0	120.0
Khlong Yai Dam				
High water level	El.m	47.5	47.5	47.5
Flood water level	El.m	48.9	48.8	48.7
Surcharge volume	$10^6 m^3$	18.6	16.9	15.6
Spillway width	m	50.0	70.0	90.0
River Improvement Work				
Length	km	47.3	47.3	47.3
Earth work	$10^3 m^3$	3,880	3,910	3,950

The spillway width and surcharge volume of Nong Pla Lai dam is referred to the Phase I Study.

Also three alternatives are set up for Step "2" as shown below.

Structures	Unit	Alternatives		
		1	2	3
Khlong Thap Ma Dam				
High water level	El.m	25.7	25.7	25.7
Flood water level	El.m	27.0	26.9	26.8
Surcharge volume	$10^6 m^3$	15.2	13.5	12.8
Spillway width	m	30.0	50.0	70.0
Dam crest	El.m	29.0	28.9	28.8
River Improvement Work				
Length	km	10.5	10.5	10.5
Earth work	$10^3 m^3$	982	995	1,003

The high water levels of Khlong Yai and Khlong Thap Ma reservoirs have been determined at El. 43.5 and El. 25.7 m respectively through the land and water resources development plan. The spillway is designed as a side-channel spillway without gate and its crest elevation is the same with the high water level. The surcharge volume and flood water level are decided by routing the 500-year inflow flood.

The requirement of the river improvement work was worked out subsequent to flood routing by reservoir and according to the flood run-off simulation model presented in Section 4.2. Preliminary design of channel improvement work is carried out based on the criteria recommended by Ministry of Construction, Japan.

6.1.2 Flood Regulation by Dams

The reservoir withhelds a portion of flood run-off for a while, resulting in reduction of a peak discharge in the downstream. The regulation effect however varies with width of spillway in case of non-gated spillway. The flood regulation by reservoir was worked out for various probable floods and for each alternative based on the run-off simulation model. The summaries of the calculations are shown in Tables 46 to 50.

Due to flood regulation by reservoirs, flood frequency curves naturally vary. The modified flood frequency curves are shown in Fig. 24 following to the development sequence of dams.

6.1.3 River Improvement Works

The distribution of flood discharge is preliminarily decided for each alternative of each Step, taking the flood regulation effects of dams. It is shown in Table 51 and Fig. 34 for a case of Dok Krai, Nong Pla Lai and Khlong Yai dmas and in Table 52 and Fig. 35 for a case of four dams, including Khlong Thap Ma dam. The effect of the Khlong Thap Ma dam is limited to the Khlong Thap Ma river and the extreme downstream reach of the Rayong river.

The preliminary layout design of the river improvement works was made for Steps "1" and "2" in accordance with the criteria set forth in Section 4.3 and discharge distributions. The main stems of the Rayong and Khlong

Thap Ma rivers are divided into 7 and 3 reaches respectively as shown in Fig. 36 for the preliminary design. Channel factors applied for the preliminary design are shown in Tables 53 and 54.

Based on the preliminary design, construction quantity and construction cost were estimated for each alternative of each Step. Tables 55 to 57 show the construction quantity and cost of the river improvement works of the Rayong river in case of 3 dams (Dok Krai, Nong Pla Lai and Nong Pla Lai dams) in operation. Tables 58 to 60 summarizes the construction quantity and cost of the river improvement works of the Khlong Thap Ma river only in case of Khlong Thap Ma dam in operation.

6.1.4 Comparison of Construction Cost

The same criteria as employed in the preceding sub-section 5.1.4 is applied for comparison of construction cost. The comparison of construction cost for Steps "1" and "2" is presented below.

Description	Construction Cost (฿ 10^6)		
	Dam	River Impro. Works	Total
1. Step "1"			
Alternative 1	298.5	1,187.2	1,485.7
Alternative 2	295.0	1,190.4	1,485.4
Alternative 3	298.7	1,191.2	1,489.9
2. Step "2"			
Alternative 1	132.6	126.4	259.0
Alternative 2	131.8	127.1	258.9
Alternative 3	138.6	127.5	266.1

As shown in the above, the construction costs indicate only slight difference among the alternatives. Thus further comparison was made from the viewpoint of total construction cost of dam as tabulated below.

Dams	Spillway Width (m)	Construction Cost (฿ 10^6)		
		Dam	Spillway	Total
Khlong Yai	50	732.4	62.1	794.5
	70	718.4	72.6	791.0
	90	711.4	83.3	794.7
Khlong Thap Ma	30	314.2	43.9	358.1
	50	306.3	51.0	357.3
	70	302.9	61.2	364.1

Through the above two comparisons, the most appropriate basic flood control measures are considered to be Alternative 2 for both the Steps "1" and "2".

Accordingly, the discharge distribution in case of 4 dams (Dok Kari, Nong Pla Lai, Khlong Yai and Khlong Thap Ma dams) with the river improvement works is corresponded to the middle line in Fig. 35. The construction quantity and cost of the river improvement works are estimated for a case of 4 dams in operation as shown in Table 61.

6.1.5 Preliminary Design of Channel

The preliminary design of channel in case of 4 dams in operation is briefly described hereunder.

The dikes are aligned as smooth as possible along the existing river channel as shown in Fig. 37. The longitudinal profile is arranged almost the same slope with the existing channel as shown in Fig. 38. The typical cross section shown in Fig. 39 is laid out following the criteria set forth in Section 4.3.

The channel protection works and other associated works are the same as explained in the preceding sub-section 5.1.5.

6.2 Flood Regulation Effects by Dam

The flood control effect by dam is evaluated based on the modified flood frequency curves and flood damage curves. The evaluation was made for the following cases, taking into account the development sequence of dams.

Case 1 : Unregulated

Case 2 : Regulated by Dok Krai Dam

Case 3 : Regulated by Dok Krai and Nong Pla Lai Dams

Case 4 : Regulated by Dok Krai, Nong Pla Lai and Khlong Yai Dams

Case 5 : Regulated by Dok Krai, Nong Pla Lai, Khlong Yai and Khlong Thap Ma Dams

The flood damage reduction was calculated based on the above order and zone by zone as shown in Tables 62 and 68. The summary is given hereunder.

Cases	Residual Damages (฿ 10^6/year)							Total
	Block A	Block B	Block C	Block D	Block E	Block F	Block G	
1	5.7	5.6	9.2	16.9	36.3	16.9	56.6	147.2
2	5.7	0.4	9.2	9.4	23.2	16.9	47.0	111.8
3	0.1	0.4	9.2	2.9	10.7	16.9	34.4	74.6
4	0.1	0.4	0.2	1.4	7.3	16.9	28.3	54.6
5	0.1	0.4	0.2	1.4	7.3	2.7	23.0	35.1

The average annual flood control benefit of the respective dam is calculated as follows.

Dams	Flood Control Benefit (B10^6/yr)
Dok Krai	35.4
Nong Pla Lai	37.2
Khlong Yai	20.0
Khlong Thap Ma	19.5

6.3 Appraisal of River Improvement Works

6.3.1 General Description

The basic flood control plan of the Rayong river is preliminarily established by a combination of 4 dams and river improvement works as aforementioned. In accordance with the principles described in Section 5.3, the economic viability of the river improvement works was examined for the following cases and risk levels.

(1) Cases

Cases	Dams in Operation
1	Dok Krai, Nong Pla Lai and Khlong Yai
2	Dok Krai, Nong Pla Lai, Khlong Yai and Khlong Thap Ma
3/1	Khlong Thap Ma

/1 : Khlong Thap Ma river only

(2) Risk Levels

Risk Level	Recurrence Interval of Flood (year)
1	10
2	30
3	50

6.3.2 Channel Design and Construction Cost Estimate

The discharge distribution by the respective case and risk level is shown in Figs. 40 and 41. For Risk Level "3", the discharge distribution is that shown in Figs. 34 and 35.

Preliminary channel design is dependent on channel factors presented in Tables 69 and 70, which are adopted for the Risk Levels "1" and "2". The channel factors for the Risk Level "3" are the same with Tables 53 and 54.

The construction quantity and cost of the river improvement works are estimated for Risk Levels "1" and "2" of each case as shown in Tables 71 to 76. The construction quantity and cost for the Risk Level "3" are the same with those of the basic flood control plan.

6.3.3 Economic Comparison

The residual flood damages are obtained case by case and risk by risk based on the modified flood frequency curves and flood damage curves as shown below.

Cases	Average Annual Residual Damages (¥ 10^6/yr)							Total
	Block A	Block B	Block C	Block D	Block E	Block F	Block G	
Case 1								
Risk Level 1	0.033	0.307	0.111	1.221	6.284	15.528	24.879	48.363
Risk Level 2	0.047	0.334	0.143	1.330	6.867	16.431	27.064	52.216
Risk Level 3	0.051	0.341	0.151	1.356	7.009	16.608	27.544	53.060
Case 2								
Risk Level 1	0.033	0.307	0.111	1.221	6.284	2.475	20.110	30.541
Risk Level 2	0.047	0.334	0.143	1.330	6.867	2.639	21.914	33.270
Risk Level 3	0.051	0.341	0.151	1.356	7.009	2.676	22.340	33.924
Case 3								
Risk Level 1	-	-	-	-	-	2.475	-	2.475
Risk Level 2	-	-	-	-	-	2.639	-	2.639
Risk Level 3	-	-	-	-	-	2.676	-	2.676

By the same manner as the sub-section 5.3.3, the construction cost is converted into annual equivalent cost. The construction periods are assumed to be 7 years for Cases "1" and "2" and 3 years for Case "3" respectively.

(฿ 10^6)

Description	Construction Cost	Annual Equivalent Cost	OM Cost	Annual Benefit	Annual Net Benefit
Case 1					
Risk Level 1	1,220.1	99.7	5.0	48.4	-56.3
Risk Level 2	1,403.3	114.6	5.7	52.2	-68.1
Risk Level 3	1,457.0	119.0	6.0	53.1	-71.9
Case 2					
Risk Level 1	1,060.0	86.6	4.3	30.5	-60.4
Risk Level 2	1,136.4	92.8	4.6	33.3	-64.1
Risk Level 3	1,190.7	97.3	4.9	33.9	-68.3
Case 3					
Risk Level 1	127.1	10.4	0.6	2.5	-8.5
Risk Level 2	131.5	10.7	0.6	2.6	-8.7
Risk Level 3	139.3	11.4	0.6	2.7	-9.3

As shown in the above, the river improvement works are not economically attractive for all the cases studied. However, it is recommendable to execute the flood protective work in some local areas, where flood hazards are serious. It would also be recommended to conduct systematic flood damage statistical survey so that economic and financial losses in the basin will be realistically clarified.

REFERENCES

1. EAST COAST WATER RESOURCES DEVELOPMENT PROJECT; JICA, MAR. 1982.
2. WATER RESOURCES DEVELOPMENT IN THAILAND COMPLETED TO THE END OF 1979 AND UNDER CONSTRUCTION IN 1980; PROGRAM COORDINATION AND BUDGET DIVISION, RID, DEC. 1980.
3. IRRIGATION PFOJECT MAPS IN EASTERN AREA; DESIGN DIVISION, RID, APR. 1976.
4. MANUAL FOR RIVER AND SABO WORKS IN JAPAN; INTERNATION ENGINEERING CONSULTANTS ASSOCIATION, JAPAN, 1977.

TABLES

Table 1 OVERALL PROFILES OF KHLONG LUANG RIVER (1/3)

Accumulated Distance (km)	Elevation (El. m)	Remarks
Khlong Luang River		
0	-2.0	Confluence of Bang Pakong River
3.0	-1.0	Tide gate (End of drainage canal)
7.0	-0.5	Confluence of Huai Nong Takha River
10.5	-	Head of drainage canal
10.5	0.0	Confluence of Khlong Soet River
15.6	-	Confluence of Khlong Sala Daeng River
18.8	-	Bridge of Route No.315
29.2	10.0	Bridge
33.0	11.5	Confluence of Huai Yang River
41.3	-	Bridge of Route No.331
52.9	20.0	
55.0	-	Khlong Luang potential damsite
56.5	30.0	
61.0	34.0	Confluence of Khlong Wang Rakam River
66.8	40.0	
69.9	42.5	Confluence of Khlong Bung Duan River
77.5	50.0	
80.1	60.0	
85.5	70.0	
87.0	80.0	
87.6	90.0	
88.9	100.0	
89.5	120.0	
89.8	140.0	
Huai Nong Takha River		
0	-0.5	Confluence of drainage canal
6.5	9.8	Bridge of Route No.315
6.6	10.0	
10.1	20.0	
11.7	30.0	
14.0	40.0	
15.8	50.0	
17.5	59.0	Bridge of Route No.3133
17.7	60.0	
18.8	70.0	
20.5	80.0	
21.7	90.0	
23.0	100.0	
23.4	110.0	
23.5	120.0	
23.9	140.0	
24.0	160.0	
24.1	180.0	

Table 1 OVERALL PROFILES OF KHLONG LUANG RIVER (2/3)

Accumulated Distance (km)	Elevation (El. m)	Remarks
24.2	200.0	
24.7	300.0	
25.0	400.0	
25.2	500.0	
25.5	600.0	
Khlong Soet River		
0	0.0	Confluence of Khlong Nam Khem river
8.0	-	Bridge of Route No.3133
11.5	10.0	
13.5	20.0	
18.3	29.4	
Huai Yang River		
0	11.5	Confluence of Khlong Luang River
8.2	20.0	
14.5	30.0	
21.0	40.0	
23.5	-	Bridge
24.5	50.0	
27.3	60.0	
29.6	70.0	
30.0	-	Ban Bung Dam
32.5	80.0	
34.5	90.0	
36.0	100.0	
37.0	110.0	
38.6	120.0	
39.5	130.0	
39.8	140.0	
Khlong Wang River		
0	34.0	Confluence of Khlong Luang River
5.2	40.0	
7.1	50.0	
10.9	60.0	
14.5	70.0	
16.0	80.0	
17.8	90.0	
19.0	100.0	
20.0	110.0	
21.0	120.0	
21.9	140.0	

Table 1 OVERALL PROFILES OF KHLONG LUANG RIVER (3/3)

Accumulated Distance (km)	Elevation (El. m)	Remarks
Khlong Bung Duan River		
0	42.5	Confluence of Khlong Luang River
4.3	50.0	
6.7	60.0	
7.7	70.0	
9.0	80.0	
11.2	90.0	

Table 2 FEATURE OF KHLONG LUANG RIVER

Section No.	Accumulated distance (km)	River-bed elevation (m)	Ground Height	
			Left (m)	Right (m)
L - 31	0.00	0.03	4.44	5.68
L - 30	1.08	1.14	4.86	4.96
L - 29	2.68	1.39	5.38	5.43
L - 28	4.08	2.43	5.20	5.53
L - 27	5.48	2.61	5.62	5.96
L - 26	7.18	1.99	5.27	5.52
L - 25	8.23	1.43	5.66	5.55
L - 24	9.38	1.57	5.49	5.70
L - 23	10.43	2.74	5.83	5.53
L - 22	11.48	2.94	5.69	5.64
L - 21	14.48	1.83	5.49	5.78
L - 20	16.08	3.60	6.07	5.77
L - 19	17.98	4.20	6.08	6.10
L - 18	19.75	3.94	6.06	6.32
L - 17	21.38	4.13	7.96	7.39
L - 16	23.48	4.10	7.32	7.46
L - 15	24.68	3.37	7.98	7.45
L - 14	26.38	5.86	9.96	9.49
L - 13	27.98	8.00	11.84	11.53
L - 12	32.33	12.51	15.77	15.71
L - 11	33.66	14.35	17.35	17.45
L - 10	35.08	14.95	18.24	18.10
L - 9	36.08	15.07	18.51	19.04
L - 8	37.33	15.70	19.88	20.23
L - 7	38.78	17.71	20.89	19.76
L - 6	39.58	17.77	21.74	22.35
L - 5	40.93	20.26	24.14	23.53
L - 4	41.93	20.40	24.78	24.55
L - 3	42.98	20.95	25.51	25.70
L - 2	43.41	20.59	26.07	25.64
L - 1	44.53	22.71	25.69	27.53
L - 0	46.08	24.50	29.11	28.46

Table 3 OVERALL LONGITUDINAL PROFILES OF RAYONG RIVER (1/2)

