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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF IRRIGATION AND DRAINAGE
MINISTRY OF AGRICULTURE
MALAYSIA

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

VOL. V

SUPPORTING REPORT – 2

AUGUST 1994

CTI ENGINEERING CO., LTD.

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DEPARTMENT OF IRRIGATION AND DRAINAGE
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MALAYSIA

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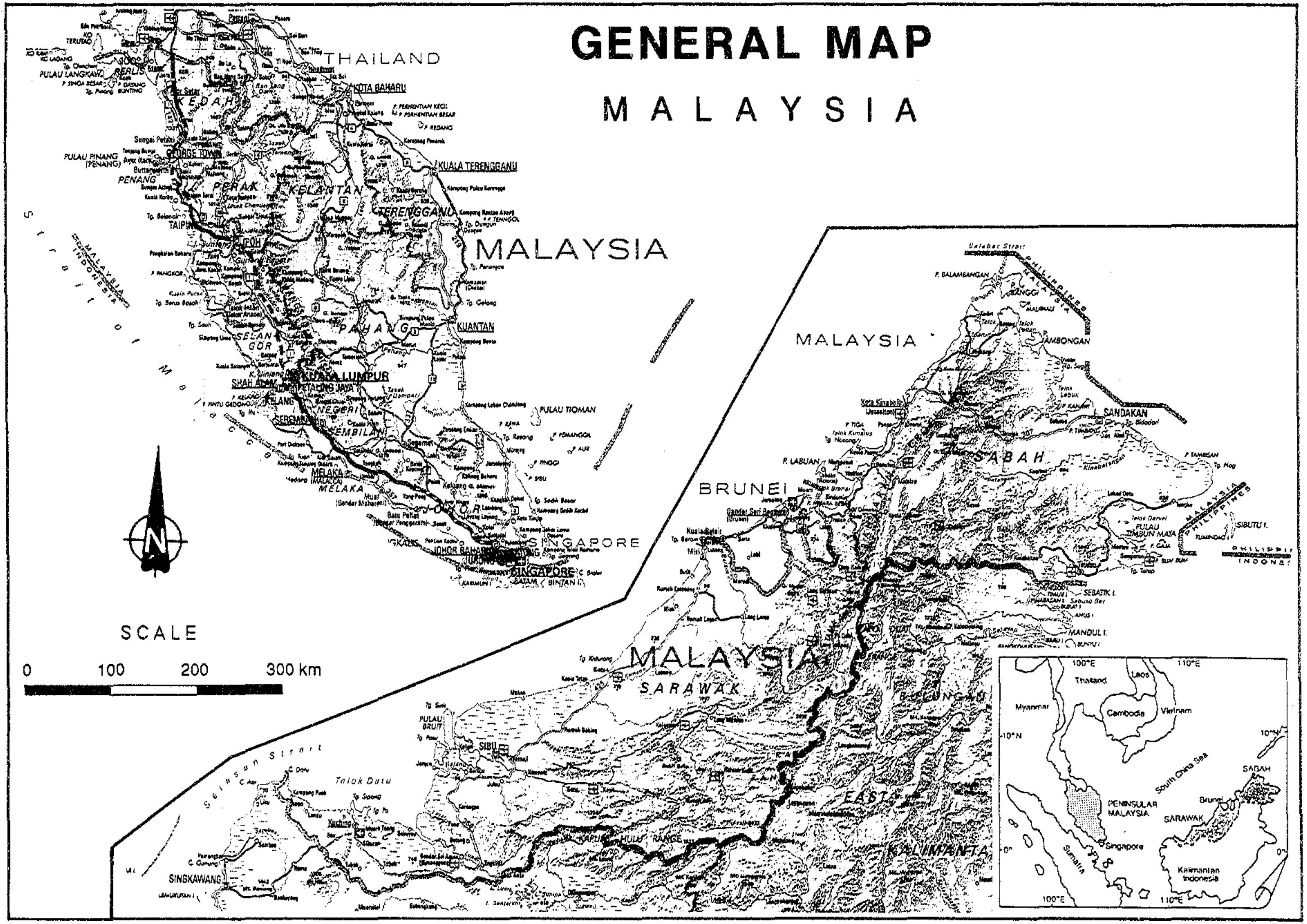
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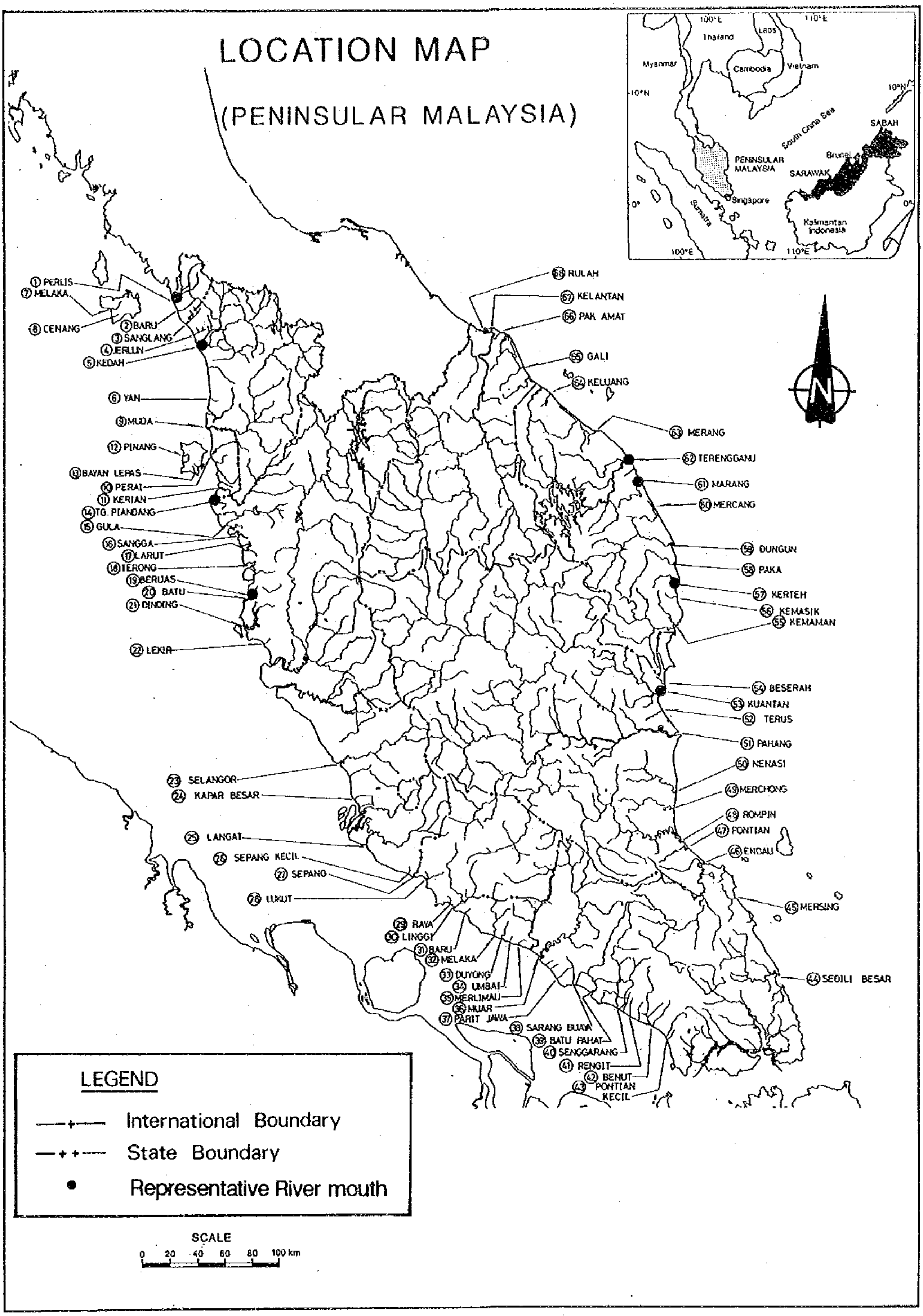
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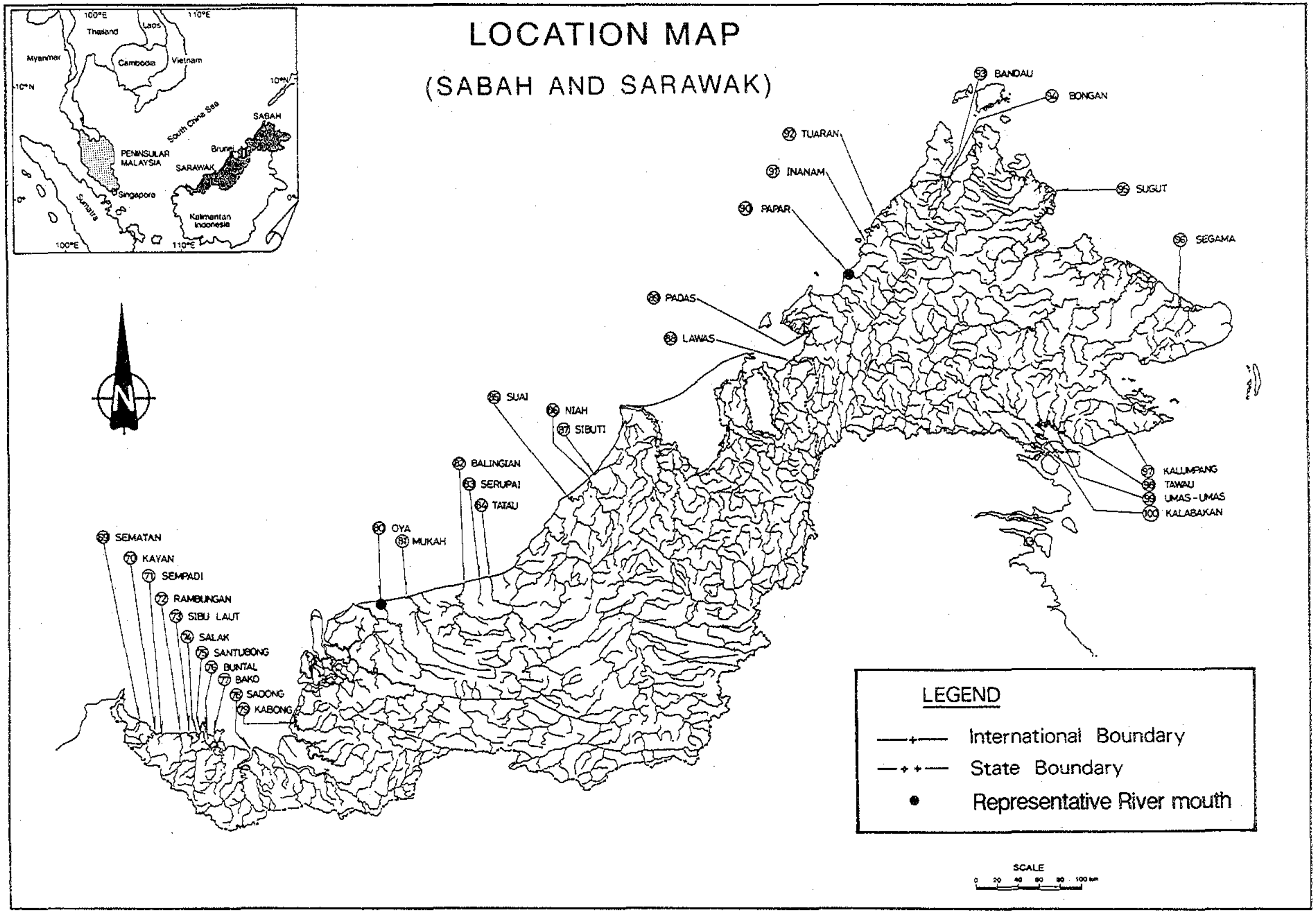
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6. PRELIMINARY DESIGN

THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA

SUPPORTING REPORT NO. 6

PRELIMINARY DESIGN

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SUPPORTING REPORT NO. 6

PRELIMINARY DESIGN

1. DESIGN CRITERIA FOR THE MASTER PLAN

1.1 General

There are several countermeasures to deal with the problem of river mouth clogging and they can be classified into structural method and non-structural method. Structural methods include the breakwater, the jetty, the training wall and the groin. The non-structural methods are dredging and the reservoir.

1.2 Design Base

The design of countermeasures is based on the following design manuals:

(1) Shore Protection Manual, U.S. Army Corps of Engineers, 1984.

(2) Technical Standards for Port and Harbour Facilities in Japan, The Overseas Coastal Area Development Institute of Japan, 1991.

(3) Dredging for Navigation, United Nations, 1991.

(4) Others (similar projects in Malaysia and Japan).

1.3 Design Criteria for Each Countermeasure

For the improvement of the representative river mouth, the alternative countermeasures studied are dredging, breakwater, jetty, training wall, groin and reservoir. The criteria for these countermeasures for river mouth improvement are discussed below.

Dredging

To design dredging, the dredging width, side slope, depth and stretch must be clarified. The criteria to figure out the dimensions are as follows:

(1) Width

A two-lane navigation channel is provided to assure safe navigation. The following equation to determine the width of the dredging channel, which is commonly used for dredging a two-lane navigation channel in Malaysia such as Kuala Sg. Sedili, is applied:

$$W = 10 * B$$

where,

W: dredging width (m)
B: ship beam (m)

However, for the river stretch where the river width is narrower than the above "W", the following equation for dredging a one-lane navigation channel is applied:

$$W = 5 * B$$

(2) Side Slope

The design side slope of the dredging channel varies from 1:2 to 1:5 depending on the soil conditions. In this study, the side slope of 1:3 used in the Kuantan River Mouth is applied to the sandy coast and that of 1:5 used in the Perlis River Mouth is applied to the muddy coast.

(3) Depth

The design depth below chart datum (CD) is decided by the draft of ship plus allowance. The allowance is decided considering the squat of ships, wave, siltation, etc., which can be hardly identified unless detailed observation data are available. Herein, the clearance of 97 cm, which is used for the dredging of the Kuantan River Mouth, is applied.

(4) Stretch

The dredging stretch seaward is decided by the distance from the river mouth to the point where the seabed height corresponds to the design water depth. That of the inner channel employs the shorter distance between the following two cases as long as the river has enough width for dredging by the design width; one is from the river mouth to the point where the river bed height corresponds to the design water depth, and the other is from the river mouth to the center of the port where landing facilities are supposed to be provided. Otherwise, the stretch is decided to be the point where the design dredging width corresponds to the river width.

Breakwater

The design features of breakwater are emphasized with the height, the length, the crown width of breakwater, the width between breakwater and the side slope. The following design criteria are applied to determine the design features of the breakwater.

(1) Height

The breakwater adopts the height of the mean high water level (MHWL) plus wave height and wave run-up clearance, which has been applied to the Kemasin Semarak Project.

(2) Length

To prevent waves from coming into the navigation channel, the length of the breakwater is as long as the affected stretch.

(3) Crown Width

The crown width of 10.0 m, enough to prevent overtopping waves, is applied.

(4) Width between Breakwaters

In case two parallel breakwaters are provided, the width between breakwaters is based on the average river width near the river mouth so as not to lower the flow capacity of the river mouth.

(5) Side Slope

The breakwater employs the side slope of 1 : 1.5, which has been adopted to Chedering, Terengganu and Pelabuhan Kuantan, Pahang.

Jetty

Since the structures are similar, the design criteria for jetties follows those of the breakwaters, except the determination of height.

(1) Height

The height of jetty adopts the mean high water level (MHWL) in accordance with the Shore Protection Manual. In the land-side, the height is 1.0 m higher than the beach elevation.

(2) Length

To prevent sedimentation of drifting sand or silt in the navigation channel, the length of the jetty is as long as the dredging stretch or beyond the critical depth of sedimentation. The shorter length is applied for the design.

(3) Crown Width

The crown width of 6.0 m is applied.

(4) Width between Jetties

In case two parallel jetties are provided, the width between jetties is based on the average river width near the river mouth so as not to lower the flow capacity of the river mouth.

(5) Side Slope

The side slope of 1:2 is applied to the muddy coast as adopted for the Perlis Project, and 1:1.5 for the sandy coast as adopted for the Kemasin Semarak Project.

Submerged Jetty

The design features of submerged jetties are emphasized with the height, the length, the crown width of jetty, the width between jetties and the side slope. The following design criteria are applied to determine the design features of the submerged jetty.

(1) Height

The height of the submerged jetty adopts the mean still level (MSL) which is the basis to prevent sedimentation in the navigation channel by overtopping sand or silt at ordinary wave.

(2) Length

The length of the submerged jetty is the same as the jetty, to block sedimentation of drifting sand or silt in the navigation channel.

(3) Crown Width

The crown width of the submerged jetty is 3.0 m.

(4) Width between Jetties

In case of two parallel jetties, the width between submerged jetties is as same as those of the jetty.

(5) Side Slope

The submerged jetty employs the side slope of 1:2 for the muddy coast, same as the jetty.

Training Wall

The design features of the training wall are emphasized with the height, the slope and the stretch. The criteria to determine the features are as follows:

(1) Height

The design height of the training wall is decided by the mean high water level (MHWL) or mean higher high water (MHHW) plus run-up.

(2) Side Slope

The side slope of 1:2.5 is applied as adopted for the Langkawi, Kedah Project.

(3) Stretch

The stretch of the training wall in inner channel side is decided considering the stretch influenced by the run-up of wave. That for the coastal zone is decided by the stretch to be protected judging from the land use conditions.

River Groin

The design features of the river groin are emphasized with the height, the slope, the length, the crown width and the interval. The criteria to determine the features are as follows:

(1) Height

The height of the river groin is generally decided by the mean high water level (MHWL) plus an additional height of 0.5 m to avoid unexpected influence to the bank in the neighboring area. Since the groin is provided in the tidal influence stretch, the mean still level (MSL) used in Malaysia is adopted in this study.

(2) Slope

The slope of 1:3 is adopted in accordance with the guidelines used in Malaysia.

(3) Length

The length corresponding to 1/10 up to 1/7 of the river width is applied.

(4) Crown Width

The crown width of 2.0 m is adopted.

(5) Interval

The interval corresponding to 1.7 to 3 times the groin length is applied.

Coastal Groin

There is no particular criteria for coastal groins where the design feature is emphasized with the height, the slope, the length, the crown width and the interval, because of different beach profiles, river mouth shape, incident wave conditions and alongshore sediment. Therefore, the criteria for jetties and groins are applied considering the similarity of structures and purpose.

(1) Height

The design seaward height is decided by the MHWS or MHHW for the purpose of accumulating sand. The landward height is the high water level plus up-rush.

(2) Slope

The slope of 1:1.5 is applied, same as the jetty in sandy coast.

(3) Length

The length is extended to the wave breaking line at dominant ordinary waves.

(4) Crown Width

The crown width of 2.0 m is applied, same as river groins.

(5) Interval

The interval between groins is equal to 2 to 3 times the groin length from bern crest to the seaward end.

Reservoir

Since a swampy area or a lagoon is used for the reservoir in alternative case study, the design of the reservoir shall consider the presently existing conditions such as the swampy area or the lagoon. Hence, the design criteria is not herein specified. The general layout of structure and navigation dredging are shown in Fig. 6.1-1 and 6.1-2.

1.4 Selection of Structural Type

The structural countermeasures proposed in the Master Plan for river mouth improvement are (a) Breakwater, (b) Jetty, (c) Submerged Jetty, (d) Training Wall, and (e) Groin. The first three are of various types and the selection of the optimum type is based on foundation conditions, exposure to wave action and availability of materials.

Foundation conditions may have a significant influence on the selection of the type of structure. For structural stability, a rock bottom is not suitable and a stone mat or geo-textile filter could be used for soft bottom. As the location of high waves, light structures such as timber for light rip-rap cannot be used; hence, wave exposure may control the selection of both the structural type and the detail geometrical design. The materials for the structure can be of stone, wooden, steel sheet pile, concrete caisson and sand-filled tube. Only the sand-filled tube is not available in Malaysia, but it is proposed in this project because it has been successfully used in coast protection works. Alternative types for each countermeasure are set up as below, and selection of the most suitable type is based on the comparison of costs.

(1) Breakwater (Fig. 6.1-3)

Alternative 1:	Rubble Mound
Alternative 2:	Double Steel Sheet Pile Wall with Top Concrete
Alternative 3:	Rubble Mound with Concrete Type

(2) Jetty (Fig. 6.1-4)

Alternative 1:	Double Concrete Sheet Pile Wall
Alternative 2:	Rubble Mound
Alternative 3:	Rubble Mound with Concrete Sheet Pile Wall
Alternative 4:	Rubble Mound with Sand-Filled Tube

(3) Submerged Jetty (Fig. 6.1-5)

Alternative 1:	Rubble Mound
Alternative 2:	Rubble Mound with Sand-Filled Tube
Alternative 3:	Sand-Filled Tube
Alternative 4:	Rubble Mound with Concrete Pile Wall

(4) Training Wall and Groin (Fig. 6.1-6)

1.5 Work Volume

Based on the design criteria and the results of the structural alternative study, the work volume of each countermeasure was calculated for each of the ten representative river mouths. The combination of countermeasures for each representative river mouth is as shown in Table 6.1-1 and the respective work volumes are given in Table 6.1-2 to Table 6.1-5. The work volume of countermeasures for the other 65 river mouths was obtained on the following concepts (refer to Table 6.1-6):

(1) Capital Dredging

The volume of capital dredging is related to the dredging stretch, width and depth of both the outer and inner channels. Since the only source of information available for the calculation of these parameters are the chart with a scale of 1/200,000 and the river mouth depth observed at the field investigation, the dredging volume for the outer channel is estimated based on the presumed parameters using the chart and the observed river mouth depth and design width, while the volume for the inner channel is estimated using the ratio between the volumes for the outer channel and the inner channel of the representative river mouth.

$$V = Vo + Vi$$

$$Vo = D \times B \times L \times k1$$

$$Vi = Vo \times k2$$

$$k1 = Vro / (Dr \times Br \times Lr)$$

$$k2 = Vri / Vro$$

where,

V, Vo, Vi : dredging volume for outer channel, inner channel and total of each river mouth.

Vro, Vri	:	dredging volume for outer channel and inner channel of representative river mouth based on bathymetric survey result.
D, B, L	:	dredging depth, width and stretch of each river mouth.
Dr, Br, Lr	:	average dredging depth, width and stretch of representative river mouth.
k1	:	ratio between volume of outer channel by bathymetric survey result and *DrBrLr*.
k2	:	ratio between volume of outer and inner channels of representative river mouth.

(2) Maintenance Dredging

The volume of maintenance dredging in the muddy coast is estimated based on the siltation rate at the representative river mouth and the dredging width and stretch. That in the sandy coast adopts the volume for the representative river mouth unless the volume of maintenance dredging is more than the volume of capital dredging. In case that the volume of maintenance dredging is more than the volume of capital dredging, the volume of maintenance dredging is assumed as the volume of capital dredging.

(3) Jetty

The volume of the jetty is estimated based on the stretch, width and depth of each river mouth using the following equation:

$$Jv = L \times kj1$$

$$kj1 = Jvr / Lr$$

where,

Jv, Jvr	:	volume of jetty proposed at each river mouth and representative river mouth.
L	:	length of jetty proposed at each river mouth.
Lr	:	length of jetty proposed at representative river mouth.
kj1	:	ratio between volume of jetty and Lr.

(4) Breakwater

As mentioned in the possible combination of countermeasures for representative river mouths, the breakwater in combination with the jetty and offshore breakwater is adopted.

The work volume of the breakwater is difficult to obtain from the currently available data, while the work volume of the jetty can be calculated in the manner mentioned above. Since the volume of breakwater is related to that of the jetty, the volume of the breakwater is calculated using the ratio between the jetty and the breakwater for the representative river mouth. As for the offshore breakwater, the ratio between the proposed and the representative river mouth widths is adopted.

(5) River Groin, Coastal Groin, Training Wall and Reservoir

The work volume of the river groin, the coastal groin, the training wall and the reservoir is hardly pertinent to mention with the data currently available.

The construction costs of river groin, coastal groin, training wall and reservoir are small amounts compared with the total construction cost. For example, the Marang River Mouth is calculated at 5% of the total construction cost. Therefore, these costs will not affect the project cost very much.

The volume for each river is calculated using the ratio between the construction cost and the total construction cost for the representative river mouth.

2. DESIGN CRITERIA FOR THE FEASIBILITY STUDY

2.1. Project Criteria

The major criteria outlined for the Project are:

(1) The Project should provide improved navigation conditions at the river mouth in terms of both accessibility and greater depth allowing vessels of increased draft;

(2) To maintain the navigation channel after capital constructions;

(3) From the sociological perspective, the Project should enhance the economic and social well-being of the local population; and

(4) From the environmental point of view, the Project should conserve the existing local conditions.

2.2 Design Base

2.2.1 Definitions

In the specifications and on the drawings the following terminologies are used:

(1) Head - the end of the breakwater most offshore.

(2) Trunk - the part of the breakwater between head and connection to the shore.

(3) Crest - the horizontal platform on top of the breakwater, i.e., the highest part.

(4) Core - the center inside of the breakwater.

(5) Cover-layer - the outside layer of the breakwater covering the side slopes and the crest.

(6) Underlayer - the layer covering the side slopes and top of the core, and forming the base of the cover-layer.

