shown in Table 7.2-1 and thus, the same consideration should be given for project implementation.

7.3 Tanjung Piandang River Mouth

7.3.1 River Mouth Geomorphology

The Tg. Piandang River Mouth is selected as the representative river mouth in Group 5, where river mouth formation is emphasized with the straight coast formed by the external forces of low waves and small tidal prisms (see Table 7.1-1).

Topography

The Tg. Piandang River Mouth is located in the northernmost part of Perak State in the west coast of Peninsular Malaysia. The river mouth faces the open sea of the Strait of Malacca, except to the NNW where Pulau Pinang is located 20 km from the river mouth as shown in Fig. 7.3-1.

The Tg. Piandang River presently functions as a drainage channel under the Kerian Sg. Manik Project with a drainage area of 9 km^2 and a channel length of 10 km. The area is protected from saltwater intrusion by tidal bunds constructed inland, and these bunds usually divide the cultivation area and the mangrove forests.

External Force

Waves generated in the Strait of Malacca and the Andaman Sea by the wind predominantly from the direction between west and northwest are partly sheltered by Pinang Island located 20 km to the northwest of the river mouth. These waves are attenuated by breaking, with bottom friction as they move into the shallow water area near the shore.

The tidal intrusion volume of the Tanjung Piandang River Mouth is small, because the tidal gate provided at 2.7 km upstream is usually closed to prevent the intrusion of saltwater.

Offshore Geomorphology

As illustrated in Fig. 7.3-2 to 7.3-4, seabed profiles are relatively gentle at about 1/400 for the stretch from the shoreline to about 3 km offshore. The gradient of the seabed from the river mouth 2 km offshore is also gentle at around 1/1,400, and this gradually steepens to 1/180 at 4 km offshore presenting a generally convex profile.

Seabed geomorphology in this area seems to be formed by tidal current in the Strait of Malacca and, accordingly, the NNW-SSE alignment is predominant.

Bed Material

As illustrated in Fig. 7.1-6, bed materials are clayey silt with 23% clay (<0.002 mm), 71% silt (0.002 to 0.063 mm) and 6% sand (0.063 to 2.0 mm). These are the typical materials in muddy coasts.

There is no distinct difference between materials in and out of the mouth and, accordingly, materials of the inner channel are presumed to be of marine origin.

Coastal Change in Neighboring Areas

Shoreline retreat is severe in the northern shore in the 3 km stretch from the mouth at the rate of 300 m for 8 years from 1966 to 1974, 250 m for 7 years from 1974 to 1981, and 250 m for 5 years from 1981 to 1986. In the stretch from 3 km to 4.6 km to the north of the mouth, shoreline accretion of 200 m for 8 years from 1966 to 1974 is found. No distinct change is observed in this stretch from 1974 to 1981. (Refer to Fig. 7.3-5.)

At the mouth of the river, both banks are retreating due to the demise of mangrove forest, widening the channel by 70 m on average for the 8 years from 1966 to 1974. The southern shorelines, to the contrary, have a lot of variations.

River Mouth Configuration

The longitudinal profile of the Tg. Piandang River presents a downward slope from the upstream gate to the mouth, and this fact characterizes the Tg. Piandang River Mouth. In the other rivers, inner channels are maintained relatively deeper and the shallowest

part is usually off the mouth. This is because the Tg. Piandang River is originally one of the channels radiately flowing in the alluvial fan with a relatively steep gradient. In addition, it has only a small catchment area and hence, discharge is not much and release of water from the gate is limited only during the flood season.

7.3.2 Identification of Problems and Measures Taken

Present Problem

The water depth which is only about 1.0 m below LSD becomes some 10 cm at low tide both in the inner channel and the approach channel, while the draft of boats is about 1.5 m. The channel filled with seawater also becomes very narrow, so that fishing boats as well as fishing activities are forced to depend on the tide.

River mouth shifting and wave intrusion are not serious problems at the Tg. Piandang River Mouth. As to inundation due to river mouth siltation, this may not be a serious concern. No inundation has been reported except in high tide and incidental heavy rains.

Measures Taken

In the drainage channel in the Kerian Laut area where the Tanjung Piandang River Mouth is located, efforts were made to increase channel depth by using a mud-wheeler and ship propeller, and promising results were obtained from the ship propeller trials. Dredging works in this river mouth are further scheduled in the Sixth Malaysia Plan.

Related Projects

In the Tanjung Piandang drainage channel, a tide control gate consisting of two sluice gates facing the upper stream of the river channel and two flap gates facing seaward were constructed in the 1970's under the Kerian Sg. Manik Integrated Agricultural Development Project which was completed in 1989.

7.3.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

The condition of Tanjung Piandang River Mouth is similar to the Perlis River Mouth; therefore, some countermeasures are also conceptually excluded as discussed in Section 7.1.3.

As regards dredging, the applicability of agitation dredging is worth studying, since the Tanjung Piandang River Mouth seems to have some favorable conditions for agitation dredging. However, it was determined that agitation dredging is not applicable because of the size of materials, velocity of tidal current, etc. In this connection, the following two alternative cases have been studied:

Case 1: Capital and Maintenance Dredging

Case 2: Case 1 plus Submerged Jetty

The combination of countermeasures for each study case is given in Table 7.1-2, for comparison with those of other representative river mouths.

Design Feature of Countermeasures

The design feature of countermeasures is described below.

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features for dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is shown in Table 7.1-4.

(2) Maintenance Dredging by Conventional Equipment

The necessary maintenance dredging volume is calculated for the Tg. Piandang River Mouth based on the annual siltation height of 1.0 m for muddy coasts, as given in Table 7.1-4.

(3) Submerged Jetty

Since the mean sea level of Tanjung Piandang River Mouth is 0.1 m above LSD (1.5 m above CD), the crown elevation of the jetty is LSD 0.1 m at the river mouth. The other design features and work volume of the submerged jetty are as given in Table 7.1-5. The annual maintenance dredging volume will be 32,600 m^3, calculated in the same manner as Perlis River Mouth.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated by applying the unit cost described in Chapter 6 to the work volume based on the design features. The total cost in a manner of net present value is summarized below, assuming that the project life is 30 years and the discount rate is 8%. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	2,668	508	10,738
Case 2	11,167	247	19,991

Selection of Optimum Countermeasure

The optimum countermeasure is selected on the least cost basis, because the benefit is assumed to be the same among the two alternative study cases. Thus, the combination of capital and maintenance dredging which has an economical advantage and is also more reliable in the technical aspect than the submerged jetty, is selected as the optimum countermeasure for the Tanjung Piandang River Mouth. (Refer to Fig. 7.3-6.)

7.3.4 Project Benefit

The Tanjung Piandang River Mouth has a number of fishing boats (485 in total), although most of them are small in size and a few commercial boats are observed. No flooding problem due to the river mouth siltation has been reported, as discussed in

Section 6.2. Benefits are therefore expected to accrue from the fishery. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Tanjung Piandang River Mouth exist 480 small size (less than 10 GRT) and 5 medium size (10.0 to 39.9 GRT) boats. The annual benefit is RM 0.96 million, as given in Table 7.1-7.

7.3.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of Tanjung Piandang River Mouth are capital and maintenance dredging. The possible environmental impacts of these countermeasures, as given in Table 7.3-1, are quite similar to the case of Perlis River Mouth and thus, the same considerations should be given for project implementation.

7.4 Beruas River Mouth

7.4.1 River Mouth Geomorphology

The Beruas River Mouth is selected as the representative river mouth in Group 7, where river mouth formation is emphasized with the estuary formed by the external forces of low waves and large tidal prism (refer to Table 7.1-1).

Topography

The Beruas River Mouth is located in the approximate center of the coastline of Perak State in the west coast of Peninsular Malaysia. To the east of the river mouth, the Bintang-Imas mountains stretch from north to south and end at Beruas Town. The Beruas River collects water in the southern slope of this mountain with a catchment area of 240 km^2 and the river length of 45 km.

To the north of the river mouth, there is a shore of submergence where the river mouths of Sangga, Larut and Terong are located, and there exists Tg. Batu 2 km to the south, as shown in Fig. 7.4-1.

External Force

Waves generated in the Strait of Malacca and the Andaman Sea by the wind predominantly from the direction between west and northwest are attenuated by breaking, with bottom friction as they move into the shallow water area near the shore.

Tidal currents in the river as a result of rising and ebbing tide and the river discharge are abundant. These are the main factors forming the estuary. The Beruas River Mouth has a tidal intrusion stretch of about 7 km with an average river width of about 50 m in this stretch and, accordingly, the tidal prism of the Beruas River Mouth is relatively large.

Offshore Geomorphology

As illustrated in Fig. 7.4-2 to 7.4-5, bottom elevations in the center of the channel in the stretch are higher than those in the off-channels in the other stretch from the mouth to 800 m offshore. The bottom of the channel in this part is flat at about LSD -1.2 m, and from this point the seabed has a gradient of 1/450 to the elevation of LSD -5 m. In the off channel part, seabed profile is about 1/600 from the shore.

Bed Material

A gradation curve of seabed materials sampled in the outer channel at the mouth is presented in Fig. 7.1-6. As illustrated, bed materials are silty with 10% clay (<0.002 mm), 63% silt (0.002 to 0.063 mm) and 27% sand (0.063 to 2.0 mm). The materials are slightly sandy when compared to the northern river mouth of Perlis, Kedah and Tg. Piandang, with the median diameter d50 at 0.033 m and the mean particle diameter dm at 0.158.

Coastal Change in Neighboring Areas

Shoreline retreat is 50 m for the period of 15 years from 1966 to 1981 in the northern shore, and this corresponds to 3 m annually (refer to Fig. 7.4-2). In the southern shore, the shoreline near Sg. Batu has retreated by about 50 m for the period of 7 years from 1974 to 1981. However, the rate of shoreline retreat in this area is comparatively

smaller than those in Perlis, Kedah and Tg. Piandang. The location of river banks in the inner channel is stable and no change has been observed for the last 15 years.

River Mouth Configuration

The river mouth configuration is characterized with a gradually narrowed river width toward upstream sections in the tidal prism stretch. The shallowest part is about LSD -1.4 m, as shown in Fig. 7.4-5.

7.4.2 Identification of Problems and Measures Taken

Present Problem

The natural waterway formed by the flow of the Beruas River serves as the navigation channel for fishing boats. Although the minimum water depth in the inner channel is maintained relatively deep at about 2.5 m below LSD, the shallow shore with a depth of about 1.5 m below LSD blocks the entrance channel at a distance of about 400 m from the river mouth. In view of this and the congested condition within the inner channel, fishing boats with the draft of about 1.5 m have to wait inordinately for a long time between two and three hours for returning to land their catch.

Shifting of river mouth and wave intrusion are not serious problems at the Beruas River Mouth. So far, no inundation due to river mouth siltation has been reported, and river mouth siltation may not bring about any inundation problem judging from the siltation condition as aforementioned.

Measures Taken

To cope with the river mouth siltation problem, the DID conducted dredging works seaward as well as the inner channel from 1988 to 1990. The dredging volume was about 122,000 m^3.

Related Projects

No specific project has been planned or conducted in the area around the Beruas River Mouth, except minor shore protection works at the left side and some small scale jetties for landing of fish catch.

7.4.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

Some countermeasures are conceptually excluded as in the case of the Perlis River Mouth. The following two alternative cases are studied.

Case 1: Capital and Maintenance Dredging

Case 2: Case 1 plus Submerged Jetty

The combination of countermeasures for each study case is presented in Table 7.1-2, for comparison with those of the other representative river mouths.

Design Feature of Countermeasures

The design feature of countermeasures is described below.

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features of dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design feature is shown in Table 7.1-4.

(2) Maintenance Dredging

The necessary maintenance dredging volume is calculated for the Beruas River Mouth based on the annual siltation height of 1.0 m for muddy coasts. (Refer to Table 7.1-4.)

(3) Submerged Jetty

Since the mean sea level of the Beruas River Mouth is 0.2 m above LSD (1.5 m above CD), the crest elevation of the jetty is LSD 0.2 m at the river mouth. The other design features and work volume for the submerged jetty are as given in Table 7.1-5. In this case, the annual maintenance dredging volume will be reduced to 57,700 m^3.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated by applying the unit cost described in Chapter 6 to the work volume based on the design features. The total cost in a manner of net present value is summarized as follows, assuming that project life is 30 years and discount rate is 8%. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	4,464	897	18,660
Case 2	11,559	389	22,202

Selection of Optimum Countermeasure

The combination of capital and maintenance dredging which has an economical advantage and is also more reliable in the technical aspect than the submerged jetty, is selected as the optimum countermeasure for the Beruas River Mouth. (Refer to Fig. 7.4-6.)