Accumulated Distance (km)	Elevation (El. m)	Remarks
Rayong River		
0.0	-4.83	: Estuary
2.1	-1.93	: Ban Pak Nam bridge
3.7	-0.96	
5.2	-0.93	
6.4	-1.02	
9.0	-0.88	
10.8	-1.68	: Bridge in Rayong city
11.2	-0.48	: Downstream of 1st diversion channel
11.4	-	: Confluence of Khlong Kha river
11.7	-	: Highway Route-No. 3 bridge
11.9	-0.84	
13.4	-	: Confluence of Khlong Thap Ma river
14.2	-0.18	
15.1	-	: Wat Sa Pathum bridge
16.2	1.00	
16.6	-	: Ban Don bridge
19.4	2.12	: Ban Kao
20.4	2.73	
23.1	3.72	
23.7	-	: Wooden bridge
24.2	-	: Confluence of Khlong Yai Lam
25.1	4.26	
27.1	5.00	: Route-No. 3138 by-pass bridge
27.5	-	: Wat Phai Lom bridge
29.1	6.20	: Upstream of Khlong Nam Ngu
31.0	6.29	: Bridge
31.7	-	: Confluence of Khlong Nam Yen
32.4	7.41	: Ban Khai weir
32.6	-	: Wooden bridge
34.0	9.10	
34.3	-	: Confluence of Khlong Bang Kradan
35.7	8.98	
37.4	10.88	: Bridge
40.2	16.00	
40.8	-	: Confluence of Khlong Yai river
Nong Pla Lai River		
42.3	14.28	
42.4	-	: Confluence of Khlong Dok Krai river
43.0	15.64	
45.1	21.00	
46.7	22.44	
47.7	22.18	: Ban Nong Mapring gauging station
47.8	-	: Confluence of Khlong Rawoeng
48.8	26.16	: Proposed Nong Pla Lai dam axis
56.5	40.00	
58.5	-	: Confluence of Khlong Pluak Daeng river
62.0	50.00	
64.5	60.00	
69.5	70.00	
70.5	-	
73.0	80.00	: Confluence of Huai Prap river
77.0	90.00	
77.5	-	: Route-No. 331 bridge
79.0	100.00	
81.0	110.00	
83.5	120.00	
85.5	140.00	
87.5	160.00	
89.0	200.00	
90.0	300.00	
91.0	542.00	: Mt. Khao Nam Cho

Table 3 OVERALL LONGITUDINAL PROFILES OF RAYONG RIVER (2/2)

Accumulated Distance (km)	Elevation (El. m)		Remarks
Khlong Yai River			
0.0	-	:	Confluence of Rayong river
2.0	20		
4.0	-	:	Bridge
5.0	-	:	Confluence of Khlong Luai river
6.0	-	:	Bridge
9.5	-	:	Confluence of Khlong Ma Mui river
10.0	30		
10.5	-	:	Ban Pak Phraek gauging station
13.5	-	:	Khlong Yai potential damsite
15.0	40		
21.0	50	:	Ban Khlong Nam Dam (1)
25.0	60	:	Confluence of Khlong Map Khai Nao river
30.0	70		
31.5	80		
34.5	90		
35.0	100		
35.5	179	:	Mt. Khao Liang Khwai
Khlong Dok Krai River			
0.0	-	:	Confluence of Nong Pla Lai river
3.0	30	:	Confluence of Khlong Noi river
8.5	-	:	Dok Krai Reservoir
15.0	-	:	Confluence of Khlong Phlu river
16.0	40		
23.0	60		
28.0	70		
31.0	80		
31.5	90		
36.5	100		
39.0	110	:	Route-No. 331 bridge
39.5	120		
40.5	130		
41.0	140		
41.5	180		
42.0	306	:	Mt. Khao Chak Kluai
Khlong Thap Ma River			
0.0	-	:	Confluence of Rayong river
0.7	-	:	Bridge
2.5	-	:	Route-No. 3138 bridge
9.0	10		
10.5	-	:	Khlong Thap Ma potential damsite
11.5	-	:	Confluence of Khlong Matum river
12.0	-	:	Confluence of Khlong Chang Tai river
12.5	20		
14.0	30		
18.5	40		
21.0	50		
22.5	60		
23.0	70		
29.0	80		
32.0	100		
33.0	120		
33.5	140		

Table 4 FEATURE OF RAYONG RIVER

Section No.	Accumulated distance (km)	River-bed elevation (m)	Ground Height	
			Left (m)	Right (m)
0	0.0	- 4.83	2.00	2.60
2	2.1	- 1.93	2.70	1.40
3	3.7	- 0.96	1.30	2.00
4	5.2	- 0.93	1.00	1.02
5	6.4	- 1.02	0.85	1.00
6	9.0	- 0.88	1.01	1.21
7	10.8	- 1.68	1.90	2.46
8	11.2	- 0.48	2.50	1.90
9	11.9	- 0.84	2.82	1.60
10	14.2	- 0.18	2.39	2.52
11	16.2	1.00	3.13	3.14
12	19.4	2.12	4.73	4.81
13	20.4	2.73	5.04	5.12
14	23.1	3.72	5.81	6.35
15	25.1	4.26	7.40	7.70
16	27.1	5.00	8.46	9.13
17	29.1	6.20	10.22	9.97
18	31.0	6.29	10.93	11.07
19	32.6	7.41	12.86	12.84
20	34.0	9.10	11.47	13.20
21	35.7	8.98	14.32	13.49
22	37.4	10.88	15.80	14.69
23	40.2	16.00	20.36	20.48
24	42.3	14.28	17.11	18.31
25	43.0	15.64	20.02	19.42
26	45.1	21.00	24.79	24.70
27	46.7	22.44	24.20	25.25
28	47.7	22.18	25.62	25.86

Table 5 FEATURE OF KHLONG YAI AND KHLONG THAP MA RIVERS

Section No.	Accumulated distance (km)	River-bed elevation (m)	Ground Height	
			Left (m)	Right (m)
Khlong Yai river				
Y - 12	0.00	13.49	17.21	16.81
Y - 11	1.45	15.58	19.63	19.49
Y - 10	2.60	16.11	20.54	21.12
Y - 9	3.85	17.77	21.04	19.68
Y - 8	5.05	19.01	22.04	22.33
Y - 7	6.40	20.18	22.90	24.45
Y - 6	7.40	21.59	23.80	24.29
Y - 5	9.00	23.32	26.05	25.24
Y - 4	10.45	25.83	28.82	28.81
Y - 3	11.85	29.76	32.27	31.99
Y - 2	13.10	30.23	33.82	33.73
Y - 1	14.45	33.82	35.01	34.50
Khlong Thap Ma river				
T - 12	0.00	- 0.79	1.76	1.93
T - 11	0.70	- 0.72	1.64	1.22
T - 10	1.75	- 0.35	1.92	1.15
T - 9	2.70	0.06	2.73	1.45
T - 8	3.50	0.35	1.80	1.63
T - 7	4.45	1.29	2.48	2.69
T - 6	5.20	1.72	3.61	3.86
T - 5	6.85	2.88	4.91	4.03
T - 4	7.75	3.39	5.68	5.07
T - 3	8.45	4.00	5.69	5.56
T - 2	9.40	6.48	7.94	8.01
T - 1	10.45	7.12	9.63	9.01

Table 6 ANNUAL MAXIMUM DAILY DISCHARGE AT BAN MAI STREAM GAUGE

Year	Date	Water Level (El. m)	Discharge (m^3/sec)
1965	Oct. 10	23.70	13.9
1966	Sept. 19	25.24	25.6
1967	Oct. 3	25.45	39.0
1968	Aug. 6	25.12	25.8
1969	Sept. 22	25.83	105.0
1970	Jun. 29	25.20	34.0
1971	Oct. 12	25.79	95.0
1972	Sept. 9	25.54	52.2
1973	Sept. 19	25.67	71.0
1974	Oct. 19	26.56	350.0
1975	Oct. 4	25.67	71.0
1976	Sept. 15	25.54	47.8
1977	Sept. 2	24.45	16.7
1978	Sept. 19	25.72	81.0
1979	Oct. 3	25.11	25.2
1980	Sept. 24	25.58	53.9
1981	Sept. 23	25.68	73.0

Table 7 ANNUAL MAXIMUM DAILY DISCHARGE AT BAN KHAI WEIR

Year	Date	Water Level (El. m)	Discharge (m^3/sec)	
			Without Dok Krai dam	With Dok Krai dam
1967	Oct. 9	9.64	101.4	-
1968	Sept. 29	9.55	88.6	-
1969	Sept. 22	9.75	109.7	-
1970	Jun. 11	9.41	60.6	-
1971	Oct. 13	9.64	94.6	-
1972	Oct. 7	9.74	109.7	-
1973	Oct. 8	10.05	121.6	-
1974	Oct. 20	10.72	156.2	-
1975	Oct. 4	10.05	131.2	99.5
1976	Sept. 6	11.06	135.6	131.7
1977	Oct. 19	9.76	90.7	64.6
1978	May 15	10.22	145.3	109.2
1979	Oct. 4	9.80	68.3	62.2
1980	Oct. 24	10.44	135.0	133.8
1981	Sept. 23	10.18	121.2	125.7

Table 8 INUNDATION DEPTH AND DURATION OF PAST FLOOD IN THE KHLONG LUANG RIVER BASIN BY INTERVIEW SURVEY

Point No. /1	River	District (Amphoe)	Village (Tambon)	1974 Oct. Flood Inundation Depth (m)	1974 Oct. Flood Duration (day)	1981 Sep. Flood Inundation Depth (m)	1981 Sep. Flood Duration (day)	Remarks
Khlong Luang River Basin								
6	Khlong Luang	Phanat Nikhom	Tha Bun Mi	1.5	4	-	-	no flood in 1981
7	- do -	- do -	Ko Chan	2.0	2	-	-	no flood in 1981
8	- do -	- do -	- do -	1.9	3	0.6	0.5	
1	- do -	- do -	Tha Bun Mi	1.0	0.5	-	-	no flood in 1981
3	- do -	- do -	- do -	2.0	3	-	-	no flood in 1981
2	Khlong Kabo	- do -	- do -	0.3	2 hr.	-	-	no flood in 1981
4	Khlong Luang	- do -	- do -	1.5	1	1.0	1	
5	Huai Krasang	- do -	- do -	3.0	2	1.0	1	
13	Khlong Luang	- do -	Na Roed	-	-	-	-	no flood
26	Huai Na Wang Hin	- do -	Nong Hiang	0.4	4	-	-	no flood in 1981
24	Khlong Luang	- do -	Wat Luang	1.4	7	0.5	7	
12	Khlong Tan Dam	Ban Bung	Nong Irun	1.0	3	0.5	1	
17	Huai Yang	Phanat Nikhom	Mon Nang	0.9	3	0.2	3	
56	Khlong Yai	Ban Bung	Nong Irun	1.5	2	1.0	2	
23	Huai Nong Suang	Phanat Nikhom	Kut Ngong	1.1	3	-	-	no flood in 1981
25	Khlong Sala Daeng	- do -	Wat Bot	1.7	7	0.8	7	
20	Khlong Nam Khem	- do -	Phan Thong	2.0	60	0.5	20	
18	Khlong Phan Thong	- do -	Ban Nang	1.4	20	0.3	10	
27	Khlong Thanon	- do -	Hua Thanon	(0.9)	(3)	0.5	4	1976 flood was the maximum in the past
21	Khlong Hua Sakae	- do -	Na Pradu	1.5	15	0.6	10	
55	Huai Sup	Ban Bung	Nong Bon	1.2	2	-	-	no flood in 1981
10	Huai Mong Makhua	- do -	Ban Bung	(0.8)	(3 hr.)	-	-	no flood in 1981
57	Khlong Soet	Phanat Nikhom	Nong Khayai	(0.8)	(6)	-	-	no flood in 1981
22	- do -	Phan Thong	Map Pong	1.0	3	1.0	3	
9	Huai Yang	Ban Bung	-	-	-	-	-	no flood
11	Huai Nong Takha	- do -	Nong Samsak	(0.5)	(3)	-	-	no flood in 1981
15	- do -	Phan Thong	Nong Hong	0.6	3	-	-	no flood in 1981
16	- do -	- do -	Nong Kakha	(0.3)	(1)	-	-	1976 flood was the maximum in the past
58	-	A.M. Chon Buri	Samnak Bok	(0.4)	(1)	-	-	no flood in 1981
14	-	- do -	Dan Hua Lo	0.8	2	0.5	2	
19	Phan Thong Drainage Canal	Phan Thong	Bang Nang	(1.4)	(20)	-	-	no flood in 1981

/1 : Refers to Fig. 15

Note: Figures in parentheses are estimated value.

Table 9 INUNDATED AREA FOR 1974 - FLOOD
IN KHLONG LUANG RIVER BASIN

Inundated Depth

(unit : ha)

Depth (m)	Paddy field	Orchard & plantation	Village area	Other lands	Total
0 to 0.5	8,490	1,790	110	3,160	13,550
0.5 to 1.0	14,270	260	1,140	6,830	22,500
1.0 to 1.5	13,650	80	320	3,390	17,440
1.5 to 2.0	3,500	-	150	960	4,610
above 2.0	180	-	-	40	220
Total	40,090	2,130	1,720	14,380	58,320

Inundated Duration : Paddy field

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	4,410	4,080	-	-	-	8,490
0.5 to 1.0	-	10,920	540	1,780	1,030	14,270
1.0 to 1.5	-	7,120	2,960	-	3,570	13,650
1.5 to 2.0	-	-	680	1,020	1,800	3,500
above 2.0	-	-	-	-	180	180
Total	4,410	22,120	4,180	2,800	6,580	40,090

Inundated Duration : Uplands

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	1,240	550	-	-	-	1,790
0.5 to 1.0	-	260	-	-	-	260
1.0 to 1.5	-	80	-	-	-	80
1.5 to 2.0	-	-	-	-	-	-
above 2.0	-	-	-	-	-	-
Total	1,240	890	-	-	-	2,130

Table 10 INUNDATED AREA FOR 1981 - FLOOD
IN KHLONG LUANG RIVER BASIN

Inundated Depth

(unit : ha)

Depth (m)	Paddy field	Orchard & plantation	Village area	Other lands	Total
0 to 0.5	11,980	1,540	550	2,650	16,720
0.5 to 1.0	15,780	110	930	7,430	24,250
1.0 to 1.5	2,670	-	40	750	3,460
1.5 to 2.0	-	-	-	-	-
above 2.0	-	-	-	-	-
Total	30,430	1,650	1,520	10,830	44,430

Inundated Duration : Paddy field

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	7,310	2,910	1,760	-	-	11,980
0.5 to 1.0	-	7,510	3,770	2,610	1,890	15,780
1.0 to 1.5	-	-	-	580	2,090	2,670
1.5 to 2.0	-	-	-	-	-	-
above 2.0	-	-	-	-	-	-
Total	7,310	10,420	5,530	3,190	3,980	30,430

Inundated Duration : Uplands

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	1,370	170	-	-	-	1,540
0.5 to 1.0	-	90	20	-	-	110
1.0 to 1.5	-	-	-	-	-	-
1.5 to 2.0	-	-	-	-	-	-
above 2.0	-	-	-	-	-	-
Total	1,370	260	20	-	-	1,650

Table 11 INUNDATION DEPTH AND DURATION OF PAST FLOOD IN THE RAYONG RIVER BASIN BY INTERVIEW SURVEY

Point No. /1	River	District (Amphoe)	Village (Tambon)	1974 Oct. Flood Inundation Depth (m)	1974 Oct. Flood Duration (day)	1981 Sep. Flood Inundation Depth (m)	1981 Sep. Flood Duration (day)	Remarks
Rayong River Basin								
28	Nong Pla Lai	Pluak Daeng	Mae Nam Khu	-	-	-	-	no flood since 1922
29	- do -	- do -	- do -	-	-	-	-	near the Ban Nong Mapring gauge station
51	Khlong Yai	- do -	Lahan	(0.5)	(3)	-	-	
52	- do -	Ban Khai	Nong Bua	(2.0)	(5)	0.5	5	
53	- do -	- do -	- do -	(1.0)	(4)	0.5	4	
54	Rayong	- do -	- do -	1.0	6	1.0	3	1976 flood was the maximum in the past
50	- do -	- do -	- do -	0.6	7	0.5	2	
41	- do -	- do -	Nong Lalok	1.5	3	1.0	3	
49	Khlong Khao Suan	- do -	Nong Bua	(0.5)	(15)	0.5	5	
40	Rayong	- do -	- do -	1.0	15	0.9	3	
42	- do -	- do -	Nong Lalok	-	-	-	-	no flood since 1975
47	Khlong Nam Ngu	Ban Khai	Bang But	-	-	-	-	no flood
48	- do -	- do -	- do -	(0.6)	(3)	0.5	3	
39	Rayong	- do -	Nong Lalok	0.8	5	0.7	5	
37	- do -	- do -	Ban Khai	2.0	3	1.0	3	
38	- do -	- do -	Nong Lalok	0.7	5	0.6	5	
46	Khlong Yai Lam	- do -	Chak Bok	0.7	7	0.6	2	1976 flood was the maxi-in the past
45	- do -	- do -	- do -	0.9	5	-	-	no flood in 1981
36	Rayong	- do -	Ban Khai	1.1	3	1.0	3	
35	Khlong Kamaeng	- do -	Nong Saphan	(1.0)	(7)	0.8	3	
34	Khlong Lalok	- do -	Ta Khan	1.0	5	0.3	3	
44	Khlong Kha	A.M. Rayong	Choeng Noen	(1.1)	(7)	1.1	7	
30	Khlong Thap Ma	- do -	Thap Ma	(0.3)	(1)	-	-	no flood in 1981
31	Khlong Map Kabak	- do -	Noen Phra	(0.3)	(1)	-	-	no flood in 1981
33	Khlong Thap Ma	A.M. Rayong	Thap Ma	1.5	3	0.6	3	
32	- do -	- do -	Choeng Noen	1.5	7	1.0	7	
43	Rayong	- do -	- do -	2.0	30	0.5	20	

/1 : Refers to Fig. 16

Note: Figures in parentheses are estimated value.