(7) Toe - a separate rubble formation supporting the cover-layer, or the deepest part of a cover-layer when no separate rubble formation exist.

(8) Berm - horizontal platform on top of the toe of a separately existing rubble formation.

2.2.2 Stability Equation

The structural design of the breakwater is based mainly on the Shore Protection Manual, Breakwater. The design of the structures is based on the results of the model tests carried out by the Ampang Research Station and past experiences with similar projects.

For determining the weight of armor units, Hudson's formula is used. Hudson (1953) developed this empirical formula to determine the weight of armor units based upon his analysis of model data obtained at the United States Army Corps of Engineers Waterways Experiment Station. The equation is given as follows:

$$W = \frac{W_r \cdot H^3}{K_D\ (S_r - 1)^3 \cot \alpha} = \frac{W_r \cdot H^3}{K_D\ (W_r/W_o - 1)^3 \cot \alpha}$$

where,

W	:	minimum weight of rubble or concrete block
W_r	:	mass density of armor unit
H	:	wave height
K_D	:	stability coefficient determined by the armoring material and damage rate
S_r	:	specific gravity of armor unit, relative to the water at the structure

α	:	slope of breakwater
W_o	:	mass density of seawater

However, for the armor material placed deeper than 1.5H beneath the still water surface, a weight smaller than that given by the formula may be used.

2.3 Design Criteria for Tanjung Piandang River Mouth

Tg. Piandang River Mouth is located in the west coast of Peninsular Malaysia. The river mouth is covered with siltation materials and the bed slope is very gentle.

2.3.1. Determination of Design Conditions

The countermeasure design conditions for Tg. Piandang River Mouth consider the following factors:

(1) Optimum Countermeasures

The optimum countermeasures selected for Tg. Piandang River Mouth are a combination of capital and maintenance dredging as mentioned in Volume 1, Master Plan Study. In addition, shipping jetty and bank protection are selected in the Feasibility Study because there are a number of small boats that cannot use their own jetty inside of the estuary beyond the dredging stretch in low tide. Bank protection works are placed in front of the proposed shipping jetty.

(2) Tide Level

The tide levels at Tg. Piandang River Mouth are as follows:

HAT	:	1.7 m (LSD)
MHWS	:	1.0 m
MHWN	:	0.3 m
MSL	:	0.1 m
MLHW	:	- 0.1 m

MLWS : - 1.0 m

LAT : - 1.5 m

(3) Design Boat Size

In the Master Plan Study Stage, the design boat size of 40 GRT was given as the design criteria. In the Feasibility Study, the design boat size is examined considering the present and the expected future distribution of boat size. Although the future distribution of boat size is difficult to project because of unknown factors involved such as fishing resources, market and government policy, DOF presumes the following future distribution:

Period	Distribution of Boat Size (No.)		
	10 GRT>	10-40 GRT	40-GRT<
Present	481	5	0
1995	476	0	0
2000	456	0	0
2005	438	0	0

According to this table, it is expected that only boats with the size of less than 10 GRT will engage in fishing at the Tg. Piandang River Mouth even in 2005. There is no plan to accommodate fishing boats from the other river mouths nearby. Therefore, the design boat size of 10 GRT with the length of 14.02 m, beam of 2.80 m, depth of 1.00 m and draft of 1.00 m is applied to the design of dredging in the Feasibility Study.

(4) Siltation Rate

To design the maintenance dredging volume, it is necessary to figure out the rate of annual siltation. Based on the siltation rate analysis, the rate of siltation is 0.9 m in the outer and 0.3 m in the inner channel.

2.3.2. Design Criteria

(1) Capital Dredging

To design dredging, the dredging width, side slope, depth and stretch must be clarified. The criteria to figure out the dimensions are as follows:

(a) Width

A two-lane navigation channel is provided to assure safety to navigation. The following equation to determine the width of the dredging channel, which is commonly used for dredging a two-lane navigation in Malaysia such as Kuala Sg. Sedili, is applied:

$$W = 10 * B = 28.0\ m$$

where,

W	:	dredging width (m)
B	:	ship beam (m)

(b) Side Slope

The design side slope od the dredging channel varies from 1:2 to 1:5 depending on the soil conditions. In this study, 1:5 is applied to the muddy coast.

(c) Depth

The design depth below chart datum (CD) is decided by the draft of ship plus allowance. The allowance is decided considering the squat of ship, draft, wave, siltation, etc., which can be hardly identified in the side. Herein, the clearance of 1.0 m is used for the 40 GRT and 0.5 m is applied for the 10 GRT design boat size.

(d) Stretch

The general idea is based on the Master Plan design; the dredging stretch seaward is decided by the distance from the river mouth to the point where the seabed height corresponds to the design water depth. That of the inner channel is decided to be the point where the design dredging width corresponds to the river width or until the public facilities such as jetty or gate structure.

<u>*Outer Channel*</u>

The dredging stretch seaward is decided by the distance from the river mouth to the point where the sea bed height corresponds to the design water depth. As shown in Fig. 6.2-1, the stretch will be 1.9 km from the river mouth in the Feasibility Study due to the reduction of the design dredging depth, while it was 2.3 km in the Master Plan Study.

<u>*Inner Channel*</u>

The dredging stretch of the inner channel is from the river mouth to the 0.9 km point where the design dredging width corresponds to the river width from the following reasons:

- The river width becomes narrower from some ten meters to a few meters at 0.9 km from the river mouth. A number of private jetties have been constructed on soft mud along the inner channel with only a few meters in width, where fishermen maneuver their boats for going out and coming in. Although it is desirable to dredge the whole stretch where the fishing boats navigate for landing their catch, dredging is not realistic for such a narrow channel because it causes collapse of private jetties and evacuation problem on houses and loading facilities.

- *The first private jetty is located 0.6 km inward from the river mouth* and fishermen can somehow land their catch even in low tide should common jetties be provided in the section around 0.6 km.

In this connection, common jetties are proposed to assure landing the catch even at low tide.

(2) Maintenance Dredging

The design criteria for maintenance dredging are the same as those for capital dredging. The calculation of maintenance dredging volume is based on the rate of siltation mentioned in the design conditions.

(3) Jetty

Jetty works will be located 0.55 km from the river mouth. They will be constructed of wooden pile and board; the length of the jetty will be 40.0 m from the bank and the number of jetty is three. The height of the ship jetty is MLWS+1.0 m for easier loading of fish. The facilities for fish loading consist of a simple house and an open space with pavement of reddish sand and gravel stone. An approach road is also provided from the existing road. (Refer to Fig. 6.2-2.)

(4) Bank Protection

Gabion mattress is used for bank protection in front of the jetty and the slope will follow the existing condition. The size of gabion mattress is 3.0 m by

1.5 m by 0.5 m. Stone masonry will be placed on top of the gabion mattress 0.3 m high.

2.3.3 Principal Features of Countermeasures for Tanjung Piandang River Mouth

Based on the above design criteria, the principal features of countermeasures for Tg. Piandang River Mouth are given as below, and the calculation of dredging volume is as shown in the annex hereto attached.

Design Boat Size	:	10 GRT
Countermeasures	:	Capital and Maintenance Dredging
Dredging Stretch		
- Inner Channel	:	0.9 km
- Outer Channel	:	1.9 km
Design Cross Section		
- Bottom Width	:	28 m
- Depth	:	LSD-2.5 m
- Slope Gradient	:	1:5
Volume of Capital Dredging		
- Inner Channel	:	58,900 m^3
- Outer Channel	:	56,500 m^3
Volume of Maintenance Dredging		
- Inner Channel	:	7,500 m^3
- Outer Channel	:	47,900 m^3
Common Jetty for Landing	:	1 unit
Bank Protection	:	1 unit

2.4 Design Criteria for Marang River Mouth

The Marang River Mouth is located in the east coast of Peninsular Malaysia. Vast quantities of sediment has been transported around the Marang river area and this material has either deposited as part of the growth of the delta or become part of the "system" which includes wave action and littoral processes. The predominant wave directions are NNE and ENE, and the deposited sediment is transported to the south direction. The proposed countermeasures for the improvement of Marang River Mouth are breakwater, jetty, river and coastal groin, reservoir and dredging.

2.4.1. Determination of Design Conditions

The design conditions for the breakwater, the jetty and the groin consider the following factors:

(1) Optimum Countermeasures

The proposed countermeasures for the improvement of Marang River Mouth are breakwater, jetty, river groin, coastal groin, reservoir and dredging, same as in the Master Plan Study.

(2) Wind

The DID has a database of deepwater waves around the territory of Malaysia that were observed on shipboard from 1949 to 1983. Wave statistics were obtained for each square area, called Marsden Square, with a scale of 1 degree (latitude) by 1 degree (longitude). To develop wind roses for each of the subject river mouths, the wave data of one or two closest squares were applied statistically. The dominant wave direction is NNE to ENE.

(3) Tide Level

The tidal difference between mean higher high water and mean lower low water is 2.1 m and surface ocean current is about 0.3 m/s in December from northwest to southeast. The tidal prism of the Marang River Mouth is large with a 20 km of the tidal intrusion stretch and the river width of 80 m. The tide levels at the Marang River Mouth are as shown below:

HAT	:	2.0 m (LSD)
MHHW	:	1.3 m
MHW	:	0.6 m
MSL	:	0.3 m
MLW	:	- 0.1 m
MLLW	:	- 0.8 m
LAT	:	- 1.3 m

(4) Wave

There are two kinds of design wave for this Study; one is for sediment movement and the other is for structural stability. Both design wave heights have to be used for their specific purposes.

(a) Design Wave for Sediment Movement

The design wave for sediment movement can be determined from two data; one is the survey data from October to November 1992 and the other is the statistical analysis of 34 year's data. In general, the design wave is not the biggest wave. It depends on the frequency and interval of waves. Here, the significant wave height of one-third can be introduced for the design wave height, which is a statistical term relating to the one-third highest waves of a given wave group and defined by the average of their heights.

Therefore, the design wave height H_o can be estimated as follows:

$$H_o = H(1/3) = 2.36\ m$$

$$T_o = T(1/3) = 8\ sec.$$

where;

H_o	:	design wave height (m)
T_o	:	design wave period (sec.)
$H(1/3)$	:	1/3 significant wave height (m)
$T(1/3)$	:	1/3 significant wave period (sec.)

(b) Design Wave for Structural Stability

The design wave for structural stability can be estimated at the critical situation, which is the existing highest wave in front of the structure. Therefore, the design wave depends on the water depth from the sea bottom. Tide is chosen as HWWL + 1.3 m (LSD), design wave period T_o = 8 sec., and design wave length L_o = 99.84 m. The design wave height is calculated as shown in the following table, using Fig. 6.2-3.

Depth (m)	h_b (m)	h_b (m)	H_b/h_b*1	H_b (m)	H_b/H_o*2	H_o (m)
-3.5	+4.8	0.048	0.73	3.50	1.10	3.18
-3.2	+4.5	0.045	0.73	3.20	1.11	2.96
-3.1	+4.4	0.044	0.73	3.21	1.11	2.89
-3.0	+4.3	0.043	0.74	3.18	1.12	2.84
-2.5	+3.8	0.038	0.74	2.81	1.14	2.46
-2.0	+3.3	0.033	0.75	2.47	1.16	2.13

Note: Elevation is based on LSD; *1 and *2 are based on Fig. 6.2-3; h_b = breaking wave depth; H_b = breaking wave height.

(5) Sea Bottom Conditions

Bed materials were sampled at 50 locations for the Feasibility Study, from 1.1 km upstream of the river mouth to 500 m offshore. Gradation analysis and specific gravity tests were conducted for these samples. Median diameter d50 of the samples is 0.356 mm and the predominant material is sand.

(6) Critical Water Depth for Sediment Movement

The structure to be constructed on a coast to prevent alongshore sediment has to consider the critical water depth for sediment movement *(h_c)*, because h_c is an important factor to determine the seaward length of the structure. Using several ways such as the calculation equation, comparison of bathymetric survey results and model experimentation, the approximate amount of h_c was determined at around -4.5 m (LSD), as follows:

(a) By Calculation

Using the formula below, the critical water depth *(hc)* for sediment movement is calculated.

$$Y_i = \alpha \left(\frac{H_o}{L_o}\right) \left(\frac{L_o}{d}\right)^n$$

where;

H_o	:	deepwater wave height (m)
L_o	:	deepwater wave length (m)
d	:	diameter of sand (mm)
Y_i	:	coefficient of h_c / L_o
h_c	:	critical water depth for sediment movement (m)
α, n	:	constant number
		assumed $(\alpha = 0.417, n = 1/3)$

By given:

$$H_o = 2.36\ m$$
$$L_o = 99.84\ m$$
$$d = 0.356\ mm$$

Y_i can be calculated as 0.644, using the figure

$$h_c / L_o = 0.055$$

Thus,

$$h_c = -5.49 \approx -5.5\ m\ (LSD)$$

(b) By Bathymetric Survey Results

By comparison of the bathymetric survey results, the critical water depth for sediment movement is determined at around -4.5 m (LSD).

(c) By Model Experimentation

From the observations of the model experimentation, the critical water depth is noticed at around -4.0 m (LSD).

(7) Design Boat Size

In the Master Plan Study Stage, the design boat size of 40 GRT was given as the design criteria. In the Feasibility Study, the design boat size is examined considering the present and the expected future distribution of boat size. Although the future distribution of boat size is difficult to project because of unknown factors involved such as fishing resources, market and government policy, DOF presumes the following future distribution:

Period	Distribution of Boat Size (No.)		
	10 GRT>	10-40 GRT	40 GRT<
Present	140	48*	0
1995	130	40	0
2000	110	30	10
2005	90	20	20

* Out of 48 fishing boats, the size of 42 boats are smaller than 21 GRT, while 6 are larger than 21 GRT.

According to this table, all boats are smaller than 40 GRT and the majority is less than 21 GRT against only 6 boats larger than 21 GRT. It is expected that boat sizes become larger and the total number decreases in the future. In the Feasibility Study, 40 GRT is selected as the design boat size with the length of 14.2 m, beam of 4.20 m, depth of 2.40 m and draft of 1.7 m; same as the Master Plan Study.

2.4.2. Determination of Cross Section

The following criteria are applied for determining the cross section:

(1) The crown height of a breakwater should be not less than 0.6 times the design significant wave height above the mean high water level.

(2) The crown width should be the width equivalent to three or more units of irregular armor blocks.

(3) If there are considerable overtopping waves, the armoring materials at the top of the breakwater becomes unstable. Therefore, the crown width should be sufficiently wide. The crown width of a sloping breakwater varies with the properties of the armoring materials and wave conditions. Therefore, the crown width should be preferably determined by proper model experiments.

(4) The gradient of the slope should be determined from the result of the stability calculation.

(5) In the foundation of a sloping breakwater, protection work against scouring and sand sucking should be provided.

2.4.3. Design Criteria

Breakwater

(1) Location

Breakwater will be constructed in the offshore part of north jetty, in order to prevent waves coming into the navigation channel.

The connection part between breakwater and jetty should be a gentle shift without any rough step. The design wave chosen was a high wave in the northeast monsoon season. Moreover, location should be based on the experimental results, wave direction and alignment of navigation.

(2) Alignment

High wave direction is concentrated between NNE and ENE, therefore, the alignment of breakwater should curve smoothly from the jetty until it becomes perpendicular to the NE direction, the center of both dominant wave directions.

(3) Length

The length of breakwater should prevent incident waves from coming into the navigation channel directly, and should consider smooth ship navigation. The design length is 200 m.

(4) Height of Crest

The design crest height is decided with the design wave conditions and the type of structures. In this Study, the structural type is rubble mound structure which has to consider wave run-up, transmission and overtopping. With non-breaking condition of design wave, transmitted wave is superimposed with overtopping wave, which does not obviously function at present. Therefore, crest height is considered to be 0.5 m as a clearance height.

To save on construction cost, and to apply the basic river mouth improvement plan, the breakwater may allow waves transmitted with the reduction of crest height by less than 40 cm. Here, the depth in front of the breakwater is -3.5 m (LSD), and the design wave height is around 3.2 m [refer to Subsection 2.4.1(4)].

The design crest height of the breakwater is calculated in the following procedure:

(a) Breaking Wave Condition

$h_b = 1.3\ m + 3.5\ m = 4.8\ m$; where 1.3 m is MHHW (+LSD) and 3.5 m is seabed height (-LSD).

$L_o = 1.56T^2 = 1.56 \times 8^2 \approx 100\ m$

$h_b / L_o = 4.8 / 100 = 0.048$

$I = 1/50$

where;

h_b	:	breaking wave depth
L_o	:	wave length
T	:	wave period
I	:	seabed gradient

(b) Breaking Wave Height

$h_b / H_b \approx 0.73$ (obtained from Fig. 6.2-3)

$H_b = 0.73 \times 4.8 = 3.5\ m$

$H_b / H_o = 1.1$ (obtained from Fig. 6.2-3)

$H_o = 3.5 / 1.1 = 3.2\ m$

where;

H_b : breaking wave height

H_o : deepsea wave height

The design crest height is decided based on the relation between H_t/H_o and R/H_o shown in Fig. 6.2-4, allowing 10% of the wave height to be transmitted to the breakwater considering the guidelines for fishing port planning:

$B / L_o = 6/100 = 0.06$

$H_{t'} / H_{o'} = 0.01$

$R / H_{o'} = 1$

$R = 3.2\ m$ *(above MHHW; about 5.0 m +LSD)*

where;

B : crest length (= 6 m)

$H_{t'}$	:	wave height to be transmitted (m)
$H_{o'}$	:	deepsea wave height (= H_o m)
R	:	crest height (m)

Jetty

(1) Location

To maintain the navigation channel and to prevent structural materials from falling into the channel, the jetty and the channel should have a certain distance. The head of the north jetty is connected to the breakwater and the shift part should curved smoothly. Under the above conditions and the result of model experiments, the location of the jetty will be decided.

(2) Width between Breakwater and Jetty

Considering of the rise of water level and the flow capacity at flood stage, the minimum width between structures is calculated at 90 m using the non-uniform flow theory. In this project, in consideration of the model experimental results and to obtain the maximum flushing effect of sediment between the breakwater and the south jetty, the width is decided at 90 m.

(3) Alignment

The main purpose is to prevent alongshore sediment from flowing into the navigation channel and to connect the jetty to the breakwater smoothly. Therefore, the jetty is aligned nearly parallel to the channel alignment and the angle between jetty and current flow should be bigger than 90 degrees.

(4) Length

Since the depth of sediment limit is - 4.5 m [refer to Subsection 2.4.1(6)] and the design depth for 40 GRT boat size is - 3.5 m, it is not necessary to have protection beyond the -3.5 m. In the land-side, the length of the jetty should consider the wave run-up to the shoreline and the wind-blown sand moving at the beach. Hence, the backshore length of the north jetty is 100 m and the seaside length is 380 m. The south jetty has the same backshore length for protection against wave action at the back of the structure, and the seaside length is 350 m.

(5) Height of Crest

In general, the height of crest land-side is 1.0 m higher than the highest elevation of the sandbar. The highest elevation at left bar is +1.5 m (LSD); hence, the height is +2.5 m. By considering the results of model experiments, the crest height is decided at 3.0 m.

At seaside, the head of the jetty is usually under water level, because the jetty is an isolated structure and only deals with the alongshore sediment. In this project, the jetty is connected to the breakwater and the wave direction is not regularly the same; thus, the crest of the jetty will be connected to the breakwater's crest at the same height. In addition, the land-side crest height will extend to the depth of -1.5 m in accordance with the analysis of the model experiment.

As to the head portion of the south jetty, the height is determined on the condition that some wave overtopping is allowed under the maximum possible wave (critical wave) in front of the jetty. By the same method used in the design of breakwater, the critical wave height (H_b) and the design wave height at -3.1 m (LSD) are given by using Fig. 3.3-3 as follows:

$$H_b = 3.21\ m$$

$$H_o = 2.89\ m$$

Generally, the crest height (H_s) of a jetty under the MHHW tidal condition is derived by using the following formula:

$$H_s = 1/2 * H_b + MHHW$$
$$= 1.605 + 1.3$$
$$= 2.905\ m\ (LSD)$$

From the wave diminishing effect, the jetty in terms of height and width is designed as follows:

Given: Width of Jetty *(B)* = 6.0 m
Design Wave Length *(L)* = 99.84 m

By using Fig. 3.3-4 and assuming that $R/H_{o'} = 0.5$ and $B/L = 0.06$, the wave transmission coefficient $H_t/H_{o'}$ is found to be around 0.13. This means that the design wave height is reduced to about 0.38 m at the inner seaside of the jetty.

Thus, $R = H_{o'} \times 0.5 = 1.445$; and $H_s = 1.445 + 1.3 = 2.745\ m\ (LSD)$.

By considering the above results, the crest height and the width of the south jetty are determined at +3.0 m (LSD) and 6.0 m, respectively.

River Groin

The design features of river groin are emphasized with the height, slope, crown width and interval. The height of river groin is decided to be the MHW plus an additional height of 0.5 m to avoid unexpected influence to the bank in the neighboring area. The slope of groin is 1:3 and the length is 40 m with 2.0 m of crown width. Moreover, the interval of 120 m corresponding to 3 times the groin length is applied.

Coastal Groin

The design features of the coastal groin is similar to the jetty in view of the similarity of structure and purpose. The design height is 2.0 m LSD, which is the MHHW plus uprush. The slope is 1:1.5, and the length is 50 m at land-side and 150 m offshore. The crown width is 4.0 m to prevent wave overtopping and for easier implementation of construction. The interval between groins is two times the groin length from berm crest to the seaward end.

Reservoir

The design of the reservoir is made considering the present condition of the lagoon. The civil works is mainly concerned with the stability of the slope to maintain the existing tidal volume effectively.

Dredging

For the design of dredging, the width, depth and stretch must be clarified. The concept is the same as the design criteria of dredging for Tg. Piandang River Mouth.

(1) Width

A two-lane navigation channel is provided to assure safety to navigation. For the 40 GRT boat size, the width of dredging is 45.0 m.

(2) Side Slope

Since the dredging materials at Marang River consist of sand, 1:3 is applied as the side slope.

(3) Depth

An allowance is provided considering the squat of ships, wave, siltation, etc. The clearance of 1.0 m is used for 40 GRT and 0.6 m for 20 GRT. Therefore, the design dredging depth is given as follows:

Boat Size	Boat Draft	Clearance	Design Dredging Depth
40 GRT	1.70 m	1.0 m	- 3.5 m (LSD)
30 GRT	1.40 m	0.8 m	- 3.0 m (LSD)
20 GRT	1.20 m	0.6 m	- 2.6 m (LSD)

(5) Stretch

The dredging stretch seaward is decided by the distance from the river mouth to the point where the seabed height corresponds to the design water depth. For the inner channel, the stretch is from the river mouth to the center of the port where landing facilities are supposed to be provided. Since the nearest landing facility from the Marang River Mouth is the LKIM's jetty, the dredging length at seaside shall be 460 m and at land-side, 790 m.

2.4.4 Principal Features of Countermeasures for Marang River Mouth

Based on the above design criteria, the principal features of countermeasures for Marang River Mouth are tabulated as follows, and the calculation of stone and dredging volume is given in the annex hereto attached. (Refer to Fig. 6.2-5 to 6.2-6.)

Design Boat Size	:	40 GRT
Countermeasures	:	Combination of Jetty, Breakwater, River and Coastal Groins, Reservoir, and Capital Dredging
Jetty (North Side)		
- Length	:	490 m
- Crown Width	:	6 m
- Design Height	:	LSD +3.0 to 5.0 m
- Slope Gradient	:	1:2; 1:1.5

Jetty (South Side)

- Length	:	450 m
- Crown Width	:	6 m
- Design Height	:	LSD +3.0 m
- Slope Gradient	:	1:2; 1:1.5

Breakwater

- Length	:	200 m
- Crown Width	:	6 m
- Design Height	:	LSD +5.0 m
- Slope Gradient	:	1:2; 1:1.5

River Groin	:	4 units
- Length	:	40 m
- Crown Width	:	2 m
- Design Height	:	LSD +0.8 m
- Slope Gradient	:	1:3

Coastal Groin	:	2 units
- Length	:	200 m
- Crown Width	:	4 m
- Design Height	:	LSD +2.0 m
- Slope Gradient	:	1:1.5

Reservoir	:	1 unit
- Reservoir Area	:	11.6 ha

Capital Dredging

- Length (Inner Channel)	:	790 m
- Length (Outer Channel)	:	460 m
- Bottom Width	:	45 m
- Dredging Depth	:	LSD -3.5 m

- Slope Gradient : 1:2
- Volume of Dredging
  (Inner Channel) : 79,700 m^3
  (Outer Channel) : 51,300 m^3

2.4.5 Stability of Structures

Stability of Armor Rock

Stability of armor rock can be calculated with the stability equation (refer to Subsection 2.2.2), and the design size of armor rock for breakwater and jetty is estimated as follows:

(1) Breakwater

The breakwater is designed at the depth of -3.5 m (LSD), the design wave height chosen is the critical wave H_b = 3.5 m [refer to Subsection 2.4.1(4)], the stability coefficient K_D is as shown in Table 6.2-1, and rough angular rock with each layer consisting of three units in thickness is placed at random. For non-breaking waves, the following factors are employed:

For Trunk, $K_D = 4.5$; for Head, $K_D = 4.2$

Given: $\cot\alpha = 2.0$, $W_r = 2.60$, $W_o = 1.025$, $H = 3.5\ m$

Applying the Hudson Equation:

(a) Head

$$W = \frac{W_r * H^3}{K_D\,(W_r / W_o - 1)^3 \cot\ \alpha}$$

$$= \frac{2.6 * 3.5^3}{4.2\ (2.52 - 1)^3 * 2} = 3.78\ tons$$

(b) Trunk

$$W = \frac{2.6 * 3.5^3}{4.5\ (2.52 - 1)^3 * 2} = 3.53\ tons$$

Therefore, armor rock is determined at around 5.0 tons at the most critical situation of the breakwater. For a rubble mound structure, the recommended ratio between W of a 3-layer section as suggested from the SPM (refer to Fig. 6.2-14), the recommended stone size and the design stone size are as follows.