7.4.4 Project Benefit

Benefits at the Beruas River Mouth will accrue only in the area of fishery, since the mouth is used exclusively for fishery with a total of 653 fishing boats registered, and no flooding problem has been reported as discussed in Section 6.2. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Beruas River Mouth exist 283 small size (less than 10 GRT), 357 medium size (10.0 to 39.9 GRT), 10 large size (40 to 69.9 GRT) and 3 deepsea (70 GRT and above) boats. The annual benefit is RM 2.27 million, as given in Table 7.1-7.

7.4.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of Beruas River Mouth are capital and maintenance dredging. The possible environmental impacts of these countermeasures, as given in Table 7.4-1, are quite similar to the case of the Perlis River Mouth and thus, the same considerations should be given for project implementation.

7.5 Kuantan River Mouth

7.5.1 River Mouth Geomorphology

The Kuantan River Mouth is selected as the representative river mouth in Group 2, where river mouth formation is emphasized with the straight coastline formed by the external forces of high and oblique waves and large tidal prism (refer to Table 7.1-1). The high and oblique wave generates a littoral current which carries drifting sand.

Incidentally, the Kuantan River Mouth is located adjacent to a headland which has a sheltering effect to the wave action. Since most of the river mouths in this group, six out of ten, are located adjacent to the headland, the existence of the headland is considered to examine the river mouth condition in this group.

Topography

The Kuantan River Mouth is situated almost in the center of the eastern coastline of Peninsular Malaysia and at the same time in the northern tip of Pahang State. The catchment area is 1,710 km² and the river length is 80 km.

Two hills, Bt. Tg. Tembeling Hill, 337 m high protruding into the sea, and Bt. Galing Hill, 973 m high located more landward approximately 650 m W-NW of Tg. Tembeling are prominent landmarks in the area. Areas except these hills are low,

flat lands. Tg. Tembeling shelters the river mouth from N-NE winds predominant in the area.

The shoreline has been stable for a long time and the location of the mouth, just west of Tg. Tembeling, seems to be in the balanced condition.

The left bank of the river mouth has been developed as Kuantan City, but a vast swampy terrain extends in the remaining areas including the right bank of the mouth, and 5 km from the river mouth and the upstream.

External Force

Since the Kuantan River Mouth is protected to the east by the protruding Tg. Tembeling and to the south by the protruding coast of the outlet of the Pahang River, only incident waves from between the northeast and southeast are expected. Accordingly, oblique waves from the northeast direction predominant during the Northeast Monsoon season are the major forces forming the river mouth configuration.

The tidal difference between mean higher high water and mean lower low water is 2.7 m, while ocean current is less than 0.5 m/s. As noticed that the Kuantan River has a tidal influence stretch of about 25 km and the width is about 130 m on average in this stretch, the tidal prism of the Kuantan River Mouth is quite large.

Offshore Geomorphology

A shallow shore zone extends up to 2 km from the shore near the mouth. The profile of the outer channel shows the bottom elevation of about LSD -2 to LSD -3 m for the stretch of 0.7 to 2.2 km from the mouth. All outer channel profiles of different years show M-shaped form with the shallowest bed of about LSD -2 m at 0.8 km and 2.2 km, and the bed between these points show a concave profile with the lowest bed elevation of about LSD -3 m. The offshore shallow zone is presumably formed by wave action, namely littoral sand drift, and the near shore shallow zone is by river discharge. The sea bed gradient from this shallow zone offshore is about 1/1,100. (Refer to Fig. 7.5-2 to 7.5-7.)

Bed Material

The bed materials are 100% sand (defined as 0.063 to 2.0 mm) with the median diameter d50 of 0.20 mm and the mean grain diameter of 0.19 mm. (Refer to Fig. 7.5-6.)

Coastal Change in Neighboring Areas

As shown in Fig. 7.5-2, no coastline change has been observed from the photographs and it seems that the shoreline in this area has been quite stable. However, the south shoreline tends to erode and protection works are ongoing.

River Mouth Configuration

The river mouth configuration conditions are summarized as follows:

(1) The location of the mouth is fixed.

(2) The inner channel is naturally maintained deep.

(3) A shallow shore zone extends at the stretch from -0.6 km to -2.6 km with elevations from LSD -2 to LSD -3 m.

(4) The outer channel is shifting year by year.

(5) The width of the naturally maintained outer channel is about 200 to 300 m.

The river mouth configuration under these conditions is normally characterized with the development of a sand spit from one side of the river bank which tends to shift the river mouth depending on force balance between wave and river flow discharge. However, the existence of a headland and/or island which shelters the wave action sometimes prevent such development of sand spit but reversely promote the development of wide shallow shore around the river mouth, and the channel in this shallow shore sometimes shifts its course due to the littoral current. Thus, the river mouth configuration has changed.

7.5.2 Identification of Problems and Measures Taken

Present Problem

The natural waterway formed by the water flow of the Kuantan River serves as the navigation channel at the Kuantan River Mouth. Entering and leaving the port at the river mouth is generally not possible at low tide due to the presence of shallow areas 1 to 2 km offshore. The depth of the water in the approach channel which is about 2 m below LSD becomes only 1.0 m at spring low tide, while the draft of boats of more than 40 GRT is over 2.5 m (refer to Table 4.2-1 and Fig. 7.5-5).

On the other hand, the inner channel of the river mouth is relatively well maintained by the river water as well as the current in the tidal prism. The depth of the inner channel is between 7 m and 11.5 m below LSD.

So far, no inundation due to river mouth siltation has been reported. Flood damage in the upper reaches was reported when high tide and flood occur at the same time.

Measures Taken

Although measures to alleviate river mouth problems have not been taken so far, a study on the matter was conducted in March 1976 under the Kuantan Fishing Port Project (refer to Fig. 7.5-7). In this study, three alternative measures were proposed and it was concluded through the hydraulic model experiment that dredging of the approach channel without any training dike would be sufficient.

Dredging is scheduled in 1993 at the shore side of the approach channel with a length of about 3 km, a width of 60 m and a depth of 3.7 m below CD. The total volume of about 400,000 m^3 is expected to be dredged with the budget of RM 2.0 million (US$800,000).

Related Projects

Some projects related to the Kuantan River Mouth are the following:

(1) Kuantan Port

To meet the growth in the number of vessels for export and import in the east coast, the Kuantan Port was constructed at Tanjung Gelang about 25 km north of Kuantan.

(2) Land Reclamation at Shore near River Mouth

For tourism development, the reclamation of 290 ha of land on the coast in the Tanjung Tembeling area near the left side of the Kuantan River Mouth is proposed, where hotel, golf course, lagoon resort, etc., are to be provided.

(3) Bridge Construction

A bridge crossing the Kuantan River at about 500 m upstream of the river mouth is under construction to connect Kuantan City and the villages situated in the coastal zone south of the Kuantan River Mouth.

7.5.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

Dredging of the Kuantan River Mouth was already selected as a suitable countermeasure in the previous study and it is scheduled in the beginning of 1993. However, the following two alternative cases were studied in this master plan to confirm the adequacy of the dredging countermeasure.

Case 1: Capital and Maintenance Dredging

Case 2: Capital Dredging, Jetty and Coastal Groin

The combination of countermeasures for each study case is presented in Table 7.1-2, for comparison with those of the other representative river mouths.

Design Features of Countermeasures

The design feature of countermeasures is described as follows.

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features of dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is shown in Table 7.1-4.

(2) Maintenance Dredging

The necessary maintenance dredging volume corresponds to the annual volume of longshore transport and sediment from the catchment in case that the siltation rate does not exceed the capital dredging volume. In the Kuantan River Mouth, the capital dredging volume is more than the annual volume of longshore transport and sediment from the catchment. The maintenance dredging volume is shown in Table 7.1-4.

(3) Jetty

Since the higher high water level of the Kuantan River Mouth is 1.6 m above LSD (3.3 m above CD), the crown elevation of the jetty is LSD 1.6 m at the river mouth. The design features are shown in Table 7.1-5. The work volume of the jetty based on the design features is also shown in the table.

(4) Groin (Coastal Groin)

Beach erosion may occur downstream of the current by the construction of jetty. Three groins, 1,000 m, 500 m and 150 m long, respectively, will be set up at the southern beach of the river mouth. (Refer to Table 7.5-1.)

Cost Comparison of Alternative Cases

The total cost in a manner of net present value is summarized as follows, assuming that project life is 30 years and discount rate is 8%. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	3,706	1,302	23,502
Case 2	18,777	90	25,452

Selection of Optimum Countermeasure

The optimum countermeasure is selected on the least cost basis. As may be noticed from the cost comparison, there is not much difference in cost between the two alternative study cases. Thus, dredging is selected as the optimum countermeasure for the Kuantan River Mouth for the following reasons:

(1) In the previous study for the Kuantan Fishing Port, it was concluded through the hydraulic model test that dredging is the optimum countermeasure.

(2) In case of a jetty, it may cause adverse influence to the adjacent coast because a large amount of longshore transport will be trapped by the jetty resulting in the erosion downstream of the littoral current. It is, however, necessary to conduct a more detailed study to confirm the adequacy of the coastal groin adopted in this study.

A general layout of the proposed countermeasures is given in Fig. 7.5-8.

7.5.4 Project Benefit

Benefits at the Kuantan River Mouth will accrue only from the fishing activities of the 163 boats registered. Commercial boats anchor at the Kuantan Port located at Tg. Gelang 25 km north of the river mouth, so that no sea transport benefit is expected and, as discussed in Section 6.2, the vicinity of the river mouth is not vulnerable to flooding. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Kuantan River Mouth exist 1 small size (less than 10 GRT), 38 medium size (10.0 to 39.9 GRT), 61 large size (40.0 to 69.9 GRT), and 63 deepsea fishing

(70 GRT and above) boats. The annual benefit is RM 2.66 million, as given in Table 7.1-7.

7.5.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of the Kuantan River Mouth are capital and maintenance dredging. The possible environmental impacts of these countermeasures, as given in Table 7.5-2, are quite similar to the case of the Perlis River Mouth and thus, the same considerations should be given for project implementation.

Dredging at the Kuantan River Mouth is scheduled to start in 1993 and the environmental impact by dredging may then be studied. Periodical observation has to be conducted for reference in further project execution.

7.6 Kerteh River Mouth

7.6.1 River Mouth Geomorphology

The Kerteh River Mouth is selected as the representative river mouth in Group 3, where river mouth formation is emphasized with the straight coast formed by the external forces of high and oblique waves and small tidal prism (refer to Table 7.1-1). Incidentally, the Kerteh River Mouth is located adjacent to a headland which has a sheltering effect to the wave action. Since two out of three river mouths included in Group 3 have a headland or an island, the effect of the existence of a headland or an island were considered to examine the river mouth condition in this group.

Topography

The Kerteh River originates in hilly areas 10 to 20 km inland from the shoreline, and flows in heavily meandered channels in low, wet lands extending along the shore (refer to Fig. 7.6-1). The catchment area is 240 km^2 and the total channel length is 40 km.

External Force

The Kerteh River Mouth is exposed to the South China Sea and subject to extreme wave conditions, especially during the Northeast Monsoon season which causes waves obliquely rushing to the river mouth. The tidal prism of the Kerteh River Mouth is relatively small with a tidal intrusion stretch of about 5 km of and the river width of about 30 m on average.

Offshore Geomorphology

The seabed gradient of 1,000 km left and right of the mouth show a quite different formation. The profile in the left bank of the mouth, namely, the northern stretch from the tip of the headland, shows steep gradients of about 1/20 from the shore to the elevation of LSD -5 m for a length of 100 m, and from that point offshore the gradient is 1/100 to LSD -12 m. (Refer to Fig. 7.6-2 to 7.6-5.)

On the other hand, in the right of the mouth, an LSD -5 m seabed is in a distance of 1.5 km from the shore with a gradient of about 1/300, and from that point offshore the gradient is about 1/175.

Bed Material

Bed materials are much coarser than the materials in the other representative river mouths in the sandy coast, consisting of 39% of sand (defined as 0.063 to 2.0 mm) and 61% of gravel (2.0 to 75 mm). The median diameter d50 and the mean grain diameter dm are 2.36 mm and 2.46 mm, respectively.