Table 12 INUNDATED AREA FOR 1974 - FLOOD IN RAYONG RIVER BASIN

Inundated Depth

(unit : ha)

Depth (m)	Paddy field	Orchard & plantation	Village area	Other lands	Total
0 to 0.5	3,710	3,430	1,080	1,940	10,160
0.5 to 1.0	4,200	510	370	1,910	6,990
1.0 to 1.5	2,530	20	190	200	2,940
1.5 to 2.0	900	-	-	-	900
above 2.0	-	-	-	-	-
Total	11,340	3,960	1,640	4,050	20,990

Inundated Duration : Paddy field

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	2,630	1,080	-	-	-	3,710
0.5 to 1.0	-	1,930	2,020	250	-	4,200
1.0 to 1.5	-	-	1,240	1,120	170	2,530
1.5 to 2.0	-	-	-	180	720	900
above 2.0	-	-	-	-	-	-
Total	2,630	3,010	3,260	1,550	890	11,340

Inundated Duration : Uplands

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	1,970	1,430	30	-	-	3,430
0.5 to 1.0	-	90	270	130	20	510
1.0 to 1.5	-	-	-	10	10	20
1.5 to 2.0	-	-	-	-	-	-
above 2.0	-	-	-	-	-	-
Total	1,970	1,520	300	140	30	3,960

Table 13 INUNDATED AREA FOR 1981 - FLOOD IN RAYONG RIVER BASIN

Inundated Depth

(unit : ha)

Depth (m)	Paddy field	Orchard & plantation	Village area	Other lands	Total
0 to 0.5	3,680	1,240	720	1,510	7,150
0.5 to 1.0	4,830	490	470	1,610	7,400
1.0 to 1.5	1,860	10	40	510	2,420
1.5 to 2.0	-	-	-	-	-
above 2.0	-	-	-	-	-
Total	10,370	1,740	1,230	3,630	16,970

Inundated Duration : Paddy field

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	3,120	560	-	-	-	3,680
0.5 to 1.0	-	3,210	1,230	380	10	4,830
1.0 to 1.5	-	-	1,260	370	230	1,860
1.5 to 2.0	-	-	-	-	-	-
above 2.0	-	-	-	-	-	-
Total	3,120	3,770	2,490	750	240	10,370

Inundated Duration : Uplands

(unit : ha)

Duration	0 to 1	1 to 4	4 to 7	7 to 10	above 10	Total
0 to 0.5	780	30	-	-	-	810
0.5 to 1.0	370	360	10	-	-	740
1.0 to 1.5	20	-	-	-	-	20
1.5 to 2.0	20	-	-	-	-	20
above 2.0	50	100	-	-	-	150
Total	1,240	490	10	-	-	1,740

Table 14 FLOOD DAMAGE OF PADDY FOR 1974 - FLOOD IN KHLONG LUANG RIVER BASIN

Inundation Condition		Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
Duration (day)	Depth (m)					
0 to 1	0 to 0.5	4,410	13,760	60,700	0.08	4,900
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	-	do	-	-	-
	Sub total	4,410		60,700		4,900
1 to 4	0 to 0.5	4,080	13,760	56,100	0.13	7,300
	0.5 to 1.0	10,920	do	150,300	0.16	24,000
	1.0 to 1.5	7,120	do	98,000	0.46	45,100
	Sub total	22,120		304,400		76,400
4 to 7	0 to 0.5	-	13,760	-	-	-
	0.5 to 1.0	540	do	7,400	0.23	1,700
	1.0 to 1.5	2,960	do	40,700	0.23	9,400
	1.5 to 2.0	680	do	9,400	0.65	6,100
	Sub total	4,180		57,500		17,200
7 to 10	0 to 0.5	-	13,760	-	-	-
	0.5 to 1.0	1,780	do	24,500	0.24	5,900
	1.0 to 1.5	-	do	-	-	-
	1.5 to 2.0	1,020	do	14,000	0.66	9,200
	Sub total	2,800		38,500		15,100
above 10	0 to 0.5	-	13,760	-	-	-
	0.5 to 1.0	1,030	do	14,200	0.66	9,400
	1.0 to 1.5	3,570	do	49,100	0.66	32,400
	1.5 to 2.0	1,800	do	24,800	0.66	16,400
	above 2.0	180	do	2,500	0.66	1,700
	Sub total	6,580		90,600		59,900
Total		40,090		551,700		173,500

Table 15 FLOOD DAMAGE OF CASSAVA FOR 1974 - FLOOD IN KHLONG LUANG RIVER BASIN

Inundation Condition		Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
Duration (day)	Depth (m)					
0 to 1	0 to 0.5	1,240	7,130	8,800	0.11	1,000
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	-	do	-	-	-
	Sub total	1,240		8,800		1,000
1 to 4	0 to 0.5	550	7,130	3,900	0.30	1,200
	0.5 to 1.0	260	do	1,900	0.40	800
	1.0 to 1.5	80	do	600	0.63	400
	Sub total	890		6,400		2,400
Total		2,130		15,200		3,400

Table 16 FLOOD DAMAGE OF HOUSE AND HOUSEHOLD EFFECTS FOR 1974 - FLOOD IN KHLONG LUANG RIVER BASIN

Inundation Depth (m)	Inundation Area (ha)	Nos. House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	110	1,110	39,600	44,000	0.03	1,300
0.5 to 1.0	1,140	11,510	do	455,800	0.03	13,700
1.0 to 1.5	320	3,230	do	127,900	0.05	6,400
1.5 to 2.0	150	1,510	do	59,800	0.07	4,200
Total	1,720	17,360		687,500		25,600

Table 17 FLOOD DAMAGE OF LIVESTOCKS FOR 1974 - FLOOD IN KHLONG LUANG RIVER BASIN

[PIG]

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	110	1,110	5,230	5,800	0.30	1,700
0.5 to 1.0	1,140	11,510	do	60,200	0.80	48,200
1.0 to 1.5	320	3,230	do	16,900	1.00	16,900
1.5 to 2.0	150	1,510	do	7,900	do	7,900
Total	1,720	17,360				74,700

[CHICKEN]

0 to 0.5	110	1,110	1,110	1,200	0.50	600
0.5 to 1.0	1,140	11,510	do	12,700	1.00	12,700
1.0 to 1.5	320	3,230	do	3,500	do	3,500
1.5 to 2.0	150	1,510	do	1,700	do	1,700
Total	1,720	17,360				18,500

[DUCK]

0 to 0.5	110	1,110	1,050	1,200	0.30	400
0.5 to 1.0	1,140	11,510	do	12,100	0.90	10,900
1.0 to 1.5	320	3,230	do	3,400	1.00	3,400
1.5 to 2.0	150	1,510	do	1,600	do	1,600
Total	1,720	17,360				16,300

GRAND TOTAL 109,500

Table 18 FLOOD DAMAGE OF PADDY FOR 1981 - FLOOD IN KHLONG LUANG RIVER BASIN

Inundation Condition		Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
Duration (day)	Depth (m)					
0 to 1	0 to 0.5	7,310	13,760	100,600	0.08	8,000
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	-	do	-	-	-
	Sub total	7,310		100,600		8,000
1 to 4	0 to 0.5	2,910	13,760	40,000	0.13	5,200
	0.5 to 1.0	7,510	do	103,300	0.16	16,500
	1.0 to 1.5	-	do	-	-	-
	Sub total	10,420		143,300		21,700
4 to 7	0 to 0.5	1,760	13,760	24,200	0.17	4,100
	0.5 to 1.0	3,790	do	52,200	0.23	12,000
	1.0 to 1.5	-	do	-	-	-
	1.5 to 2.0	-	do	-	-	-
	Sub total	5,550		76,400		16,100
7 to 10	0 to 0.5	-	13,760	-	-	-
	0.5 to 1.0	2,610	do	35,900	0.24	8,600
	1.0 to 1.5	580	do	8,000	0.66	5,300
	1.5 to 2.0	-	do	-	-	-
	Sub total	3,190		43,900		13,900
above 10	0 to 0.5	-	13,760	-	-	-
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	3,490	do	48,000	0.66	31,700
	1.5 to 2.0	490	do	6,700	0.66	4,400
	above 2.0	-	do	-	-	-
	Sub total	3,980		54,700		36,100
Total		30,450		418,900		95,800

Table 19 FLOOD DAMAGE OF CASSAVA FOR 1981 - FLOOD IN KHLONG LUANG RIVER BASIN

Inundation Condition Duration (day)	Depth (m)	Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 1	0 to 0.5	1,370	7,130	9,800	0.11	1,100
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	-	do	-	-	-
	Sub total	1,370		9,800		1,100
1 to 4	0 to 0.5	170	7,130	1,200	0.30	400
	0.5 to 1.0	90	do	600	0.40	200
	1.0 to 1.5	-	do	-	-	-
	Sub total	260		1,800		600
4 to 7	0 to 0.5	-	7,130	-	-	-
	0.5 to 1.0	20	do	100	0.75	100
	1.0 to 1.5	-	do	-	-	-
	1.5 to 2.0	-	do	-	-	-
	Sub total	20		100		100
Total		1,650		11,700		1,800

Table 20 FLOOD DAMAGE OF HOUSE AND HOUSEHOLD EFFECTS FOR 1981 - FLOOD IN KHLONG LUANG RIVER BASIN

House 1981

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	550	5,550	39,600	219,800	0.03	6,600
0.5 to 1.0	930	9,400	do	372,200	0.03	11,200
1.0 to 1.5	40	400	do	15,800	0.05	800
1.5 to 2.0	-	-	do	-	-	-
Total	1,520	15,350		607,800		18,600

Table 21 FLOOD DAMAGE OF LIVESTOCKS FOR 1981 - FLOOD
IN KHLONG LUANG RIVER BASIN

[PIG]

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	550	5,550	5,230	29,000	0.30	8,700
0.5 to 1.0	930	9,400	do	49,200	0.80	39,400
1.0 to 1.5	40	400	do	2,100	1.00	2,100
1.5 to 2.0	-	-	do	-	-	-
Total	1,520	15,350				50,200

[CHICKEN]

0 to 0.5	550	5,550	1,110	6,200	0.50	3,100
0.5 to 1.0	930	9,400	do	10,400	1.00	10,400
1.0 to 1.5	40	400	do	400	do	400
1.5 to 2.0	-	-	do	-	-	-
Total	1,520	15,350				13,900

[DUCK]

0 to 0.5	550	5,550	1,050	5,800	0.30	1,700
0.5 to 1.0	930	9,400	do	9,900	0.90	8,900
1.0 to 1.5	40	400	do	400	1.00	400
1.5 to 2.0	-	-	do	-	-	-
Total	1,520	15,350				11,000

GRAND TOTAL 75,100

Table 22 FLOOD DAMAGE OF PADDY FOR 1974 - FLOOD IN RAYONG RIVER BASIN

Inundation Condition		Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
Duration (day)	Depth (m)					
0 to 1	0 to 0.5	2,630	14,090	37,100	0.08	3,000
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	-	do	-	-	-
	Sub total	2,630		37,100		3,000
1 to 4	0 to 0.5	1,080	14,090	15,200	0.13	2,000
	0.5 to 1.0	1,930	do	27,200	0.16	4,400
	1.0 to 1.5	-	do	-	-	-
	Sub total	3,010		42,400		6,400
4 to 7	0 to 0.5	-	14,090	-	-	-
	0.5 to 1.0	2,020	do	28,500	0.23	6,600
	1.0 to 1.5	1,240	do	17,500	0.65	11,400
	1.5 to 2.0	-	do	-	-	-
	Sub total	3,260		46,000		18,000
7 to 10	0 to 0.5	-	14,090	-	-	-
	0.5 to 1.0	250	do	3,500	0.24	800
	1.0 to 1.5	1,120	do	15,800	0.66	10,400
	1.5 to 2.0	180	do	2,500	0.66	1,700
	Sub total	1,550		21,800		12,900
above 10	0 to 0.5	-	14,090	-	-	-
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	170	do	2,400	0.66	1,600
	1.5 to 2.0	720	do	10,100	0.66	6,700
	above 2.0	-	do	-	-	-
	Sub total	890		12,500		8,300
Total		11,340		159,800		48,600

Table 23 FLOOD DAMAGE OF CASSAVA FOR 1974 - FLOOD IN RAYONG RIVER BASIN

Inundation Condition		Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
Duration (day)	Depth (m)					
0 to 1	0 to 0.5	1,970	14,510	28,600	0.11	3,100
	0.5 to 1.0	-	do	-	-	-
	1.0 to 1.5	-	do	-	-	-
	Sub total	1,970		28,600		3,100
1 to 4	0 to 0.5	1,430	14,510	20,700	0.30	6,200
	0.5 to 1.0	90	do	1,300	0.40	500
	1.0 to 1.5	-	do	-	-	-
	Sub total	1,520		22,000		6,700
4 to 7	0 to 0.5	30	14,510	400	0.50	200
	0.5 to 1.0	270	do	3,900	0.75	2,900
	1.0 to 1.5	-	do	-	-	-
	1.5 to 2.0	-	do	-	-	-
	Sub total	300		4,300		3,100
7 to 10	0 to 0.5	-	14,510	-	-	-
	0.5 to 1.0	130	do	1,900	0.88	1,700
	1.0 to 1.5	10	do	100	1.00	100
	1.5 to 2.0	-	do	-	-	-
	Sub total	140		2,000		1,800
above 10	0 to 0.5	-	14,510	-	-	-
	0.5 to 1.0	20	do	300	0.88	300
	1.0 to 1.5	10	do	100	1.00	100
	1.5 to 2.0	-	do	-	-	-
	above 2.0	-	do	-	-	-
	Sub total	30		400		400
Total		3,960		57,300		15,100

Table 24 FLOOD DAMAGE OF HOUSE AND HOUSEHOLD EFFECTS FOR 1974 - FLOOD IN RAYONG RIVER BASIN

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	1,080	10,910	39,600	432,000	0.03	13,000
0.5 to 1.0	370	3,740	do	148,100	0.03	4,400
1.0 to 1.5	190	1,920	do	76,000	0.05	3,800
1.5 to 2.0	-	-	do	-	-	-
Total	1,640	16,570		656,100		21,200

Table 25 FLOOD DAMAGE OF LIVESTOCKS FOR 1974 - FLOOD IN RAYONG RIVER BASIN

[PIG]

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	1,080	10,910	1,090	11,900	0.30	3,600
0.5 to 1.0	370	3,740	do	4,100	0.80	3,300
1.0 to 1.5	190	1,920	do	2,100	1.00	2,100
1.5 to 2.0	-	-	do	-	-	-
Total	1,640	16,570				9,000

[CHICKEN]