	Ratio between W	Recommended Stone Size	Design Stone Size
Secondary Stone W2	W/10	500 kg	500 - 300 kg
Core Stone W2	W/200 - W/4000	20 - 1.25 kg	300 - 50 kg

(2) Jetty

The head of the jetty is designed at the depth of -3.1 m (LSD), the design wave height chosen is the critical wave H_b = 3.21 m [refer to Subsection 2.4.1(4)], and the stability coefficient K_D is the same as that of the breakwater. Therefore, the minimum weight of rubble rock W is calculated as follows:

(a) Head

$$W = \frac{W_r * H^3}{K_D (W_r / W_o - 1)^3 \cot \alpha}$$

$$= \frac{2.6 * 3.21^3}{4.2\ (2.52 - 1)^3 * 2} = 2.91\ tons$$

(b) Trunk

$$W = \frac{2.6 * 3.21^3}{4.5\ (2.52 - 1)^3 * 2} = 2.72\ tons$$

Thus, the armor rock at the jetty is selected using 3.0 tons at the head of jetties.

Stability Against Toe Erosion

From the results of the model experiment, erosion did not appear significantly at the toe of the structure. To maintain the stability of the structure, two methods are proposed: a berm and a protection sheet. The berm of the breakwater is designed at 3.0 m to minimize wave impact to the structure. Geo-textile with a width of 5.0 m is used as the protection sheet against toe erosion all around the structure. (Refer to Fig. 6.2-6.)

TABLES

Table 6.1-1 COMBINATION OF COUNTERMEASURES

River Mouth	Case No.	Combination of Applicable Countermeasures							
		Capital Dredging	Mainte- nance Dredging	Break Water	Jetty	Training Wall	River Groin	Costal Groin	Reservoir
Perlis	Case-1	yes	yes	-	-	-	-	-	-
	Case-2	yes	yes	-	yes*1	-	-	-	-
Kedah	Case-1	yes	yes	-	-	-	-	-	-
	Case-2	yes	yes	-	yes*1	-	-	-	-
Tg.Piandang	Case-1	yes	yes	-	-	-	-	-	-
	Case-2	yes	yes	-	yes*1	-	-	-	-
Beruas	Case-1	yes	yes	-	-	-	-	-	-
	Case-2	yes	yes	-	yes*1	-	-	-	-
Kuantan	Case-1	yes	yes	-	-	-	-	-	-
	Case-2	yes	-	-	yes	-	-	yes	-
Kerteh	Case-1	yes	yes	-	-	yes	-	-	-
	Case-2	yes	-	-	yes	-	-	yes	yes
Marang	Case-1	yes	yes	yes	-	yes	yes	-	-
	Case-2	yes	-	yes	yes	-	yes	yes	yes
Terengganu	Case-1	yes	yes	yes	-	-	yes	-	-
	Case-2	yes	-	yes	yes	-	yes	yes	-
Oya	Case-1	yes	yes	-	-	yes	-	-	-
	Case-2	yes	-	-	yes	-	-	yes	-
Papar	Case-1	yes	yes	-	-	yes	yes	-	-
	Case-2	yes	-	-	yes	-	yes	yes	yes

Note *1: Submerged jetty

Table 6.1-2 DESIGN WIDTH AND DEPTH OF DREDGING CHANNEL

River Mouth	Design Boat: Size (GRT)	Design Boat: Beam (m)	Design Channel Dimension: Width (m)	Design Channel Dimension: Bottom Level (LSD m)
1 Perlis	150	7.50	75.0	-5.2
2 Kedah	150	7.50	75.0	-5.2
3 Tg. Piandang	40	4.20	45.0	-3.7
4 Beruas	100	6.09	65.0	-4.4
5 Kuantan	200	7.30	75.0	-5.3
6 Kerteh	40	4.20	45.0	-3.8
7 Marang	40	4.20	45.0	-3.5
8 Terengganu	150	7.50	75.0	-4.7
9 Oya	40	4.20	45.0	-3.5
10 Papar	40	4.20	45.0	-3.6

Table 6.1-3 CAPITAL AND MAINTENANCE DREDGING VOLUME

RIVER MOUTH	STATE	DREDGING LENGTH OUTER km	DREDGING LENGTH INNER km	CAPITIAL DREDGING VOLUME OUTER *1000 m^3	CAPITIAL DREDGING VOLUME INNER *1000 m^3	TOTAL VOLUME *1000 m^3	AVERAGDREDGI DEPTH m	MAINTENANCE DREDGING VOLUME (PER YEAR) OUTER *1000 m^3	SUB.JE *1000 m^3	SUB.JE RESERVIOR *1000 m^3
1 PERLIS	PERLIS	4.80	0.70	1289.7	184.4	1474.11	3.57	360.9	162.4	
2 KEDAH	KEDAH	4.00	1.40	1004.4	219.4	1223.75	3.02	332.4	149.6	
3 TG. PIANDANG	PERAK	2.33	1.20	188.6	224.7	413.30	2.60	72.5	32.6	3.0
4 BRUAS	PERAK	2.17	1.58	359.8	324.3	684.10	2.81	128.2	57.7	
5 KUANTAN	PAHANG	3.80	0.00	617.7	0.0	617.70	2.17	216.0		
6 KERTEH	TERENGGAUN	0.96	1.40	120.2	158.7	278.90	2.63	120.2		
7 MARANG	TERENGGAUN	0.55	0.87	39.6	67.1	106.70	1.67	39.6		
8 TERENGGAUN	TERENGGAUN	1.10	2.87	167.1	813.2	980.30	3.29	167.1		
9 OYA	SARAWAK	1.30	0.00	31.3	0.0	31.30	0.54	31.3		
10 PAPAR	SABAH	0.45	1.03	46.0	133.9	179.90	2.70	46.0		
TOTAL						5990.06				
AVERAGE						2.50				

Table 6.1-4 DESIGN FEATURES OF BREAKWATER AND JETTY BY RIVER MOUTH

River Mouth	Design Wave		Toe		Design Elevation*1			Volume of Structure		
	Height (m)	Period (s)	Depth (m)	Length (km)	Breakwater (LSD m)	Jetty (LSD m)	Sub.jetty (LSD m)	Breakwater (1000m3)	Jetty (1000m3)	Groin
1 Perlis	0.75	6.00	-2.65	6.00			0.00		103.0	
2 Kedah	0.75	6.00	-2.65	5.00			0.00		104.4	
3 Tg.Piandang	0.75	6.00	-2.35	2.90			0.10		44.7	
4 Beruas	0.75	6.00	-2.35	1.30			0.20		16.1	
				1.50					21.2	
5 Kuantan	1.75	6.00	-1.49	3.00		1.60			161.5	46
6 Kerteh	1.75	6.00	-1.28	1.15		1.60			60.5	
7 Marang	1.75	8.00	-1.17	0.78	3.93	1.30		129.0	72.0	
				0.42				21.9*2	53.9	
8 Terengganu	1.75	8.00	-0.94	1.60	3.93	1.30		205.1	170.6	34
				0.90				68.7*2	136.8	
9 Oya	2.75	8.00	-1.32	1.05		0.60			17.9	
				1.90					61.1	
10 Papar	1.75	6.00	-1.27	0.70		1.10			4.4	
				0.50					9.5	

Note *1 : Top Elevation of Structure.
*2 : Combination with Jetty and Breakwater

Table 6.1-5 DESIGN FEATURES OF TRAINING WALL, GROIN AND RESERVOIR BY RIVER MOUTH

River Mouth	Trainin Wall	Groin Length			Reservoir	
	Length (m)	River (m)	Coastal (m)	Total (m)	Area (km2)	Length (km)
1 Perlis						
2 Kedah						
3 Tg. Piandang						
4 Beruas						
5 Kuantan			1,650	1,650		
6 Kerteh	850		300	300	0.308	5.0
7 Marang	650	160	200	360	0.116	4.1
8 Terengganu		720	450	1170		
9 Oya	1,300					
10 Papar	400	100	300	400	0.060	0.8

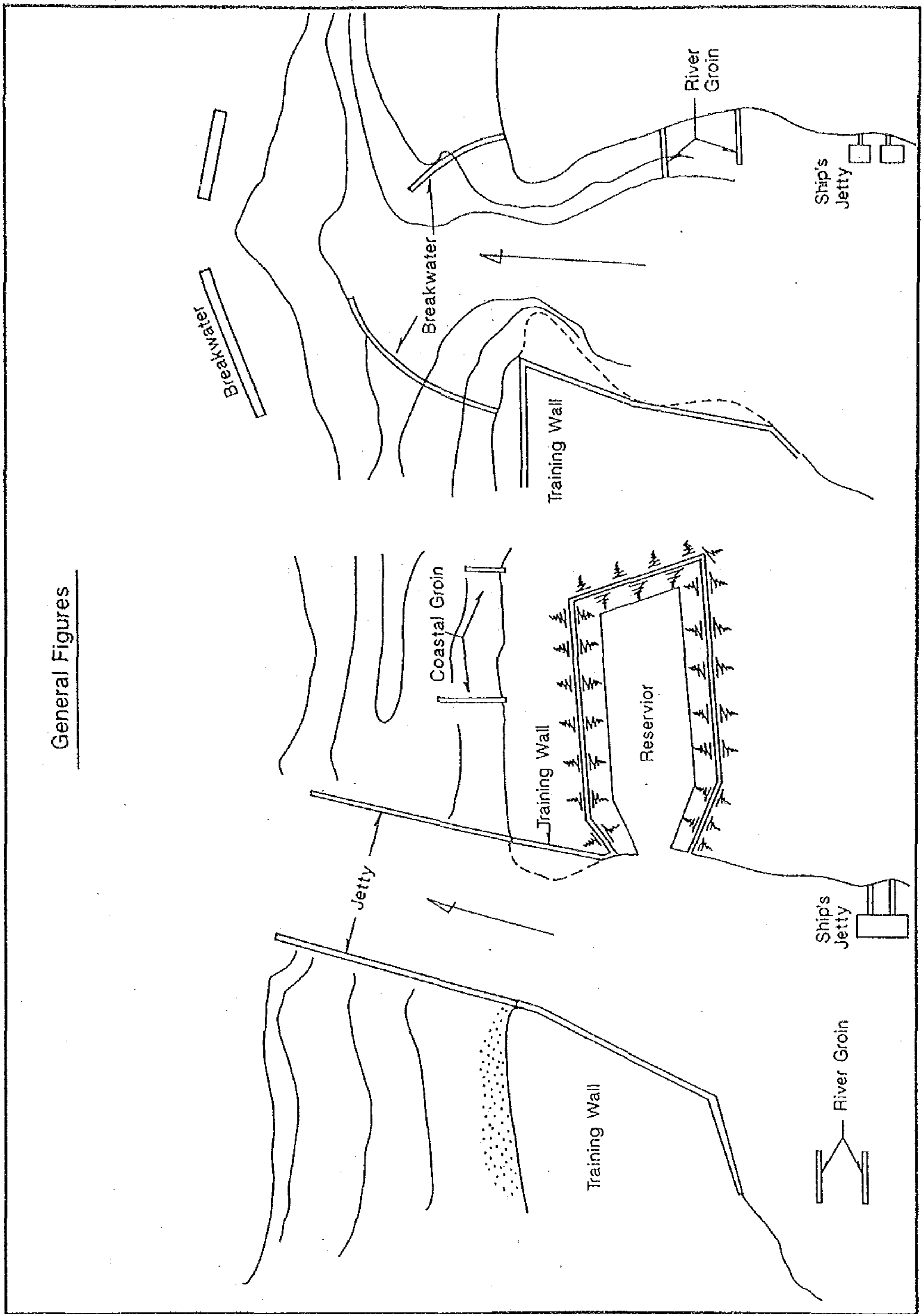
Table 6.1-6 WORK VOLUME AT OBJECTIVE RIVER MOUTHS

NO.	SERIAL	NAME	SLOPE	GRT	LENDGH (m)	WIDTH (m)	DEPTH (m)	KL	Vo (1000m3)	VI (1000m3)	V (1000m3)	Vm (1000m3)	Jv (1000m3
1	45	Mersing	0.00162	150	1,914	75	3.10	444.9	165.1	279.8	444.9	143.5	514.1
	48	Rompin	0.00187	70	775	65	1.45	73.1	27.1	46.0	73.1	27.1	208.3
	61	Marang		40	550	45	1.67	41.3	39.6	67.1	106.7	39.6	147.8
	81	Mukan	0.00120	70	1,625	65	1.95	206.0	76.4	129.5	206.0	76.4	436.5
	82	Balingian	0.00098	40	1,806	45	1.77	143.9	53.4	90.5	143.9	53.4	485.2
	84	Tatau	0.00189	40	778	45	1.47	51.5	19.1	32.4	51.5	19.1	208.9
2	44	Sedili Besar	0.00180	150	1,167	75	2.10	183.7	183.7	0.0	183.7	87.5	
	46	Endau	0.00165	200	1,745	75	2.88	377.0	377.0	0.0	377.0	130.9	
	50	Nenasi	0.00132	70	1,098	65	1.45	103.5	103.5	0.0	103.5	71.4	
	52	Terus	0.00135	40	1,681	45	2.27	171.8	171.8	0.0	171.8	75.7	
	53	Kuantan		200	3,800	75	2.17	617.7	617.7	0.0	617.7	285.0	
	55	Kemaman	0.00456	100	316	45	1.44	20.5	20.5	0.0	20.5	14.2	
	58	Paka	0.00194	40	552	45	1.07	26.6	26.6	0.0	26.6	20.3	
	59	Dungun	0.00232	100	879	65	2.04	116.6	116.6	0.0	116.6	57.2	
	60	Mercang	0.00550	40	449	45	2.47	49.9	49.9	0.0	49.9	20.2	
	92	Tuaran	0.00370	40	586	45	2.17	57.3	57.3	0.0	57.3	26.4	
3	56	Kemasik	0.00194	40	1,376	45	2.67	165.4	71.3	94.1	165.4	71.3	86.7
	57	Kerteh		40	960	45	2.63	113.5	120.2	158.7	278.9	120.2	60.5
	87	Sibuti	0.00156	40	686	45	1.07	33.0	14.2	18.8	33.0	14.2	43.2
4	1	Perlis		150	4,800	75	3.54	1274.9	1,289.7	184.4	1,474.1	360.0	
	25	Langat	0.00532	40	88	45	0.47	1.9	1.6	0.2	1.9	1.6	
	99	Umas-Umas	0.00370	40	46	45	0.17	0.4	0.3	0.0	0.4	0.3	
5	2	Baru	0.00127	40	1,945	45	2.47	216.2	98.6	117.5	216.2	87.5	
	3	Sang lang	0.00266	40	703	45	1.87	59.2	27.0	32.2	59.2	27.0	
	4	Jerlun	0.00250	40	628	45	1.57	44.4	20.2	24.1	44.4	20.2	
	6	Yan	0.00092	40	2,793	45	2.57	323.1	147.4	175.6	323.1	125.7	
	8	Cenang	0.00099	40	2,697	45	2.67	324.0	147.9	176.2	324.0	121.4	
	12	Pinang	0.00114	40	2,342	45	2.67	281.4	128.4	153.0	281.4	105.4	
	13	Bayan Lepas	0.00091	40	2,604	45	2.37	277.8	126.7	151.0	277.8	117.2	
	14	Tg.Piandang		40	2,330	45	2.60	272.8	188.6	224.7	413.3	104.9	
	20	Batu	0.00070	40	3,671	45	2.57	424.6	193.8	230.8	424.6	165.2	
	22	Lekir	0.00097	40	2,753	45	2.67	330.7	150.9	179.8	330.7	123.9	
	24	Kapar Besar	0.00150	40	1,780	45	2.67	213.9	97.6	116.3	213.9	80.1	
	26	Sepang Kecil	0.03750	40	23	45	0.87	0.9	0.4	0.5	0.9	0.4	
	27	Sepang	0.05465	40	1	45	0.07	0.0	0.0	0.0	0.0	0.0	
	30	Linggi	0.00600	40	445	45	2.67	53.5	24.4	29.1	53.5	20.0	
	31	Baru	0.00552	40	484	45	2.67	58.1	26.5	31.6	58.1	21.8	
	32	Melaka	0.00533	40	276	45	1.47	18.2	8.3	9.9	18.2	8.3	
	33	Duyong	0.00385	40	538	45	2.07	50.1	22.9	27.2	50.1	22.9	
	34	Umbai	0.00423	40	513	45	2.17	50.1	22.9	27.2	50.1	22.9	
	35	Merlimau	0.00667	40	340	45	2.27	34.8	15.9	18.9	34.8	15.3	
	37	Parit Jawa	0.00280	40	775	45	2.17	75.7	34.5	41.1	75.7	34.5	
	40	Senggarang	0.00288	40	719	45	2.07	67.0	30.6	36.4	67.0	30.6	
	41	Rengit	0.00150	40	1,447	45	2.17	141.3	64.5	76.8	141.3	64.5	
	42	Benut	0.00064	40	2,922	45	1.87	245.9	112.2	133.7	245.9	112.2	
	43	Pontian Kecil	0.00102	40	1,637	45	1.67	123.0	56.1	66.9	123.0	56.1	
	98	Tawau	0.00370	40	722	45	2.67	86.7	39 6	47.1	86.7	32.5	
6	69	Sematan	0.00109	40	1,073	45	1.17	56.5	10.2	46.3	56.5	10.2	65.2
	70	Kayan	0.00133	40	729	45	0.97	31.8	5.7	26.1	31.8	5.7	44.3
	80	Oya		40	1,300	45	2.97	173.5	31.3	142.2	173.5	15.5	79.0
7	11	Kerian	0.00056	40	1,554	45	0.87	60.8	32.0	28.8	60.8	32.0	
	15	Gula	0.00055	70	3,727	65	2.05	496.7	261.2	235.4	496.7	242.3	
	16	Sangga	0.00043	40	2,488	45	1.07	119.8	63.0	56.8	119.8	63.0	
	17	Larut	0.00044	40	3,341	45	1.47	221.0	116.2	104.8	221.0	116.2	
	18	Terong	0.00094	40	(245)	45	-0.23	2.5	1.3	1.2	2.5	1.3	
	19	Beruas		100	2,170	65	2.81	395.9	359.8	324.3	684.1	141.1	
	23	Selangor	0.00069	40	2,130	45	1.47	140.9	74.1	66.8	140.9	74.1	
	36	Muar	0.00095	40	600	45	0.57	15.4	8.1	7.3	15.4	8.1	
	39	Batu Pahat	0.00500	40	334	45	1.67	25.1	13.2	11.9	25.1	13.2	
	76	Buntal	0.00080	40	2,588	45	2.07	241.0	126.8	114.3	241.0	116.4	
	77	Bako	0.00065	40	2,262	45	1.47	149.6	78.7	70.9	149.6	78.7	
	78	Sadong	0.00047	40	2,702	45	1.27	154.4	81.2	73.2	154.4	81.2	
	89	Padas	0.00455	40	411	45	1.87	34.6	18.2	16.4	34.6	18.2	
	100	Kalabakan	0.00370	40	127	45	0.47	2.7	1.4	1.3	2.7	1.4	
8	51	Pahang	0.00210	70	643	65	1.35	56.4	9.6	46.8	56.4	9.6	124.9
	62	Terengganu		150	1,100	75	3.29	271.6	167.1	813.2	980.3	8.4	213.7
	67	Kelantan	0.00535	100	307	65	1.64	32.7	5.6	27.1	32.7	5.6	59.6
	95	Sugut	0.00370	40	19	45	0.07	0.1	0.0	0.0	0.1	0.0	3.7
9	38	Sarang Buaya	0.00200	40	785	45	1.57	55.5	11.6	43.9	55.5	11.6	24.2
	63	Merang	0.00205	40	1,205	45	2.47	133.9	28.0	105.9	133.9	28.0	37.2
	66	Pak Amat	0.00128	40	2,008	45	2.57	232.2	48.6	183.6	232.2	48.6	61.9
	90	Papar		40	450	45	3.30	66.9	46.0	173.9	219.9	46.0	13.9
10	5	Kedah		150	4,000	75	3.02	906.5	1,004.4	219.4	1,223.8	300.0	
	9	Muda	0.00082	40	2,037	45	1.67	153.0	125.6	27.4	153.0	91.6	
	88	Lawas	0.00143	40	1,168	45	1.67	87.8	72.0	15.7	87.8	52.6	

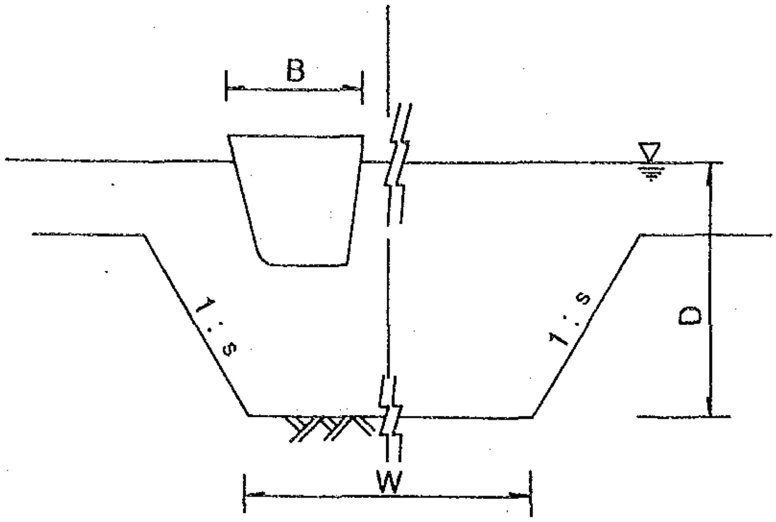
Table 6.2-1 STABILITY COEFFICIENTS

No-Damage Criteria and Minor Overtopping							
			Structure Trunk		Structure Head		
Armor Units	n	Placement	K_D		K_D		Slope
			Breaking Wave	Nonbreaking Wave	Breaking Wave	Nonbreaking Wave	Cot θ
Quarrystone							
Smooth rounded	2	Random	*1.2*	2.4	*1.1*	1.9	1.5 to 3.0
Smooth rounded	>3	Random	*1.6*	*3.2*	*1.4*	*2.3*	
Rough angular	1	Random		*2.9*		*2.3*	
Rough angular	2	Random	2.0	4.0	*1.9* *1.6* 1.3	3.2 2.8 2.3	1.5 2.0 3.0
Rough angular	>3	Random	*2.2*	*4.5*	*2.1*	*4.2*	
Rough angular	2	Special	5.8	7.0	*5.3*	6.4	
Parallelepiped	2	Special	7.0 - 20.0	*8.5 - 24.0*	--	--	
Tetrapod and Quadripod	2	Random	7.0	8.0	*5.0* *4.5* *3.5*	6.0 5.5 4.0	1.5 2.0 3.0
Tribar	2	Random	*9.0*	10.0	*8.3* *7.8* 6.0	9.0 8.5 6.5	1.5 2.0 3.0
Dolos	2	Random	15.8	31.8	*8.0* 7.0	*16.0* *14.0*	2.0 3.0
Modified cube	2	Random	*6.5*	7.5	----	*5.0*	5
Hexapod	2	Random	*8.0*	9.5	*5.0*	*7.0*	5
Toskane	2	Random	*11.0*	22.0	--	--	5
Tribar	1	Uniform	12.0	15.0	*7.5*	*9.5*	5
Quarrystone (K_{RR}) Graded angular	-	Random	2.2	2.5	--	--	

FIGURES



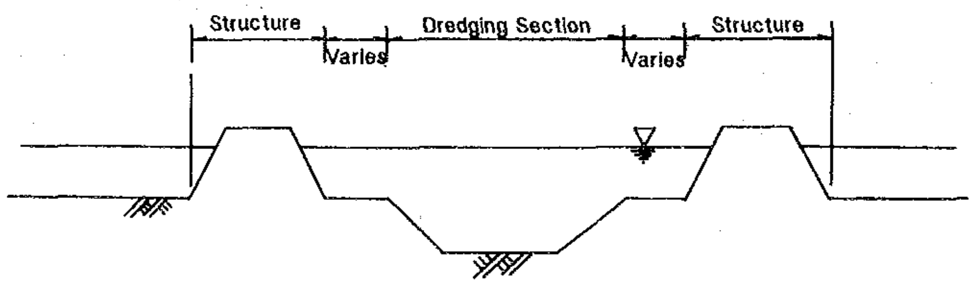
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	GENERAL LAYOUT OF COUNTERMEASURES
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.1-1