Change in Coastal Geomorphology and River Mouth Area

The river mouth area is in a very unstable condition, as shown in Fig. 7.6-6 which compares the river mouth formation in 1966, 1974 and 1983. The meandering river course flowing in the low, wet land is stable at least after 1966 and only the river mouth is unstable.

The development of a sand bar extending SSW from the mouth is distinguished, and the tip of the bar reached as far as 2.5 km from the mouth. Annual growth rates of the

bar are 75 m for the 8 years from 1966 to 1974 and 45 m for the 9 years from 1974 to 1983, and the flush of the bar is presumed to be once in several tens of years.

The river mouth is artificially fixed at present by the construction of a right bank bund. The river presently flows straight to the sea and a floodway in the upstream near the river mouth has been provided in the context of bank erosion protection. The old river course is maintained as a lagoon, but it is presently closed completely by the bund.

As to the inner channel, it is maintained comparatively deeper, as shown in Fig. 7.6-5. The riverbed is LSD -7.5 m at the 2.1 km point from the mouth and it gradually goes up towards the mouth with some local irregularity.

7.6.2 Identification of Problems and Measures Taken

Present Problem

Since the river flow and tidal prism are so small to well maintain the river mouth, the water depth at the river mouth is shallow. Furthermore, due to the presence of shallow areas in the shore, navigation at the river mouth is generally not possible at low tide. The minimum water depth of the navigation channel in the approach and inner channels are 1.0 m and 2.5 m below LSD, respectively, while the draft of fishing boats is about 1.5 m (refer to Table 4.2-1).

The location of the river mouth has been shifting year by year, while wave intrusion may not be severe because the waves break in the shallow shore zone. Since the houses are located at a higher elevation, inundation is not a serious problem around the river mouth, although right bank erosion has been reported. This was alleviated by the construction of a floodway nearby.

Measures Taken

To cope with the river mouth siltation problem, a fisherman's association constructed a jetty at the right bank and a training wall along the right bank which separated the lagoon from the river channel in 1992. The jetty is 138 m long with a crown width of 10 m and a height of 3.0 to 4.0 m.

Dredging works have also been conducted for the stretch of 0.5 km in the inner channel using a suction type dredger. The dredging volume was 53,000 m^3.

Related Projects

To prevent erosion of the right bank where a fishing village and a road exist, the DID provided revetment in a stretch of 800 m in 1985, and a flood diversion channel was constructed in 1987. The diversion channel is 400 m long, 30 m wide and 3.0 m deep.

7.6.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

To cope with the current problem of the Kerteh River Mouth, i.e., the shifting of river mouth and the shallow navigation channel at both inner and approach, the following two alternative study cases were set by applying these countermeasures in combination with each other in accordance with the considerations for alternative study cases mentioned in Subsection 6.4.2.

Case 1: Capital and Maintenance Dredging and Training Wall

Case 2: Capital Dredging, Jetty, Coastal Groin and Reservoir

The combination of countermeasures for each study case is given in Table 7.1-2, for comparison with those of the other representative river mouths.

Design Feature of Countermeasures

The design feature of countermeasures is described below.

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features for dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is shown in Table 7.1-4.

(2) Maintenance Dredging

In the Kerteh River Mouth, the capital dredging volume is less than the annual volume of drifting sand and sediment from the catchment. Therefore, the capital dredging volume for the outer channel is adopted to the maintenance dredging volume, as given in Table 7.1-4.

(3) Jetty

Applying the higher high water level, the height of the jetty is 1.6 m at the river mouth. The work volume of the jetty based on the other design features is given in Table 7.1-5.

(4) Reservoir

At present, there exists a lagoon on the right side which is now shut off from the Kerteh River by a training dike. This can be used as reservoir to increase the tidal prism only by providing a culvert box. The size of the reservoir is roughly estimated at 462,000 m^3. (Refer to Fig. 7.5-1.)

Since the tidal volume increases to 41,250 m^3, which corresponds to 9.8% of the present tidal prism (see Subsection 6.5.3), the navigation channel is expected to deepen to 0.2 m from the present navigation channel bed height; thus, the dredging volume will decrease.

(5) Groin

For the prevention of beach erosion downstream of the current, two groins, 200 m and 100 m long, are to be constructed at the southern beach, as shown in Fig. 7.6-7. The stretch is as given in Table 7.5-1.

(6) Training Wall

For stabilization of the right bank at the river mouth, training wall is provided along the flow direction. The stretch for the training wall is as given in Table 7.5-1.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated by applying the unit cost described in Chapter 6 to the work volume based on the design features, as summarized below. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	2,670	609	12,194
Case 2	6,614	31	8,974

Selection of Optimum Countermeasure

In the case of the Kerteh River Mouth, the direction of long shore transport from south to north is predominant, so that a one-side jetty on the northern side seems to be enough to prevent the intrusion of sediment into the navigation channel and this will minimize the cost of construction of the jetty (Case 2). On the other hand, the cost of maintenance dredging is quite large because of the large amount of longshore transport. Thus, the combination of capital dredging, jetty, coastal groin and reservoir is selected as the optimum countermeasure for the Kerteh River Mouth. (Refer to Fig. 7.6-7.)

7.6.4 Project Benefit

The Kerteh River Mouth is used as a fishing port by 51 fishing boats. No particular sea transport services has been observed, although the industrial estate of Petronas has been developed about 10 km away from the river mouth in the south. As discussed in Section 6.2, the vicinity of the river mouth is not vulnerable to flooding. In this context, only the fishery benefit is expected at the Kerteh River Mouth. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Kertch River Mouth exist 44 small size (less than 10 GRT) and 7 medium size (10.0 to 39.9 GRT) with no bigger size boats. The annual benefit is RM 0.23 million, as given in Table 7.1-7.

7.6.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of Kerteh River Mouth are jetty, capital dredging and reservoir. The possible environmental impacts of these countermeasures could be as follows (refer to Table 7.6-1):

(1) Beach erosion in the adjacent coastline due to the modification of the littoral sediment transport and sediment supply from the river, as well as the destruction of the buffer zone along the river mouth.

(2) Destruction of nursery and breeding areas by siltation during the dredging period.

(3) Impact to aquatic and marine life and their estuarine and marine habitats and communities.

To alleviate such impacts, it is necessary to consider the following:

(1) Provision of dumping yard for dredged materials at areas where erosion and destruction of the buffer zone are expected.

(2) Provision of countermeasures to prevent coastal erosion.

(3) Appropriate planning of the construction schedule and selection of the construction method to minimize the impact.

(4) Selection of appropriate site for the dumping yard to minimize the impact to aquatic and marine life and their estuarine and marine habitats and communities.

7.7 Marang River Mouth

7.7.1 River Mouth Geomorphology

The Marang River Mouth is selected as the representative river mouth in Group 1, where river mouth formation is emphasized with the straight coast formed by the external forces of high and straight waves and large tidal prism (refer to Table 7.1-1).

Topography

The Marang River has a catchment area of 460 km^2 and a total channel length of 50 km, and its mouth is located 15 km SSE from the Terengganu River Mouth in Terengganu State.

The shoreline of the area for a stretch of 70 km from the Terengganu River Mouth to the Dungun River Mouth consists of a continuous sandy beach with a straight coastline and is generally aligned in a N35°W direction, as shown in Fig. 7.7-1. Although an island, Kapas Island, is located 5 km offshore of the mouth, the topography of the area is not affected by the island.

The Marang River originates in 600 m high hills, but most of the channel runs in a low, flat land and this implies a low sediment production in the catchment.

External Force

Although the river mouth is partly sheltered by Kapas Island, it is exposed to the South China Sea, subject to extreme wave conditions especially during the Northeast Monsoon season which cause waves rushing straight to the river mouth. The tidal prism of the Marang River Mouth is large with a 20 km of the tidal intrusion stretch and the river width of about 80 m.

Offshore Geomorphology

A very shallow zone exists at the river mouth, but the stretch of the shallow zone with elevations above LSD -5 m is very short at about 1.4 km. The seabed gradient in this area is steep at about 1/100 to 1/150. (Refer to Fig. 7.7-2 to 7.7-4.)

Bed Material

The median diameter d50 of the samples is in the range of 0.013 to 1.2 mm, and the predominant material is sand. The average composition is 6.0% of fines (below 0.063 mm), 91.8% sand (0.063 to 2.0 mm) and 2.2% gravel (2.0 to 60 mm). The typical gradation curve is presented in Fig. 7.5-6.

Change in Neighboring Coasts and River Mouth

The shoreline in the stretch from Terengganu to Dungun seems to be generally stable. As shown in the aerial photograph interpretation for the year 1966, 1974 and 1980 (see Fig. 7.7-5), the course of the inner channel is not stable and has moved from right to left, or vice versa. Recently, however, the course of the inner channel seems to be stable and the left side of the main channel is almost steady.

The river mouth configuration is characterized with the development of a sand spit from both banks, sometimes one side of the river mouth, and sand dunes are seen in the inner channel. Sediment transported from the river basin is deposited at the shore side around the river mouth resulting in a shallow shore, and sediment is pushed back toward the inner channel and deposited there when the wave and tidal current are so strong.

7.7.2 Identification of Problems and Measures Taken

Present Problem

The minimum water depth of the navigation channel at the river mouth is about 1.5 m below LSD, while the draft of fishing boats is about 2.5 m. Thus, navigation at the river mouth is generally not possible at low tide (refer to Fig. 7.7-3 and 7.7-4, and Table 4.2-1).

The river mouth and river channel course are shifting and unstable, and wave intrusion is expected to be severe when the river mouth is kept open. Since the houses are located at a higher elevation, inundation is not a serious problem around the river mouth.

Measures Taken

To cope with the river mouth siltation problem, the DID conducted dredging works for a volume of about 231,000 m^3 from October to December 1980. Further dredging works are scheduled in the Sixth Malaysia Plan.

Related Projects

Some projects related to the Marang River mouth are the following:

(1) Bank Protection Works at River Mouth

To prevent bank erosion, cylindrical concrete piles have been provided by JKR along both river banks from the bridge to the river mouth in the stretch of 700 m.

(2) Development of a Recreation Park

This project is planned to improve the town of Marang as a tourist resort and as a jetty for tourists traveling to Kapas Island. The study area involves the Marang River Mouth from Kijin River's lagoon in which the high attraction force will provide the water recreation.

7.7.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

To cope with the current problem of the Marang River Mouth, i.e., the shifting of the river mouth and the river channel course, the intrusion of straight waves, and the shallow navigation channel of both inner and approach, the following two alternative study cases are set by applying these countermeasures in accordance with the considerations on alternative study cases mentioned in Subsection 6.4.2. (Refer to Table 7.1-2.)

Case 1: Capital and Maintenance Dredging, Breakwater, Training Wall and River Groin

Case 2: Capital Dredging, Jetty, Breakwater, Coastal and River Groins, and Reservoir

Design Feature of Countermeasures

The design feature of countermeasures is described as follows.

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features for dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is given in Table 7.1-4.

(2) Maintenance Dredging

In the Marang River Mouth, the capital dredging volume is less than the annual volume of drifting sand and sediment from the catchment. Therefore, the capital dredging volume for the outer channel is adopted to the maintenance dredging volume, as given in Table 7.1-4.

(3) Breakwater

Since the mean higher high water level of the Marang River Mouth is 1.3 m above LSD (2.6 m above CD) and the uprash is 0.87 m, the height of the breakwater is 3.93 m at the river mouth. The design features, together with the work volume, are shown in Table 7.1-5.

(4) Jetty

Applying the mean higher high water level, the height of the jetty is 1.3 m at the river mouth. The other design features are the same as those of the breakwater, as given in Table 7.1-5.

(5) Training Wall

As mentioned in the breakwater, the design height adding the uprash to the mean high water springs is 2.17 m. The stretch to provide the training wall is as given in Table 7.5-1.

(6) Reservoir

At present, there exists a lagoon on the left side which is connected with the Marang River by a shallow channel. This lagoon can be used as a reservoir to

increase the tidal prism only by widening the shallow channel to assure the connection between the lagoon and the Marang River Mouth. The size of the reservoir is roughly estimated at 174,000 m^3.

Since the tidal volume increases to 57,700 m^3 which corresponds to 5.2% of the present tidal prism (see Subsection 6.5.3), the navigation channel is expected to deepen to 0.1 m from the present navigation channel bed height; thus, the maintenance dredging volume for the inner channel will decrease.