0 to 0.5	1,080	10,910	54.8	600	0.50	300
0.5 to 1.0	370	3,740	do	200	1.00	200
1.0 to 1.5	190	1,920	do	100	do	100
1.5 to 2.0	-	-	do	-	-	-
Total	1,640	16,570				600

[DUCK]

0 to 0.5	1,080	10,910	19.4	200	0.30	100
0.5 to 1.0	370	3,740	do	100	0.90	100
1.0 to 1.5	190	1,920	do	0	1.00	0
1.5 to 2.0	-	-	do	-	-	-
Total	1,640	16,570				200

GRAND TOTAL 9,800

Table 26 FLOOD DAMAGE OF PADDY FOR 1981 - FLOOD IN RAYONG RIVER BASIN

Inundation Condition Duration (day)	Depth (m)	Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 1	0 to 0.5	3,120	14,090	44,000	0.08	3,500
	0.5 to 1.0	-		-		-
	1.0 to 1.5	0		-		-
	Sub total	3,120		44,000		3,500
1 to 4	0 to 0.5	560		7,900	0.13	1,000
	0.5 to 1.0	3,210		45,200	0.16	7,200
	1.0 to 1.5	-		-		-
	Sub total	3,770		53,100		8,200
4 to 7	0 to 0.5	-		-		-
	0.5 to 1.0	1,230		17,300	0.23	4,000
	1.0 to 1.5	1,260		17,800	0.65	11,600
	1.5 to 2.0	-		-		-
	Sub total	2,490		35,100		15,600
7 to 10	0 to 0.5	-		-		-
	0.5 to 1.0	380		5,400	0.24	1,300
	1.0 to 1.5	370		5,200	0.66	3,400
	1.5 to 2.0	-		-		-
	Sub total	750		10,600		4,700
above 10	0 to 0.5	-		-		-
	0.5 to 1.0	10		100	0.66	100
	1.0 to 1.5	230		3,200	0.66	2,100
	1.5 to 2.0	-		-		-
	above 2.0	-		-		-
	Sub total	240		3,300		2,200
Total		10,370		146,100		34,200

Table 27 FLOOD DAMAGE OF CASSAVA FOR 1981 - FLOOD IN RAYONG RIVER BASIN

Inundation Condition		Inundation Area (ha)	Unit Price (฿/ha)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
Duration (day)	Depth (m)					
0 to 1	0 to 0.5	780	14,510	11,300	0.11	1,200
	0.5 to 1.0	370	do	5,400	0.27	1,500
	1.0 to 1.5	20	do	300	0.38	100
	1.5 to 2.0	20	do	300	0.38	100
	above 2.0	50	do	700	0.38	300
	Sub total	1,240		18,000		3,200
1 to 4	0 to 0.5	30	do	400	0.30	100
	0.5 to 1.0	360	do	5,200	0.40	2,100
	1.0 to 1.5	-	do	-	-	-
	1.5 to 2.0	-	do	-	-	-
	above 2.0	100	do	1,500	0.63	900
	Sub total	490		7,100		3,100
4 to 7	0 to 0.5	-	do	-	-	-
	0.5 to 1.0	10	do	100	0.75	100
	1.0 to 1.5	-	do	-	-	-
	Sub total	10		100		100
Total		1,740		25,200		6,400

Table 28 FLOOD DAMAGE OF HOUSE AND HOUSEHOLD EFFECTS FOR 1981 - FLOOD IN RAYONG RIVER BASIN

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	720	7,270	39,600	287,900	0.03	8,600
0.5 to 1.0	470	4,750	do	188,100	0.03	5,600
1.0 to 1.5	40	400	do	15,800	0.05	800
1.5 to 2.0	-	-	do	-	-	-
Total	1,230	12,420		491,800		15,000

Table 29 FLOOD DAMAGE OF LIVESTOCKS FOR 1981 - FLOOD IN RAYONG RIVER BASIN

[PIG]

Inundation Depth (m)	Inundation Area (ha)	Nos. of House (nos)	Unit Price (฿/house)	Damageable Value (฿ 10^3)	Damage Ratio	Damage Amount (฿ 10^3)
0 to 0.5	720	7,270	1,090	7,900	0.30	2,400
0.5 to 1.0	470	4,750	do	5,200	0.80	4,200
1.0 to 1.5	40	400	do	400	1.00	400
1.5 to 2.0	-	-	do	-	-	-
Total	1,230	12,420				7,000

[CHICKEN]

0 to 0.5	720	7,270	54.8	400	0.50	200
0.5 to 1.0	470	4,750	do	300	1.00	300
1.0 to 1.5	40	400	do	0	do	0
1.5 to 2.0	-	-	do	-	-	-
Total	1,230	12,420				500

[DUCK]

0 to 0.5	720	7,270	19.4	100	0.30	0
0.5 to 1.0	470	4,750	do	100	0.90	100
1.0 to 1.5	40	400	do	0	1.00	0
1.5 to 2.0	-	-	do	-	-	-
Total	1,230	12,420				100

GRAND TOTAL 7,600

Table 30 STRETCH OF INUNDATION BLOCK

River	Channel	Stretch	
		Upstream	Downstream
Khlong Luang	A	Khlong Luang damsite	confluence of K. Kabo river
	B	Khlong Kabo river	confluence of Huai Yang river
	C	Huai Yang river	road No. 315
	D	area extends to southernward of road No. 315	
	E	road No. 315	river mouth
Rayong	A	Nong Pla Lai damsite	confluence of K. Yai river
	B	Dok Krai damsite	confluence of Nong Pla Lai river
	C	Khlong Yai damsite	confluence of Nong Pla Lai river
	D	K. Yai river	Ban Khai weir
	E	Ban Khai weir	Khlong Yai Lam river
	F	K. Thap Ma damsite	confluence of Rayong river
	G	K. Yai Lam river	Rayong bridge

Table 31 PROBABLE FLOOD RUNOFF OF KHLONG LUANG RIVER UNDER PRESENT CONDITION/1

(Unit : m^3/s)

Point No. /2	Location	Return period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
-	Inflow of Khlong Luang damsite	567	729	858	1,015	1,101	1,224	1,346	1,462
1	Outflow of Khlong Luang damsite	567	729	858	1,015	1,101	1,224	1,346	1,462
4	Upstream of confluence of Khlong Kabo river	176	210	238	273	292	319	347	381
7	Upstream of confluence of Huai Yang river	141	166	188	213	227	247	266	290
-	Inflow of Ban Bung damsite	159	202	228	265	283	306	332	365
8	Outflow of Ban Bung damsite	159	202	228	265	283	306	332	365
10	Huai Yang river	499	659	729	850	908	986	1,058	1,160
13	Panat Nikhom	202	250	289	344	361	389	426	452
18	River mouth	285	361	411	493	520	565	607	658

/1 : With existing Ban Bung dam

/2 : Refer to Fig. 25

Table 32 PROBABLE FLOOD RUNOFF OF KHLONG LUANG RIVER WITH BAN BUNG DAM

(Unit : m^3/s)

Point No. /1	Location	Return period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
-	Inflow of Khlong Luang damsite	567	729	858	1,015	1,101	1,224	1,346	1,462
1	Outflow of Khlong Luang damsite	567	729	858	1,015	1,101	1,224	1,346	1,462
4	Upstream of confluence of Khlong Kabo river	176	210	238	273	292	319	347	381
7	Upstream of confluence of Huai Yang river	141	166	188	213	227	347	266	290
-	Inflow of Ban Bung damsite	159	202	228	265	283	306	332	365
8	Outflow of Ban Bung damsite	11	15	17	22	23	26	28	31
10	Huai Yang river	464	615	681	795	850	924	993	1,085
13	Panat Nikhom	198	245	283	339	354	382	418	444
18	River mouth	279	353	402	483	509	554	595	645

/1 : Refer to Fig. 25

Table 33 PROBABLE FLOOD RUNOFF OF KHLONG LUANG RIVER WITH BAN BUNG DAM AND KHLONG LUANG DAM[1]

(Unit : m^3/s)

Point No. [2]	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
1	Inflow of Khlong Luang damsite	567	729	858	1,015	1,101	1,224	1,346	1,462
1	Outflow of Khlong Luang damsite	37	55	69	86	95	107	120	139
4	Upstream of confluence of Khlong Kabo river	62	70	75	88	96	109	121	139
7	Upstream of confluence of Huai Yang river	80	91	101	112	118	124	132	142
-	Inflow of Ban Bung damsite	159	202	228	265	283	306	332	365
8	Outflow of Ban Bung damsite	11	15	17	22	23	26	28	31
10	Huai Yang river	464	615	681	795	850	924	993	1,085
13	Panat Nikhom	174	215	239	274	295	319	340	370
18	River mouth	278	352	400	481	507	552	593	645

[1] : With spillway width 70 m

[2] : Refer to Fig. 25

Table 34 PROBABLE FLOOD RUNOFF OF KHLONG LUANG RIVER WITH BAN BUNG DAM, KHLONG LUANG DAM/1 AND RIVER IMPROVEMENT

(Unit : m^3/s)

Point No. /2	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
-	Inflow of Khlong Luang damsite	567	729	858	1,015	1,101	1,224	1,346	1,462
1	Outflow of Khlong Luang damsite	37	55	69	86	95	107	120	139
4	Upstream of confluence of Khlong Kabo river	125	161	187	223	237	262	297	331
7	Upstream of confluence of Huai Yang river	218	277	331	393	423	467	520	580
-	Inflow of Ban Bung damsite	159	202	228	265	283	306	332	365
8	Outflow of Ban Bung damsite	11	15	17	22	23	26	28	31
10	Huai Yang river	464	615	681	795	850	924	993	1,085
13	Panat Nikhom	681	891	1,010	1,101	1,272	1,391	1,510	1,670
18	River mouth	681	891	1,010	1,101	1,272	1,391	1,510	1,670

/1 : With spillway width 70 m

/2 : Refer to Fig.25

Table 35 CHANNEL FACTOR FOR CHANNEL DESIGN FOR KHLONG LUANG RIVER

Alternative	Stretches		Length (Km)	Design Discharge Q (m^3/sec)	Gradient I	River Width B (m)	Low Water C. Width b_1 (m)	Low Water C. Depth hl (m)	Water Depth of High Water C. H (m)	Dike Height hd (m)
1	I	0.0-12.2	11.5	1,300	1/5,000	150	71.7	4.0	3.6	4.6
	II	12.2-22.5	8.5	1,300	1/5,000	150	71.7	2.5	4.8	5.8
	III	22.5-29.5	6.0	1,300	1/1,400	150	71.7	2.2	3.5	4.5
	IV	29.5-38.0	8.5	430	1/1,100	100	14.6	3.4	1.8	2.6
	V	38.0-44.2	6.0	240	1/1,100	50	7.5	4.0	1.1	1.9
	VI	44.2-47.0	2.5	80	1/1,100	50	1.8	4.2	0	0.4
2	I	0.0-12.2	11.5	1,300	1/5,000	150	71.7	4.0	3.6	4.6
	II	12.2-22.5	8.5	1,300	1/5,000	150	71.7	2.5	4.8	5.8
	III	22.5-29.5	6.0	1,300	1/1,400	150	71.7	2.2	3.5	4.5
	IV	29.5-38.0	8.5	430	1/1,100	100	14.6	3.4	1.8	2.6
	V	38.0-44.2	6.0	240	1/1,100	50	7.5	4.0	1.1	1.9
	VI	44.2-47.0	2.5	95	1/1,100	50	2.1	4.2	0.1	0.7
3	I	0.0-12.2	11.5	1,300	1/5,000	150	71.7	4.0	3.6	4.6
	II	12.2-22.5	8.5	1,300	1/5,000	150	71.7	2.5	4.8	5.8
	III	22.5-29.5	6.0	1,300	1/1,400	150	71.7	2.2	3.5	4.5
	IV	29.5-38.0	8.5	430	1/1,100	100	14.6	3.4	1.8	2.6
	V	38.0-44.2	6.0	240	1/1,100	50	7.5	4.0	1.1	1.9
	VI	44.2-47.0	2.5	120	1/1,100	50	2.7	4.2	0.3	0.9

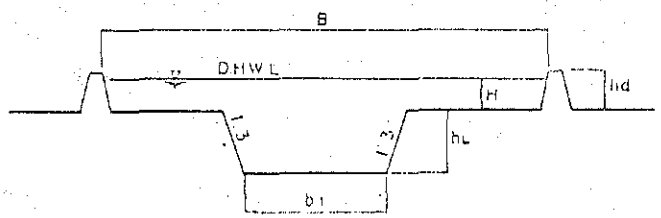

Table 36 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS, ALTERNATIVE 1, KHLONG LUANG RIVER

1$ = ¥250 = 23฿

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	910		18,670	
2. Excavation	m^3	5,712,000	1.08	6,168	23.3	133,090	
3. Embankment	m^3	4,640,000	0.58	2,691	11.0	51,040	
4. Disposal	m^3	502,000	0.48	241	7.1	3,564	
5. Revetment							
- Low water channel	m^2	56,000	15.5	868	485.0	27,160	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	25	21,800	545	230,000	5,750	
7. Backwater levee							
- Excavation	m^3	171,000	1.08	185	23.3	3,984	
- Embankment	m^3	154,000	0.58	89	11.0	1,694	
8. Bridge	m^2	5,600	375	2,100	6,500	36,400	
9. Sub-total (2 ∿ 8)				13,008		266,708	
10. Miscellaneous (1+9) × 10%	L.S	-	-	1,391	-	28,538	
Total				15,309		313,916	
B. Acquisition and Compensation	ha	448	-	-	347,600	155,725	
A. + B.				15,309		469,641	
C. Eng. service and Administration (A+B) × 15%				2,296		70,446	
D. Contingency (A+B+C) × 15%				2,635		81,013	
Grand Total				20,240		621,100	฿ 1,086,600,000

Note : Excluding dam cost

Table 37 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS, ALTERNATIVE 2, KHLONG LUANG RIVER

1$ = ¥250 = 23฿

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	911		18,682	
2. Excavation	m^3	5,718,000	1.08	6,175	23.3	133,229	
3. Embankment	m^3	4,644,000	0.58	2,694	11.0	51,084	
4. Disposal	m^3	502,000	0.48	241	7.1	3,564	
5. Revetment							
- Low water channel	m^2	56,000	15.5	868	485.0	27,160	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	25	21,800	545	230,000	5,750	
7. Backwater levee							
- Excavation	m^3	171,000	1.08	185	23.3	3,984	
- Embankment	m^3	154,000	0.58	89	11.0	1,694	
8. Bridge	m^2	5,600	375	2,100	6,500	36,400	
9. Sub-total (2 ∿ 8)				13,018		266,891	
10. Miscellaneous (1+9) × 10%	L.S	-	-	1,391	-	28,562	
Total				15,320		314,135	
B. Acquisition and Compensation	ha	448	-	-	347,600	155,725	
A. + B.				15,320		469,860	
C. Eng. service and Administration (A+B) × 15%				2,300		70,480	
D. Contingency (A+B+C) × 15%				2,640		81,050	
Grand Total				20,260		621,390	฿ 1,087,370,000

Table 38 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS, ALTERNATIVE 3, KHLONG LUANG RIVER

1$ = ¥250 = 23฿

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	912		18,698	
2. Excavation	m^3	5,725,000	1.08	6,183	23.3	133,393	
3. Embankment	m^3	4,650,000	0.58	2,697	11.0	51,150	
4. Disposal	m^3	502,000	0.48	241	7.1	3,564	
5. Revetment							
- Low water channel	m^2	56,000	15.5	868	485.0	27,160	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	25	21,800	545	230,000	5,750	
7. Backwater levee							
- Excavation	m^3	171,000	1.08	185	23.3	3,984	
- Embankment	m^3	154,000	0.58	89	11.0	1,694	
8. Bridge	m^2	5,600	375	2,100	6,500	36,400	
9. Sub-total (2 ∿ 8)				13,029		267,121	
10. Miscellaneous (1+9) × 10%	L.S	-	-	1,394	-	28,582	
Total				15,335		314,401	
B. Acquisition and Compensation	ha	448	-	-	347,600	155,725	
A. + B.				15,335		470,126	
C. Eng. service and Administration (A+B) × 15%				2,300		70,519	
D. Contingency (A+B+C) × 15%				2,645		81,095	
Grand Total				20,280		621,740	฿ 1,088,180,000

Table 39 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR KHLONG LUANG RIVER, BLOCK A