Dredging Cross Section

No. of Lane	Width (W)
1	5B
2	10B

	Side Slope(s)
Muddy Beach	5
Sandy Beach	3

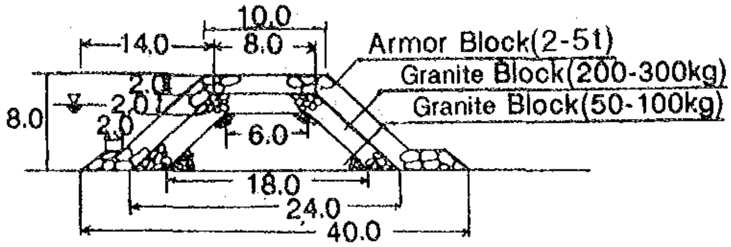


General Section

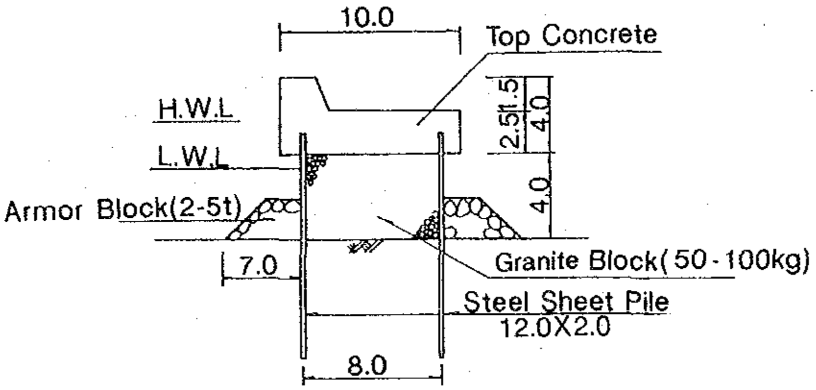
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	GENERAL CROSS SECTION OF DREDGING
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.1-2

BREAKWATER

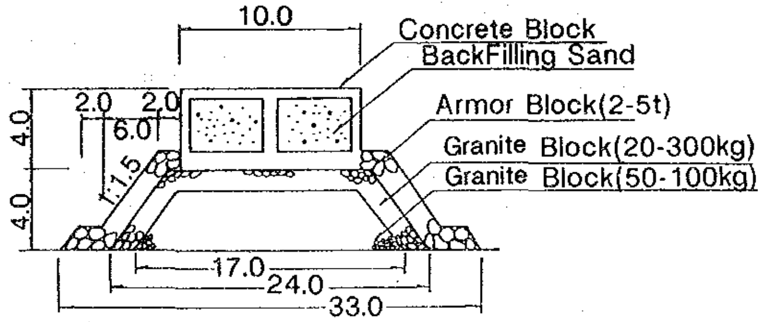
(1) Breakwater Rubble Mound with Cassion Cross Section



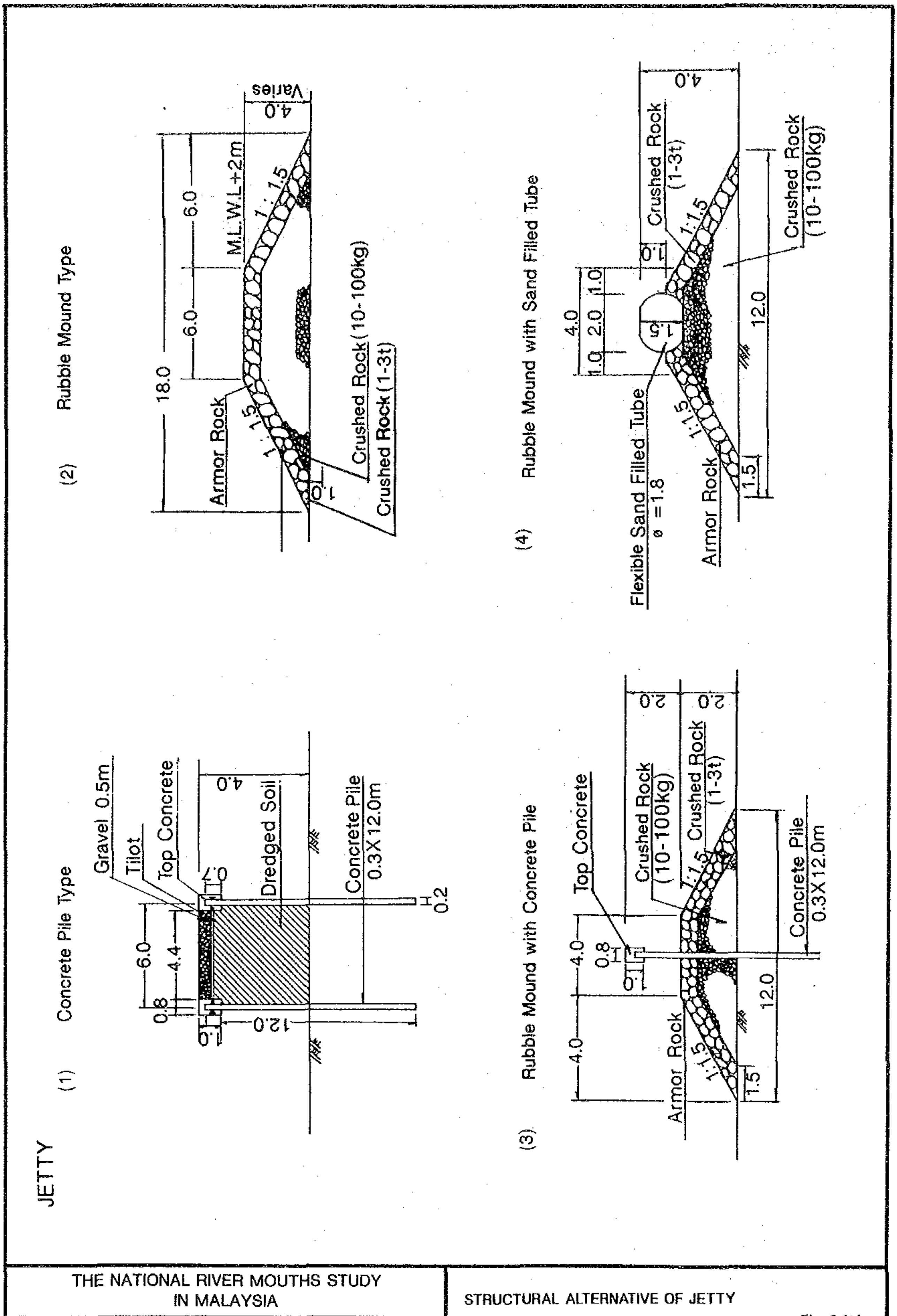
(2) Breakwater Sheet Pile with Top Concrete Cross Section



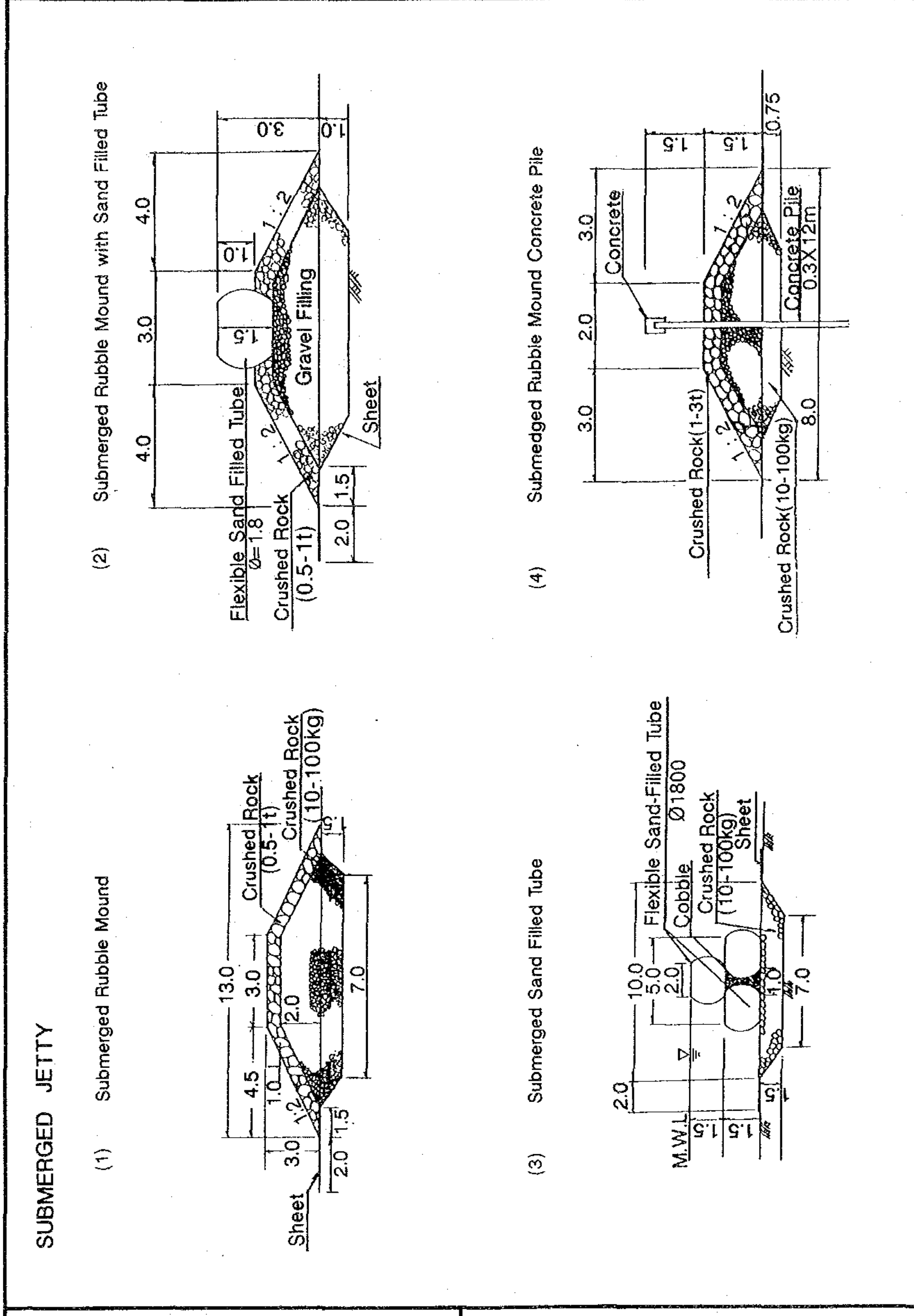
(3) Breakwater Rubble Mound Type Cross Section



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	STRUCTURAL ALTERNATIVE OF BREAKWATER WALL AND GROIN
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.1-3



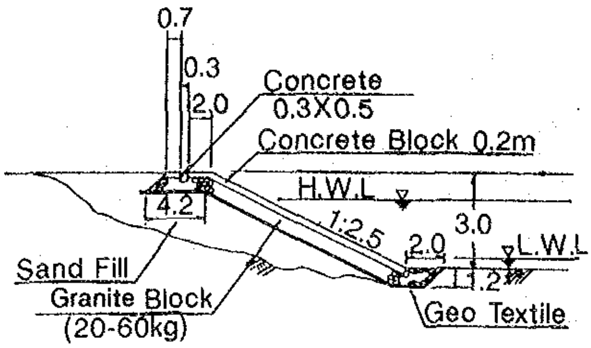
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	STRUCTURAL ALTERNATIVE OF JETTY
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.1-4



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	STRUCTURAL ALTERNATIVE OF SUBMERGED JETTY
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.1-5

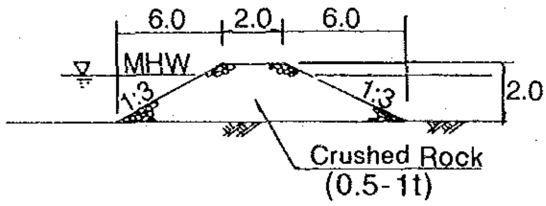
TRIANING WALL

Training Wall Cross Section

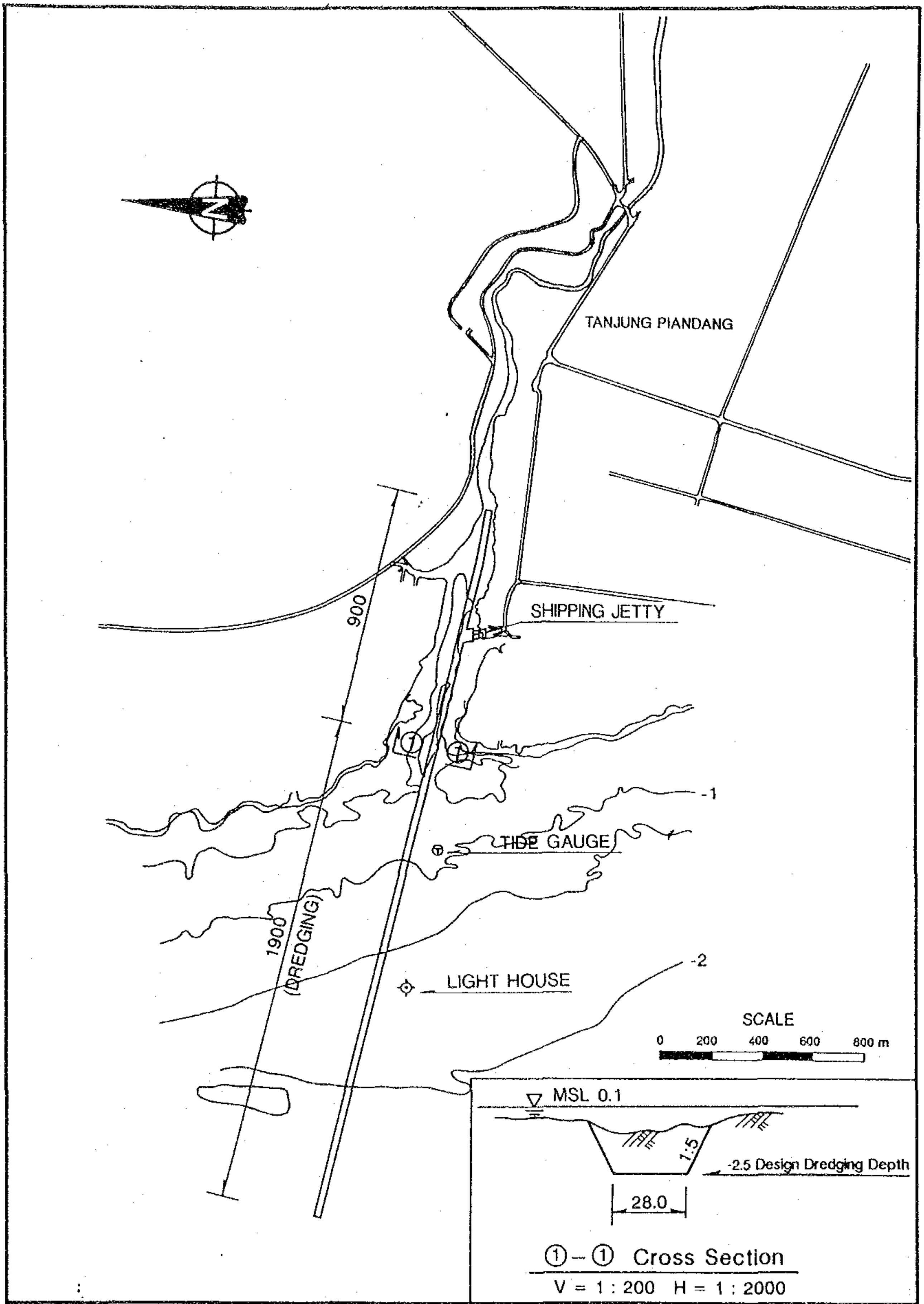


GROIN

Groin Cross Section



THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	STRUCTURAL CROSS SECTION OF TRAINING
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.1-6

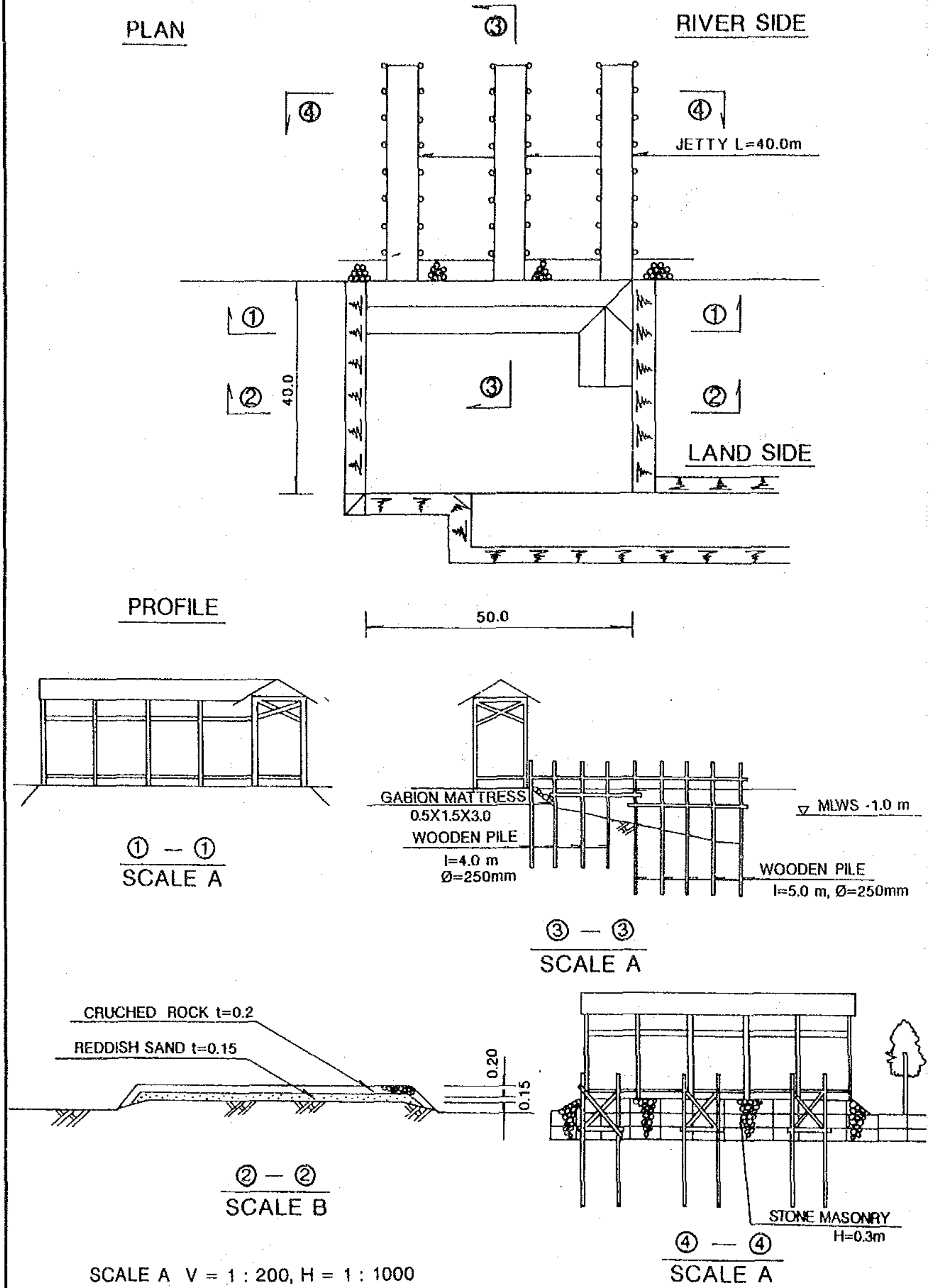


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

JAPAN INTERNATIONAL COOPERATION AGENCY

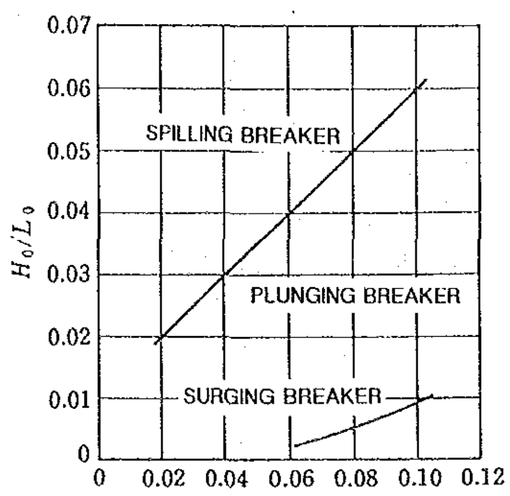
GENERAL LAYOUT OF OPTIMUM COUNTERMEASURES AT TG. PIANDANG RIVER MOUTH

Fig. 6.2-1

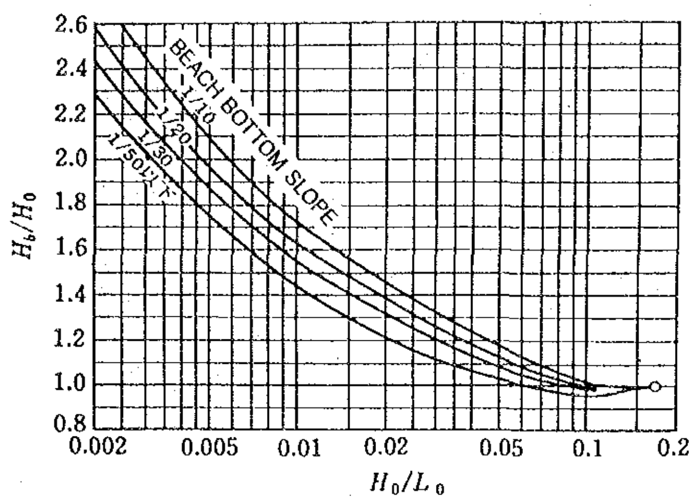


SCALE A V = 1 : 200, H = 1 : 1000
SCALE B V = 1 : 100, H = 1 : 1000

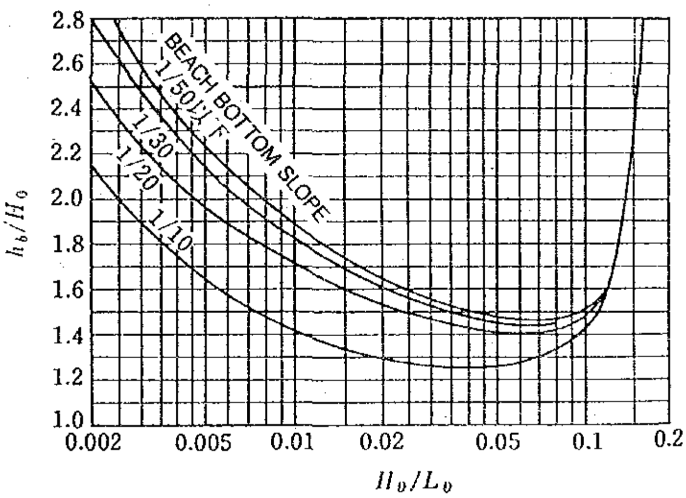
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	GENERAL LAYOUT OF SHIPPING JETTY
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.2-2