(7) Groin

Since the course of the inner channel is always changing due to the drifting sand pushed back by the tide, it is necessary to provide a river groin to stabilize the course of the inner channel. A group of river groins is provided at the middle of the inner channel. The length and number of groins at the interval of 120 m are as given in Table 7.5-1. For the prevention of beach erosion, one 200 m long coastal groin is set at the southern beach.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated by applying the unit cost described in Chapter 6 to the work volume based on the design features, as given in the following table. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	11,809	198	19,040
Case 2	22,700	73	17,335

Selection of Optimum Countermeasure

In the case of the Marang River Mouth, the sea bed gradient is relatively steep, so that the stretch of the jetty is short resulting in the reduction of construction cost. On the other hand, the longshore transport is so large that the cost for maintenance dredging is relatively large. Thus, the combination of capital dredging, jetty, breakwater, river

and coastal groins, and reservoir is selected as the optimum countermeasure for Marang River Mouth. (Refer to Fig. 7.7-6.)

7.7.4 Project Benefit

The Marang River Mouth is used for fishery with a total of 187 fishing boats registered, and also for passenger ferry to Pulau Kapas. No flooding problem in the vicinity of the river mouth has been reported, as discussed in Section 6.2. Benefits are therefore expected in the areas of fishery and sea transport. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Marang River Mouth exist 139 small size (less than 10 GRT) and 48 medium size (10.0 to 39.9 GRT) with no bigger size boats. The annual benefit is RM 1.46 million, as given in Table 7.1-7.

Ferry service to Kapas Island is available through 16 passenger boats of about 40 GRT, and the number of trips per annum is estimated at about 10,800. The annual benefit in the area of sea transport amounts to RM 0.23 million, as given in Table 6.8-3.

The annual average benefit therefore totals RM 1.69 million under present conditions, as given in Table 7.1-8.

7.7.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of Marang River Mouth are jetty, capital dredging, breakwater, groin and reservoir. The possible environmental impacts of these countermeasures, as given in Table 7.7-1, are also similar to the case of the Kerteh River Mouth and thus, the same considerations should be given for project implementation.

Dredging at the Marang River Mouth was once conducted in 1980 for a volume of 231,000 m^3 which is twice the proposed capital dredging volume. No adverse influence has been reported; however, the proposed structures and capital dredging may bring about unbalanced supply of drifting materials at the neighboring coastline, so that careful consideration is required for project execution.

7.8 Terengganu River Mouth

7.8.1 River Mouth Geomorphology

The Terengganu River Mouth is selected as the representative river mouth in Group 8, whose river mouth formation is emphasized with the protruding coast formed by the external forces of high and straight waves and large tidal prisms (refer to Table 7.1-1).

Topography

The Terengganu River Mouth has a catchment area of 4,650 km^2 and a total channel length of 180 km. The river mouth is located on a protruding coastline at the center of the coastline of Terengganu State in the east coast of the Peninsula (refer to Fig. 7.7-1). Shoreline of this area consists of a continuous sandy beach; straight coastline of N35°W to the south of the mouth and coastline generally aligned in N45°W to Sg. Merang to the north with N30°W 5 km coast just north of the mouth.

External Force

The Terengganu River Mouth is exposed to the South China Sea and subject to extreme wave conditions, especially during the Northeast Monsoon season which causes waves rushing straight to the river mouth. It has been reported that the Terengganu River Mouth experiences long periods of swell generated by typhoons in the South China Sea.

The tidal prism of the Terengganu River Mouth is quite large with a tidal intrusion stretch of about 22 km and the river width of about 200 m.

River Mouth and Offshore Geomorphology

The River Mouth is very deep because the width is narrowed by the left bank sand bar, and the deepest point bed is below LSD -9 m. The bed suddenly becomes shallow and the deepest elevation at a distance of 400 m from the mouth is LSD -3 m. Outside of the mouth, a river mouth terrace where bed configuration is unstable has formed for the stretch of 2 km in the longshore direction and 1.3 km in the offshore direction. (Refer to Fig. 7.8-1 to 7.8-3.)

Coastline change around the river mouth is a combination of retreat and accretion; however, as far as sand spit is concerned, it has eroded in the shore side while it tends to develop in the inner channel. (Refer to Fig. 7.8-4.)

Bed Material

The bed materials at the Terengganu River Mouth are of the marine alluvial origin consisting of alluvium gravel, sand, silt and clay, and sand is the most common material around the river mouth. The gradation curve of the material sampled on the beach surface is shown in Fig. 7.5-6. As illustrated, the material is composed of uniform sand with a median diameter d50 of 0.34 mm.

Coastal Change in the River Mouth Area

Erosion is severe in the shoreline area on the left side of the mouth, and the left side sand bar is increasing in length and at the same time decreasing in width. The riverside of the sandbar is in accretion. (Refer to Fig. 7.8-4.)

The right bank of the mouth is also in a tendency of erosion; however, it became stable after the construction of revetment. The condition of the revetment is not good, however, and back-filling material has blown off in some portions.

7.8.2 Identification of Problems and Measures Taken

Present Problem

Although the water depth at the river mouth is very deep at 9 m below LSD, the water depth becomes very shallow at 2.0 m below LSD at about 0.5 km offshore of the mouth and 3.5 m (LSD) about 2.5 km upstream in the inner channel (refer to Fig. 7.8-3). The shallow shore zone seasonally changes its location, so that commercial and large sized fishing boats can hardly locate the navigation channel at low tide and cannot also have access to the jetties and landing facilities located 1 to 2 km upstream of the river mouth.

The river channel course tends to shift, which is also one of the river mouth problems. Formerly, the river mouth has shifted due to the development or erosion of the sand

spit. However, this problem seems to have been settled after the construction of training works at the right bank. Wave intrusion is expected to be severe when the river mouth is kept open.

As to inundation, it has been reported that inundation in the area around the river mouth occurs a few times a year, which is due mainly to the insufficient drainage facilities. It is not clear whether the inundation is attributed to river mouth siltation.

Measures Taken

Some measures were taken for the Terengganu River Mouth, as follows:

(1) Dredging Works

Dredging works were conducted in 1976 by the Marine Department to maintain the navigation channel for commercial boats only in the inner channel. Since then, dredging has been conducted repeatedly in 1987, 1988 and 1991. The stretch dredged is about 1.3 km between 1.7 km and 3.0 km of the river mouth, and the depth and width are 3 m and 6 m, respectively.

As of 1992, maintenance dredging is ongoing in the inner channel of the Terengganu River Mouth. Dredging works in the approach channel are scheduled in 1993.

(2) Construction of Training Wall

A training dike has been constructed at the right bank of the Terengganu River Mouth to stabilize the river mouth and to prevent erosion of the river bank.

Related Projects

The projects related to the Terengganu River Mouth are the following:

(1) Coastal Protection Works at Severang Takir

In the feasibility study and detailed design of the Coastal Protection Works at Seberang Takir (Terengganu), beach nourishment was proposed for coastal protection. The volume of sand is expected to be 3,600,000 m^3, which is to be

taken from the Terengganu River Mouth. This was implemented starting in 1992.

(2) Land Reclamation

In the context of a resettlement plan, the swampy area extending in the left bank near the river mouth is to be reclaimed by the State Government.

(3) Transfer of Oil Base

Tankers carrying crude oil navigate through the Terengganu River Mouth to an oil base of Petronas located at the river mouth. This oil base is scheduled to be transferred by 1994.

7.8.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

To cope with problems such as the shifting of river channel, the shallow navigation channel of both inner and approach, and the development of sand bar, the following two alternative cases are studied (refer to Table 7.1-2):

Case 1: Capital and Maintenance Dredging, Breakwater and Groin

Case 2: Capital Dredging, Jetty, Breakwater, and Coastal and River Groins

Design Feature of Countermeasures

The design feature of countermeasures is described as follows:

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features for dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is given in Table 7.1-4.

(2) Maintenance Dredging

In the Terengganu River Mouth, the capital dredging volume is less than the annual volume of drifting sand and sediment from the catchment. Therefore, the capital dredging volume for the outer channel is adopted to the maintenance dredging volume, as given in Table 7.1-4.

(3) Breakwater

Since the mean higher high water level of the Terengganu River Mouth is 1.3 m above LSD (2.6 m above CD) and the uprash is 0.87 m, the height of the breakwater is 3.93 m at the river mouth. The design features and work volume of the breakwater are as given in Table 7.1-5.

(4) Jetty

Applying the mean higher high water level, the height of the jetty is 1.3 m at the river mouth. The other design features are the same as those of the breakwater, as given in Table 7.1-5.

(5) Groin

Since the course of the inner channel is always changing due to the drifting sand pushed back by the tide and flood discharge, it is necessary to provide river groins to stabilize the course of the inner channel. A group of river groins is then provided at the middle of the inner channel; the length and number of groins at 200 m interval are as given in Table 7.5-1.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated by applying the unit cost described in Chapter 6 to the work volume based on the design features, as given in the following table. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	26,453	836	46,667
Case 2	51,108	187	51,624

Selection of Optimum Countermeasure

A jetty proposed with a long stretch due to the relatively gentle gradient becomes costly. Moreover, it may cause coastal erosion in the adjacent coast which currently has a severe erosion problem. Thus, dredging is selected as the optimum countermeasure for the Terengganu River Mouth. (Refer to Fig. 7.8-5.)

7.8.4 Project Benefit

A number of fishing and commercial boats are utilizing the Terengganu River Mouth where the capital city of Terengganu State is located. Of the representative river mouths, only the Terengganu River Mouth is vulnerable to flooding, as discussed in Section 6.2. Benefits are therefore expected in the areas of fishery, sea transport and flood mitigation. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Terengganu River Mouth exist a total of 107 fishing boats, consisting of 38 small size (less than 10 GRT), 49 medium size (10.0 to 39.9 GRT), 10 large size (40.0 to 69.9 GRT), and 10 deepsea fishing (70 GRT and above) boats. The annual benefit is RM 0.26 million, as given in Table 7.1-7.

Large size vessels use the port for international, home and local trades with an annual trip number of about 680. The annual benefit in the area of sea transport amounts to RM 0.75 million, as given in Table 6.8-3.

The Terengganu river channel has a flow capacity of 2,600 m^3/s near the river mouth, which corresponds to a 2.4-year return period flood. In other words, flood discharge of more than 2,600 m^3/s will cause flooding in the areas along the river course, but the possible maximum flood discharge (3.8-year return period) is estimated at 3,500 m^3/s because huge flood discharges overtop the river banks in the upper and middle reaches and do not reach the downstream.

The flood-prone area at the river mouth is estimated at 45 ha, and 530 houses could be possibly submerged. The value of properties including houses and their interior effects is estimated at RM 15.9 million (530 x RM 30,000). Losses caused by a 3.8-year return period flood are calculated at RM 477,000 by multiplying the damage rate of 3% with the value of properties. The annual average benefit of flood mitigation is RM 37,000, as given in the following table:

	Particulars	Without Project	With Project
a.	Loss by 2.4-yr flood ('000 RM)	0	0
b.	Loss by 3.8-yr flood ('000 RM)	477	0
c.	Reduction of loss by project ('000 RM)	-	477
d.	Average reduction ('000 RM)	-	239
e.	Expectation (1/2.4 - 1/3.8)	-	0.1535
b.	Annual average benefit (d x e)	-	37

The annual average benefit therefore amounts to RM 1.05 million under present conditions, consisting of RM 0.26 million for fishery activities, RM 0.75 million for sea transport and RM 0.04 million for flood control, as given in Table 7.1-8.

7.8.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of Terengganu River Mouth are capital dredging, breakwater and groin. The possible environmental impacts of these countermeasures, as given in Table 7.8-1, are quite similar to the case of the Marang River Mouth and thus, the same considerations should be given for project implementation.

7.9 Oya River Mouth

7.9.1 River Mouth Geomorphology

The Oya River Mouth is selected as the representative river mouth in Group 6, where river mouth formation is emphasized with the estuary formed by the external forces of high and oblique waves and large tidal prism (refer to Table 7.1-1).

Topography

The Oya River has a catchment area of 1,820 km^2 and a total length of 150 km. The river mouth is located at approximately the center of the coastline of Sarawak State and to the north of Sibu City. The river originates in 600 m class hills, but it heavily meanders in low wetland for more than half of the stretch. This low wetland is very large, formed by the Rajang and other rivers. The total shoreline of this low land amounts to about 500 km with an area of approximately 17,000 km^2 (see Fig. 7.9-1).