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
127	300.0	1.8				
			1.000	2.300	2.300	2.300
140	200.0	2.8				
			1.000	4.450	4.450	6.750
162	100.0	6.1				
			0.333	7.600	2.531	9.281
176	66.7	9.1				
			0.445	13.650	6.074	15.355
210	22.2	18.2				
			0.117	21.000	2.457	17.812
238	10.5	23.8				
			0.072	27.200	1.958	19.770
273	3.3	30.6				
			0.013	32.000	0.416	20.186
292	2.0	33.4				
			0.010	35.100	0.351	20.537
319	1.0	36.8				
			0.005	38.450	0.192	20.729
347	0.5	40.1				
			0.003	41.950	0.126	20.855
381	0.2	43.8				
2. Regulated by Khlong Luang Dam						
50	300.0	0.0				
			1.000	0.050	0.050	0.050
52	200.0	0.1				
			1.000	0.010	0.100	0.150
58	100.0	0.1				
			0.333	0.100	0.033	0.183
62	66.7	0.1				
			0.445	0.150	0.067	0.250
70	22.2	0.2				
			0.117	0.250	0.029	0.279
75	10.5	0.3				
			0.072	0.400	0.029	0.308
88	3.3	0.5				
			0.013	0.550	0.007	0.315
96	2.0	0.6				
			0.010	0.750	0.008	0.323
109	1.0	0.9				
			0.005	1.100	0.006	0.329
121	0.5	1.3				
			0.003	2.000	0.006	0.335
139	0.2	2.7				

Table 40 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR KHLONG LUANG RIVER, BLOCK B

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
102	300.0	1.2				
			1.000	1.500	1.500	1.500
112	200.0	1.8				
			1.000	2.600	2.600	4.100
129	100.0	3.4				
			0.333	4.750	1.582	5.682
141	66.7	6.1				
			0.445	9.300	4.139	9.821
166	22.2	12.5				
			0.117	14.150	1.656	11.477
188	10.5	15.8				
			0.072	17.700	1.274	12.751
213	3.3	19.6				
			0.013	20.250	0.263	13.014
227	2.0	20.9				
			0.010	21.550	0.216	13.230
247	1.0	22.2				
			0.005	22.750	0.114	13.344
266	0.5	23.3				
			0.003	23.750	0.071	13.415
290	0.2	24.2				
2. Regulated by Khlong Luang Dam						
61	300.0	0.1				
			1.000	0.150	0.150	0.150
66	200.0	0.2				
			1.000	0.250	0.250	0.400
74	100.0	0.3				
			0.333	0.400	0.133	0.533
80	66.7	0.5				
			0.445	0.650	0.289	0.822
91	22.2	0.8				
			0.117	0.950	0.111	0.933
101	10.5	1.1				
			0.072	1.450	0.104	1.037
112	3.3	1.8				
			0.013	2.000	0.026	1.063
118	2.0	2.2				
			0.010	2.500	0.025	1.088
124	1.0	2.8				
			0.005	3.300	0.017	1.105
132	0.5	3.8				
			0.003	5.200	0.016	1.121
142	0.2	6.6				

Table 41 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR KHLONG LUANG RIVER, BLOCK C (1/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
135	300.0	4.5				
			1.000	6.000	6.000	6.000
153	200.0	7.5				
			1.000	10.750	10.750	16.750
184	100.0	14.0				
			0.333	16.000	5.328	22.078
202	66.7	18.0				
			0.445	27.600	12.282	34.360
250	22.2	37.2				
			0.117	49.500	5.792	40.152
289	10.5	61.8				
			0.072	75.000	5.400	45.552
344	3.3	88.2				
			0.013	94.200	1.225	46.777
361	2.0	100.2				
			0.010	107.700	1.077	47.854
389	1.0	115.2				
			0.005	122.400	0.612	48.466
426	0.5	129.6				
			0.003	138.900	0.417	48.883
452	0.2	148.2				
2. Regulated by New Ban Bung Dam						
127	300.0	4.0				
			1.000	5.000	5.000	5.000
146	200.0	6.0				
			1.000	9.000	9.000	14.000
177	100.0	12.0				
			0.333	14.900	4.962	18.962
198	66.7	17.8				
			0.445	26.900	11.971	30.933
245	22.2	36.0				
			0.117	44.150	5.166	36.099
283	10.5	52.3				
			0.072	69.250	4.986	41.085
339	3.3	86.2				
			0.013	91.700	1.192	42.277
354	2.0	97.2				
			0.010	103.850	1.039	43.316
382	1.0	110.5				
			0.005	118.600	0.593	43.909
418	0.5	126.7				
			0.003	131.000	0.393	44.302
444	0.2	135.3				

(cont'd)

Table 41 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR KHLONG LUANG RIVER, BLOCK C (2/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
3. Regulated by New Ban Bung and Khlong Luang Dams						
122	300.0	3.5				
			1.000	4.000	4.000	4.000
135	200.0	4.5				
			1.000	6.500	6.500	10.500
159	100.0	8.5				
			0.333	10.150	3.380	13.880
174	66.7	11.8				
			0.445	17.700	7.877	21.757
215	22.2	23.6				
			0.117	28.700	3.358	25.115
239	10.5	33.8				
			0.072	42.250	3.042	28.157
274	3.3	50.7				
			0.013	56.350	0.733	28.890
295	2.0	62.0				
			0.010	69.400	0.694	29.584
319	1.0	76.8				
			0.005	81.900	0.410	29.994
340	0.5	87.0				
			0.003	96.350	0.289	30.283
370	0.2	105.7				

Table 42 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR KHLONG LUANG RIVER, BLOCK E (1/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
181	300.0	15.5				
			1.000	20.750	20.750	20.750
209	200.0	26.0				
			1.000	38.750	38.750	59.500
256	100.0	51.5				
			0.333	63.250	21.062	80.562
285	66.7	75.0				
			0.445	99.900	44.456	125.018
361	22.2	124.8				
			0.117	135.300	15.830	140.848
411	10.5	145.8				
			0.072	156.900	11.297	152,145
493	3.3	168.0				
			0.013	171.900	2.235	154.380
520	2.0	175.8				
			0.010	180.300	1.803	156.183
565	1.0	184.8				
			0.005	188.400	0.942	157.125
607	0.5	192.0				
			0.003	196.200	0.589	157.714
658	0.2	200.4				
2. Regulated by New Ban Bung Dam						
179	300.0	16.0				
			1.000	20.000	20.000	20.000
205	200.0	24.0				
			1.000	36.250	36.250	56.250
252	100.0	48.5				
			0.333	60.300	20.080	76.330
279	66.7	72.1				
			0.445	97.350	43.321	119.651
353	22.2	122.6				
			0.117	132.350	15.485	135.136
402	10.5	142.1				
			0.072	154.050	11.092	146.228
483	3.3	166.0				
			0.013	169.050	2.198	148.426
509	2.0	172.1				
			0.010	177.600	1.776	150.202
554	1.0	183.1				
			0.005	187.000	0.935	151.137
595	0.5	190.9				
			0.003	194.850	0.585	151.722
645	0.2	198.8				

(cont'd)

Table 42 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR KHLONG LUANG RIVER, BLOCK E (2/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
3. Regulated by New Ban Bung and Khlong Luang Dams						
176	300.0	14.5				
			1.000	19.000	19.000	19.000
203	200.0	23.5				
			1.000	34.750	34.750	53.750
248	100.0	46.0				
			0.333	59.000	19.647	73.397
278	66.7	72.0				
			0.445	97.250	43.276	116.673
352	22.2	122.5				
			0.117	132.250	15.473	132.146
400	10.5	142.0				
			0.072	153.900	11.081	143.227
481	3.3	165.8				
			0.013	168.900	2.196	145.423
507	2.0	172.0				
			0.010	177.500	1.775	147.198
552	1.0	183.0				
			0.005	186.900	0.935	148.133
593	0.5	190.8				
			0.003	194.800	0.584	148.717
645	0.2	198.8				

Table 43 CHANNEL FACTORS FOR CHANNEL DESIGN, RISK LEVELS 1 & 2 , KHLONG LUANG RIVER

	Stretches	Q (m^3/sec)	L (Km)	I	B (m)	b_1 (m)	hl (m)	H (m)	hd (m)
	30-yr (Risk Level : 2)								
I	0.0 - 12.2	1,150	11.5	1/5,000	150	66.5	4.0	3.4	4.4
II	12.2 - 22.5	1,150	8.5	1/5,000	150	66.5	2.5	4.5	5.5
III	22.5 - 29.5	1,150	6.0	1/1,400	150	66.5	2.2	3.3	4.3
IV	29.5 - 38.0	400	8.5	1/1,100	100	14.6	3.4	1.8	2.6
V	38.0 - 44.2	230	6.0	1/1,100	50	7.5	4.0	1.1	1.9
VI	44.2 - 47.0	90	2.5	1/1,100	50	1.8	4.2	0.0	0.6
	10-yr (Risk Level : 1)								
I	0.0 - 12.2	1,050	11.5	1/5,000	150	61.5	4.0	3.2	4.2
II	12.2 - 22.5	1,050	8.5	1/5,000	150	61.5	2.5	4.3	5.3
III	22.5 - 29.5	1,050	6.0	1/1,400	150	61.5	2.2	3.1	4.1
IV	29.5 - 38.0	340	8.5	1/1,100	100	12.6	3.4	1.6	2.4
V	38.0 - 44.2	190	6.0	1/1,100	50	5.1	4.0	0.9	1.5
VI	44.2 - 47.0	70	2.5	1/1,100	50	1.8	4.2	0.0	0.6

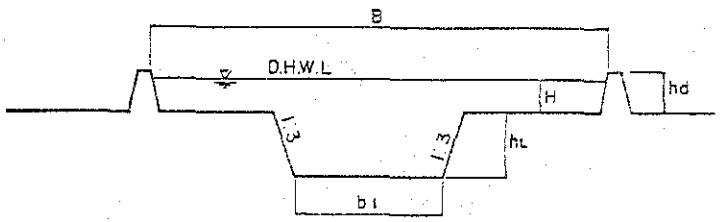

Table 44 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS FOR RISK LEVEL 1, KHLONG LUANG RIVER

$1 = ¥250 = ฿23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				$\times 10^3$		$\times 10^3$	
A. Main Civil Works							
1. Preparation (9 × 7 %)	L.S	-	-	798		16,346	
2. Excavation	m^3	4,780,000	1.08	5,162	23.3	111,374	
3. Embankment	m^3	3,890,000	0.58	2,256	11.0	42,790	
4. Disposal	m^3	412,000	0.48	198	7.1	2,925	
5. Revetment							
- Low water channel	m^2	56,000	15.5	868	485.0	27,160	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	25	21,800	545	230,000	5,750	
7. Backwater levee							
- Excavation	m^3	93,000	1.08	100	23.3	2,167	
- Embankment	m^3	84,000	0.58	49	11.0	924	
8. Bridge	m^2	5,600	375	2,100	6,500	36,400	
9. Sub-total (2 ∿ 8)				11,399		233,516	
10. Miscellaneous (1 + 9) × 10 %	L.S	-	-	1,223	-	24,984	
Total				13,420		274,846	
B. Acquisition and Compensation	ha	440	-	-	347,600	152,944	
Total (A + B)				13,420		427,790	
C. Eng. Service and Administration (A + B) × 15 %				2,010		64,170	
D. Contingency (A + B + C) × 15 %				2,320		73,790	
Grand Total				17,750		565,750	฿ 974,000,000

Table 45 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS FOR RISK LEVEL 2, KHLONG LUANG RIVER

$ 1 = ¥ 250 = ฿ 23

Item	Unit	Quantity	F.C (US$) Unit Cost	F.C (US$) Amount	L.C (฿) Unit Cost	L.C (฿) Amount	Remarks
				$\times 10^3$		$\times 10^3$	
A. Main Civil Works							
1. Preparation (9 × 7 %)	L.S	-	-	861		17,465	
2. Excavation	m^3	5,297,000	1.08	5,721	23.3	123,420	
3. Embankment	m^3	4,286,000	0.58	2,486	11.0	47,146	
4. Disposal	m^3	481,000	0.48	231	7.1	3,415	
5. Revetment							
- Low water channel	m^2	56,000	15.5	868	485.0	27,160	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	25	21,800	545	230,000	5,750	
7. Backwater levee							
- Excavation	m^3	143,000	1.08	154	23.3	3,332	
- Embankment	m^3	129,000	0.58	75	11.0	1,419	
8. Bridge	m^2	5,600	375	2,100	6,500	36,400	
9. Sub-total (2 ∿ 8)				12,301		252,068	
10. Miscellaneous (1 + 9) × 10 %	L.S	-	-	1,318	-	26,952	
Total				14,480		296,485	
B. Acquisition and Compensation	ha	444	-	-	347,600	154,335	
Total (A + B)				14,480		450,820	
C. Eng. Service and Administration (A + B) × 15 %				2,170		67,620	
D. Contingency (A + B + C) × 15 %				2,500		77,770	
Grand Total				19,150		596,210	฿ 1,036,660,000

Table 46 PROBABLE FLOOD RUNOFF OF RAYONG RIVER
UNREGULATED

(Unit : m^3/s)

Point No. /1	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	247	306	344	417	443	492	530	589
2	Nong Pla Lai river	278	343	385	467	496	552	589	649
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
7	Upstream of confluence of Khlong Luai river	181	221	247	299	314	348	373	408
11	Ban Krai weir	609	732	811	966	1,021	1,120	1,193	1,290
14	Upstream of confluence of Khlong Thap Ma river	531	632	696	825	869	955	1,016	1,122
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
19	Khlong Thap Ma river	159	197	222	263	278	301	322	354
21	Rayong bridge	396	458	495	563	584	626	658	689

/1 : Refer to Fig. 32

Table 47 PROBABLE FLOOD RUNOFF OF RAYONG RIVER, REGULATED BY DOK KRAI DAM

(Unit : m^3/s)

Point No. /1	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	92	106	115	133	139	152	162	180
2	Nong Pla Lai river	278	343	385	467	496	552	589	649
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
7	Upstream of confluence of Khlong Luai river	181	221	247	299	314	348	373	408
11	Ban Khai weir	493	590	644	753	791	862	915	980
14	Upstream of confluence of Khlong Thap Ma river	452	534	583	677	709	774	819	895
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	373	480	542	658	699	771	840	918
19	Khlong Thap Ma river	159	197	222	263	278	301	322	354
21	Rayong bridge	371	425	459	523	541	579	608	640

/1 : Refer to Fig. 32

Table 48 PROBABLE FLOOD RUNOFF OF RAYONG RIVER, REGULATED BY DOK KRAI AND NONG PLA LAI DAMS

(Unit : m^3/s)

Point No. /1	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	92	106	115	133	139	152	162	180
2	Nong Pla Lai river	83	109	126	160	172	195	211	239
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
7	Upstream of confluence of Khlong Luai river	181	221	247	299	314	348	373	408
11	Ban Khai weir	347	424	456	522	544	592	629	670
14	Upstream of confluence of Khlong Thap Ma river	352	419	455	518	539	583	616	664
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
19	Khlong Thap Ma river	159	197	222	263	278	301	322	354
21	Rayong bridge	339	386	418	480	495	530	557	593

/1 : Refer to Fig. 32

Table 49 PROBABLE FLOOD RUNOFF OF RAYONG RIVER, REGULATED BY DOK KRAI, NONG PLA LAI AND KHLONG YAI/1 DAMS

(Unit : m^3/s)

Point No. /2	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	92	106	115	133	139	152	162	180
2	Nong Pla Lai river	83	109	126	160	172	195	211	239
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	57	78	92	121	130	152	168	190
7	Upstream of confluence of Khlong Luai river	44	61	71	86	91	102	109	121
11	Ban Khai weir	287	333	359	412	432	453	477	503
14	Upstream of confluence of Khlong Thap Ma river	317	373	404	466	488	529	554	600
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
19	Khlong Thap Ma river	159	197	222	263	278	301	322	354
21	Rayong bridge	322	362	392	449	466	499	523	560

/1 : With spillway width 70 m

/2 : Refer to Fig. 32

Table 50 PROBABLE FLOOD RUNOFF OF RAYONG RIVER, REGULATED BY DOK KRAI, NONG PLA LAI, KHLONG YAI AND KHLONG THAP MA DAMS

(Unit : m /s)