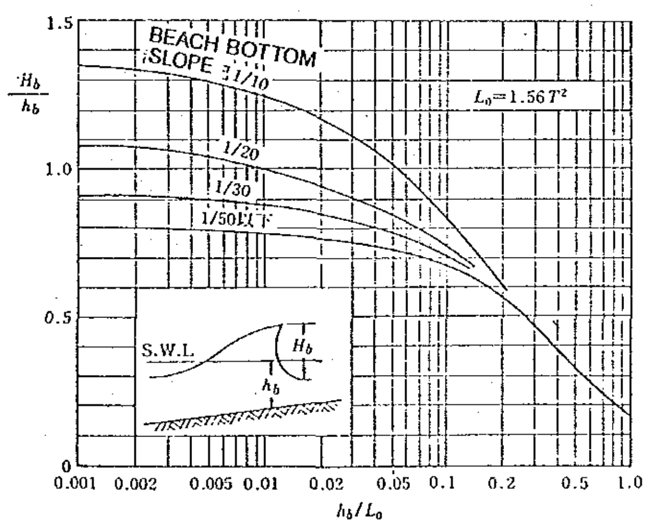
TYPE OF BREAKERS



DEPTH OF BREAKING

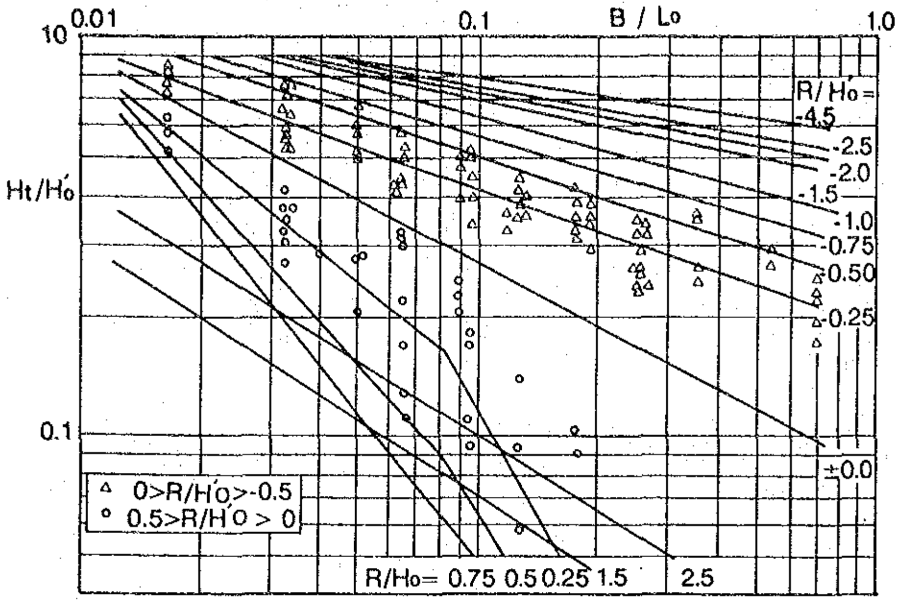


WAVE HEIGHT OF BREAKERS

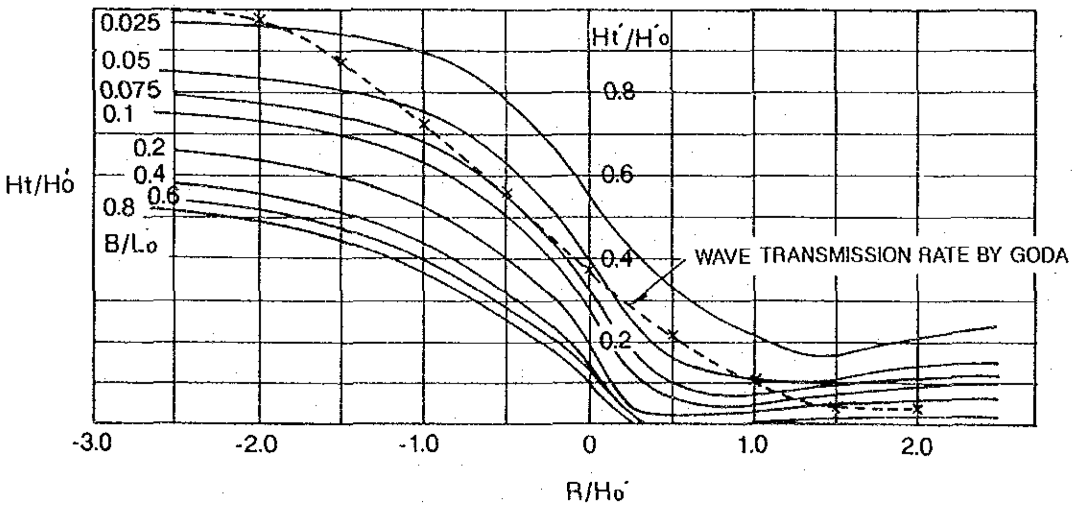


BREAKING LIMIT

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	ESTIMATION CHART OF WAVE HEIGHT OF BREAKERS
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.2-3

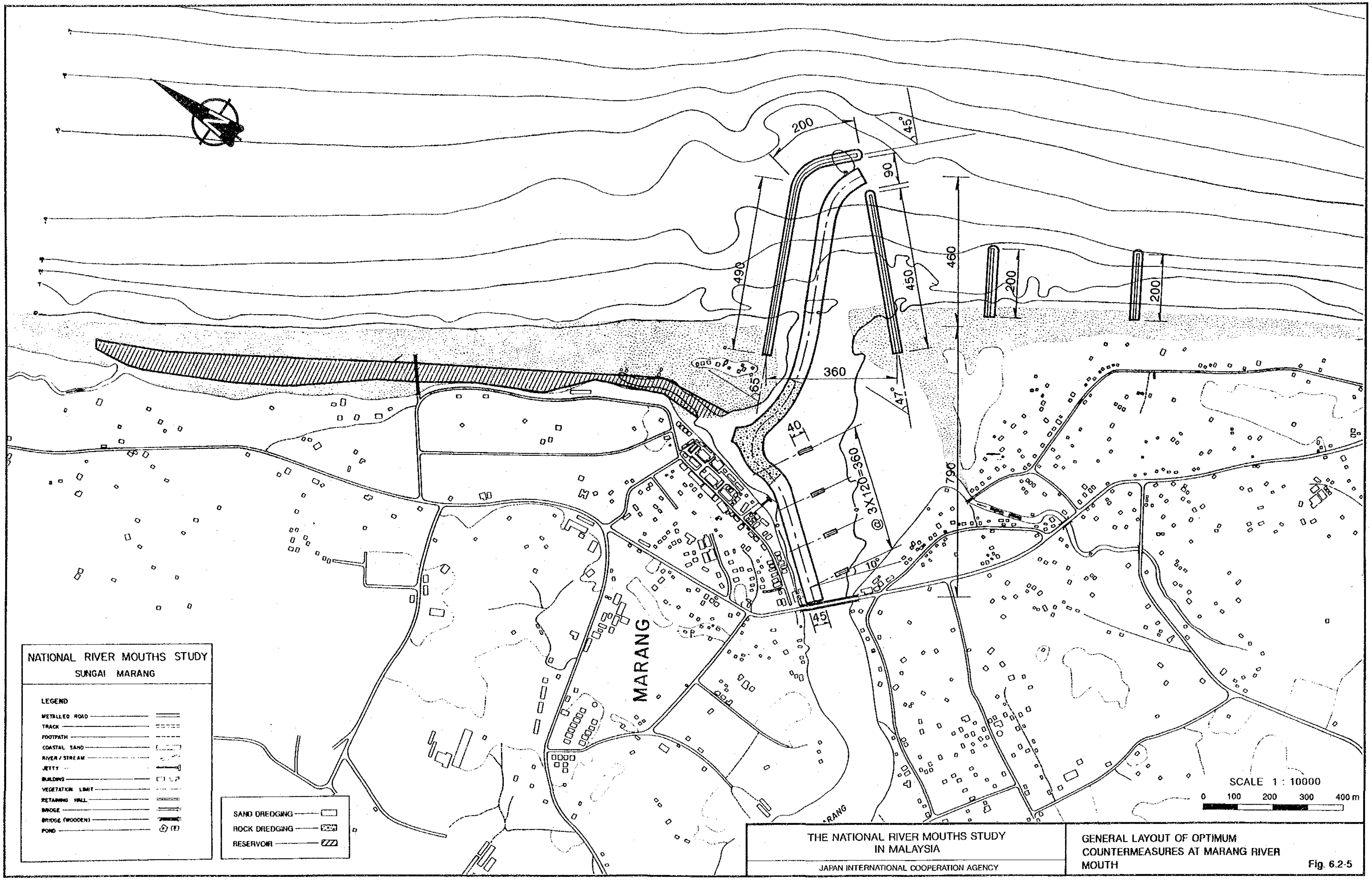


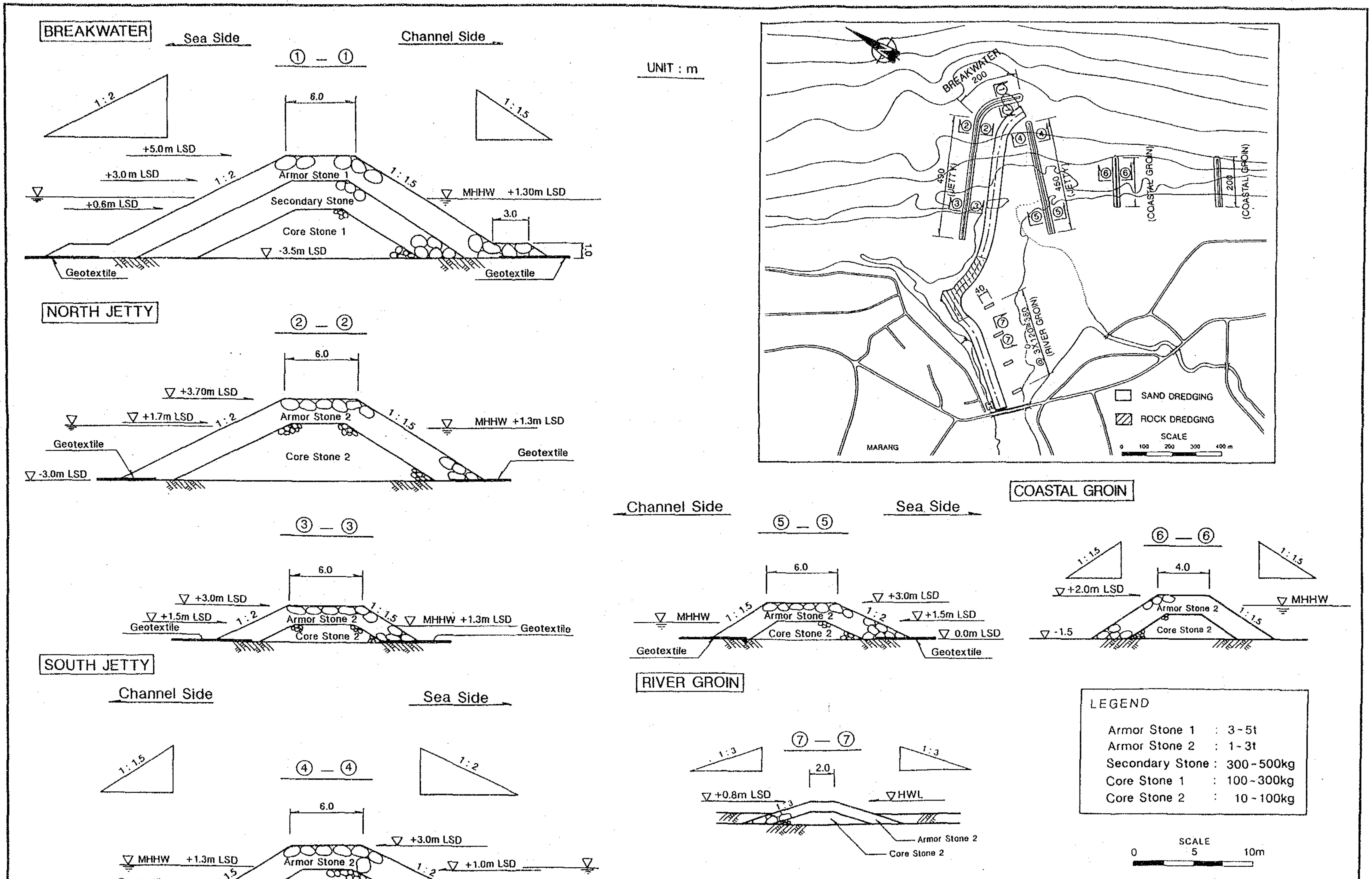
REDUCTION EFFECT OF WAVE HEIGHT BY BREAKWATER HEIGHT
(RELATION BETWEEN Ht/H'o AND B/Lo)



REDUCTION EFFECT OF WAVE HEIGHT BY BREAKWATER HEIGHT
(RELATION BETWEEN Ht/Ho AND R/Ho)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA / JAPAN INTERNATIONAL COOPERATION AGENCY	CALCULATION DIAGRAM OF WAVE TRANSMISSION COEFFICIENT	Fig. 6.2-4


NATIONAL RIVER MOUTHS STUDY
SUNGAI MARANG
LEGEND
METALLED ROAD
TRACK
FOOTPATH
COASTAL SAND
RIVER / STREAM
JETTY
BUILDING
VEGETATION LIMIT
RETAINING WALL
BRIDGE
BRIDGE (WOODEN)
POND
SAND DREDGING
ROCK DREDGING
RESERVOIR
MARANG
200
45
90
490
450
460
200
200
65
360
47
40
@ 3X120=360
790
10
45
SCALE 1 : 10000
0 100 200 300 400 m
THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA
JAPAN INTERNATIONAL COOPERATION AGENCY
GENERAL LAYOUT OF OPTIMUM
COUNTERMEASURES AT MARANG RIVER
MOUTH
Fig. 6.2-5

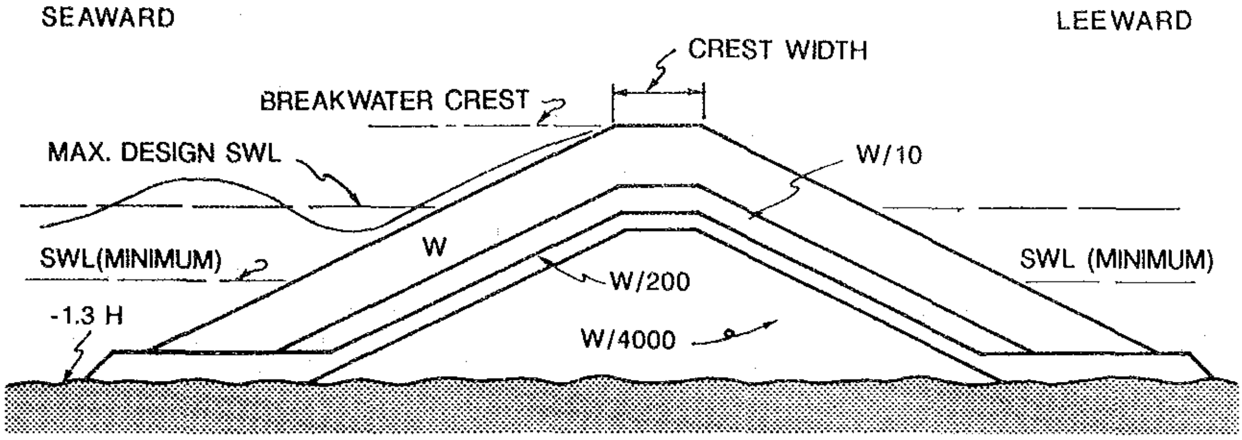


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA

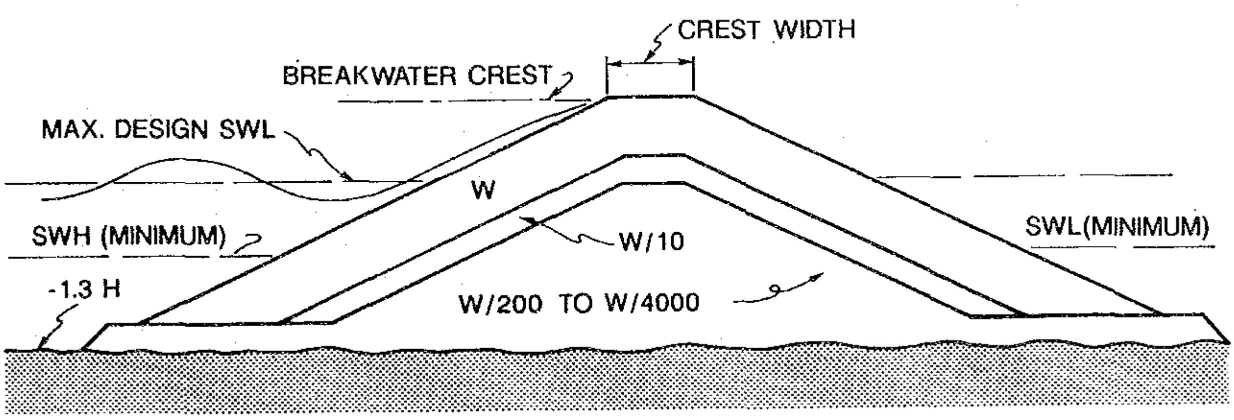
JAPAN INTERNATIONAL COOPERATION AGENCY

PROPOSED CROSS SECTION OF BREAKWATER, JETTY AND GROIN AT MARANG RIVER MOUTH

Fig. 6.2-6



I DEALIZED MULTILAYER SECTION



RECOMMENDED THREE-LAYER SECTION

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	RECOMMENDED RUBBLE-MOUND STRUCTURE
JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 6.2-7

ANNEXES

WORK ITEM AND QUANTITIES AT TG. PIANDANG

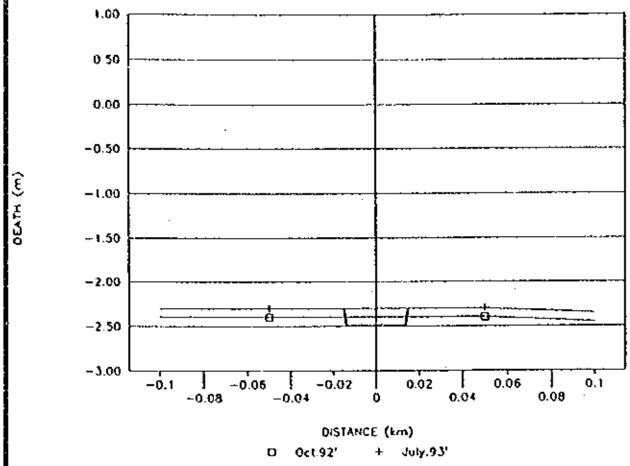
Item	Unit	Quantity	Remark
1 Dredging Works			
1) Captial Dredging			
Outer	m3	56,500	L=1900 m
Inner	m3	58,900	L=900 m , mooring area
2) Maintenance Dredging			
Outer	m3	47,900	assume siltation return
Inner	m3	7,600	0.9m outer, 0.3m inner
2 Shiping Jetty Works			
1) Clearing and Grubbing	m2	2,000	
2) Embanhment	m3	300	
3) Reddish sand	m3	300	t=0.15 m
4) Gravel Pavement	m2	2,800	t=0.2 m
5) Wooden Works for Jetty	m2	720	(40.0m*6.0m*3 jetties)
6) Jetty House	L/S	1	
3 Bank Protection			
1) Stone Masonry	m3	42	with concrete
2) Gabion Mattress	m2	1,050	used gabion mattress (3.0m*1.5m*0.5m)

SURVEY BASED ON OCT. 1992
DREDGING VOLUME OF TUNJUNG PIANDANG RIVER
10 GRT DESIGN DEPTH -2.5 m

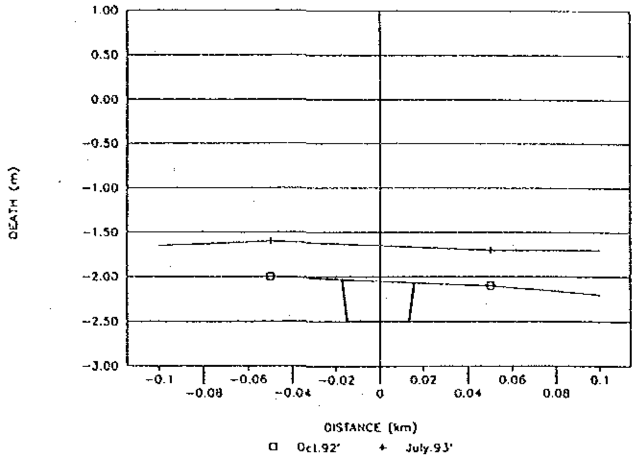
Line No.	Distance (m)	Area (m2)	Ave.Area (m2)	Volume (m3)	
-1900					
-1500	400	6	3	1,116	
-980	520	18	12	6,166	
-740	240	31	24	5,859	
-480	260	53	42	10,881	Total Volume
-240	240	78	66	15,736	of Outer
0	240	61	70	16,740	56,498 m3
120	120	58	59	7,134	
190	70	60	59	4,113	
350	160	62	61	9,792	
590	240	65	64	15,276	Total Volume
810	220	64	64	14,137	of Inner
900	90	71	67	6,059	56,511 m3
1003	103	58	64	6,643	
1230	227	60	59	13,393	
Total				133,044	

Mooring Volume 40*60*1.0
2,400 m2

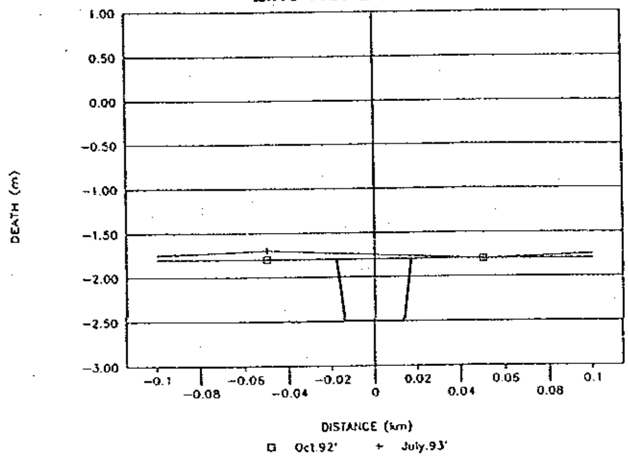
Line No. 1.50km



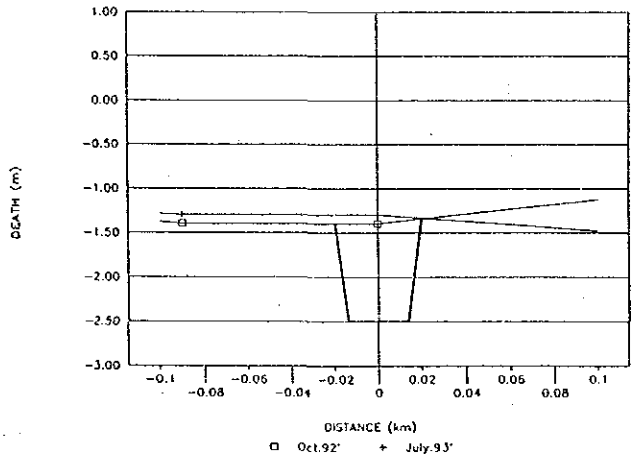
Line No. 0.98km



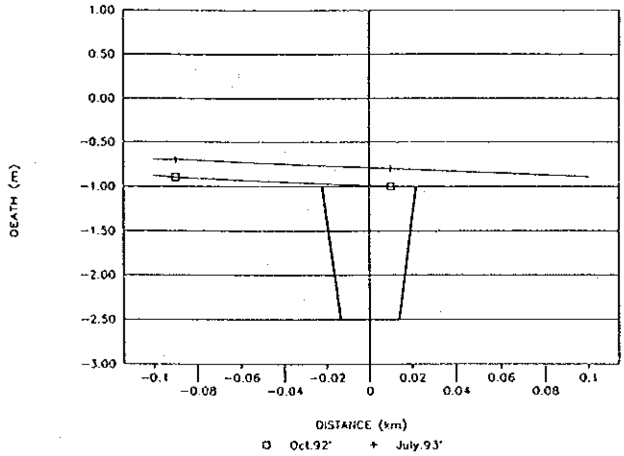
Line No. 0.74km



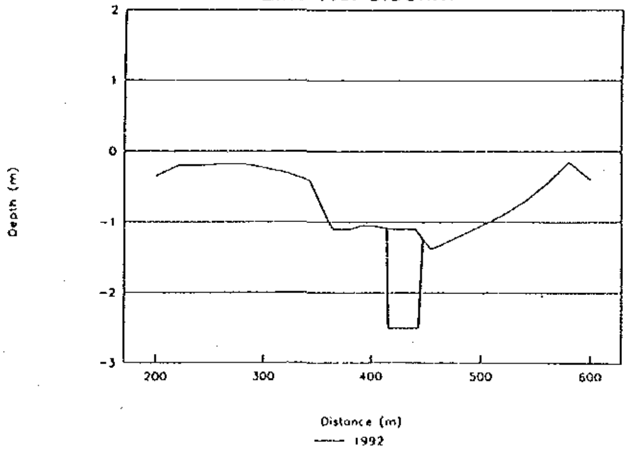
Line No. 0.48km



Line No. 0.24km



Line No. 0.00km

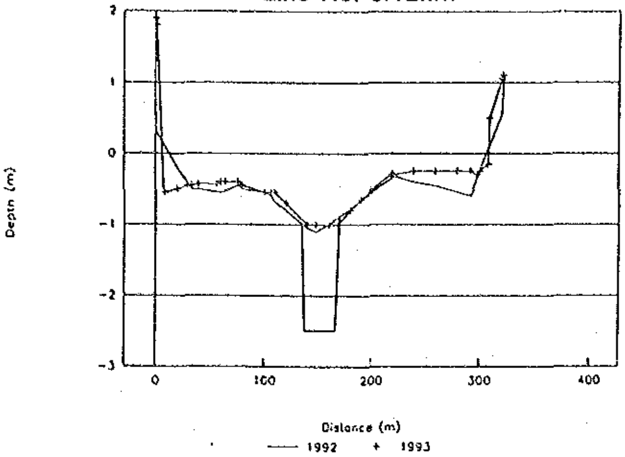


LEGEND

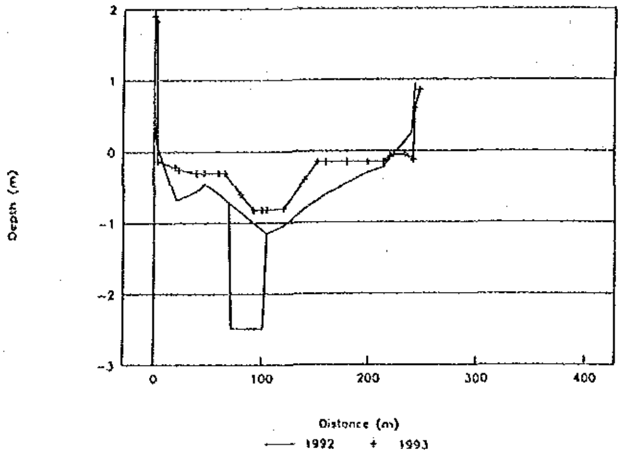
——— for 10GRT, -2.5m(LSD)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CROSS SECTION OF DREDGING AT TG. PIANDANG RIVER MOUTH (SEA SIDE)
JAPAN INTERNATIONAL COOPERATION AGENCY	