External Force

The Oya River Mouth is exposed to the South China Sea and subject to extreme wave conditions especially during the Northeast Monsoon season which causes wave rushing obliquely to the river mouth. The influence of the Southwest Monsoon on the wave environment is, however, not as significant since the winds blow seaward.

The tidal prism of the Oya River Mouth is quite large with 25 km of tidal intrusion stretch and a river width of about 150 m.

Offshore Topography and River Mouth Condition

As shown in Fig. 7.9-2 and 7.9-3, the seabed from the river mouth to elevation of about LSD -3 m presents a protruding terrace formed by river discharge. The channel is stable on the west side.

These seabed contour lines as well as the topography at the river mouth imply that the overall drifting sand direction is predominantly to the west. This river mouth terrace might be pushed offshore with a relation of force of river discharge and wave, but this

will be cleared. The shallowest part of the outer channel in the balanced condition will be at LSD -1.8 m.

Inner channels are maintained relatively deep, as shown in Fig. 7.9-4, profile of inner and outer channel bottom by the discharge of the river. Drifting of sand from the outer to the inner channel was not observed.

Bed Material

The gradation curve of the sample at the shoreline is presented in Fig. 7.5-6. The curve is similar to that in the west coast of the Peninsula. The material is composed of 100% sand with a median diameter d50 at 0.2 mm.

Coastal Change

As illustrated in Fig. 7.9-5, numerous beach ridge developments are found in both banks and implies coastal accretion in a long time range. The illustration also shows that the right bank is generally stable with slight erosion from 1978 to 1984, probably of some human action, and in the left bank, the sand bar is becoming thinner and the shore is eroded. The shoreline retreated 150 m for the 12 years from 1972 to 1984 at the most severe point.

7.9.2 Identification of Problems and Measures Taken

Present Problem

Although the water depth of 3.5 m below LSD in the inner channel is relatively deep, that of about 1.0 m below LSD in the approach channel is quite shallow, which may be due to the sedimentation of sand from the upper reaches and littoral drift sand, so that entering and leaving the river mouth are generally not possible at low tide. A shallow shore zone emerges in the near shore between 0.3 km and 1.0 km.

Shifting is also one of the river mouth problems of Oya River Mouth. Since the houses are located at a higher elevation, inundation is not a serious problem. Only the coincidence of high tide and storm rainfall once a year brings about inundation.

Measures Taken

So far, no specific measures have been taken to cope with the river mouth siltation problem.

Related Projects

The Sarawak Economic Development Corporation (SEDC) has a number of proposals to boost the fishery activity and to develop the river mouth area such as aquaculture and the construction of a reinforced concrete wharf. Recently, prawn aquaculture facilities have been provided. Besides, an ice storage facility is presently being provided by a privately-owned ice factory.

7.9.3 Selection of Countermeasures

Applicability of Countermeasures and Alternative Cases

To cope with the current problem of the Oya River Mouth, i.e., the shifting river mouth and the shallow navigation channel approach, the following two alternative study cases were studied.

Case 1: Capital and Maintenance Dredging and Training Wall

Case 2: Capital Dredging, Jetty and Coastal Groin

The combination of countermeasures for each study case is given in Table 7.1-2, for comparison with those of the other representative river mouths.

Design Feature of Countermeasures

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features for dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is given in Table 7.1-4.

(2) Maintenance Dredging

In the Oya River Mouth, the capital dredging volume is less than the annual volume of longshore transport and sediment from the catchment. Therefore, the capital dredging volume for the outer channel is adopted to the maintenance dredging volume, as given in Table 7.1-4.

(3) Jetty

Since the mean higher high water level of the Oya River Mouth is 0.6 m above LSD (2.3 m above CD), the height of the jetty is 0.6 m at the river mouth. The other design features based on the design criteria and the work volume of the jetty based on the design features is as given in Table 7.1-5.

(4) Training Wall

As mentioned in the jetty, the design height adding the uprash to the mean higher high water spring level is 1.97 m. The stretch to provide the training wall is as given in Table 7.5-1.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated by applying the unit cost described in Chapter 6 to the work volume based on the design features as summarized below. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	2,107	157	5,134
Case 2	6,621	37	9,090

Selection of Optimum Countermeasure

In the case of the Oya River Mouth, the stretch of the jetty becomes long due to the relatively gentle sea bed slope resulting in high construction cost, though the longshore transport is also large. Thus, dredging is selected as the optimum countermeasure for the Oya River Mouth. (Refer to Fig. 7.9-6.)

7.9.4 Project Benefit

The number of fishing boats registered at the Oya River Mouth is more than one hundred. The river mouth is used also for the transportation of timber, construction materials and other commodities, but the frequency is so limited that benefit from sea transport may be negligibly small. Flooding may not occur in the vicinity of the river mouth, as discussed in Section 6.2. Benefits are therefore expected to accrue only from the fishery. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Oya river mouth exist a total of 104 fishing boats, consisting of 80 small size (less than 10 GRT), 22 medium size (10.0 to 39.9 GRT) and 2 large size (40.0 to 69.9 GRT) with no deepsea boats. The annual benefit is RM 0.27 million, as given in Table 7.1-7.

7.9.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of Oya River Mouth are training wall, capital and maintenance dredging. The possible environmental impacts of these countermeasures, as given in Table 7.9-1, are quite similar to the case of the Kuantan River Mouth and thus, the same considerations should be given for project implementation.

7.10 Papar River Mouth

7.10.1 River Mouth Geomorphology

The Papar River Mouth is selected as the representative river mouth in Group 9, where river mouth formation is characterized with the protruding coastline formed by the external forces of high and oblique waves and small tidal prism (refer to Table 7.1-1).

Topography

The Papar River has a catchment area of 770 km^2 and a total length of 70 km. The river mouth is located on a northwest facing coast about 30 km SSW of Kota Kinabalu, the capital of Sabah, in East Malaysia. Northern mountain ridges in Borneo Island run parallel to the coast in SW-NE direction about 30 km inland with Mount Kinabalu in the northeastern end, as shown in Fig. 7.10-1.

External Force

The Papar River Mouth is exposed to the South China Sea and subject to extreme wave conditions, especially during the Northeast Monsoon season, which causes waves rushing obliquely to the river mouth. The influence of the Southwest Monsoon on the wave environment is, however, not so significant since the winds blow seaward.

The tidal prism of the Papar River Mouth is relatively small with 6 km of tidal intrusion and an average river width of about 30 m.

Offshore and River Mouth Topography

The off-the-mouth seabed gradient is steep at about 1/50 on both sides. The offshore seabed contourline show a protruding river mouth terrace formation to the elevations of about LSD -4 m, as shown in Fig. 7.10-2 and 7.10-3. This terrace is considered to be a part of the sand spit that developed from east to west. The sand spit is sometimes flushed in relation to the external force balance of river discharge and waves.

The inner channel is maintained deep, generally below LSD -3 m, as shown in the riverbed profile on Fig. 7.10-4.

Bed Material

The shoreline material is composed of very uniform sand similar to that in the other sandy representative river mouths. The median diameter d50 is 0.2 mm and the material is composed of 100% sand (0.062 to 2.0 mm), with the uniformity coefficient at 1.9.

Shoreline Change in the River Mouth Area

Fig. 7.10-5 compares the shorelines in 1972 and in 1986. The sand spit extends 2 km from the present river mouth location to WSW with a width of about 150 m. The river flows W-SW along the sand spit.

In 1986, the sand spit was cut and the river flowed almost straight from the inner channel to the direction of W-NW. At the river mouth, terrace exists. In accordance with the aerial observation conducted during the First Field Survey in February 1992 after the monsoon season, there are traces of sand spit offshore on the left bank.

7.10.2 Identification of Problems and Measures Taken

Present Problem

Since the river flow and tidal prism are not enough to well maintain the river mouth, the water depth at the river mouth and the outer channel are very shallow, so that entering and leaving the river mouth are generally not possible at low tide. The minimum water depth of the navigation channel at the shore side is 1 m below LSD, while the draft of fishing boats is about 1.2 m.

Shifting of the river mouth and the river channel course is also a severe problem. On the other hand, the water depth of the inner channel which seems to be formed in the rainy season is about 3 m, deeper than those of the river mouth and the outer channel. After construction of the diversion channel in the 1970's, flood damage has not been reported; thus, the river mouth seems to be free from flood damage caused by river mouth siltation.

Measures Taken

No specific measure has been taken to cope with the river mouth siltation problem.

Related Projects

To cope with the severe bank erosion problem, State DID has been conducting bank protection works for a total stretch of about 3 km since 1987.

7.10.3 Selection of Countermeasures

Application of Countermeasures and Setting of Alternative Cases

To cope with the current problem of the Papar River Mouth, i.e., the shifting of the river mouth and the shallow navigation channel of both inner and approach, the following two alternative study cases are studied.

Case 1: Capital and Maintenance Dredging, Training Wall and River Groin

Case 2: Capital Dredging, Jetty, Coastal and River Groins, and Reservoir

The combination of countermeasures for each study case is given in Table 7.1-2, for comparison with those of the other representative river mouths.

The optimum countermeasure is selected through the comparative study on the above alternative study cases.

Design Feature of Countermeasures

The design feature of countermeasures is described below.

(1) Capital Dredging

In accordance with the design criteria and the design size of boats and design alignment, the design features for dredging works are figured out, as given in Table 7.1-3. The required dredging volume based on the design features is shown in Table 7.1-4.

(2) Maintenance Dredging

In the Papar River Mouth, the capital dredging volume is less than the annual volume of longshore transport and sediment from the catchment. Therefore, the capital dredging volume for the outer channel is adopted to the maintenance dredging volume, as given in Table 7.1-4.

(3) Jetty

Since the mean higher high water level of the Papar River Mouth is 1.1 m above LSD (2.1 m above CD), the height of the jetty is 1.1 m at the river mouth. The other design features based on the design criteria and the work volume of the jetty based on the design features are given in Table 7.1-5.

(4) Training Wall

As mentioned in the breakwater, the design height adding the uprash to the mean high water spring level is 1.97 m. The stretch for the training wall is as given in Table 7.5-1.

(5) Reservoir

At present, there exists a swampy area along the river course which can be used as a reservoir to increase the tidal prism by excavation. The expected capacity of the reservoir is roughly estimated at 90,000 m^3.

Since the tidal volume increases to 7,200 m^3, which corresponds to 5.8% of present tidal prism (see Subsection 6.5.3), the navigation channel is expected to deepen to 0.07 m from the present navigation channel bed height and thus, the maintenance dredging volume for the inner channel will decrease.

(6) Groin

For the purpose of preventing beach erosion, two coastal groins 200 m and 100 m long, respectively, are to be provided at the western beach.

Cost Comparison of Alternative Cases

The cost of countermeasures including initial cost and maintenance cost is calculated applying the unit cost described in Chapter 6 to the work volume based on the design features as summarized below. (Refer to Table 7.1-6.)

Case	Capital Direct Cost (1000 RM)	Annual Maintenance Cost (1000 RM)	NPV of Project Cost (1000 RM)
Case 1	2,080	230	5,756
Case 2	2,791	10	3,742

Selection of Optimum Countermeasure

In the case of the Papar River Mouth, the stretch of the jetty is not long due to the relatively steep sea bed slope resulting in low construction cost, although the longshore transport is not so large. Thus, the combination of capital dredging, jetty, coastal groin and reservoir is selected as the optimum countermeasure for the Papar River Mouth. (Refer to Fig. 7.10-6.)

7.10.4 Project Benefit

The number of fishing boats registered at the Papar River Mouth is more than one hundred, although all of them are less than 10 GRT, but the river mouth is not used briskly for sea transport. Flooding may not occur in the vicinity of the river mouth, as discussed in Section 6.2. Benefits are therefore expected to accrue only from the fishery. Calculation of annual benefit is based on the concepts and methodology mentioned in Section 6.8.

At the Papar River Mouth exist 123 small size fishing boats (less than 10-GRT) and the annual benefit is RM 0.24 million, as given in Table 7.1-7.

7.10.5 Environmental Impact Assessment

The proposed countermeasures for the improvement of the Papar River Mouth are capital dredging, jetties, groins and reservoir. The possible environmental impacts of these countermeasures, as given in Table 7.10-1, are quite similar to the case of the Marang River Mouth and thus, the same considerations should be given for project implementation.