Point No. /2	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	92	106	115	133	139	152	162	180
2	Nong Pla Lai river	83	109	126	160	172	195	211	239
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	57	78	92	121	130	152	168	190
7	Upstream of confluence of Khlong Luai river	44	61	71	86	91	102	109	121
11	Ban Khai weir	287	333	359	412	432	453	477	503
14	Upstream of confluence of Khlong Thap Ma river	317	373	404	466	488	529	554	600
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	36	50	59	77	84	97	108	122
19	Khlong Thap Ma river	71	83	91	104	112	120	128	140
21	Rayong bridge	307	339	367	420	436	474	503	545

/1 : Dok Krai dam, Nong Pla Lai dam, Khlong Yai dam with spillway width 70m and Khlong Thap Ma dam with spillway width 50m

/2 : Refer to Fig. 32

Table 51 PROBABLE FLOOD RUNOFF OF RAYONG RIVER WITH DOK KRAI, NONG PLA LAI, KHLONG YAI DAMS/1 AND RIVER IMPROVEMENT

(Unit : m^3/s)

Point No./2	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	159	201	227	275	292	325	350	386
2	Nong Pla Lai river	89	122	143	183	197	224	243	274
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	56	77	91	121	130	152	168	190
9	Upstream of confluence of Rayong river	277	354	399	484	521	580	625	690
11	Ban Khai weir	370	470	530	644	685	763	822	910
14	Upstream of confluence of Khlong Thap Ma river	588	753	847	1,029	1,095	1,219	1,304	1,435
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
19	Khlong Thap Ma river	411	531	607	737	793	872	948	1,050
21	Rayong bridge	1,329	1,745	2,009	2,412	2,626	2,903	3,135	3,490

/1 : With spillway width 70m

/2 : Refer to Fig. 32

Table 52 PROBABLE FLOOD RUNOFF OF RAYONG RIVER
WITH ALL DAMS/1 AND RIVER IMPROVEMENT

(Unit : m^3/s)

Point No. /2	Location	Return Period							
		2-yr	5-yr	10-yr	30-yr	50-yr	100-yr	200-yr	500-yr
4	Khlong Dok Krai river	159	201	227	275	292	325	350	386
2	Nong Pla Lai river	89	122	143	183	197	224	243	274
-	Inflow of Khlong Yai damsite	507	637	718	885	932	1,039	1,120	1,226
6	Outflow of Khlong Yai damsite	56	77	91	121	130	152	168	190
9	Upstream of confluence of Rayong river	277	354	399	484	521	580	625	690
11	Ban Khai river	370	470	530	644	691	763	822	910
14	Upstream of confluence of Khlong Thap Ma river	588	753	847	1,029	1,095	1,219	1,304	1,435
-	Inflow of Khlong Thap Ma damsite	377	480	542	658	699	771	840	918
16	Outflow of Khlong Thap Ma damsite	36	50	59	77	84	97	108	122
19	Khlong Thap Ma river	137	186	219	266	296	322	350	385
21	Rayong bridge	1,057	1,353	1,522	1,849	1,999	2,226	2,381	2,640

/1 : Dok Krai dam, Nong Pla Lai dam, Khlong Yai dam with spillway width 70m and Khlong Thap Ma dam with spillway width 50m

/2 : Refer to Fig. 32

Table 53 CHANNEL FACTORS FOR CHANNEL DESIGN FOR RAYONG RIVER

Alternatives	Stretches		Length (Km)	Design Discharge Q (m^3/sec)	Gradient I	River Width B (m)	Low Water C. Width b_1 (m)	Low Water C. Depth hl (m)	Water Depth of High Water C. H (m)	Dike Height hd (m)
1	I	0.00-13.40	3.6	2,650	1/2,500	300	204.0	4.0	1.7	2.9
	II	13.40-32.55	15.5	1,100	1/2,500	150	63.0	2.6	3.2	4.2
	III	32.55-40.85	5.2	700	1/1,800	100	42.1	3.6	2.3	3.3
	IV	40.85-42.80	1.2	520	1/900	100	16.1	4.0	1.7	2.7
	V	42.80-47.00	2.4	300	1/900	100	10.8	4.2	0.9	1.7
	VI	47.00-50.70	2.8	110	1/900	50	7.8	3.0	0.4	1.0
	VII	50.70-55.90	5.2	110	1/520	50	7.8	2.5	0.5	1.1
2	I	0.00-13.40	3.6	2,650	1/2,500	300	204.0	4.0	1.7	2.9
	II	13.40-32.55	15.5	1,100	1/2,500	150	63.0	2.6	3.2	4.2
	III	32.55-40.85	5.2	700	1/1,800	100	42.1	3.6	2.3	3.3
	IV	40.85-42.80	1.2	530	1/900	100	16.1	4.0	1.7	2.7
	V	42.80-47.00	2.4	310	1/900	100	11.0	4.2	1.0	1.8
	VI	47.00-50.70	2.8	140	1/900	50	9.4	3.0	0.7	1.3
	VII	50.70-55.90	5.2	140	1/520	50	9.4	2.5	0.7	1.3
3	I	0.00-13.40	3.6	2,650	1/2,500	300	204.0	4.0	1.7	2.9
	II	13.40-32.55	15.5	1,100	1/2,500	150	63.0	2.6	3.2	4.2
	III	32.55-40.85	5.2	700	1/1,800	100	42.1	3.6	2.3	3.3
	IV	40.85-42.80	1.2	540	1/900	100	16.4	4.0	1.7	2.7
	V	42.80-47.00	2.4	320	1/900	100	11.2	4.2	1.0	1.8
	VI	47.00-50.70	2.8	160	1/900	50	10.0	3.0	0.9	1.5
	VII	50.70-55.90	5.2	160	1/520	50	10.0	2.5	0.9	1.5

Note: In case of 3 dams in operation.

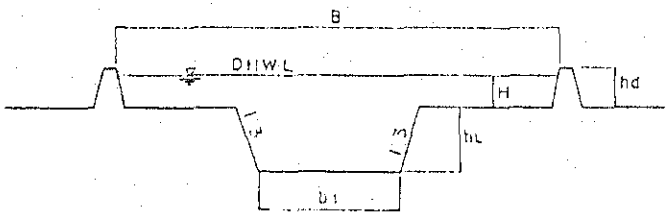

Table 54 CHANNEL FACTORS FOR CHANNEL DESIGN FOR KHLONG THAP MA RIVER

Alternatives	Stretches		Length (Km)	Design Discharge Q (m^3/sec)	Gradient I	River Width B (m)	Low Water C. Width b_1 (m)	Low Water C. Depth hl (m)	Water Depth of High Water C. H (m)	Dike Height hd (m)
1	I	0.00-13.40	3.6	2,000	1/2,500	250	145.0	4.0	1.8	2.8
	II	0.00- 3.50	3.5	290	1/4,500	100	31.5	1.0	4.2	5.0
	III	3.50- 8.00	4.5	60	1/1,500	50	7.8	1.8	0.8	1.4
	IV	8.00-11.05	3.5	60	1/600	50	6.4	2.0	0.3	0.9
2	I	0.00-13.40	3.6	2,000	1/2,500	250	145.0	4.0	1.8	2.8
	II	0.00- 3.50	3.5	300	1/4,500	100	32.0	1.0	4.2	5.0
	III	3.50- 8.00	4.5	85	1/1,500	50	11.4	1.8	0.9	1.5
	IV	8.00-11.05	3.5	85	1/600	50	8.5	2.0	0.6	1.2
3	I	0.00-13.40	3.6	2,000	1/2,500	250	145.0	4.0	1.8	2.8
	II	0.00- 3.50	3.5	310	1/4,500	100	33.0	1.0	4.2	5.0
	III	3.50- 8.00	4.5	110	1/1,500	50	14.1	1.8	1.1	1.7
	IV	8.00-11.05	3.5	110	1/600	50	9.5	2.0	0.7	1.3

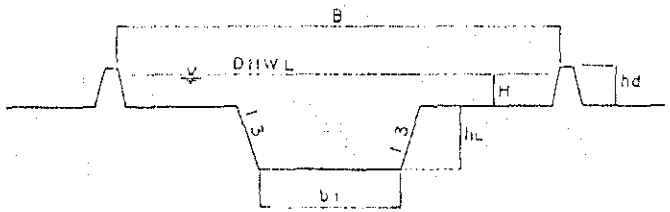

Table 55 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS OF RAYONG RIVER, ALTERNATIVE 1

$1 = ¥250 = ₿23

Item	Unit	Quantity	F.C (US$) Unit Cost	F.C (US$) Amount	L.C (₿) Unit Cost	L.C (₿) Amount	Remarks
				×10³			
A. Main civil works							
1. Preparation (9 × 7%)		-	-	1,002	-	20,283	
2. Excavation	m^3	5,860,000	1.08	6,329	23.3	136,538	
3. Embankment	m^3	3,880,000	0.58	2,251	11.0	42,680	
4. Disposal	m^3	1,560,000	0.48	749	7.1	11,076	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485	26,190	
- High water channel	m^2	11,000	11.0	121	366	4,026	
6. Drainage sluice	nos	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	459,000	1.08	496	23.3	10,695	
- Embankment	m^3	413,000	0.58	240	11.0	4,543	
8. Bridge		7,600	375.0	2,850	6,500.0	49,400	
9. Sub-total (2 ∿ 8)				14,309		289,748	
10. Miscellaneous (1 + 9) × 10%				1,532		31,004	
Total				16,843		341,035	
B. Acquisition and Compensation	ha	487	-		347,600	169,282	
Sub-Total				16,843		510,317	
C. Eng. service and Administration (A+B) × 15%				2,527		76,548	
D. Contingence (A+B+C) × 15%				2,906		88,030	
Grand Total				22,276		674,895	₿ 1,187,243,000

Table 56 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS OF RAYONG RIVER, ALTERNATIVE 2

$1 = ¥250 = ฿23

Item	Unit	Quantity	F.C (US$) Unit Cost	F.C (US$) Amount	L.C (฿) Unit Cost	L.C (฿) Amount	Remarks
A. Main civil works				$\times 10^3$			
1. Preparation (9 × 7%)		-	-	1,005	-	20,348	
2. Excavation	m^3	5,880,000	1.08	6,350	23.3	137,004	
3. Embankment	m^3	3,910,000	0.58	2,268	11.0	43,010	
4. Disposal	m^3	1,580,000	0.48	759	7.1	11,218	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485	26,190	
- High water channel	m^2	11,000	11.0	121	366	4,026	
6. Drainage sluice	nos	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	459,000	1.08	496	23.3	10,695	
- Embankment	m^3	413,000	0.58	240	11.0	4,543	
8. Bridge		7,600	375.0	2,850	6,500.0	49,400	
9. Sub-total (2 ∿ 8)				14,357		290,686	
10. Miscellaneous (1 + 9) × 10%				1,536		31,103	
Total				16,898		342,137	
B. Acquisition and Compensation	ha	487	-		347,600	169,282	
Sub-Total				16,898		511,419	
C. Eng. service and Administration (A+B) × 15%				2,535		76,711	
D. Contingence (A+B+C) × 15%				2,917		88,220	
Grand Total				22,350		676,350	฿1,190,400,000

Table 57 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPRVEMENT WORKS OF RAYONG RIVER, ALTERNATIVE 3

$1 = ¥250 = ₿23

Item	Unit	Quantity	F.C (US$) Unit Cost	F.C (US$) Amount	L.C (₿) Unit Cost	L.C (₿) Amount	Remarks
				×10³			
A. Main civil works							
1. Preparation (9 × 7%)		-	-	1,010	-	20,438	
2. Excavation	m³	5,910,000	1.08	6,383	23.3	137,703	
3. Embankment	m³	3,950,000	0.58	2,291	11.0	43,450	
4. Disposal	m³	1,600,000	0.48	768	7.1	11,360	
5. Revetment							
- Low water channel	m²	54,000	15.5	837	485	26,190	
- High water channel	m²	11,000	11.0	121	366	4,026	
6. Drainage sluice	nos	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m³	459,000	1.08	496	23.3	10,695	
- Embankment	m³	413,000	0.58	240	11.0	4,543	
8. Bridge		7,600	375.0	2,850	6,500.0	49,400	
9. Sub-total (2 ∿ 8)				14,422		291,967	
10. Miscellaneous (1 + 9) × 10%				1,544		31,241	
Total				16,976		343,646	
B. Acquisition and Compensation	ha	487	-		347,600	169,282	
Sub-Total				16,976		512,928	
C. Eng. service and Administration (A+B) × 15%				2,547		76,940	
D. Contingence (A+B+C) × 15%				2,929		88,481	
Grand Total				22,452		678,349	₿ 1,194,745,000

Table 58 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPRVEMENT WORKS OF KHLONG THAP MA RIVER, ALTERNATIVE 1

$1 = ¥250 = ₿23

Item	Unit	Quantity	F.C (US$)		L.C (₿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	103		2,082	
2. Excavation	m^3	246,000	1.08	266	23.3	5,732	
3. Embankment	m^3	982,000	0.58	570	11.0	10,802	
4. Disposal	m^3	0	0.48	0	7.1	0	
5. Revetment							
- Low water channel	m^2	9,800	15.5	152	485.0	4,753	
- High water channel	m^2	1,600	11.0	18	366.0	586	
6. Drainage sluice	nos.	4	21,800	87	230,000	920	
7. Backwater levee							
- Excavation	m^3	92,000	1.08	99	23.3	2,144	
- Embankment	m^3	82,000	0.58	48	11.0	902	
8. Bridge	m^2	600	375	225	6,500	3,900	
9. Sub-total (2 ∿ 8)				1,465		29,739	
10. Miscellaneous (1+9) × 10%	L.S	-	-	157	-	3,183	
Total				1,725		35,004	
B. Acquisition and Compensation	ha	60	-	-	347,600	20,856	
A. + B.				1,725		55,860	
C. Eng. service and Administration (A+B) × 15%				259		8,379	
D. Contingency (A+B+C) × 15%				298		9,636	
Grand Total				2,282		73,875	₿ 126,361,000

Table 59 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS OF KHLONG THAP MA RIVER, ALTERNATIVE 2

$1 = ¥250 = ฿23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	103		2,097	
2. Excavation	m^3	249,000	1.08	269	23.3	5,802	
3. Embankment	m^3	995,000	0.58	577	11.0	10,945	
4. Disposal	m^3	0	0.48	0	7.1	0	
5. Revetment							
- Low water channel	m^2	9,800	15.5	152	485.0	4,753	
- High water channel	m^2	1,600	11.0	18	366.0	586	
6. Drainage sluice	nos.	4	21,800	87	230,000	920	
7. Backwater levee							
- Excavation	m^3	92,000	1.08	99	23.3	2,144	
- Embankment	m^3	82,000	0.58	48	11.0	902	
8. Bridge	m^2	600	375	225	6,500	3,900	
9. Sub-total (2 ∿ 8)				1,475		29,952	
10. Miscellaneous (1+9) × 10%	L.S	-	-	158	-	3,205	
Total				1,736		35,254	
B. Acquisition and Compensation	ha	60	-	-	347,600	20,856	
A. + B.				1,736		56,110	
C. Eng. service and Administration (A+B) × 15%				260		8,417	
D. Contingency (A+B+C) × 15%				303		9,680	
Grand Total				2,299		74,207	฿ 127,084,000

Table 60 WORK QUANTITY AND CONSTRUCTION COST FOR RIVER IMPROVEMENT WORKS OF KHLONG THAP MA RIVER, ALTERNATIVE 3

$1 = ¥250 = ฿23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	104		2,107	
2. Excavation	m^3	251,000	1.08	272	23.3	5,849	
3. Embankment	m^3	1,003,000	0.58	582	11.0	11,033	
4. Disposal	m^3	0	0.48	0	7.1	0	
5. Revetment							
- Low water channel	m^2	9,800	15.5	152	485.0	4,753	
- High water channel	m^2	1,600	11.0	18	366.0	586	
6. Drainage sluice	nos.	4	21,800	87	230,000	920	
7. Backwater levee							
- Excavation	m^3	92,000	1.08	99	23.3	2,144	
- Embankment	m^3	82,000	0.58	48	11.0	902	
8. Bridge	m^2	600	375	225	6,500	3,900	
9. Sub-total (2 ∿ 8)				1,483		30,087	
10. Miscellaneous (1+9) × 10%	L.S	-	-	159	-	3,220	
Total				1,746		35,414	
B. Acquisition and Compensation	ha	60	-	-	347,600	20,856	
A. + B.				1,746		56,270	
C. Eng. service and Administration (A+B) × 15%				262		8,441	
D. Contingency (A+B+C) × 15%				302		9,707	
Grand Total				2,310		74,418	฿ 127,548,000