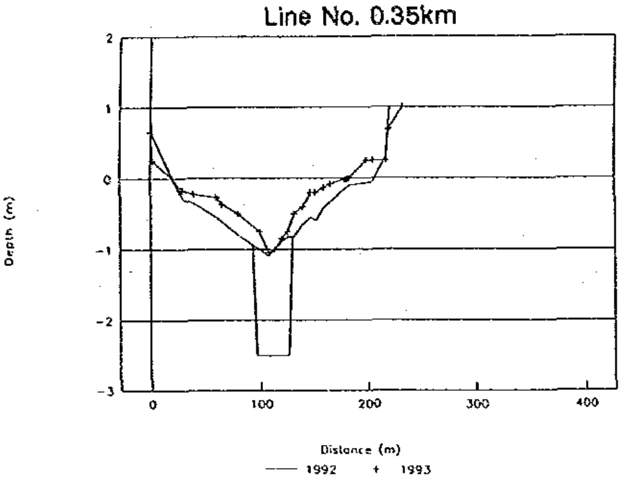
Line No. 0.12km



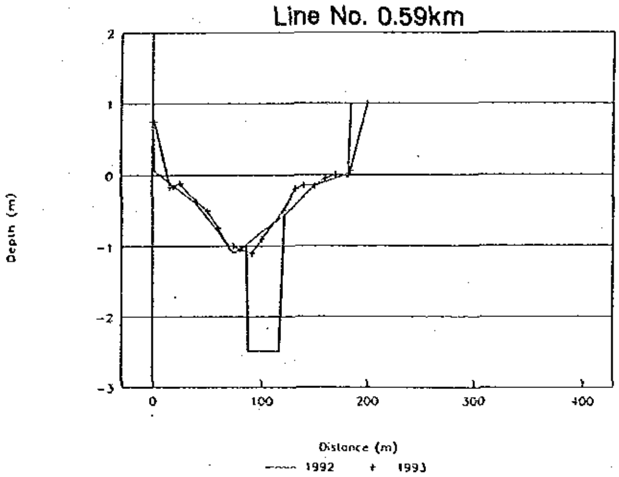
Line No. 0.19km



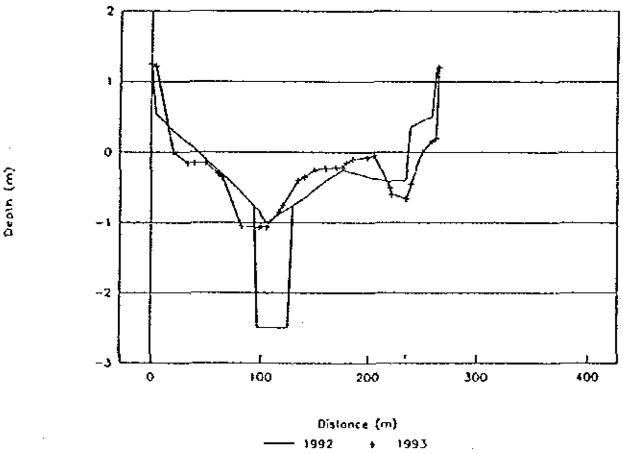
Line No. 0.35km



Line No. 0.59km



Line No. 0.81km



LEGEND

——— for 10GRT, -2.5m(LSD)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CROSS SECTION OF DREDGING AT TG. PIANDANG RIVER MOUTH (INNER CHANNEL)
JAPAN INTERNATIONAL COOPERATION AGENCY	

WORK ITEMS AND QUANTITIES OF MARANG RIVER MOUTH IMPROVEMENT PROJECT

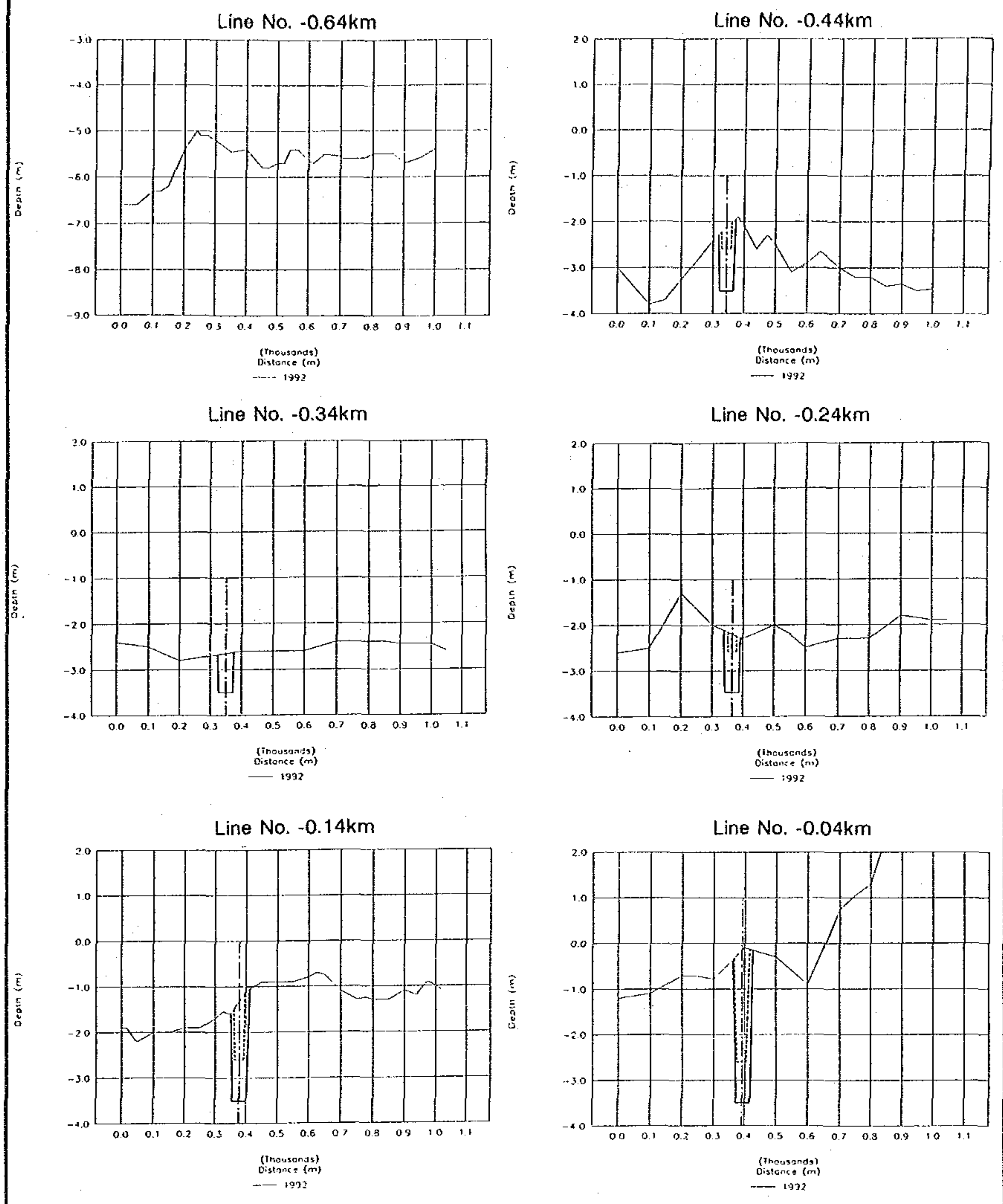
Item		Unit	Quantity	Remarks
1. Dredging Works				
1) 20 GRT	Sand	cu.m.	42,000	Boat clearlance 0.6 m
	Rock	cu.m.	9,800	
2) 30 GRT	Sand	cu.m.	75,500	Boat clearlance 0.8 m
	Rock	cu.m.	15,900	
3) 40 GRT	Sand	cu.m.	109,000	Boat clearlance 1.0 m
	Rock	cu.m.	22,000	
2. Structure Works				
1) Breakwater				L= 200 m
	Armor Stone 1	cu.m.	15,700	3-5 t
	Secondary stone	cu.m.	11,200	300-500 kg
	Core Stone 1	cu.m.	11,300	100-300 kg
	Geo-Textile Mat	sq.m.	2,200	440 m * 5 m
2) Jetty				
North Jetty				L= 490 m
	Armor Stone 2	cu.m.	19,600	1-3 t
	Core Stone 2	cu.m.	18,800	10-100 kg
	Geo-Textile Mat	sq.m.	2,450	490 m * 5 m
South Jetty				L= 450 m
	Armor Stone 2	cu.m.	12,600	1-3 t
	Core Stone 2	cu.m.	10,900	10-100 kg
	Geo-Textile Mat	sq.m.	2,250	450 m * 5 m
3) River Groin				L= 40 m * 2
	Armor Stone 2	cu.m.	1,840	1-3 t
	Core Stone	cu.m.	720	10-100 kg
4) Coastal Groin				L= 200 m * 2
	Armor Stone 2	cu.m.	9,900	1-3 t
	Core Stone 2	cu.m.	7,800	10-100 kg
5) Reservoir		m	4,100	Excavation & Bank Works

SURVEY BASED ON OCT. 1992
DREDGING VOLUME OG MARANG RIVER
40 GRT DESIGN DEPTH -3.5M

Line No.	Distance	Area (m2)	Ave.Area (m2)	Volume (m3)	
-1190	0	0	0	0	
-690	500	0	0	0	
-460	230	68	34	7,820	
-440	20	68	68	1,360	
-340	100	42	55	5,500	
-240	100	66	54	5,400	
-140	100	115	91	9,050	Total Volume
-40	100	196	156	15,550	of Outer
0	40	133	164	6,572	51,252 m3
90	90	122	127	11,462	
180	90	198	160	14,414	
300	120	164	181	21,708	
400	100	104	134	13,365	Total Volume
620	220	37	70	15,455	of Inner
790	170	0	18	3,128	79,531 m3
Total				130,783	

SURVEY BASED ON OCT. 1992
DREDGING VOLUME OF MARANG RIVER
20 GRT DESIGN DEPTH -2.6M

Line No.	Distance	Area (m2)	Ave.Area (m2)	Volume (m3)	
-1190	0	0	0	0	
-690	500	0	0	0	
-460	230	14	7	1,610	
-440	20	14	14	280	
-340	100	0	7	700	
-240	100	12	6	600	
-140	100	41	27	2,650	Total Volume
-40	100	99	70	7,000	of Outer
0	40	74	86	3,452	16,292 m3
90	90	58	66	5,904	
180	90	88	73	6,557	
300	120	74	81	9,708	
400	100	55	65	6,450	Total Volume
620	220	4	30	6,523	of Inner
790	170	0	2	340	35,482 m3
Total				51,774	



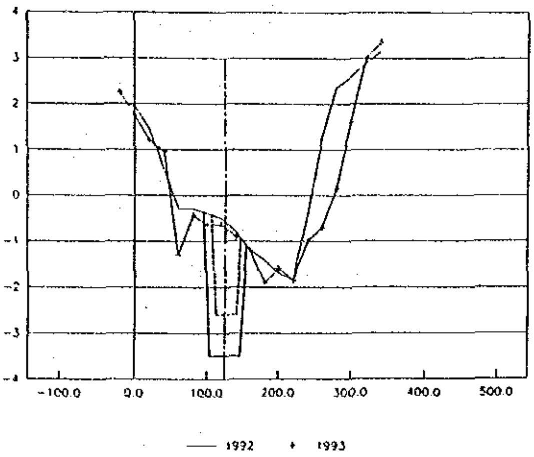
LEGEND

——— for 40GRT, -3.5m(LSD)

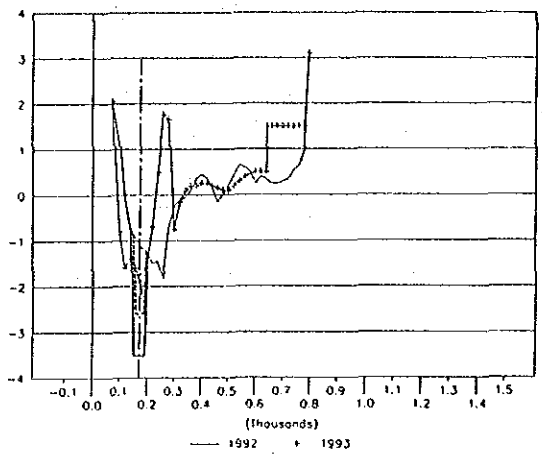
- - - - - for 20GRT, -2.6m(LSD)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CROSS SECTION OF DREDGING AT MARANG RIVER MOUTH (SEA SIDE)
JAPAN INTERNATIONAL COOPERATION AGENCY	

Line No. 0.00km



Line No. 0.09km



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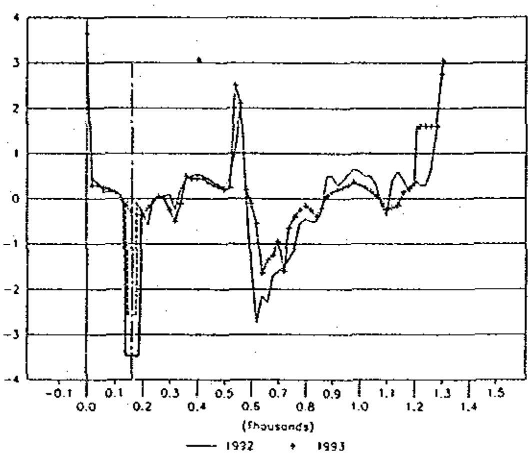
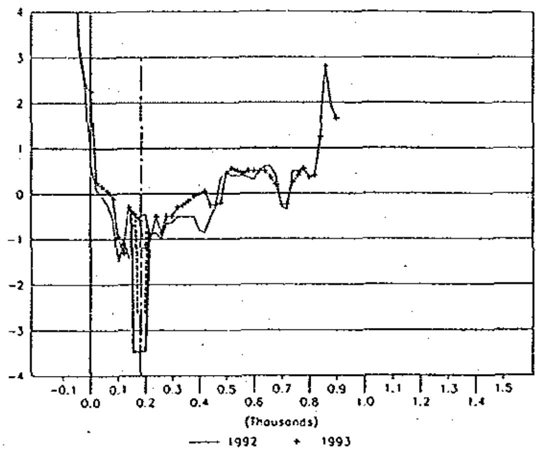
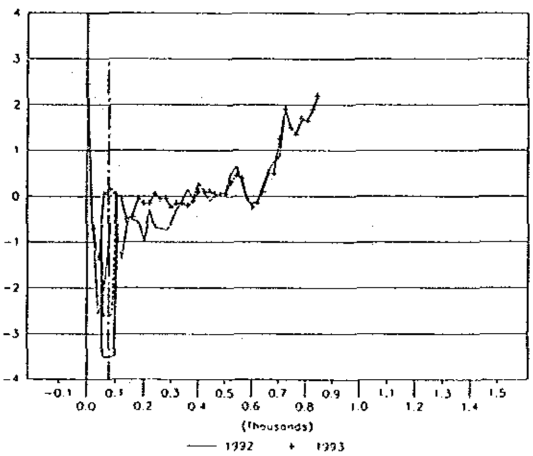


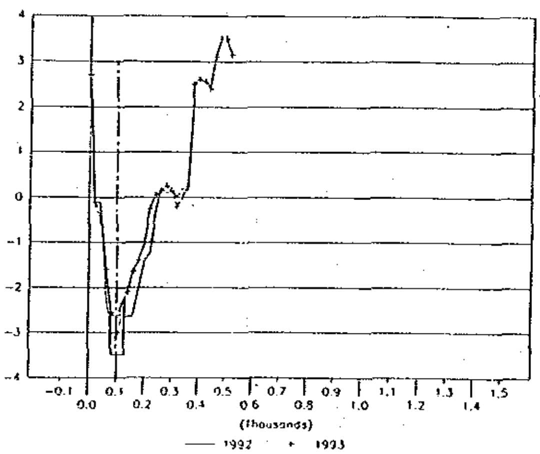
Line No. 0.30km



Line No. 0.40km



Line No. 0.62km

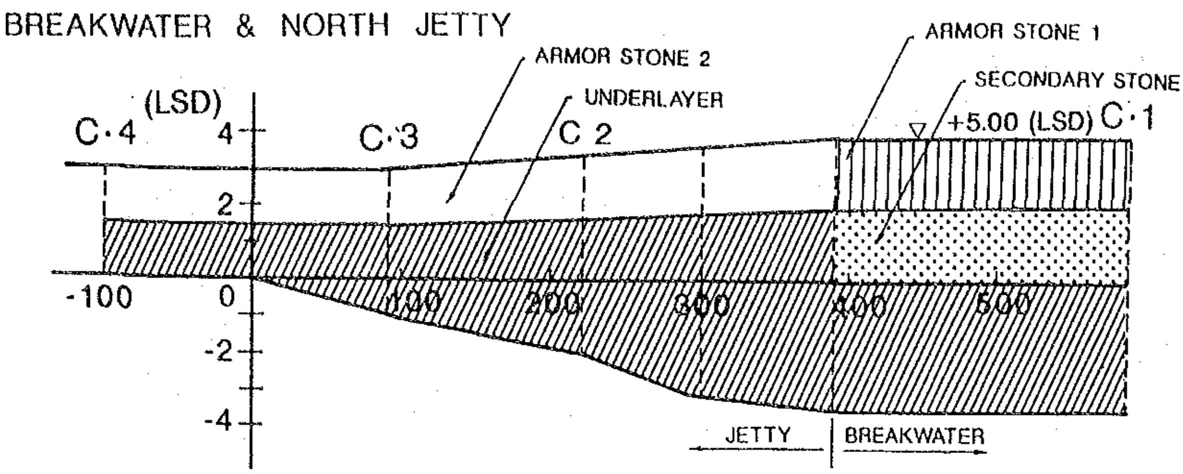


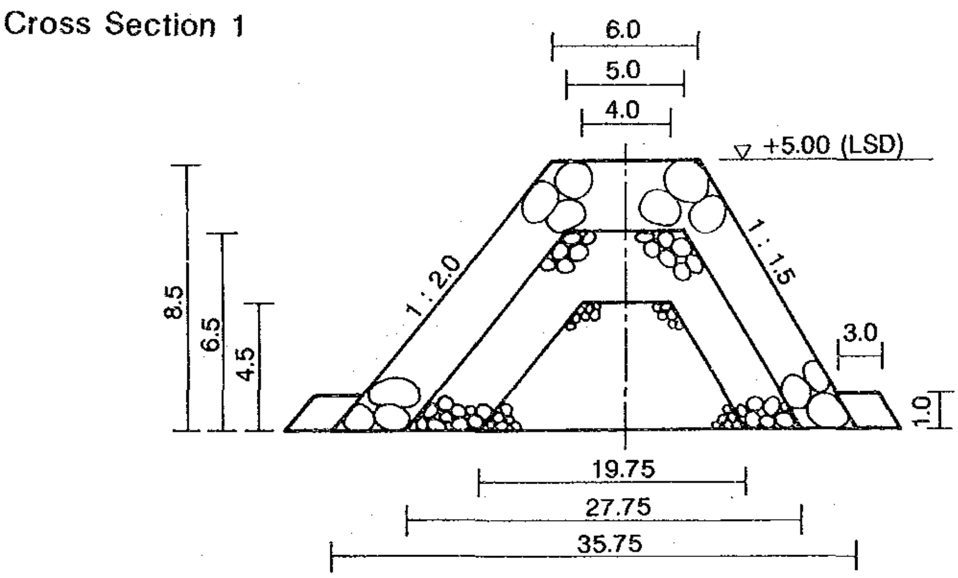
LEGEND

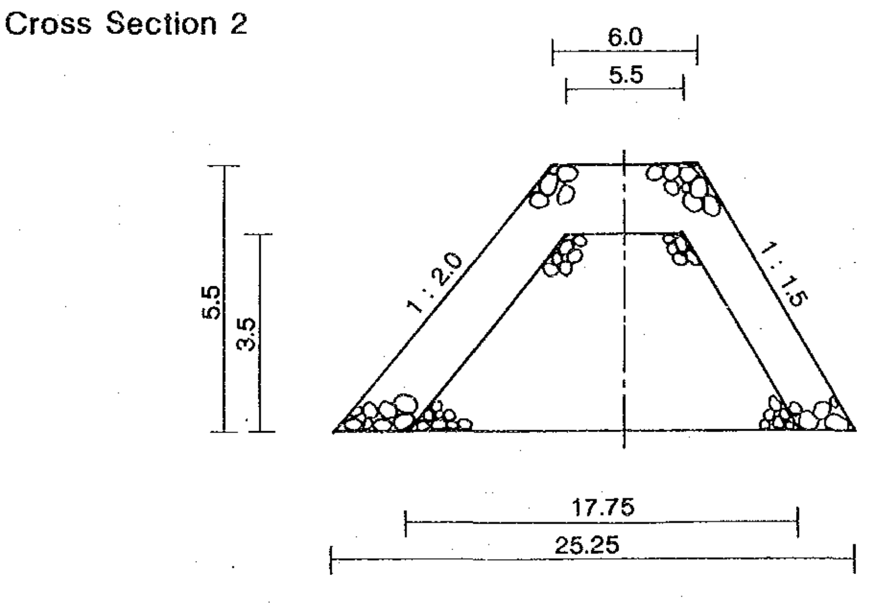
——— for 40GRT, -3.5m(LSD)

- - - - - for 20GRT, -2.6m(LSD)

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	CROSS SECTION OF DREDGING AT MARANG RIVER MOUTH (INNER CHANNEL)
JAPAN INTERNATIONAL COOPERATION AGENCY	

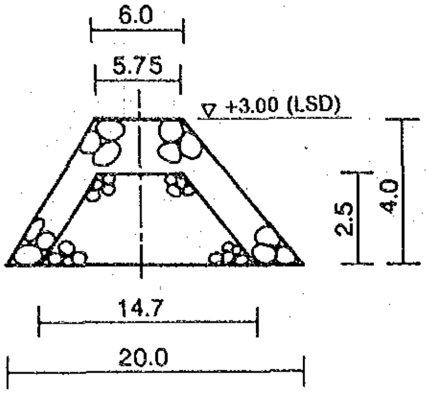




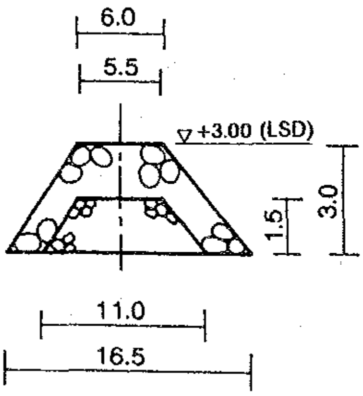


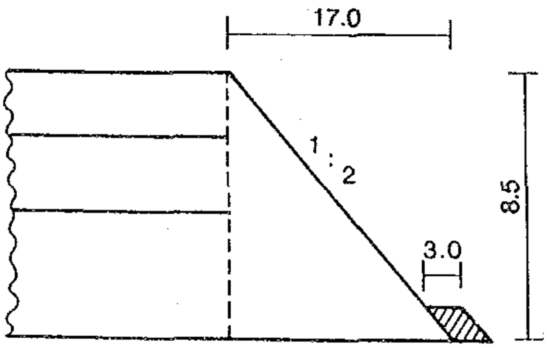
THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA JAPAN INTERNATIONAL COOPERATION AGENCY	STRUCTURAL PROFILE OF NORTH JETTY AND BREAKWATER (1)

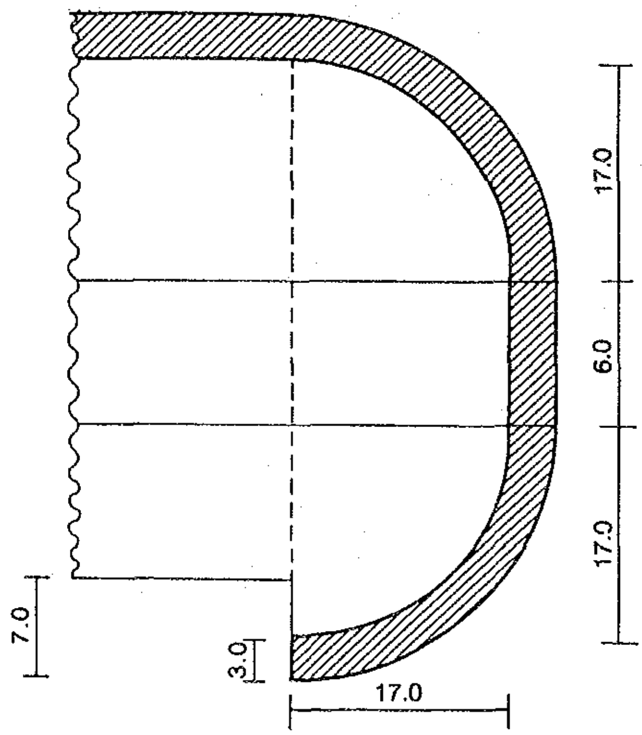
Cross Section 3



Cross Section 4

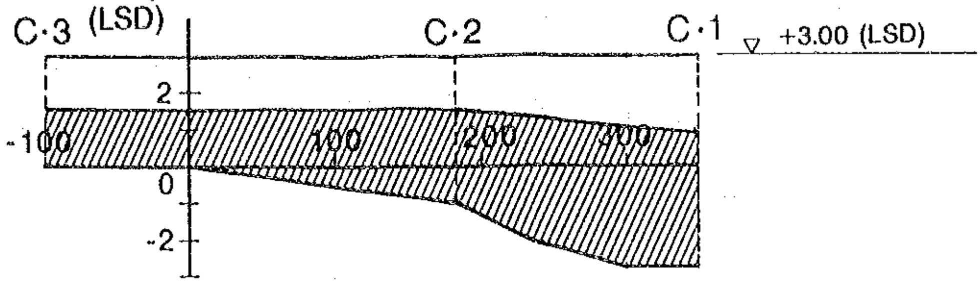




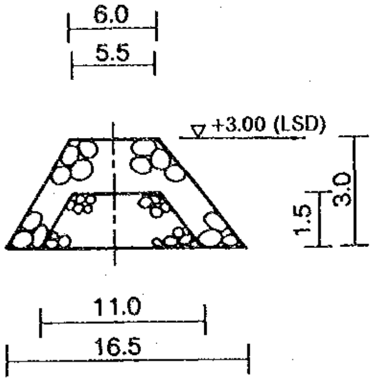


THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	STRUCTURAL PROFILE OF NORTH JETTY AND BREAKWATER (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	