CHAPTER 8. MASTER PLAN

8.1 Master Plan for Objective River Mouth

The Master Plan is formulated for the 75 objective river mouths selected out of the 100 river mouths originally proposed.

8.1.1 Cost of Countermeasures

Countermeasures for Each River Mouth

The countermeasures selected for the representative river mouth in a group are applied to the other river mouths in the same group for the estimation of cost.

Work Volume

Based on the work volume for the representative river mouth, the work volume for each of the other river mouths is calculated in the following manner:

(1) Capital Dredging

The volume of capital dredging is related to the dredging stretch, the width and the depth of both the outer and inner channels. Since the only sources 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. The formula for the estimation is given as follows:

$$V = Vo + Vi$$

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

$$Vi = Vo \times k2$$

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

$$k2 = Vri / Vro$$

where,

V, Vo, Vi	:	dredging volume for whole stretch, outer and inner channels 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 over the volume of capital dredging. In case that the volume of maintenance dredging is over 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 formula:

$$Jv = L \times kjl$$
$$kjl = Jvr / Lr$$

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.
kjl	:	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 jetty and offshore breakwater is adopted.

The work volume for the breakwater is difficult to obtain from the currently available data, while the work volume for the jetty can be calculated in the manner mentioned above. Since the volume of breakwater is related to that of the jetty, the volume for the breakwater is calculated using the ratio between jetty and 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 for the river groin, coastal groin, training wall and reservoir is hardly pertinent to mention with the currently available data.

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, the construction costs for these structures 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.

Cost for Each River Mouth

The cost for each river mouth improvement works is estimated based on the project work volume calculated as shown in Table 8.1-1 and the unit price of each countermeasure quoted in Subsection 6.7.1 through the application of the cost of the ten (10) representative river mouth improvement works. The project costs shown in the table are expressed in net present value (NPV).

8.1.2 Annual Benefit for Each River Mouth

Annual benefit for river mouths other than the representative river mouths is estimated, as presented in Table 8.1-2, based on the concepts and methods described as follows.

Fishery Benefit

Fishery benefit is basically subject to the existing minimum water depth and the number and size of fishing boat at each river mouth. The relationship between water depth and benefit per boat is obtained by the size of boat at the representative river mouth as shown in Fig. 8.1-1, and, in line with the grouping of the 75 objective river mouths, the annual benefit at the other river mouths is estimated by applying the existing minimum water depth to the above-said relationship of their representative river mouth, multiplying the number of boats by each boat size. The fishing industry is assumed to

augment by 2% per annum in the future until 2005, as derived from the annual average growth rate in the total number of powered fishing boats from 1970 to 1990.

Sea Transport Benefit

Sea transport benefit is expected at four representative river mouths, but it is not practicable to apply those benefits to the other river mouths where commercial boats are not available as discussed in Subsection 6.8.3. In this context, the benefit at Mersing is calculated separately. The benefit is also expected to increase until 2005 at the annual rate of 2%, considering the estimated annual population growth rate from 1990 to 2000 in the Peninsula.

Flood Mitigation Benefit

Flooding problems due to river mouth siltation are recognized only at Terengganu, one of the representative river mouths. Since flooding conditions are considerably related to the physical condition of river channels, flood mitigation benefit can be expected at the other river mouths in the same group. (Grouping of river mouths is based on the physical conditions.)

The magnitude of flood loss depends mainly on the value of properties in the flood-prone area and the inundation water depth, and so is the benefit, because the reduction of loss is counted as benefit. In applying the Terengganu's benefit to the other river mouths in the group, however, the areal ratio of urban areas along the river course near the river mouth is used as a parameter which is most related to the benefit amount, and considered to be the best method within the availability of data.

8.1.3 Cost-Benefit Ratio

Cost-benefit ratio (B/C) for each river mouth is calculated using the above-said cost and benefit assuming that project life is 30 years and the discount rate is 8%. The ratio at each river mouth is shown in Table 8.1-3, and the following matters are pointed out:

(1) Most of the representative river mouths well known for having a critical river mouth problem are higher in rank; especially, Kuantan, Perlis and Kedah which are expected to have a high economic return.

(2) Although a high economic return is not expected in most of the river mouths, the B/C ratio of 0.72 as a whole is not so low.

(3) For comparison of priority between river mouths in Category 1 (Critical) and those in Category 2 (Significant), the B/C ratio of the former category is 0.98, while that of the latter is only 0.23. Thus, the adequacy of categorization can be verified as a whole.

8.2 Project Evaluation

As identified in the cost-benefit ratio, the economic viability of the Master Plan is not so high. However, the economic viability for the critical group shows a relatively high economic return with a B/C ratio of 0.98. Consequently, the Master Plan puts emphasis on the critical group, while project execution for the significant group considers the future development of the area surrounding the river mouth.

8.3 Formulation of the First Phase Project

In accordance with the principle of master plan formulation, countermeasures for each of the 75 objective river mouths are selected and costs and benefits are also calculated. Since the number of river mouths for the Master Plan is too large that it may be difficult to simultaneously execute a project covering all the objective river mouths, a First Phase Project in the critical group is examined to facilitate project realization.

8.3.1 Conditions for the Formulation of First Phase Project

The First Phase Project is formulated under the following conditions:

(1) The objective river mouths for the First Phase Project are the 35 river mouths under critical condition, where urgent project implementation is necessary.

(2) The 35 river mouths are classified into groups of 3 and 4 for priority of project execution. The prioritization is made considering economic efficiency, regional income distribution, social need, etc.

(3) It is assumed that the First Phase Project is completed within the target year 2005 which corresponds to the last year of the 8th Malaysia Plan. As alternative cases, those with target year extending up to the end of the 9th and the 10th Malaysia Plans are examined for comparison.

8.3.2 Prioritization of River Mouth

Prioritization is made considering several aspects such as economic efficiency, regional income distribution, social need and so on. For the purpose, the following factors are taken into consideration:

(1) For the economic efficiency, cost and benefit ratio is applied.

(2) For the regional income distribution, the State where the river mouth is located is considered.

(3) For the social needs, the development strategy of the fishing industry is considered, especially the LKIM complex and the fishing base of the Department of Fisheries. The design boat size for the river mouth improvement is also considered.

Table 8.3-1 shows the factors for prioritization. In accordance with these factors, the prioritization is made, as shown in Table 8.3-2, in the following principles:

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

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

(3) Prioritization among the river mouths in each State is made considering the economic efficiency, the design boat size, the LKIM complex and the DOF base. Among these, more emphasis is put on the LKIM complex which is regarded as the development strategy of the fishing industry.

8.3.3 Implementation Schedule and Construction Cost

Implementation Schedule

As mentioned above, it is assumed that the First Phase Project is completed within the target year 2005 starting from 1996, after the feasibility study and detail design of the river mouth improvement are completed. This period corresponds to the 7th and 8th Malaysia Plan.

The implementation schedule including alternative cases which follows the principles of prioritization is 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 considering the implementation schedule. In this connection, it was assumed that the annual disbursement of cost for each priority group is distributed equally for each year in each construction stage. (Refer to Table 8.3-3.)

8.3.4 Selection of Optimum Case

For the selection of the optimum case, the following are considered:

(1) To satisfy the people concerned in navigation, it is desirable to adopt a project with a short period of implementation because it may not be realistic to have a first project with a long implementation period of over 20 years.

(2) In case the project with a short period of implementation is adopted, the main issues are the capability for project execution and the financial restriction of agencies concerned.

(3) The main agencies responsible for river mouth improvement are MD and DID. MD is mainly concerned with 6 river mouths out of the 35, while the remaining river mouths are managed by DID. Judging from the current capability of these agencies, which are handling improvement works for more than 10 river mouths a year, it seems to be possible to gradually increase their capability within 10 years to handle the 35 river mouths.

(4) In general, maintenance cost is shouldered by the beneficiaries, while the initial cost is by the Government. In this connection, it may be possible to allocate the initial cost of about RM 200 million within 10 years judging from the current budget allocation and future economic development.

(5) On the other hand, it may be possible to require the beneficiaries to shoulder the maintenance cost of about RM 890 per year per capita, which corresponds to about 4% of the wholesale price of fish of RM 2.1 per kg. Since it may not be fair to require all beneficiaries to shoulder the maintenance costs equally, it

is necessary to carefully examine the collection system of maintenance cost from the institutional point of view.

Based on the above considerations, it is recommended that Case 2-1 be selected as the Implementation Schedule of the First Phase Project. Table 8.3-4 shows the prioritization of river mouths for implementation, together with the agencies involved in the implementation.

8.3.5 Economic Viability of the First Phase Project

The economic viability of the First Phase Project is assessed by means of internal rate of return (IRR) based on the cash flow presented in Table 8.3-5. The IRR is figured out at 11.5%, which is higher than the generally understood borderline of 10% for this kind of infrastructure project. Further, expected are intangible benefits such as the enhancement of safety to navigation and the stabilization of living standards of people concerned.

It is evaluated that the First Phase Project has enough economic viability to promote it for implementation, and that the Project can provide favorable socio-economic impacts for thousands of people.

CHAPTER 9. INSTITUTIONS AND REGULATIONS

9.1 General

An institution with the appropriate administrative and legislative powers to make it effective is essential to ensure the proper management and conservation of river mouths in Malaysia. General assessments of the institutional and legal requirements are given in the following sections.

9.2 Main Functions at River Mouth and Related Activities

In general, the functions of a river mouth and the related activities are as given below (refer to Table 9.2-1):

(1) Drainage Outlet of River Flow

The principal function of a river mouth is to drain flood discharge and normal flow safely into the sea. This function has to be maintained without any disturbance by other activities and, for that purpose, various structures are provided at the river mouth such as dikes, revetments, groins, gates and pumps.

(2) Navigation

River mouths play an important role as a part of the navigation route for fishing and shipping which sometimes encounter difficulty in navigating through the river mouth due to siltation, as well as strong and turbulent waves and river flow. It is therefore essential to keep the river mouth in favorable and navigable condition to maintain the economic activities of the region.

To maintain the river mouth for navigation, provided are works such as dredging, jetty, breakwater, training wall, and navigation facilities like the beacon and so on.

(3) Port and Mooring Place for Boats

As a link between land transportation and marine transportation, river mouths serve as port for loading and unloading of cargoes as well as mooring for boats. For this purpose, port and mooring facilities such as jetty, berth, wharf, dock, warehouse and so on are provided.

(4) Land Development Zone

The area around the river mouth could provide a zone for land development because of its geological advantage, strategic significance of industrial development, etc., and the main purposes include agriculture, urban, industrial, aquaculture, water resources, resort development and others. Several works are then carried out such as land reclamation, land clearing, and provision of several facilities including intake and drainage.

(5) Mining

River flow transports a large volume of sand and deposits them at the river mouth. Sand mining for construction materials is one of the vivid activities, and sand mining facilities are sometimes provided at the river mouth.

(6) Natural Preservation Zone

Natural ecology systems which should be protected from destructive activities exist around the river mouth. Artificial facilities except those for preserving the ecology system are not specified for this function.

9.3 Existing Government Institutions

Government institutions and agencies concerned in Malaysia have been provided to ensure the functions and activities at the river mouth (refer to Table 9.2-1). Those concerned in such functions are as described below.

(1) Drainage Outlet of River Flow

To control rivers and streams in Malaysia, the Water Enactment has been provided as a state legislation. This law regulates and controls the use of rivers and streams, and imposes rigid prohibition against the unauthorized use of rivers and the alteration or diversion of river banks and river courses. To prevent the blockage of river waters and pollution of these waters, the act of discharging or emitting any deposit or waste into any river is prohibited. Further, construction of walls and buildings on banks of rivers or within flood channels is restricted.

The law is also applied to assure the function of the river mouth as a drainage outlet of river flow. Although there is another law regarding drainage works, namely; the Drainage Works Ordinance which includes such stipulations as declaration of drainage area, imposing of drainage rate, etc., it may not be much concerned in the river mouth function.

As for the agencies concerned regarding this function, DID and JKR are mainly involved. DID is the agency responsible for coping with the inundation by flood and drainage problems under the Waters Enactment and it has been constructing breakwaters or tidal gates at river mouths as a part of regional development projects including flood control and drainage. JKR is sometimes involved in maintaining the river mouth through protection works for bank erosion in the context of coastal protection works as seen in the Marang River Mouth.

(2) Navigation Route

The Merchant Shipping Ordinance has been provided for matters relating to merchant shipping including registry of ships, preservation of safety, wreck and salvage, lighthouse, etc. Under this ordinance, the port limit for minor ports which should be managed by the Marine Department is stipulated.