Table 61 WORK QUANTITY AND CONSTRUCTION COST FOR OVERALL BASIC FLOOD CONTROL PLAN OF RAYONG RIVER

$1 = ¥250 = ฿23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	823		16,768	
2. Excavation	m^3	4,251,000	1.08	4,591	23.3	99,048	
3. Embankment	m^3	3,557,000	0.58	2,063	11.0	39,127	
4. Disposal	m^3	269,000	0.48	129	7.1	1,910	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485.0	26,190	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	459,000	1.08	496	23.3	10,695	
- Embankment	m^3	413,000	0.58	240	11.0	4,543	
8. Bridge	m^2	7,600	375	2,850	6,500	49,400	
9. Sub-total (2 ∼ 8)				11,763		239,539	
10. Miscellaneous (1+9) × 10%	L.S	-	-	1,254	-	25,637	
Total				13,840		281,944	
B. Acquisition and Compensation	ha	389	-	-	347,600	135,216	
A. + B.				13,840		417,160	
C. Eng. service and Administration (A+B) × 15%				2,080		62,570	
D. Contingency (A+B+C) × 15%				2,390		71,960	
Grand Total				18,310		551,690	฿ 972,820,000

Table 62 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK A

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
188	300.0	0.53				
			1.000	0.665	0.665	0.665
212	200.0	0.80				
			1.000	1.320	1.320	1.985
253	100.0	1.84				
			0.333	2.510	0.836	2.821
278	66.7	3.18				
			0.445	3.925	1.747	4.568
343	22.2	4.67				
			0.117	4.920	0.576	5.144
385	10.5	5.17				
			0.072	5.405	0.389	5.533
467	3.3	5.64				
			0.013	5.710	0.074	5.607
496	2.0	5.78				
			0.010	5.880	0.059	5.666
552	1.0	5.98				
			0.005	6.045	0.030	5.696
589	0.5	6.11				
			0.003	6.170	0.019	5.715
649	0.2	6.23				
2. Regulated by Nong Pla Lai Dams						
70	120.0	0.0				
			0.200	0.005	0.001	0.001
74	100.0	0.01				
			0.333	0.015	0.005	0.006
83	66.7	0.02				
			0.445	0.040	0.018	0.024
109	22.2	0.06				
			0.117	0.080	0.009	0.033
126	10.5	0.10				
			0.072	0.190	0.014	0.047
160	3.3	0.28				
			0.013	0.325	0.004	0.051
172	2.0	0.37				
			0.010	0.485	0.005	0.056
195	1.0	0.60				
			0.005	0.700	0.004	0.060
211	0.5	0.80				
			0.003	1.125	0.003	0.063
239	0.2	1.45				

Table 63 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK B

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
164	300.0	0.76				
			1.000	0.920	0.920	0.920
187	200.0	1.08				
			1.000	1.455	1.455	2.375
223	100.0	1.83				
			0.333	2.285	0.761	3.136
247	66.7	2.74				
			0.445	3.345	1.489	4.625
306	22.2	3.95				
			0.117	4.085	0.478	5.103
344	10.5	4.22				
			0.072	4.330	0.312	5.415
417	3.3	4.44				
			0.013	4.500	0.059	5.474
443	2.0	4.56				
			0.010	4.615	0.046	5.520
492	1.0	4.67				
			0.005	4.715	0.024	5.544
530	0.5	4.76				
			0.003	4.785	0.014	5.558
589	0.2	4.81				
2. Regulated by Dok Krai Dam						
76	300.0	0.04				
			1.000	0.055	0.055	0.055
80	200.0	0.07				
			1.000	0.095	0.095	0.150
88	100.0	0.12				
			0.333	0.130	0.043	0.193
92	66.7	0.14				
			0.445	0.185	0.082	0.275
106	22.2	0.23				
			0.117	0.270	0.032	0.307
115	10.5	0.31				
			0.072	0.375	0.027	0.334
133	3.3	0.44				
			0.013	0.500	0.007	0.341
139	2.0	0.56				
			0.010	0.595	0.006	0.347
152	1.0	0.63				
			0.005	0.690	0.003	0.350
162	0.5	0.75				
			0.003	0.855	0.003	0.353
180	0.2	0.96				

Table 64 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK C

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
127	300.0	1.40				
			1.000	1.615	1.615	1.615
142	200.0	1.83				
			1.000	2.490	2.490	4.105
166	100.0	3.15				
			0.333	3.785	1.260	5.365
181	66.7	4.42				
			0.445	5.320	2.367	7.732
221	22.2	6.22				
			0.117	6.505	0.761	8.493
247	10.5	6.79				
			0.072	7.085	0.510	9.003
299	3.3	7.38				
			0.013	7.470	0.097	9.100
314	2.0	7.56				
			0.010	7.660	0.077	9.177
348	1.0	7.76				
			0.005	7.840	0.039	9.216
373	0.5	7.92				
			0.003	8.005	0.024	9.240
408	0.2	8.09				
2. Regulated by Khlong Yai Dam						
40	94.0	0.00				
			0.273	0.035	0.010	0.010
44	66.7	0.07				
			0.445	0.150	0.067	0.077
61	22.2	0.23				
			0.117	0.290	0.034	0.111
71	10.5	0.35				
			0.072	0.445	0.032	0.143
86	3.3	0.54				
			0.013	0.585	0.008	0.151
91	2.0	0.63				
			0.010	0.730	0.007	0.158
102	1.0	0.83				
			0.005	0.925	0.005	0.163
109	0.5	1.02				
			0.003	1.190	0.004	0.167
121	0.2	1.36				

Table 65 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK D (1/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
443	300.0	2.40				
			1.000	2.850	2.850	2.850
485	200.0	3.30				
			1.000	4.650	4.650	7.500
564	100.0	6.00				
			0.333	6.990	2.328	9.828
609	66.7	7.98				
			0.445	9.630	4.285	14.113
732	22.2	11.28				
			0.117	11.850	1.386	15.499
811	10.5	12.42				
			0.072	13.020	0.937	16.436
966	3.3	13.62				
			0.013	13.770	0.179	16.615
1,021	2.0	13.92				
			0.010	14.160	0.142	16.757
1,120	1.0	14.40				
			0.005	14.550	0.073	16.830
1,193	0.5	14.70				
			0.003	14.910	0.045	16.875
1,290	0.2	15.12				
2. Regulated by Dok Krai Dam						
370	300.0	1.30				
			1.000	1.525	1.525	1.525
403	200.0	1.75				
			1.000	2.250	2.250	3.775
460	100.0	2.75				
			0.333	3.125	1.041	4.816
493	66.7	3.50				
			0.445	5.450	2.425	7.241
590	22.2	7.40				
			0.117	8.385	0.981	8.222
644	10.5	9.37				
			0.072	10.525	0.758	8.980
753	3.3	11.68				
			0.013	11.865	0.154	9.134
791	2.0	12.05				
			0.010	12.470	0.125	9.259
862	1.0	12.89				
			0.005	13.120	0.066	9.325
915	0.5	13.35				
			0.003	13.540	0.041	9.366
980	0.2	13.73				

(cont'd)

Table 65 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK D (2/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
3. Regulated by Dok Krai and Nong Pla Lai Dams						
258	300.0	0.40				
			1.000	0.475	0.475	0.475
282	200.0	0.55				
			1.000	0.675	0.675	1.150
323	100.0	0.80				
			0.333	0.935	0.311	1.461
347	66.7	1.07				
			0.445	1.575	0.701	2.162
424	22.2	2.08				
			0.117	2.350	0.275	2.437
456	10.5	2.62				
			0.072	3.500	0.252	2.689
522	3.3	4.38				
			0.013	4.790	0.062	2.751
544	2.0	5.20				
			0.010	6.320	0.063	2.814
592	1.0	7.44				
			0.005	8.160	0.041	2.855
629	0.5	8.88				
			0.003	9.480	0.028	2.883
670	0.2	10.08				
4. Regulated by Dok Krai, Nong Pla Lai and Khlong Yai Dams						
209	300.0	0.20				
			1.000	0.250	0.250	0.250
228	200.0	0.30				
			1.000	0.350	0.350	0.600
257	100.0	0.40				
			0.333	0.490	0.163	0.763
287	66.7	0.58				
			0.445	0.750	0.334	1.097
333	22.2	0.92				
			0.117	1.060	0.124	1.221
359	10.5	1.20				
			0.072	1.515	0.109	1.330
412	3.3	1.83				
			0.013	2.010	0.026	1.356
432	2.0	2.19				
			0.010	2.375	0.024	1.380
453	1.0	2.56				
			0.005	2.810	0.014	1.394
471	0.5	3.06				
			0.003	3.385	0.010	1.404
503	0.2	3.71				

Table 66 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK E (1/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
392	300.0	5.2				
			1.000	6.350	6.350	6.350
429	200.0	7.5				
			1.000	9.900	9.900	16.250
493	100.0	12.3				
			0.333	14.450	4.812	21.062
531	66.7	16.6				
			0.445	20.500	9.123	30.185
632	22.2	24.4				
			0.117	25.800	3.019	33.204
696	10.5	27.2				
			0.072	28.700	2.066	35.270
825	3.3	30.2				
			0.013	30.700	0.399	35.669
869	2.0	31.2				
			0.010	31.750	0.318	35.987
955	1.0	32.3				
			0.005	32.700	0.164	36.151
1,016	0.5	33.1				
			0.002	33.650	0.101	36.252
1,122	0.2	34.2				
2. Regulated by Dok Krai Dam						
348	300.0	3.7				
			1.000	4.100	4.100	4.100
375	200.0	4.5				
			1.000	5.850	5.850	9.950
423	100.0	7.2				
			0.333	8.000	2.664	12.614
452	66.7	8.8				
			0.445	12.900	5.741	18.355
534	22.2	17.0				
			0.117	19.200	2.246	20.601
583	10.5	21.4				
			0.072	23.900	1.721	22.322
677	3.3	26.4				
			0.013	26.950	0.350	22.672
709	2.0	27.5				
			0.010	28.400	0.284	22.956
774	1.0	29.3				
			0.005	29.700	0.149	23.105
819	0.5	30.1				
			0.003	30.800	0.092	23.197
895	0.2	31.5				

(cont'd)

Table 66 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK E (2/2)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
3. Regulated by Dok Krai and Nong Pla Lai Dams						
273	300.0	1.7				
			1.000	1.950	1.950	1.950
295	200.0	2.2				
			1.000	2.750	2.750	4.700
332	100.0	3.3				
			0.333	3.550	1.182	5.882
352	66.7	3.8				
			0.445	5.400	2.403	8.285
419	22.2	7.0				
			0.117	8.100	0.948	9.233
455	10.5	9.2				
			0.072	12.100	0.871	10.104
518	3.3	15.0				
			0.013	16.300	0.212	10.316
539	2.0	17.6				
			0.010	19.500	0.195	10.511
583	1.0	21.4				
			0.005	22.500	0.113	10.624
616	0.5	23.6				
			0.003	24.800	0.074	10.698
664	0.2	26.0				
4. Regulated Dok Krai, Nong Pla Lai and Khlong Yai Dams						
245	300.0	1.2				
			1.000	1.300	1.300	1.300
264	200.0	1.4				
			1.000	1.850	1.850	3.150
299	100.0	2.3				
			0.333	2.550	0.849	3.999
317	66.7	2.8				
			0.445	3.700	1.647	5.646
373	22.2	4.6				
			0.117	5.450	0.638	6.284
404	10.5	6.3				
			0.072	8.100	0.583	6.867
466	3.3	9.9				
			0.013	10.950	0.142	7.009
488	2.0	12.0				
			0.010	14.200	0.142	7.151
529	1.0	16.4				
			0.005	17.700	0.089	7.240
554	0.5	19.0				
			0.003	20.850	0.063	7.303
600	0.2	22.7				

Table 67 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK F

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
107	300.0	2.80				
			1.000	3.250	3.250	3.250
121	200.0	3.70				
			1.000	4.850	4.850	8.100
145	100.0	6.00				
			0.333	6.630	2.208	10.308
159	66.7	7.26				
			0.445	8.820	3.925	14.233
197	22.2	10.38				
			0.117	11.070	1.295	15.528
222	10.5	11.76				
			0.072	12.540	0.903	16.431
263	3.3	13.32				
			0.013	13.590	0.177	16.608
278	2.0	13.86				
			0.010	14.190	0.142	16.750
301	1.0	14.52				
			0.005	14.850	0.074	16.824
322	0.5	15.18				
			0.003	15.510	0.047	16.871
354	0.2	15.84				
2. Regulated by Khlong Thap Ma Dam						
52	300.0	0.25				
			1.000	0.425	0.425	0.425
58	200.0	0.60				
			1.000	0.725	0.725	1.150
66	100.0	0.85				
			0.333	1.550	0.516	1.666
71	66.7	1.10				
			0.445	1.350	0.601	2.267
83	22.2	1.60				
			0.117	1.775	0.208	2.475
91	10.5	1.95				
			0.072	2.275	0.164	2.639
104	3.3	2.60				
			0.013	2.850	0.037	2.676
112	2.0	3.10				
			0.010	3.375	0.034	2.710
120	1.0	3.65				
			0.005	3.950	0.020	2.730
128	0.5	4.25				
			0.003	4.800	0.014	2.744
140	0.2	5.35				

Table 68 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK G (1/3)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
1. Unregulated						
307	300.0	9.3				
			1.000	10.500	10.500	10.500
332	200.0	11.7				
			1.000	15.600	15.600	26.100
372	100.0	19.5				
			0.333	22.600	7.526	33.626
396	66.7	25.7				
			0.445	31.400	13.973	47.599
458	22.2	37.1				
			0.117	38.950	4.557	52.156
495	10.5	40.8				
			0.072	42.350	3.049	55.205
563	3.3	43.9				
			0.013	44.350	0.577	55.782
584	2.0	44.8				
			0.010	45.300	0.453	56.235
626	1.0	45.7				
			0.005	46.050	0.230	56.465
658	0.5	46.4				
			0.003	46.600	0.140	56.605
689	0.2	46.8				
2. Regulated by Dok Krai Dam						
292	300.0	7.7				
			1.000	8.850	8.850	8.850
313	200.0	10.0				
			1.000	12.600	12.600	21.450
350	100.0	15.2				
			0.333	17.250	5.744	27.194
371	66.7	19.3				
			0.445	25.900	11.526	38.720
425	22.2	32.5				
			0.117	34.900	4.083	42.803
459	10.5	37.3				
			0.072	39.800	2.866	45.669
523	3.3	42.3				
			0.013	42.750	0.556	46.225
541	2.0	43.2				
			0.010	43.950	0.440	46.665
579	1.0	44.7				
			0.005	45.150	0.226	46.891
608	0.5	45.6				
			0.003	45.950	0.138	47.029
640	0.2	46.3				

(cont'd)

Table 68 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK G (2/3)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
3. Regulated by Dok Krai and Nong Pla Lai Dams						
265	300.0	5.3				
			1.000	6.200	6.200	6.200
285	200.0	7.1				
			1.000	8.900	8.900	15.100
318	100.0	10.7				
			0.333	12.150	4.046	19.146
339	66.7	13.6				
			0.445	18.550	8.255	27.401
386	22.2	23.5				
			0.117	27.400	3.206	30.607
418	10.5	31.3				
			0.072	35.300	2.542	33.149
480	3.3	39.3				
			0.013	40.050	0.521	33.670
495	2.0	40.8				
			0.010	41.800	0.418	34.088
530	1.0	42.8				
			0.005	43.200	0.216	34.304
557	0.5	43.6				
			0.003	44.400	0.133	34.437
593	0.2	45.2				
4. Regulated by Dok Krai, Nong Pla Lai and Khlong Yai Dams						
255	300.0	4.5				
			1.000	5.250	5.250	5.250
274	200.0	6.0				
			1.000	7.550	7.550	12.800
304	100.0	9.1				
			0.333	10.050	3.347	16.147
322	66.7	11.0				
			0.445	14.100	6.275	22.422
362	22.2	17.2				
			0.117	21.000	2.457	24.879
392	10.5	24.8				
			0.072	30.350	2.185	27.064
449	3.3	35.9				
			0.013	36.950	0.480	27.544
466	2.0	38.0				
			0.010	39.500	0.395	27.939
499	1.0	41.0				
			0.005	41.650	0.208	28.147
523	0.5	42.3				
			0.003	43.050	0.129	28.276
560	0.2	43.8				