SOUTH JETTY



Cross Section 3



Calculation of Area

$(6+16.5)\times 3/2=33.75$

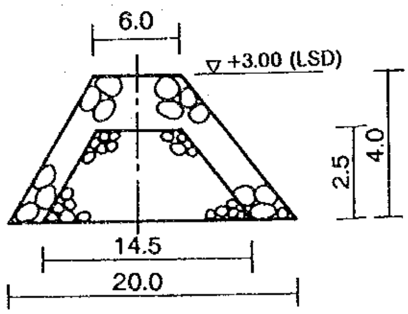
$(5.5+11)\times 1.5/2=12.38$

$33.75-12.38=21.37$

Armor stone 2 21.37 m²

Underlayer 12.38 m²

Cross Section 2



$(6+20)\times 4/2=52$

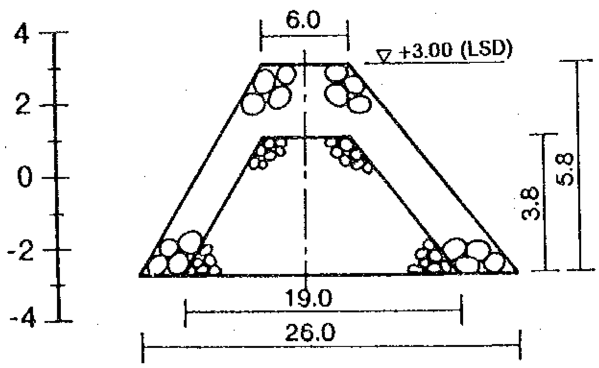
$(6+14.5)\times 2.5/2=25.63$

$52-25.63=26.37$

Armor stone 2 26.37 m²

Underlayer 25.63 m²

Cross Section 1



$(6+26)\times 5.8/2=92.8$

$(6+19)\times 3.8/2=47.5$

$92.8-47.5=45.3$

Armor stone 2 45.3 m²

Underlayer 47.5 m²

THE NATIONAL RIVER MOUTHS STUDY IN MALAYSIA	STRUCTURAL PROFILE OF SOUTH JETTY
JAPAN INTERNATIONAL COOPERATION AGENCY	

7. CONSTRUCTION PLAN AND COST ESTIMATE

THE NATIONAL RIVER MOUTHS STUDY
IN MALAYSIA

SUPPORTING REPORT NO. 7

CONSTRUCTION PLAN AND COST ESTIMATE

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SUPPORTING REPORT NO. 7

CONSTRUCTION PLAN AND COST ESTIMATE

1. MASTER PLAN STUDY

1.1 Introduction

Various structural types of each countermeasure are proposed in Supporting Report No. 6, Preliminary Design. The purpose of this Supporting Report No. 7 is to select the optimum alternative countermeasures through cost comparison and to estimate the project cost for the representative river mouths. To serve these objectives, the basic factors such as construction unit cost, dredging unit cost and conditions of cost estimate are studied and determined.

1.2 Selection of Countermeasures

1.2.1 Alternative Study Cases

The following countermeasures are proposed for the master plan of river mouth improvement: (a) Breakwater; (b) Jetty; (c) Submerged Jetty; (d) Training Wall; (e) Groin; (f) Reservoir; and (g) Dredging.

The above countermeasures are of various types or methods according to material or machinery employed. To select the optimum type, cost comparison is made for only the breakwater, the jetty and the submerged jetty; while selection of the optimum type for the other countermeasures is based on the currently employed type or method in Malaysia. Alternative types are set for the countermeasures as enumerated below, and their structural outlines are shown in Table 7.1-1 to 7.1-4.

(1) Breakwater

Alternative 1	:	Rubble Mound
Alternative 2	:	Double Steel Sheet Pile Wall with Top Concrete
Alternative 3	:	Rubble Mound with Concrete Caisson

(2) Jetty

Alternative 1	:	Double Concrete Sheet Pile Wall
Alternative 2	:	Rubble Mound
Alternative 3	:	Rubble Mound with Concrete Sheet Pile Wall
Alternative 4	:	Rubble Mound with Sand-Filled Tube

(3) Submerged Jetty

Alternative 1	:	Rubble Mound
Alternative 2	:	Rubble Mound with Sand-Filled Tube
Alternative 3	:	Sand-Filled Tube
Alternative 4	:	Rubble Mound with Concrete Pile Wall

(4) Training Wall	:	Concrete Block
(5) Groin	:	Rubble Mound
(6) Reservoir	:	Excavation by Excavator
(7) Dredging	:	Dredging by cutter suction dredger

1.2.2 Selection of Optimum Type of Structure

To select the optimum type of countermeasures for the master plan, costs are estimated in consideration of currently tendered projects and construction costs of projects under DID, MD and JKR based on the price level in late 1992. The following most economical types are selected as the optimum countermeasures:

(1) Breakwater : Rubble Mound (Alternative 1)

(2) Jetty : Rubble Mound (Alternative 2)

(3) Submerged Jetty : Rubble Mound with Sand-Filled Tube (Alternative 2)

1.2.3 Selection of Optimum Dredging Type

Dredging Material

Depending on location, a big difference in sea/river bed materials is found at river mouths in Malaysia. The most striking characteristic difference is the extremely soft muddy soil in the east coast and sand with rather uniform diameter in the west coast of Peninsular Malaysia. Taking these characteristics of river/sea bed materials into account, the dredging method is studied.

Dredging with Conventional Equipment

As the conventional dredging method, there are basically three kinds of dredging method applicable to navigation channel dredging for the objective river mouths, as follows:

Method 1: Cutter suction dredger with a booster station, discharging to the coastal area. Disposal of dredged soil at sea can be possible as well if the conditions meet the dredging guidelines.

Method 2: Trailing suction hopper dredger, pumping ashore to the coastal area or continuing to the disposal ground offshore.

Method 3: Dredging by grab or clamshell, discharging to barges; barges being unloaded and pumped onto the coastal area or offshore disposal ground.

Agitation Dredging

Unlike dredging with conventional equipment which is generally costly requiring high investment cost, intensive machinery and trained manpower for operation, agitation dredging has developed as the low-cost dredging method. Agitation dredging is especially suited to maintenance dredging, and is generally considered to be effective for river mouths in muddy coasts.

Selection of Dredging Method

Method 1 is the most popular and reliable dredging method for navigation channels and is applicable to almost all objective river mouths. The bigger the dredging volume, the lower is the cost. Besides, dredging capacity per day is bigger than the other methods. This means less time-consuming and lower total cost.

Method 2 is feasible if the dredged materials are soft soil and lose fine sand. However, dredging efficiency is inferior to Method 1. Besides, this method requires a longer time for traveling to an offshore disposal ground at times of low water.

Method 3 is usually employed for a small-scale dredging of the inner channel. This method is far slower than the other two methods.

For the muddy coast, agitation dredging is not applicable because of its being less effective as discussed in Section 5.

Taking all these factors into consideration, Method 1 is adopted for this master plan study.

1.3 Estimation of Unit Cost

1.3.1 Construction Unit Cost

Unit Cost of Main Works

Representative samples of current tenders and construction costs of similar types of works in the country have been collected to make a general set of unit cost suitable for use in the master plan study. Rates of unit cost used in the study are given in Table 7.1-5.

Unit Cost of Proposed Countermeasures

Unit costs for the breakwater, the jetty, the submerged jetty, the training wall, the groin and the reservoir are estimated by cost comparison among alternative types. The results are shown in Table 7.1-1 to 7.1-4 and summarized in the following table. The unit cost for dredging is discussed separately.

Countermeasure	Unit Cost (RM)
Breakwater	14,880/m
Jetty	3,708/m
Submerged Jetty	5,165/m
Training Wall	1,500/m
Groin	1,500/m
Reservoir	10/m

1.3.2 Unit Cost of Dredging

Dredging cost is quite difficult to obtain accurately for every objective river mouth, because of many unknown factors. For the estimation of dredging cost for this master plan, cost investigation through several experienced Malaysian contractors was made and costs quoted in similar projects undertaken by DID, MD and JKR were taken into account.

The table below shows the survey results for unit dredging cost by the cutter suction dredger.

Particulars	Unit Cost of Dredging (RM/m^3)	
	1986-1989	1989-1992
Projects by DID	3.0 - 5.0	4.0 - 6.0
Projects by MD	less than 5.0	5.0 - 7.0
Projects by JKR	approx. 3.0	---
Contractors	2.5 - 4.5	4.0 - 9.0

As can be seen on the table, the range of unit cost is too big to identify the adequate unit cost for the estimation od dredging cost. Hence, a rough cost estimate calculation is tried based on the data collected in Malaysia and the cost estimate method in Japan to obtain the appropriate unit costs that can be applied to the master plan.

The calculation results are shown in Table 7.1-6 and summarized in the following table.

Dredged Material	Calculated Unit Cost	
	L < 1.5 km (Inner Channel)	1.5 km < L < 3.0 km (Offshore Channel)
Sandy Soil	RM 5.0/m^3	RM 6.0/m^3
Clayey Soil	RM 6.0/m^3	RM 7.0/m^3

The conditions of calculation are as follows:

(a) Cutter Suction Type Dredger: 2,250 HP

(b) Dredging Capacity Per Hour (m^3/hr):

Dredged Material	Dredging Capacity per Hour	
	L < 1.5 km (Inner Channel)	1.5 km < L < 3.0 km (Offshore Channel)
Sandy Soil	450 m^3	400 m^3
Clayey Soil	550 m^3	500 m^3

(c) *Operation Time of Dredger: 16 hours/day, 2 shifts*

(d) Operation Time of Anchor Boat: 8 hours/day

1.4 Estimation of Project Cost

1.4.1 Conditions for Cost Estimate

Direct construction cost is estimated by using the unit costs mentioned in Subsection 1.3.2. Project cost for the objective river mouths is estimated under the following conditions.

(1) Construction works are to be executed by bidding.

(2) Total construction cost is estimated in consideration of the following components:

(a) Main Works
(b) Minor and Preparatory Works [10% of (a)]
(c) Engineering and Administration Cost [10% of (a)+(b)]
(d) Physical Contingencies [15% of (a)+(b)+(c)]

(3) It is assumed that land acquisition is not required for the river mouth improvement works.

(4) Operation and maintenance cost (O&M) is calculated based on the following percentages of total construction costs:

(a)	Rock Structures	:	0.6%
(b)	Concrete Structures	:	1.0%

As for the flexible sand-filled tube, full replacement is to be made in every 15 years considering the durability of the material.

1.4.2 Project Cost of Representative River Mouth

To select the optimum countermeasure for the representative river mouth, cost comparison of alternative countermeasures is made. The countermeasures include maintenance dredging which has to be done every year. Therefore, the project cost is presented in net present value for the period of 30 years starting from the present year. The cost comparison study results for the representative river mouths are given in Table 7.1-7 to 7.1-16.

1.5 Project Implementation Schedule

1.5.1 First Phase Project

In accordance with the principle of master plan formulation, countermeasures for each of the 75 river mouths are selected and the costs are calculated. Furthermore, a First Phase Project is planned to facilitate project realization.

The First Phase Project is formulated based on the assumption that it is completed within the target year 2005, which corresponds to the last year of the 8th Malaysia Plan. As the alternative cases, those which extend the target up to the end of the 9th and 10th Malaysia Plan are examined for reference.

1.5.2 Prioritization of River Mouth

Prioritization of the objective river mouths is made considering several aspects such as economic efficiency, regional income distribution, social need and so on. The prioritization is made on the following principles, and the results are as shown in Table 7.1-17.

(1) The number of river mouths to be implemented in each stage is basically the same but adjusted considering the financial burden; i.e., the initial and maintenance costs. In this adjustment, there are two cases to be considered: (a) total cost consisting of initial and maintenance costs is equally distributed, and (b) only the initial cost is equally distributed. Consequently, there are six cases considered in combination with three cases by the change of the target year.

(2) Considering the regional income distribution, at least one river mouth in each State is to be implemented in the early stage.

(3) Prioritization among the river mouths in each State is to be made considering the economic efficiency, design boat size, LKIM complex and DOF base. Among these, more emphasis is put on the LKIM complex which is regarded as the strategy of the fishing industry. Besides, the Tg. Piandang and Marang river mouths which are selected as the objective river mouths for the Feasibility Study are given high priority.

1.5.3 Implementation Schedule and Construction Cost

<u>Implementation Schedule</u>

The assumptions for the formulation of the implementation schedule are: that the First Phase Project is to be implemented within the target year 2005 starting from 1996 after the feasibility study and that the detailed design of the river mouth improvement works is completed in the period corresponding to the 7th and 8th Malaysia Plan stage.

The implementation schedule including alternative cases which follow the prioritization is as shown in the following table.

Case	Priority	Malaysia Plan			
		7th	8th	9th	10th
Case 1-1 and 2-1	First, Second	---------	*	*	*
	Third, Fourth		---------	*	*
Case 1-2 and 2-2	First	---------	*	*	*
	Second		---------	*	*
	Third			---------	*
Case 1-3 and 2-3	First	---------	*	*	*
	Second		---------	*	*
	Third			---------	*
	Fourth				---------

* Maintenance work

Construction Cost

The construction cost required for the First Phase Project is estimated in accordance with the implementation schedule. The proposed disbursement schedules for the First Phase Project are presented in Table 7.1-18. The annual disbursement of the cost of each priority group in the table is assumed to be equally distributed for each year in each construction stage.

2. FEASIBILITY STUDY

2.1 Introduction

This section presents the proposed construction plan which includes the dredging method, and the cost estimate necessary to implement the river mouth improvement project for the Tg. Piandang and the Marang river mouths. The objective is to provide a guide for the execution of construction works, as well as the construction cost estimate.

The construction plan is formulated based on the basic assumptions made in the preparation of the construction schedule. This plan gives an outline of possible procedures, construction and dredging methods and type of construction equipment and dredgers suitable for the project.

The project cost is estimated from financial and economic viewpoints to evaluate the projects.

2.2 Construction Plan

2.2.1 Outline of the Project

Tg. Piandang River Mouth

The major work is dredging of the navigation channel in both offshore sea and inside the river mouth. Some minor works for shipping jetty and bank protection are proposed at the downside portion of the existing jetty. The dredging consists of capital dredging and annually recurrent maintenance dredging.

Marang River Mouth

The project works is composed mainly of rock armoring and riprapping for the jetty and breakwater which are to be extended from the river mouth, and the installation of groin on the leftside shoreline. In addition to these structures, capital dredging for the navigation channel is also included in the project.

2.2.2 Conditions for Construction

Tg. Piandang River Mouth

(1) Topography and Site Geology

The river mouth is located at the tip of the alluvial fan formed by the numerous streams flowing out from the Inas mountains west of the central mountain ridges of the Peninsula. Tg. Piandang River flows generally westward in the center of the fan. This alluvial fan is presently used for paddy cultivation and the Tg. Piandang River with a channel length of 10 km presently functions as a drainage channel. The area is protected from saltwater intrusion by tidal bunds constructed inland, and these bunds usually separate the cultivation area from the mangrove forest. In the nearshore area, the seabed is made of rather soft muddy soil and seabed profiles are quite gentle at about 1/400 for the stretch from the shoreline to about 3 km offshore.

(2) Access to the Site

The project site is readily accessible from the state road. For dredgers and vessels, access to the river mouth is attained only during high tide. It is recommended that dredging works should commence from the offshore sea.

(3) Labor Force

Skilled and common labor in sufficient number can be recruited at the project area without seasonal variation.

(4) Construction Materials

The required construction materials for the proposed works such as cement, wood, cobblestone and steel are available locally at nearby major cities.

(5) Construction Equipment

Dredging works, the major works of the project, will not take a long period at the project site. Therefore, dredgers and other construction equipment will be arranged by the contractor on a rental basis.

(6) Workable Day and Working Hours

Dredging works should be suspended on rainy days with a daily rainfall of more than 10 mm and the average wave height is 0.60 m. According to the rainfall record of 1982 in the northwest region, the number of rainy days with a daily rainfall of more than 10 mm was 59 days. Furthermore, the official holidays (Sunday and national holidays) are not counted as workable days for construction works. In this context, the workable days for the proposed works are estimated as follows:

Official Holidays = 53 Sundays + 12 national holidays = 65 days

Workable Days/year = 365 - (65 holidays + 59 rainy days) = 241 days

As to the workable hours for dredging, 10 hours (2 hours added to regular working hours) is adopted taking the effective use of dredgers into account.

Marang River Mouth

(1) Topography and Site Geology

The Marang River has a catchment area of 460 km^2 and a total channel length of 50 km, and its river mouth is located 15 km SSE from Terengganu City. The shoreline of the area consists of a sandy beach with a straight coastline aligned in a N35W direction. The river originates in 600 m high hills, but most of the channel runs in a low, flat land. The seabed formation in this area has generally less irregularity and seabed gradient is steep at about 1/100 to 1/50. A very shallow zone exists at the river mouth, but the stretch of the shallow zone with elevation of about LSD-5 m is short at about 1.4 km. As to the seabed materials, sand with diameter ranging from 0.013 to 1.2 mm is predominant. In some limited areas at the river mouth, soft rocks are exposed.

(2) Access to the Site

The site is close to the state road, but a temporary road/bridge over the lagoon which lies at the river mouth will be provided for hauling rocks and stones necessary for sea works.

(3) Labor Force

Common labor can be recruited at the project area. On the other hand, there is a shortage of skilled labor in the east coast area. Therefore, they will be recruited from other areas such as the west coast region and Kuala Lumpur.

(4) Construction Materials

Rocks and stones as the major construction materials for the expected works are available in the area within a distance of 30 km from the project site. Other materials are also available locally at the major towns in the east coast region.

(5) Construction Equipment

The required equipment to be used for a long period is considered to be purchased or rented by the contractor depending on the availability of equipment in the country.

(6) Workable Day and Working Hours

Workable days are estimated as follows:

(a) Official Holidays = 53 Sundays + 12 national holidays = 65 days

(b) Suspended Days by Rainfall

In this region, heavy rainfall concentrates during the northwest monsoon season (November to February). The rainfall record in 1982 shows that the number of rainy days with a daily rainfall of more than 10 mm is 60 days. In heavy rainy days, wave height at the nearshore area is also considered to be big.

(c) Workable Days per Year

365 - (65 + 60) = 240 days (or 8 months)

(d) Working Hours per Day

The working hours per days are 8 hours for regular civil works and 20 hours (2 shifts) for dredging works.

(7) Swell Factor of Major Construction Materials

The following swell and recompression factors are assumed for the unit cost estimate.

Material	Loose/Bank	Embankment/Bank
Common	1.18	0.90
Sand and Rock	1.15	0.95
Weathered Rock	1.30	1.00
Rock	1.64	1.18

(8) Care for Environment

From the preservation of fish ecology, both sea works and dredging works should be refrained during the fish breeding season (January to February).

2.2.3 Mode of Construction

Tg. Piandang River Mouth

Considering the scale and the nature of the works involved in terms of the expected contract, the construction works will be executed in one package. The "Bill of Quantities" contract system is used for local open competitive bids. The works will be administrated by DID, in association with a local consulting firm as required.

Marang River Mouth

To implement the project works within the limited construction period, international open competitive bidding based on the "Bill of Quantities" contract system is employed. From the nature of the project works and the scale of the works, the project is proposed to be executed in two parts, namely; sea works composed of jetty and breakwater, and dredging works. The construction works will be administered and supervised by DID, with assistance from an international engineering consulting firm.

2.2.4 Work Items and Quantities

Tg. Piandang River Mouth

The major work for Tg. Piandang is dredging of the navigation channel in both offshore and inside of the river mouth. As the minor works, wooden jetties for fishing boats as well as bank protection are proposed at the downside portion of the existing jetties. The dredging projected consists of capital dredging and annually recurrent maintenance dredging. The work items and quantities are given in Table 7.2-1 and summarized below.

(1) Main Works

(a) Capital Dredging

- Inner Channel	:	58,900 m^3
- Outer Channel	:	56,500 m^3
Total	:	115,400 m^3

(b) Annual Maintenance Dredging

- Inner Channel	:	7,500 m^3
- Outer Channel	:	47,900 m^3
Total	:	55,400 m^3

(2) Minor Works

(a) Jetty Works

- Land Adjustment	:	2,000 m^2
- Wooden Jetty	:	700 m^2 (3 units)
- Jetty House	:	1 unit
- Gravel Pavement	:	2,800 m^2

(b) Bank Protection Works

- Stone Masonry : 42 m^3
- Gabion Mattress : 1,050 m^2
  (3.0m x 1.2m x 0.5m)

Marang River Mouth

The project consists of construction of north and south jetties, breakwater, river and coastal groins, and dredging of the navigation channel. The structures are made up of sea works such as riprapping, stone filling, rock armoring and placement of geo-textile mat. Capital dredging will be done to realize the design section of the proposed channel. Regular maintenance dredging will also be required to keep the design section from siltation. Since the sediment volume in the channel is expected to be small, maintenance dredging is incorporated into the O&M works. The work items and quantities are given in Table 7.2-2 and summarized below.

(1) Breakwater

- Armor Stone 1 (3-5 ton) : 15,700 m^3
- Secondary Stone
  (300-500 kg) : 11,200 m^3
- Core Stone 1 (100-300 kg) : 11,300 m^3
- Geo-textile Mat : 2,200 m^2

(2) Jetty

- Armor Stone 2 (1-3 ton) : 32,200 m^3
- Core Stone 2 (10-100 kg) : 29,700 m^3
- Geo-textile Mat : 4,700 m^2

(3) River Groin

- Armor Stone 2 (1-3 ton) : 1,840 m^3
- Core Stone 2 (10-100 kg) : 720 m^3

(4) Coastal Groin

- Armor Stone 2 (1-3 ton) : 9,900 m^3
- Core Stone 2 (10-100 kg) : 7,800 m^3

(5) Navigation Channel Dredging

- Capital Dredging

  Loose Sand : 109,000 m^3

  Soft Rock : 22,000 m^3

- Maintenance Dredging : (included in O&M works)

(6) Reservoir Improvement : 4,100 m

2.2.5 Selection of Dredging Method for Tanjung Piandang River Mouth

<u>Introduction</u>

The Master Plan Study selects dredging as the most suitable measure for river mouth improvement on the west coast. In accordance with the design features of the navigation channel, more detailed study on dredging is carried out based on an in-depth supplemental survey to decide the suitable dredging method and to estimate the cost.

To draw up the dredging plan, the following conditions are considered:

(1) Water Depth of the Sea at the Entrance of River Mouth

The water depth of the nearshore zone and the river mouth area is too shallow for dredgers to operate normally. For this reason, dredging works should commence from the offshore portion. Dredging and other vessels with a small draft should be employed.

(2) Environmental Impact

The dumping site for dredged materials should be selected not only from the economical aspect, but also from the environmental aspects such as the preservation of mangrove, the protection of fishing zone and so on.

(3) Passage of Fishing Boats

During the operation of dredger and other working vessels, obstruction to the passage of fishing boats should be minimized as much as possible.

(4) DID Guidelines for Dredging Work

DID's guidelines pertaining to dredging work should be followed.

Disposal of Dredged Materials

Sea/river bed materials are identified as clay to silt having a particle diameter range of 0.05 to 0.001 mm. The surface layer to be dredged is very soft, and its N value (SPT) is estimated at less than 4. Therefore, dredging production rates are considered rather high.

As to the disposal of dredged materials, there are basically three options: (a) Disposal in inland spoil bank; (b) Disposal in spoil bank on coastal area; and (c) Dumping at sea.

(1) Disposal in Inland Spoil Bank

Inland areas adjacent to the river mouth are utilized intensively as agricultural land. There seems to be no land available for the spoil bank.

(2) Disposal in Spoil Bank on Coastal Area

The coast in both north and south of the river mouth is composed of mangrove swamps having a zone width of 300 to 700 m. The inland area is protected by the bund from seawater intrusion. The plan to dispose dredged materials is to provide a spoil bank by enclosing a part of the mangrove area with bund. In view of the distance from the river mouth, this spoil bank would be both convenient and economical for the dredging. According to this plan, about 9 ha of the mangrove area would be replaced by the spoil bankyard.