The River Launches Enactment covers the control of launches used on rivers; namely, declaration of rivers, launches to be licensed, penalty for breach of rules, etc.

To assure the function of a river mouth as a navigation route, the Marine Department and DID are engaged in the dredging of navigation channels. The former agency covers the area of port limit which is used mainly for commercial boats, while the latter maintains the navigation route for fishing boats upon request of the Department of Fisheries.

Besides, the Marine Department installs facilities to show the navigation route such as beacons, lighthouses, buoys, etc. DID undertakes construction works to maintain the navigation channel at the river mouth such as construction of breakwater, jetty, training wall, groin, etc.

JKR is sometimes involved in the works to maintain the navigation channel through the construction of jetties, groins, etc., as seen in the case of the Inanam River Mouth in Sabah.

(3) Port and Mooring Place for Boats

The Merchant Shipping Ordinance and River Launches Enactment are also concerned in this function. The Marine Department, JKR, LKIM and DOF are the main agencies related on this matter.

(4) Land Development Zone

Regarding land use control, various laws have been enacted such as the National Land Code, the Land Acquisition Act, the Town and Country Planning Act, and the Land Conservation Act.

The National Land Code has been enacted to clarify the right of authorization regarding land tenure, registration of title to land, collection of revenue, etc. This law stipulates the power of the Federation and of Federal officers, power of the States and of state officers, classification and use of land, etc.

The Land Acquisition Act, which has been provided to clarify matters regarding the acquisition of land, assessment of compensation on account of such acquisition and other matters incidental thereto, describes the acquisition of land, declaration of intended acquisition, procedure of inquiry, payment of compensation, restoration of land and so on.

The Town and Country Planning Act has been provided for the proper control and regulation of town and country planning in local authority areas, etc. This law stipulates the general planning policy, local planning authority, development plans, declaration of development area, prohibition of development without planning permission, etc.

The Land Conservation Act has been provided with the purpose of conservation of hilly land, protection of soil from erosion and the inroad of silt, etc. This law stipulates the declaration of hilly land, restrictions on clearing and cultivation of hilly land, control of silt and erosion, authority to make orders and nature of orders, etc.

As the term of land development implies, most of the governmental agencies, especially the state government, are concerned in this function.

(5) Mining

The Mining Enactment has been provided to control and manage the disordered development of mining resources. This act provides the authority for issuance of licenses, right to remove and dispose of minerals, control of water vested rights in the Ruler of Sate, etc.

In addition to land development, the state government is also concerned in mining.

(6) Natural Preservation Zone

To preserve the natural condition in the area around the river mouth, several laws have been provided, namely; the Environmental Quality Act, the Waters Enactment, the National Land Code, the Land Conservation Act, the

Protection of Wild Life Act, the National Parks Act, the Forest Enactment, the Mining Enactment, etc. These laws provide restrictions and control of development to preserve the natural condition as the title of the law implies.

The Environmental Quality Act which is related to the prevention, abatement and control of pollution and enhancement of the environment, etc., is essential to the preservation of the natural zone. Most of the government agencies engaged in the work related to development or preservation of natural conditions are concerned in this function.

9.4 Institutional Arrangement in Japan

As an example of institutional arrangement, that in Japan is described herein. As in Malaysia, an institutional arrangement exclusively dealing with river mouth problems is not provided in Japan and river mouth problems are taken as a part of the management of a river channel, port or coast.

Institutional Arrangement for Each Function

For comparison with Malaysia, the related law and agencies are shown in Table 9.4-1 according to river mouth functions described below.

(1) Drainage Outlet of River Flow

In Japan, it is a principal function of the river mouth to drain flood discharge and normal flow safely into the sea. The safe drainage of flood discharge is the main concern of the Japanese Government and, for that purpose, various structures are provided at the river mouth such as dikes, revetments, groins, gates, pumps and jetties.

For effective management, the River Law was promulgated in 1894 and revised in 1964 to comprehensively administer all the rivers in Japan, so that occurrence of disasters due to floods and high tides may be prevented and that proper utilization and normal functions of river water may be assured.

The River Law stipulates the administration of rivers classified into three classes, delimitation of river stretch for the administration, regulation concerning construction of riparian structures, authorization or permission for water use and so on.

The Flood Fighting Act was enacted in 1948 and this act stipulates the flood fighting system, the flood forecasting and warning system, the organization of flood fighting troops and the financial aspects of such activities.

In accordance with the River Law, the Ministry of Construction (MOC) has the responsibility of administering major rivers designated as first class rivers, while the local governments have the responsibility for the other classes of rivers.

As to flood fighting, MOC and the Meteorological Agency have the joint responsibility for the dissemination of flood forecasting and warning, while the responsibility for the organization of flood fighting troops is burdened to the local government.

(2) Navigation Route

Although river mouths in Japan do not play the role of navigation route so much, especially for fishing boats compared with those in Malaysia, several facilities to ensure the navigation of boats have been provided. For the smooth navigation including management of these facilities, provided were the Port and Harbour Law in 1950, the Fishing Port and Harbour Law in 1950, the Maritime Traffic Safety Law in 1972, the Aid to Navigation Law in 1949, etc. The Ministry of Transportation (MOT), the Ministry of Agriculture, Forestry and Fisheries and local governments are concerned in this function.

(3) Port and Mooring Place for Boats

In Japan, the major ports are mostly located in bay areas or coasts and the river mouths are usually used as minor ports. The Port and Harbour Law applying for both major and minor ports was enacted in order to develop marine transportation, to provide the necessary facilities in orderly manner, and to manage the port and mooring place appropriately. The law stipulates that the

delimitation of the port area is handled by the MOT or the local government. The formulation of the port development plan and permission of construction in the port area are also stipulated in this law. The Fishing Port and Harbour Law was provided specifically for fishing boats.

The MOT, the Ministry of Agriculture, Forestry and Fisheries, and local governments are among the major agencies concerned in this function.

(4) Land Development Zone

Historically, the area around the river mouth has been developed more in Japan than in Malaysia because of geological advantage, political significance, etc.

For the land development, several laws were promulgated such as the Basic Land Act in 1988, which defines the basic concept of land and the obligations of the central and local governments on land use; the National Land Use Planning Act in 1974, which stipulates the fundamental matters to formulate the land use plan and control and regulation on land use, etc.; the City Planning Law in 1968 to contribute to orderly urban development and to enhance social welfare; the State Water Reclamation Law in 1921, which defines state water, permission for reclamation, restrictions on use of reclaimed land, etc. Therefore, most of the agencies engaged in land development are concerned in this function.

(5) Mining

For sand mining, the Sand and Gravel Mining Law was promulgated in 1968. The law stipulates the application and permission of sand mining which are handled by local governments or the MOC depending on the area administered.

(6) Natural Preservation Zone

As in Malaysia, several laws have been provided to preserve the natural condition in the area around the river mouth, though they were enacted not only for river mouths but also the area concerned.

The laws include the Natural Environment Preservation Act of 1972, the Basic Act for Environment Pollution Control of 1970, the Water Pollution Control Act of 1970, the Natural Park Act of 1957 and others.

As the name implies, the Natural Environment Preservation Act stipulates the basic concept for the preservation of the natural environment and the fundamental matters to preserve the natural environment to ensure the current and future healthy cultural life. In this connection, activities which may bring about the destruction of favorable natural environment such as the construction of facilities, reclamation of water surface, change of the water level and water quantity, and land clearing are strictly prohibited.

The main agency handling this matter is the Environment Agency, although most of the agencies engaged in development are concerned also in this function.

Comparison of Institutional Arrangements between Malaysia and Japan

Although they are not provided to specifically cope with the river mouth problem, Malaysia and Japan in principle have provided the necessary laws as well as the agencies responsible. Therefore, the institutional arrangement in Japan can be made as reference for the improvement of that in Malaysia through a detailed comparative study between both systems. On the other hand, it is necessary to understand the different backgrounds of developing the system in both countries.

The difference of the institutional arrangements between Malaysia and Japan may be found in the following points:

(1) The main administration body of the river is the local government in Malaysia, while it is the central government in Japan.

(2) The main function of the river mouth relating to the main river mouth problem seems to be the navigation of fishing boats in Malaysia, while the main function is as drainage outlet for flood discharge in Japan.

(3) The development of the function of the river mouth is still under progress in Malaysia, while it is coming to the optimal stage in Japan.

Thus, the emphasis on river mouth management is slightly different between Malaysia and Japan.

9.5 General Assessment

River Mouth Problem Due to Lack of Effective Institution

For the river mouth problems whose cause and consequences could be easily identified, i.e., navigation problem for fishing boats and commercial boats due to river mouth siltation, shifting of river mouth due to the development of sand spit, etc., the agency responsible is relatively clear. The present institutional system in Malaysia seems to function well, especially in the case where a single agency is solely responsible.

However, the present institutional system seems not to function well where the agency responsible is not clear because the causes and consequences are hardly identified due to the compound factors involved, and several agencies are concerned in these problems. These may be found in the following examples:

(1) After land development in the upper basin, the river mouth siltation problem became severe.

(2) After construction of river structures such as weir, dam, tidal barrage, etc., the river mouth siltation problem became severe.

(3) After land reclamation in the river mouth area, drastic change in configuration of the river mouth and the ecology system emerged.

(4) After land development, demise of mangrove was observed.

(5) Sand mining and dredging of navigation channel brought about intrusion of seawater resulting in water quality problems for irrigation or domestic water and change of the ecology system. Also, this brought about coastal erosion in the neighboring area.

As main causes for these consequences, the following are pointed out in the present system:

(1) Lack of coordination and less opportunity for exchange of information among agencies concerned.

(2) Lack of suitable engineering consultation and shortage of qualified engineers.

(3) Indistinct scope of responsibility of the agencies concerned, especially for the compound issues on cause and consequences.

Recommendation of Measures in Terms of Institution

As pointed out in the main causes for consequences on the river mouth problem, the establishment or consolidation of a suitable organization for coordination is needed, subdivided into committees to seek solutions individually in terms of engineering, administration and legislation.

Engineering expertise on river mouth problems including coastal engineering and river engineering are in shortage and there is a need to train more local engineers on the specialized field of river and coastal engineering.

The scope of responsibility of the agencies concerned should be spelled out to avoid confusion. In the case of land development, each agency tends to execute the plan considering only the direct influence of the development and to prescribe solution only for the direct influence based on their scope of responsibility. For secondary or compound influences, sometimes no measure is undertaken.

Although legislation on such a compound issue may not be an easy matter, it is necessary to cope with the problem in the long term prospect. For that purpose, data compilation on issues attributed to the indistinct scope of responsibility should be made.

CHAPTER 10. RECOMMENDATIONS

(1) In this Study, the Master Plan for the river mouth improvement project is formulated to cover 75 river mouths; i.e., 57 river mouths in Peninsular Malaysia, 10 river mouths in Sarawak and 8 river mouths in Sabah. Although the economic viability of the Master Plan is not high, this kind of infrastructure project is essential to improve the living conditions of people in the vicinity of the river mouth. In this connection, it is recommended that the Master Plan be considered as a part of the Malaysian National Development Plan.

(2) To facilitate the realization of the Master Plan, a First Phase Project having 2005 as the target year is also formulated putting emphasis on the improvement of 35 river mouths in critical condition as identified in the Study. The First Phase Project should be considered for further study, since its economic viability of EIRR 11.5% with the total cost of about RM 300 million is high enough to promote it to the further study stage. In consideration of the future development of the fishing industry, however, the prioritization of components of the First Phase Project should be carefully made.

(3) One of the major countermeasures for river mouth improvement is dredging. Since the siltation of a river mouth is a natural and continuous phenomenon, further maintenance dredging, even after capital dredging, has to be carried out on a regular basis to ensure the accessibility of the navigation channel to fishing and other boats. However, such maintenance dredging works are sometimes not carried out as a result of the lack of funds. In this connection, it is necessary to assure the provision of funds from among the source options: the Federal and State governments and beneficiaries.

(4) The major river mouth problems pertain to the navigation problem of fishing boats and the flooding problem due to river mouth siltation which may not be serious at present but could become worse in the future due to the rapid urban development of the area around the river mouth. In this connection, the urban

development of the flood-prone area should be carefully monitored and regulated.