(cont'd)

Table 68 RESIDUAL AVERAGE ANNUAL FLOOD DAMAGE FOR RAYONG RIVER, BLOCK G (3/3)

Flood Discharge	Expected Frequency Event per 100 years (%)	Flood Damages (฿ 10^6)	Events per Year within Interval	Average Damage per Interval (฿ 10^6)	Average Annual Flood Damages (฿ 10^6)	Accumulated Average Annual Damages (฿ 10^6)
5. Regulated by Dok Krai, Nong Pla Lai, Khlong Yai and Khlong Thap Ma Dams						
248	300.0	2.3				
			1.000	3.800	3.800	3.800
265	200.0	5.3				
			1.000	6.500	6.500	10.300
292	100.0	7.7				
			0.333	8.500	2.831	13.131
307	66.7	9.3				
			0.445	11.450	5.095	18.226
339	22.2	13.6				
			0.117	16.100	1.884	20.110
367	10.5	18.6				
			0.072	25.050	1.804	21.914
420	3.3	31.5				
			0.013	32.800	0.426	22.340
436	2.0	34.1				
			0.010	36.500	0.365	22.705
474	1.0	28.9				
			0.005	40.050	0.200	22.905
503	0.5	41.2				
			0.003	42.350	0.127	23.032
545	0.2	43.5				

Table 69 CHANNEL FACTORS FOR CHANNEL DESIGN OF RAYONG RIVER FOR CASE 1
(with K. Yai dam)

Stretches			Q (m^3/sec)	L (Km)	I	B (m)	b_1 (m)	hl (m)	H (m)	hd (m)
30-yr										
I	0.0(New)	- 13.40	2,450	3.6	1/2500	300	201.0	4.0	1.5	2.7
II	13.40	- 32.55	1,050	15.5	1/2500	150	58.0	2.6	3.2	4.2
III	32.55	- 40.85	650	5.2	1/1800	100	39.7	3.6	2.1	3.1
IV	40.85	- 42.80	490	1.2	1/900	100	13.6	4.0	1.7	2.5
V	42.80	- 47.00	280	2.4	1/900	100	10.5	4.2	0.8	1.6
VI	47.00	- 50.70	130	2.8	1/900	50	9.4	3.0	0.6	1.2
VII	50.70	- 55.90	130	5.2	1/520	50	9.4	2.5	0.7	1.3
VIII*	0.00	- 3.50	740	3.5	1/4500	200	90.0	1.0	4.2	5.2
IX*	3.50	- 8.00	660	4.5	1/1500	100	53.4	1.8	2.6	3.6
X*	8.00	- 11.05	660	3.5	1/600	100	34.0	2.0	1.9	2.9
10-yr										
I	0.0(New)	- 13.40	2,050	3.6	1/2500					
II	13.40	- 32.55	850	15.5	1/2500	150	37.0	2.6	3.2	4.2
III	32.55	- 40.85	530	5.2	1/1800	100	36.4	3.6	1.8	2.8
IV	40.85	- 42.80	400	1.2	1/900	100	12.0	4.0	1.5	2.3
V	42.80	- 47.00	230	2.4	1/900	100	9.5	4.2	0.6	1.4
VI	47.00	- 50.70	95	2.8	1/900	50	7.4	3.0	0.4	1.0
VII	50.70	- 55.90	95	5.2	1/520	50	7.4	2.5	0.4	1.0
VIII*	0.00	- 3.50	610	3.5	1/4500	200	74.0	1.0	4.2	5.2
IX*	3.50	- 8.00	550	4.5	1/1500	100	44.5	1.8	2.6	3.6
X*	8.00	- 11.05	550	3.5	1/600	100	28.3	2.0	1.9	2.9

Note * ···K. Thap Ma River

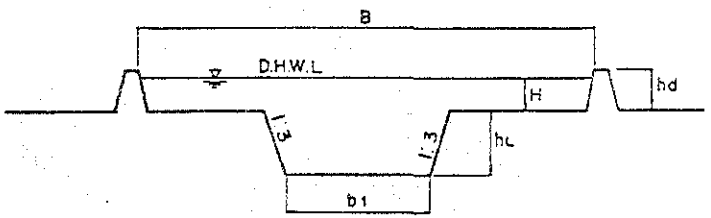

Table 70 CHANNEL FACTORS FOR CHANNEL DESIGN OF RAYONG RIVER FOR CASES 2 AND 3
(with K. Yai and Thap Ma dams)

Stretches			Q (m^3/sec)	L (Km)	I	B (m)	b_1 (m)	hl (m)	H (m)	hd (m)
30-yr										
I	0.0(New)	- 13.40	1,850	3.6	1/2,500	250	136.0	4.0	1.7	2.7
II	13.40	- 32.55	1,050	15.5	1/2,500	150	58.0	2.6	3.2	4.2
III	32.55	- 40.85	650	5.2	1/1,800	100	39.7	3.6	2.1	3.1
IV	40.85	- 42.80	490	1.2	1/900	100	13.6	4.0	1.7	2.5
V	42.80	- 47.00	280	2.4	1/900	100	10.5	4.2	0.8	1.6
VI	47.00	- 50.70	130	2.8	1/900	50	9.4	3.0	0.6	1.2
VII	50.70	- 55.90	130	5.2	1/520	50	9.4	2.5	0.7	1.3
VIII*	0.00	- 3.50	270	3.5	1/4,500	100	28.0	1.0	4.2	5.0
IX*	3.50	- 8.00	80	4.5	1/1,500	50	11.4	1.8	0.9	1.5
X*	8.00	- 11.05	80	3.5	1/600	50	7.6	2.0	0.5	1.1
10-yr										
I	0.0(New)	- 13.40	1,550	3.6	1/2,500	250	110.0	4.0	1.7	2.7
II	13.40	- 32.55	850	15.5	1/2,500	150	37.0	2.6	3.2	4.2
III	32.55	- 40.85	530	5.2	1/1,800	100	36.4	3.6	1.8	2.8
IV	40.85	- 42.80	400	1.2	1/900	100	12.0	4.0	1.5	2.3
V	42.80	- 47.00	230	2.4	1/900	100	9.5	4.2	0.6	1.4
VI	47.00	- 50.70	95	2.8	1/900	50	7.4	3.0	0.4	1.0
VII	50.70	- 55.90	95	5.2	1/520	50	7.4	2.5	0.4	1.0
VIII*	0.00	- 3.50	220	3.5	1/4,500	100	22.0	1.0	4.2	5.0
IX*	3.50	- 8.00	60	4.5	1/1,500	50	9.1	1.8	0.7	1.3
X*	8.00	- 11.05	60	3.5	1/600	50	6.8	2.0	0.4	1.0

Note * ... K. Thap Ma River

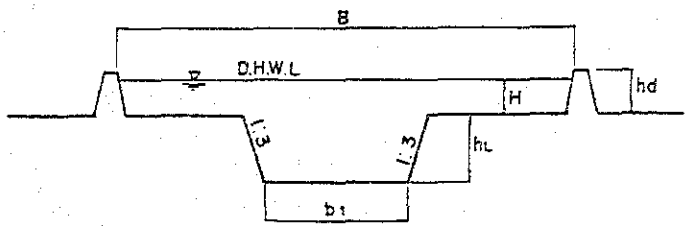

Table 71 WORK QUANTITY AND CONSTRUCTION COST OF RIVER IMPROVEMENT WORKS OF RAYONG RIVER, CASE 1 AND RISK LEVEL 1

$ 1 = ¥ 250 = ₿ 23

Item	Unit	Quantity	F.C (US$) Unit Cost	F.C (US$) Amount	L.C (₿) Unit Cost	L.C (₿) Amount	Remarks
				$\times 10^3$		$\times 10^3$	
A. Main Civil Works							
1. Preparation (9 × 7 %)	L.S	-	-	805		16,367	
2. Excavation	m^3	4,080,000	1.08	4,407	23.3	95,064	
3. Embankment	m^3	3,390,000	0.58	1,967	11.0	37,290	
4. Disposal	m^3	351,000	0.48	169	7.1	2,493	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485.0	26,190	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	444,000	1.08	480	23.3	10,346	
- Embankment	m^3	400,000	0.58	232	11.0	4,400	
8. Bridge	m^2	7,600	375	2,850	6,500	49,400	
9. Sub-total (2 ∿ 8)				11,499		233,809	
10. Miscellaneous (1 + 9) × 10 %	L.S	-	-	1,231	-	25,018	
Total				13,535		275,194	
B. Acquisition and Compensation	ha	481	-	-	347,600	167,196	
Total (A + B)				13,535		442,390	
C. Eng. Service and Administration (A + B) × 15 %				2,031		66,359	
D. Contingency (A + B + C) × 15 %				2,335		76,313	
Grand Total				17,901		585,062	₿ 996,785,000

Table 72 WORK QUANTITY AND CONSTRUCTION COST OF RIVER IMPROVEMENT WORKS OF RAYONG RIVER, CASE 1 AND RISK LEVEL 2

$ 1 = ¥ 250 = ฿ 23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				$\times 10^3$		$\times 10^3$	
A. Main Civil Works							
1. Preparation (9 × 7 %)	L.S	-	-	966		19,553	
2. Excavation	m^3	5,530,000	1.08	5,973	23.3	128,849	
3. Embankment	m^3	3,780,000	0.58	2,193	11.0	41,580	
4. Disposal	m^3	1,372,000	0.48	659	7.1	9,742	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485.0	26,190	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	450,000	1.08	486	23,3	10,485	
- Embankment	m^3	405,000	0.58	235	11.0	4,455	
8. Bridge	m^2	7,600	375	2,850	6,500	49,400	
9. Sub-total (2 ∿ 8)				13,790		279,327	
10. Miscellaneous (1 + 9) × 10 %	L.S	-	-	1,476	-	29,888	
Total				16,232		328,768	
B. Acquisition and Compensation	ha	474	-	-	347,600	164,763	
Total (A + B)				16,232		493,531	
C. Eng. Service and Administration (A + B) × 15 %				2,435		74,030	
D. Contingency (A + B + C) × 15 %				2,801		85,135	
Grand Total				21,468		652,696	฿ 1,146,460,000

Table 73 WORK QUANTITY AND CONSTRUCTION COST OF RIVER IMPROVEMENT WORKS OF RAYONG RIVER, CASE 2 AND RISK LEVEL 1

$ 1 = ¥ 250 = ฿ 23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				$\times 10^3$		$\times 10^3$	
A. Main Civil Works							
1. Preparation (9 × 7 %)	L.S	-	-	717		14,530	
2. Excavation	m^3	3,340,000	1.08	3,607	23.3	77,822	
3. Embankment	m^3	2,421,000	0.58	1,404	11.0	26,631	
4. Disposal	m^3	585,000	0.48	281	7.1	4,154	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485.0	26,190	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	444,000	1.08	480	23.3	10,345	
- Embankment	m^3	400,000	0.58	232	11.0	4,400	
8. Bridge	m^2	7,600	375	2,850	6,500	49,400	
9. Sub-total (2 ∼ 8)				10,248		207,568	
10. Miscellaneous (1 + 9) × 10 %	L.S	-	-	1,095	-	22,212	
Total				12,060		244,310	
B. Acquisition and Compensation	ha	383	-	-	347,600	133,130	
Total (A + B)				12,060		377,440	
C. Eng. Service and Administration (A + B) × 15 %				1,810		56,620	
D. Contingency (A + B + C) × 15 %				2,080		65,110	
Grand Total				15,950		499,170	฿ 866,020,000

Table 74 WORK QUANTITY AND CONSTRUCTION COST OF RIVER IMPROVEMENT WORKS OF RAYONG RIVER, CASE 2 AND RISK LEVEL 2

$ 1 = ¥ 250 = ₿ 23

Item	Unit	Quantity	F.C (US$)		L.C (₿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				$\times 10^3$		$\times 10^3$	
A. Main Civil Works							
1. Preparation (9 × 7 %)	L.S	-	-	779		15,868	
2. Excavation	m^3	3,832,000	1.08	4,139	23.3	89,286	
3. Embankment	m^3	3,462,000	0.58	2,008	11.0	38,082	
4. Disposal	m^3	23,000	0.48	11	7.1	163	
5. Revetment							
- Low water channel	m^2	54,000	15.5	837	485.0	26,190	
- High water channel	m^2	11,000	11.0	121	366.0	4,026	
6. Drainage sluice	nos.	20	21,800	436	230,000	4,600	
7. Backwater levee							
- Excavation	m^3	450,000	1.08	486	23.3	10,485	
- Embankment	m^3	405,000	0.58	235	11.0	4,455	
8. Bridge	m^2	7,600	375	2,850	6,500	49,400	
9. Sub-total (2 ∿ 8)				11,123		226,687	
10. Miscellaneous (1 + 9) × 10 %	L.S	-	-	1,188	-	24,255	
Total				13,090		266,810	
B. Acquisition and Compensation	ha	386	-	-	347,600	134,174	
Total (A + B)				13,090		400,984	
C. Eng. Service and Administration (A + B) × 15 %				1,960		60,146	
D. Contingency (A + B + C) × 15 %				2,260		69,170	
Grand Total				17,310		530,300	₿ 928,430,000

Table 75 WORK QUANTITY AND CONSTRUCTION COST OF RIVER IMPROVEMENT WORKS OF KHLONG THAP MA RIVER, CASE 3 AND RISK LEVER 1

$1 = ¥250 = ฿ 23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	92		1,867	
2. Excavation	m^3	200,000	1.08	216	23.3	4,660	
3. Embankment	m^3	800,000	0.58	464	11.0	8,800	
4. Disposal	m^3	0	0.48	0	7.1	0	
5. Revetment							
- Low water channel	m^2	9,800	15.5	152	485.0	4,753	
- High water channel	m^2	1,600	11.0	18	366.0	586	
6. Drainage sluice	nos.	4	21,800	87	230,000	920	
7. Backwater levee							
- Excavation	m^3	92,000	1.08	99	23.3	2,144	
- Embankment	m^3	82,000	0.58	48	11.0	902	
8. Bridge	m^2	600	375	225	6,500	3,900	
9. Sub-total (2 ∿ 8)				1,309		26,665	
10. Miscellaneous (1+9) × 10%	L.S	-	-	140	-	2,853	
Total				1,541		31,385	
B. Acquisition and Compensation	ha	60	-	-	347,600	20,856	
A. + B.				1,541		52,241	
C. Eng. service and Administration (A+B) × 15%				232		7,836	
D. Contingency (A+B+C) × 15%				266		9,012	
Grand Total				2,039		69,089	฿ 115,986,000

Table 76 WORK QUANTITY AND CONSTRUCTION COST OF RIVER IMPROVEMENT WORKS OF KHLONG THAP MA RIVER, CASE 3 AND RISK LEVEL 2

$1 = ¥250 = ฿ 23

Item	Unit	Quantity	F.C (US$)		L.C (฿)		Remarks
			Unit Cost	Amount	Unit Cost	Amount	
				× 10^3		× 10^3	
A. Main civil works							
1. Preparation (9. × 7%)	L.S	-	-	96		1,950	
2. Excavation	m^3	218,000	1.08	236	23.3	5,080	
3. Embankment	m^3	870,000	0.58	505	11.0	9,570	
4. Disposal	m^3	0	0.48	0	7.1	0	
5. Revetment							
- Low water channel	m^2	98,000	15.5	152	485.0	4,753	
- High water channel	m^2	1,600	11.0	18	366.0	586	
6. Drainage sluice	nos.	4	21,800	87	230,000	920	
7. Backwater levee							
- Excavation	m^3	92,000	1.08	99	23.3	2,144	
- Embankment	m^3	82,000	0.58	48	11.0	902	
8. Bridge	m^2	600	375	225	6,500	3,900	
9. Sub-total (2 ∿ 8)				1,370		27,855	
10. Miscellaneous (1+9) × 10%	L.S	-	-	147	-	2,980	
Total				1,613		32,785	
B. Acquisition and Compensation	ha	60	-	-	347,600	20,856	
A. + B.				1,613		53,641	
C. Eng. service and Administration (A+B) × 15%				242		8,046	
D. Contingency (A+B+C) × 15%				279		9,253	
Grand Total				2,134		70,940	฿ 120,022,000