(3) Dumping at Sea

The DID's guidelines pertaining to the dumping of dredged material at sea are as follows:

(a) Dumping site is to be located at least 3 km away from the river mouth;

(b) Water depth at dumping site is to be more than 10 m; and

(c) The site is to be located in the downside of littoral drift.

In addition to the above, approval by the Marine Department (MD) is necessary. From the view of protecting the fishing zone, special care should be taken. [As to (a) and (b), either of them must be fulfilled.]

Taking all these factors into account, the dumping sites (dumping at sea and disposal on the coast) are tentatively proposed, as shown on Fig. 7.2-1.

Dredging Method

There are four kinds of dredging method considered applicable to the proposed navigation channel, as follows:

Method 1: Cutter Suction Pump Dredger; small size dredger is preferable, because the draft of the dredger is restricted by the shallow nearshore zone. Dredged material is discharged by pipeline into the spoil bank on the coastal area mentioned above.

Method 2: Dredging machine with cutter suction pump, which is applicable in the shallow river mouth area, discharging by pipe into the spoil bank on the coastal area. The pipe length must be kept below 1,000 m.

Method 3: Grub (Clamshell) Dredger, discharging to hopper barges, and barges being unloaded into the offshore dumping site. Dredger and barges will be restricted to the smaller scale ones which can operate even at low tide.

Method 4: Trailing Suction Hopper Dredger, dumping to the disposal ground offshore.

The methods are compared, as shown in Table 7.2-3, and assessed as follows:

(1) Method 1 would be applicable if the spoil bank could be provided on the coastal area, as shown in Fig. 7.2-1.

(2) Method 2 is applicable only to inner channel dredging but the operation in offshore area is considered impossible, because the machine cannot resist big waves.

(3) Method 3 is applicable and advantageous, unless the dumping site is very far from the river mouth.

(4) Method 4 is not applicable, because water depth of the proposed channel is not enough for this type of dredger to pass during low tide.

Through the above considerations, Method 1 and 3 are found technically feasible. To select the best alternative, a detailed comparison study is carried out as discussed below.

<u>Selection of Dredging Method</u>

Method 1 (Cutter Suction Pump Dredger) and Method 3 (Grab Dredger) are compared in detail from various aspects, as shown in Table 7.2-4. The comparative study concludes as follows:

(1) Method 1

This method needs about 1,500 m long pipeline to discharge dredged material into the spoil bank provided on the coastal area. As a result, about 9 ha of mangrove swamp will be converted into the spoil bank. This might be debatable from the viewpoint of mangrove preservation. Besides, the pipeline might be obstructive to the passage of fishing boats. Costwise, the unit price of dredging is lower than that of Method 3; however, higher cost for pipeline setting and spoil bank treatment is required. The total cost is estimated to be higher than Method 3.

(2) Method 3

This method has been widely employed for navigation channel dredging on the west coast. Compared to Method 1, the dredging efficiency is lower and a longer hauling time is required for dumping dredged materials. This might lead to higher unit cost and longer period of dredging work. However, according to the cost estimate, the total dredging cost is estimated to be lower than Method 1. From the environmental aspect, this method is preferable, if there are suitable dumping sites available in the offshore sea not very far from the dredging site. No serious problem is expected to the navigation of fishing boats.

From the total assessment, Method 3 (Grab Dredger) is recommended for both inner and outer channel dredging.

2.2.6 Selection of Dredging Method for Marang River Mouth

Disposal of Dredged Material

Since dredged materials are expected to be basically the same in quality as that of the coast, disposal on the coast near the river mouth would be more convenient for dredging work and economically advantageous. In addition, after completion of the proposed jetty, the coastal area behind the jetty which is located in the downside of the littoral drift tends to be eroded in the long run. Considering this situation, it is recommended that the dredged materials be dumped on the coast near the foot of the rightside jetty.

Dredging Method

The dredging methods which may be considered for the Marang River Mouth are as follows:

Method 1: Cutter Suction Dredger and discharge pipeline

Method 2: Grab (Clamshell) Dredger and hauling barges

Method 3: Dipper (Dustpan) Dredger and hauling barges

Since the river mouth water zone is very shallow, the operation/activity of dredgers and hauling barges will be limited especially in case of Method (2) and (3). Besides, approach to the proposed dumping site by hauling barges is considered impossible because of their deep draft. On the other hand, disposal by pipeline to the dumping site is more efficient and less costly. The pipeline length is less than 800 m. Therefore, the cutter suction dredger is recommended for this river mouth.

Particular Conditions for Dredging

Dredging works will be carried out in consideration of the following:

(1) Discharge Pipeline and Fishing Boats

The dredged sand will be conveyed directly by a discharge pipe across the shallow river mouth sea zone to the dumping beach back of the south jetty. During the operation of dredges in the inner channel, obstruction to the passage of fishing boats may be a problem. To cope with this, a temporary boatway with a width of at least 20 m will be provided, where the discharge pipe will be lain under the riverbed or over the boats supported by columns depending on the site conditions. Considering that the period of dredging is quite short (less than one month), obstruction to the passage of fishing boats could be minimized.

(2) Dredging Period

Dredging activities in the river mouth area should be avoided during the fish breeding season which falls in the period after the northeast monsoon. Therefore, dredging should commence after the month of March.

Excavation of Riverbed Rock

Some parts of the riverbed at the river mouth contain soft rocks. The soft rocks to be removed are estimated at 2,200 m^3. To excavate these rocks, the combination of a breaker and grab (clamshell) dredger is suitable. Compared to the dredging by cutter suction dredger, the work capacity of this method is lower and as a result, the unit cost becomes higher.

2.2.7 Major Construction Works

General

The construction method is prepared conceptually as a guideline for contractors to carry out the project works. The major work items, exclusive of dredging work, are the construction of jetty, breakwater and coastal groin which are proposed for the Marang river improvement. These structures are made up of seaworks such as riprapping, stone filling, rock armoring and placement of geo-textile mat.

Jetty and Breakwater

The breakwater will be built at the leading edge of the north jetty.

(1) Material

The structure consists of three layers of rock and stone, namely; underlayer, secondary layer and armor layer. The size of rock/stone differs from 100 kg to 5 tons depending on the layer. The quarry which can supply enough materials for the jetty and breakwater can be found locally in the area within 30 km from the project site.

(2) Construction Method and Procedure

The following conditions are considered for the construction plan and procedure:

(a) Construction capability of local contractor;

(b) Availability of construction plant and equipment in the local market;

(c) Conventionally mechanized construction method;

(d) Geological and topographical conditions; and

(e) Construction method employed in similar projects in the country.

Based on the above conditions, the construction method and procedure are proposed in the following order:

(a) For Land Work

- Quarry
- Hauling by Dump Truck
- Temporary Stockyard
- Hauling by Dump Truck and Deposition from Land
- Trimming of rubble mound

(b) For Under/On Water Work

- Quarry
- Hauling by Dump Truck
- Temporary Stockyard
- Hauling by Barge
- Deposition from Barge
- Underwater Grading and Trimming of Rubble Mound

Land work can be employed in case the top elevation of the riprap mound is above sea level. On the other hand, for under or on water work, barges and vessels are used.

(3) Construction Equipment and Work Capacity

Riprapping and armoring works per group are planned to be carried out by a combination of the following major equipment.

(a) On Land Work

Loading	:	Bulldozer, 21 ton Tractor Shovel
Hauling/Deposition	:	Dump Truck, 11 ton
Trimming of Rubble Mound	:	Crawler Crane, 25 ton

(b) Under/On Water Work

Loading	:	Bulldozer, 21 ton Tractor Shovel
Hauling/Deposition	:	Pontoon Barge, 100 ton
Underwater Grading/ Trimming of Rubble Mound	:	Crawler Crane/Crawler Barge, 25 ton

Based on the above construction equipment, the work capacity per group for the major works is estimated as follows:

Underlayer (10-100 kg) on Land Work	:	100 m^3/day
Core Stone (100-300 kg) on Water Work	:	150 m^3/day
Secondary Stone (300-500 kg) on Water Work	:	150 m^3/day
Armor Stone 1 (1-3 ton) on Water Work	:	30 m^3/day
Armor Stone 2 (3-5 ton) on Water Work	:	30 m^3/day

River and Coastal Groin

Groin proposed is composed of the same core stone (10 to 100 kg) and armor stone (1 to 3 tons) adopted for the jetty mentioned above. Construction method, procedure and work capacity conform to those of the jetty.

Geo-Textile Mat Placing

This work includes loading at stockyard, hauling and placing. Most of the works are carried out on and under the water. The proposed construction equipment and vessels are as follows:

(a) Pontoon Barge, 20 ton
(b) Crane Barge, 25 ton loading
(c) Tugboat, 60 PS, and Diver's Boat

Daily accomplishment is tentatively estimated at 400 m^2.

2.3 Project Implementation Schedule

2.3.1 Tanjung Piandang River Mouth Improvement Project

The project contains a few work items and work quantities are rather small. The project, therefore, should be implemented altogether in the same year soon after the detail design and fund preparation. All works, capital dredging, jetty works and bank protection works, can be completed in the first year after commencement. The required net dredging period for the capital dredging is estimated to be 3.5 months.

In addition, maintenance dredging will be annually implemented. To perform effective maintenance work, periodical monitoring of the navigation channel is required. Besides, investigation of the dumping site is carried out to determine the appropriate site which less affects the nearby sea environment. For dredging work, about 3.0 months is required including mobilization and demobilization.

As to the dredging period, the preliminary environmental impact assessment suggests that dredging should be scheduled to avoid the southwest monsoon season (April to July), because the monsoon generates big waves which will aggravate the turbidity and water quality problems if there are dredging operations. In the implementation schedule, therefore, capital dredging will commence from August. The project implementation schedule is as shown in Fig. 7.2-2.

2.3.2 Marang River Mouth Improvement Project

Particular Conditions

In drawing up the implementation schedule for the project, considered are the following:

(1) Construction and Work Capacity

More than half of the works is undertaken under or on water, and they are subject to wave action. It is therefore impossible to complete the whole works within a one-year period even if the monsoon season is included. According to the estimate, a period of at least 17 months is required.

(2) Beach Monitoring Period

The survey and study on wave and river mouth geomorphology indicate that the wave characteristics during the monsoon season (November to January) contribute greatly to the changes in the beach profile compared to other seasons. Therefore, the construction should be suspended during the monsoon season so that changes on the beach can be monitored. Besides, sea works during the fish breeding period should be avoided from the aspect of preservation of fish ecology. The survey also shows that the fish breeding period in this river covers the late monsoon season to the following month. For these reasons, the beach monitoring period is set consecutively from the month of November to February.

Order of Construction Works

The order of construction is determined as follows, considering the direction of littoral drift, the effect of the flushing of river mouth sediment, the changes in beach profile after construction of the jetty, and the planning of effective countermeasures.

(a) Construction of North Jetty and Breakwater
(b) Construction of River Groin and Reservoir
(c) Construction of South Jetty
(d) Construction of Coastal Groin
(e) Dredging of Navigation Channel

The proposed implementation schedule based on the proposed order of construction is as presented schematically in Fig. 7.2-3. As can be seen from the chart, the project requires about three-and-a-half years to complete all the necessary works. Judging from the nature of the works, the project should be conducted in two packages; namely, construction of structures and dredging of navigation channel. Each package is to be implemented under the "Bill of Quantities" contract system.

2.4 Cost Estimate

2.4.1 Conditions for Cost Estimate

Basic Condition

Project cost is estimated on the basis of the work quantities, the construction plan for the works and the following basic conditions.

(1) Price Level

All unit costs are based on the price level in November 1992.

(2) Currency Conversion Rate and Price Escalation

Currency conversion rates are assumed at US$1.00 = RM 2.50. All costs are expressed based on the price level of late 1992 and the annual escalation rate is assumed at 2.4%.

(3) Components of Project Cost

Project cost is composed of 3 main items, namely; direct construction cost, indirect construction cost and contingencies. The direct construction cost is estimated based on the requested work items and quantities derived from the feasibility design. The indirect cost includes compensation, government administration, and engineering service costs. The indirect construction cost is estimated on percentage base. Physical contingencies are counted into both direct and indirect construction costs. Price contingencies are estimated for escalation on the final project costs.

(4) Estimation of Direct Construction Cost

The direct construction cost is estimated by multiplying the unit cost by corresponding work quantity. The preparatory works and miscellaneous works are estimated on lump sum basis with a certain percentage of the main works.

(5) Unit Cost

The unit cost for each work item is composed of the direct cost and the indirect cost, and each item has the elements given below.

(a) Direct Cost

- Materials and Fuel Cost
- Equipment Cost
- Labor Cost

(b) Indirect Cost

- Overhead, Contingencies and Miscellaneous Cost
- Profit

Data on updated materials costs (as of November 1992) were obtained from the DID, the JKR head office, the DID Terengganu state office, and private manufacturers. The materials costs used for construction cost estimate are tabulated in Table 7.2-5.

DID and JKR's pay scales as of November 1992 are basically used as the labor rate. Since there is no big difference between rates in the west and east coast areas from the data obtained, the same labor rates shown in Table 7.2-6 are used.

The rental rates of construction equipment are determined based on the data from JKR and several contractors engaged in sea works. The rates are given in Table 7.2-7.

<u>Constitution of Project Cost</u>

Project cost is composed of main construction cost (including preparatory and miscellaneous works), compensation cost, administration and engineering costs, and contingencies. *Considering the nature of the proposed works, the river mouth* improvement project cost for Tg. Piandang and Marang is as described below.

(1) Tanjung Piandang River Mouth

Since dredging works account for the most parts of the project, the total construction cost is estimated referring to DID's cost estimation practice for dredging works as follows:

(a) Main Works

(b) Miscellaneous Works [10 % of (a)]

(c) Mobilization and demobilization expenses of dredger and barges [10% of Dredging Works]

(d) Engineering and Administration Cost [10% of (a)+(b)+(c)]

(e) Physical Contingencies [10% of (a)+(b)+(c)+(d)]

(2) Marang River Mouth

Sea works such as riprap, stone filling and armoring of rocks for jetty and breakwater accounts for the major part of the project. Taking the nature of the works into account, the project cost is estimated based on the following conditions:

(a) Main Works

(b) Preparatory works including mobilization/demobilization of dredger [10% of Main and Miscellaneous Works]

(c) Miscellaneous Works [5% of Main Works]

(d) Engineering and Administration Cost [10% of (a)+(b)+(c)]

(e) Physical Contingencies [10% of (a)+(b)+(c)+(d)]

2.4.2 Construction Unit Cost

Unit cost of construction works for the feasibility study are calculated using the basic prices mentioned before and the construction plan proposed. In this case, the calculated unit costs are justified by comparing them with the actual construction unit costs adopted in similar projects in the country. The summary of unit construction costs is presented in Table 7.2-8.

2.4.3 Dredging Unit Cost

As to the dredging unit cost, it is estimated on the assumption that grab (clamshell) dredger and cutter suction dredger are employed for Tg. Piandang and Marang river mouths, respectively. The details are described below.

Dredging Unit Cost by Grab (Clamshell) Dredger

An accurate unit cost of dredging by this type is, in general, quite difficult to estimate, because there is no proper standard cost estimate system in the country. Prior to estimating dredging cost for this study, actual costs quoted in similar projects undertaken by DID were examined. The following table shows the dredging unit costs by Grab (Clamshell) dredger.

Location	Year	Dredging Volume (m^3)	Unit Cost (RM)	Site
Beruas	1988-1990	132,000	4.5	7 km offshore
Perlis	1990	15,000	10.0	Inland
Johor Bharu	1991	400,000	6.0	3 km offshore
Kuantan	1990	400,000	5.0	3 km offshore

As can be seen from the table, unit costs range from RM4.5 to RM10 depending on the total volume of dredging. The table also shows that the bigger the dredging volume, the lower is the unit cost. To estimate the proper unit cost as of 1993, a cost estimate calculation is tried based on the data collected in Malaysia and the cost estimate method in Japan. The conditions of the calculation and results are as follows, where the hourly dredging production is derived from the method described in Table 7.2-9.

(1) Calculation Conditions

- Grab (Clamshell) Dredger	:	320 HP, Bucket Capacity 3.0 m^3
- Sea/River Bed Material	:	Soft clay, N-Value < 4
- Total Dredging Volume	:	100,000 m^3
- Hourly Production	:	115 m^3
- Operation Hours	:	10 hours
- Dumping Site	:	3 km offshore
- Necessary Vessels	:	Anchor boat (1) Tugboat (2) Hauling Barge 90 m^3 (3)

(2) Results

- Unit Cost (Average)	:	RM 8.5/m^3
For Outer Channel	:	RM 7.6/m^3 (Average hauling distance: 2.0 km)
For Inner Channel	:	RM 9.5/m^3 (Average hauling distance: 3.5 km)
- Required Dredging Period	:	3.5 months

The unit cost calculated is judged responsive in comparison with the actual unit costs employed by other dredging projects in Malaysia. Therefore, the unit costs obtained above will be used for this project cost estimate.

Dredging Unit Cost by Cutter Suction Dredger

This dredging method is selected in the master plan study, and unit cost is obtained under the standardized conditions mentioned in Subsection 1.3.2. The unit cost of dredging applicable to feasibility study for the Marang River Mouth is discussed below based on the surveyed site conditions, where hourly production is given from Fig. 7.2-4.

- Capacity of Dredger : 1,000 HP class
- Sea/River Bed Material : Loose sand, N-value ≈ 5
- Hourly Production : 240 m^3
- Working Hours : 18 hours (2 shifts)
- Operation Hours : 14 hours (2 shifts)
- Daily Production : 4,320 m^3
- Pipeline Length : 600 m (average)
- Dredging Volume : 116,000 m^3
- Required Dredging Time : 3.5 months

2.4.4 Operation and Maintenance

Tanjung Piandang River Mouth

Maintenance dredging for both outer and inner channels is the only maintenance work which will be done annually, as described in detail in the next section.

Marang River Mouth

After completion of the structures and the navigation channel dredging, operation and maintenance works (O&M) will be required for the following purposes:

(1) Regular inspection of jetty, breakwater and groin.

(2) Repairs when faults on the structures are found.

(3) Some maintenance dredging of the navigation channel with respect to unforeseen siltation in the channel.

(4) Beach filling or coastal protection works in preparation for erosion which may occur in the nearby beaches back to the proposed jetties.

These O&M works should be carried out annually and costs are estimated based on the percentage of total construction cost, as follows:

(1) Structures

- Rock/Stone Structures : 0.6% of capital cost
- Concrete Structures : 1.0% of capital cost

(2) Maintenance Dredging : 10% of capital dredging cost

(3) Beach Filling and Coastal Protection Works : 0.7% of cost of structures

(4) Administration Cost : 10% of [(1)+(2)+(3)]

2.4.5 Project Cost

Tg. Piandang River Mouth

(1) Capital Project Cost

The project cost (financial cost) of the proposed river mouth improvement works is estimated, as shown in Table 7.2-10 and summarized as follows.

1.	Construction Base Cost			
(a)	Main Works			
	- Dredging	:	RM	1,059,000
	- Jetty Works for Fishing Boats	:	RM	88,000
	- Bank Protection	:	RM	68,000
(b)	Miscellaneous Works	:	RM	122,000
(c)	Mobilization/Demobilization of Dredger and Other Vessels	:	RM	134,000
2.	Compensation Cost	:	RM	0
3.	Engineering and Administration Cost	:	RM	147,000
4.	Physical Contingencies	:	RM	162,000
5.	Price Escalation	:	RM	129,000
	Total Estimated Project Cost	:	RM	1,909,000

(2) Maintenance Cost

Maintenance dredging of the navigation channel is the only maintenance work in this river mouth. Dredging volume for the maintenance, which is annually recurrent, is estimated to be 55,400 m^3, and most of it is for the outer channel. *The cost of maintenance dredging is estimated on condition that the dredging* method is the same as that of capital dredging. Hence, the same unit price mentioned before is employed. As to the mobilization cost, 20% of the total dredging cost is used considering the annual volume of dredging. The maintenance cost is estimated as follows:

1. Maintenance Dredging Cost

- Outer Channel (47,900 m^3 x RM7.6/m^3)	:	RM	364,000
- Inner Channel (7,500 m^3 x RM9.5/m^3)	:	RM	71,000
Total	:	RM	435,000

2. Mobilization/Demobilization Cost

(20% of item 1 = 20% of RM435,000)	:	RM	87,000

3. Provisional Sum and Others

(15% of items 1+2 = 15% of RM522,000)	:	RM	78,000

4. Administration Cost

(10% of items 1+2+3 = 10% of RM600,000)	:	RM	60,000
Total Annual Maintenance Cost	:	RM	660,000

Marang River Mouth

(1) Capital Project Cost

Based on the conditions mentioned above, estimated is the total project cost for all structures and dredging works corresponding to 40 GRT boat size, as given is Table 7.2-11 and summarized below.

(a)	Preparatory Works	:	RM	1,066,000
(b)	Main Works			
	- Breakwater	:	RM	2,836,000
	- North Jetty	:	RM	2,774,000
	- South Jetty	:	RM	1,737,000
	- River Groin	:	RM	196,000
	- Coastal Groin	:	RM	1,270,000
	- Navigation Channel Dredging	:	RM	1,295,000
	- Reservoir	:	RM	41,000
(c)	Miscellaneous Works	:	RM	507,000
(d)	Compensation	:	RM	0
(e)	Engineering and Administration Cost	:	RM	1,172,000
(f)	Physical Contingencies	:	RM	1,289,000
(g)	Price Escalation	:	RM	1,183,000
	Total Estimated Construction Cost	:	RM	15,366,000

(2) Operation and Maintenance Cost

Based on the specified operation and maintenance works mentioned before, the annually recurrent cost is estimated to be RM 227,000 including administration cost.

(3) Annual Disbursement Schedule

The annual disbursement schedule for the economic evaluation is prepared as shown in Table 7.2-12 based on the project implementation schedule.

2.4.6 Alternative Cases of Project Implementation at Marang River Mouth

From the nature of the works, the project is divided into two parts; namely, structural component and dredging. In implementing the dredging works, the following two cases were considered depending on the change of design boat size. These two cases were compared according to economic efficiency to select the optimum alternative.

Case 1: Construction of structures and dredging corresponding to 40 GRT.

Case 2: Construction of structures and phased dredging corresponding to 20 GRT at present, 30 GRT at 2000, and 40 GRT at 2005.

Prior to the economic evaluation, the implementation schedule for both cases was prepared, as shown in Fig. 7.2-3 and 7.2-5. Project costs were also estimated, as given in Table 7.2-12 and 7.2-13.

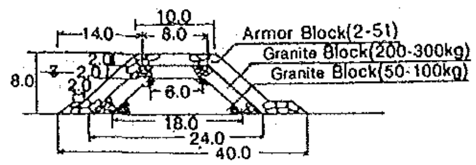
The economic viability of each of the two cases was tentatively evaluated in internal rate of return (IRR) and cost-benefit ratio (B/C). The same values were figured out, as given in Table 7.2-14 and 7.2-15.

In consideration of simplier construction and earlier accomplishment of tangible and intangible project benefits, Case 1 is adopted for the Marang River Improvement Project.

T A B L E S

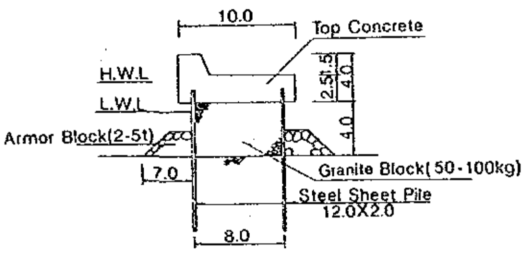
Table 7.1-1 TYPICAL CROSS SECTION OF BREAKWATER AND COST COMPARISON

(1) Rubble Mound Type



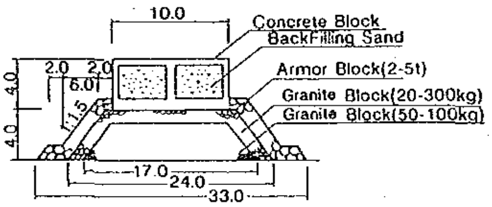
Structural Type / Structure Figure	Item	Q'ty	Volume	Unit Price (RM)	Cost (RM)
(1) Rubble Mound Type	Armor Block (2-5t)	1	96 m3	95	9,120
	Granite Block (200-300kg)	1	48 m3	60	2,880
	Granite Block (50-100kg)	1	48 m3	60	2,880
	Total Cost				14,880

(2) Sheet Pile with Top Concrete



Structural Type / Structure Figure	Item	Q'ty	Volume	Unit Price (RM)	Cost (RM)
(2) Sheet Pile with Top Concrete	Concrete	1	29.875 m3	400	11,950
	Steel Sheet Pile	2	2 m	3,800	7,600
	Armor Block (2-5t)	2	22 m3	95	2,090
	Granite Block	1	32 m3	60	1,920
	Total Cost				23,560

(3) Rubble Mound with Caisson



Structural Type / Structure Figure	Item	Q'ty	Volume	Unit Price (RM)	Cost (RM)
(3) Rubble Mound with Caisson	Concrete	1	15.64 m3	400	6,256
	Back Filling Sand	2	24.36 m3	5	122
	Armor Block	2	30 m3	95	2,850
	Granite Block (200-300kg)	1	72 m3	60	4,320
	Granite Block (50-100kg)	1	40.5 m3	60	2,430
	Total Cost				15,978