(5) The Master Plan Study was conducted based on the limited information collected. Since the coastal behavior involves so many unknown factors, and countermeasures sometimes brought about unexpected adverse influences, more detailed data and information are required to grasp such a behavior and adverse influence in order to formulate a more concrete plan. In this connection, a regular monitoring program should be provided for further study of the results so that future unexpected adverse influences could be minimized.

(6) There is at present no formal mechanism for gathering, developing and disseminating technical information on river mouth siltation. The Coastal Engineering Division of DID, which is already responsible for executing river mouth maintenance works, should assume in full, the technical responsibilities for river mouth problems in Malaysia. In this connection, it is recommended that the Coastal Engineering Branch should be responsible for the collection of basic data related to river mouths and the implementation of a regular comprehensive monitoring programme.

(7) Although the impact of land development to the river mouth siltation is not clear, the increase of sediment from the river basin may worsen the river mouth siltation problem. In this connection, the land development should be carefully monitored and regulated so as not to increase the sedimentation from the river basin.

TABLES

Table 1.2-1 LIST OF OBJECTIVE RIVER MOUTHS FOR THE STUDY

River Mouth Serial	River Mouth Name	State	Catchment Area (km2)
1	Perlis	Perlis	600
2	Baru	"	80
3	Sanglang	Kedah	80
4	Jerlun	"	40
5	Kedah	"	4,040
6	Yan	"	10
7	Melaka	"	40
8	Cenang	"	10
9	Muda	P. Pinang	4,300
10	Perai	"	450
11	Kerian	"	1,420
12	Pinang	"	20
13	Bayan Lepas	"	7
14	Tg. Piandang	Perak	9
15	Gula	"	30
16	Sangga	"	170
17	Larut	"	170
18	Terong	"	60
19	Beruas	"	240
20	Batu	"	70
21	Dinding	"	370
22	Lekir	"	5
23	Selangor	Selangor	1,820
24	Kapar Besar	"	110
25	Langat	"	1,815
26	Sepang Kecil	"	50
27	Sepang	"	90
28	Lukut	N. Sembilan	120
29	Raya	"	10
30	Linggi	"	1,270
31	Baru	Melaka	25
32	Melaka	"	500
33	Duyong	"	40
34	Umbai	"	20
35	Merlimau	"	30
36	Muar	Johor	6,160
37	Parit Jawa	"	80
38	Sarang Buaya	"	170
39	Batu Pahat	"	2,230
40	Senggarang	"	70
41	Rengit	"	100
42	Benut	"	440
43	Pontian Kecil	"	40
44	Sedili Besar	"	1,445
45	Mersing	"	250
46	Endau	"	4,740
47	Pontian	Pahang	240
48	Rompin	"	3,980
49	Merchong	"	500
50	Nenasi	"	860
51	Pahang	Pahang	29,140
52	Terus	"	40
53	Kuantan	"	1,710
54	Beserah	"	20
55	Kemaman	Terengganu	1,775
56	Kemasik	"	40
57	Kerteh	"	240
58	Paka	"	850
59	Dungun	"	1,875
60	Mercang	"	150
61	Marang	"	460
62	Terengganu	"	4,650
63	Merang	"	210
64	Keluang	"	80
65	Gali	Kelantan	10
66	Pak Amat	"	20
67	Kelantan	"	12,900
68	Rulah	"	20
69	Sematan	Sarawak	210
70	Kayan	"	1,020
71	Sempadi	"	90
72	Rambungan	"	120
73	Sibu Laut	"	120
74	Salak	"	80
75	Santubong	"	60
76	Buntal	"	40
77	Bako	"	40
78	Sadong	"	3,100
79	Kabong	"	1,500
80	Oya	"	1,820
81	Mukah	"	2,150
82	Balingian	"	2,520
83	Serupai	"	200
84	Tatau	"	4,780
85	Suai	"	1,400
86	Niah	"	1,270
87	Sibuti	"	830
88	Lawas	"	930
89	Padas	Sabah	8,600
90	Papar	"	770
91	Inanam	"	10
92	Tuaran	"	970
93	Bandau	"	290
94	Bongan	"	470
95	Sugut	"	2,900
96	Segama	"	4,300
97	Kalumpang	"	970
98	Tawau	"	130
99	Umas-Umas	"	370
100	Kalabakan	"	1,340

Table 1.2-2 MEMBERS OF JICA STUDY TEAM AND COUNTERPART PERSONNEL

Name	Designation/Office	
(Study Team)		
1. Katsuhisa Abe	Team Leader	
2. Yoshiharu Matsumoto	Assistant Team Leader	
3. Keiji Sasabe	Coastal Engineer	
4. Masami Katayama	Hydrologist	
5. Masashi Saito	Survey Expert	
6. Shuji Kaku	Structural Design Engineer	
7. Masashi Furutaguchi	Construction Planner/Cost Estimator	
8. Osamu Hiraoka	Hydraulic Model Specialist	
9. Kimio Shimomura	Project Economist	
10. Hiroshi Hashimoto	Environmental Impact Analyst	
11. Sieh Kok Chi	Institutional Specialist	
(Counterpart Personnel)		
1. Abdul Razak b. Khalan/ Ziauddin Abdul Latif	Coordinator	Dept. of Irrigation and Drainage, Ministry of Agriculture
2. Tan Teow Soon	Hydraulic Model Specialist	- ditto -
3. Ahmad Mustapha b. Hassan	Coastal Engineer	- ditto -
4. Wong Tuck Woh	Structural Design Engineer	- ditto -
5. Leong Tuck Meng	Hydrologist	- ditto -

Table 1.2-3 MEMBERS OF ADVISORY COMMITTEE

Name	Designation/Assignment	Office
1. Koji Nukazawa	Chairman	Ministry of Construction, Japan
2. Hiroaki Sato/Toru Shimizu	River Mouth Planning	- ditto -
3. Atsushi Omata/Hiroyuki Ito	Coastal Engineering	- ditto -
4. Hidetomi Oi	River Planning	Development Specialist, JICA

Table 2.3-1 TIDAL LEVEL AT STANDARD PORTS

Location	Standard Port	LAT (m)	MLWS /MLLW (m)	MLWN /MHLW (m)	MSL (m)	MHWN /MLHW (m)	MHWS /MHHW (m)	HAT (m)	Tidal Range = HAT-LAT (m)	Chart Datum (below LSD)	Remarks
West Coast	Teluk Ewa	0.0	0.6 *1	1.5 *3	1.9	2.2 <5	3.1 <7	3.8	3.8		
	Kuah	0.0	0.2 *1	1.0 *3	1.4	1.7 <5	2.6 <7	3.0	3.0		
	Kuala Perlis	0.0	0.6 *1	1.5 *3	1.9	2.2 <5	3.1 <7	3.8	3.8		
	Pulau Pinang	0.0	0.6 *1	1.3 *3	1.6	1.8 <5	2.6 <7	3.2	3.2	1.4 m	
	Lumut	-0.1	0.5 *1	1.2 *3	1.6	2.0 <5	2.7 <7	3.3	3.4		
	Bagan Datoh	0.0	0.4 *1	1.2 *3	1.7	2.1 <5	2.9 <7	3.4	3.4	1.7 m	
	Pelabuhan Klang	-0.1	0.8 *1	2.2 *3	2.9	3.6 <5	5.0 <7	5.8	5.9	2.7 m	
	Beting Sedepa	-0.2	0.6 *1	1.8 *3	2.4	3.1 <5	4.3 <7	5.0	5.2		
	Port Dickson	-0.1	0.3 *1	1.1 *3	1.5	1.9 <5	2.8 <7	3.4	3.5	1.5 m	
	Tanjung Kling	0.0	0.6 *1	1.2 *3	1.5	1.8 <5	2.4 <7	3.1	3.1		
	Kuala Batu Pahat	-0.2	0.3 *1	1.1 *3	1.5	1.9 <5	2.7 <7	3.3	3.5		
	Pulau Pisang	-0.2	0.5 *1	1.3 *3	1.8	2.3 <5	3.1 <7	3.9	4.1		
	Raffles Lighthouse	-0.1	0.5 *1	1.2 *3	1.7	2.1 <5	2.9 <7	3.5	3.6		
	Keppel Harbour	-0.3	0.4 *1	1.1 *3	1.6	2.1 <5	2.7 <7	3.4	3.7	1.6 m	
	Pasir Gudang	0.0	0.9 *1	1.6 *3	2.1	2.6 <5	3.3 <7	4.0	4.0		
	Sembawang Shipyard	-0.2	0.7 *1	1.3 *3	1.9	2.4 <5	3.1 <7	3.9	4.1	1.8 m	
	Sungai Belungkor	0.0	0.8 *1	1.4 *3	1.9	2.3 <5	3.0 <7	3.7	3.7		
East Coast	Horsburgh Lighthouse	-0.3	0.6 <2	1.3 <4	1.5	2.1 <6	2.2 <8	2.8	3.1		
	Teluk Tekek	0.0	0.6 <2	1.4 <4	1.6	1.8 <6	2.6 <8	3.4	3.4		
	Tanjung Gelang	-0.1	0.9 <2	1.7 <4	1.9	2.1 <6	2.8 <8	3.8	3.9	1.6 m	
	Tanjung Berhala	-0.1	0.7 <2	1.5 <4	1.6	1.7 <6	2.4 <8	3.2	3.3	1.3 m	
	Kerteh	-0.1	0.4 <2	0.8 <4	0.9	1.0 <6	1.4 <8	1.9	2.0	0.8 m	
	Chendering	-0.1	0.8 <2	1.5 <4	1.5	1.5 <6	2.2 <8	3.2	3.3		
	Kuala Terengganu	-0.4	0.4 <2	1.0 <4	1.0	1.0 <6	1.7 <8	2.6	3.0		
	Geting	0.0	0.6 <2	0.9 <4	0.9	0.9 <6	1.2 <8	2.4	2.4		
Sarawak & Burnei	Lundu, Kuala	0.2	1.0 <2	1.7 <4	2.4	3.6 <6	3.8 <8	4.4	4.2		
	Santubong, Kuala	0.2	1.3 <2	1.9 <4	2.9	4.1 <6	4.3 <8	5.2	5.0		
	Lakei, Pulau	0.0	1.4 <2	2.4 <4	3.1	4.2 <6	4.5 <8	5.7	5.7	3.1 m	
	Kuching	0.2	1.2 <2	2.2 <4	3.1	4.4 <6	4.7 <8	5.8	5.6	3.0 m	
	Pending	0.2	1.3 <2	2.3 <4	3.4	4.9 <6	5.2 <8	5.9	5.7	3.4 m	
	Sri Aman	0.0	0.7 <2	1.0 <4	2.2	3.6 <6	4.4 <8	5.9	5.9	0.5 m	
	Kanowit	-0.1	0.4 <2	0.8 <4	0.9	1.2 <6	1.4 <8	2.6	2.7		
	Sibu	0.5	1.4 <2	2.0 <4	2.4	2.9 <6	3.3 <8	3.9	3.4	0.4 m	
	Leba an	0.1	1.3 <2	2.2 <4	2.8	3.8 <6	4.0 <8	4.8	4.7		
	Sarikei	0.0	0.9 <2	2.1 <4	2.9	4.2 <6	4.5 <8	5.5	5.5		
	Manis, Tanjung	0.0	1.1 <2	2.2 <4	3.4	4.5 <6	4.9 <8	5.8	5.8		
	Paloh, Kuala	0.1	1.1 <2	2.0 <4	2.7	3.6 <6	4.0 <8	4.6	4.5		
	Kut, Muara	0.0	0.8 <2	1.6 <4	1.7	2.1 <6	2.7 <8	3.3	3.3		
	Igan, Kuala	0.0	0.6 <2	1.6 <4	1.7	2.0 <6	2.3 <8	2.9	2.9		
	Mukah, Kuala	-0.1	0.8 <2	1.5 <4	1.6	1.9 <6	2.2 <8	2.6	2.7		
	Balingian, Kuala	-0.1	0.6 <2	1.2 <4	1.3	1.6 <6	1.7 <8	2.2	2.3		
	Tatau, Kuala	0.1	0.7 <2		1.3		1.6 <8	2.3	2.2		<9
	Bintulu, Pelabuhan	0.2	0.6 <2		1.4		1.7 <8	2.4	2.2	1.5 m	<9
	Miri	0.0	0.6 <2		1.2		1.7 <8	2.1	2.1	1.0 m	<9
	Baram, Kuala	-0.2	0.3 <2		0.9		1.5 <8	2.0	2.2		<9
	Limbang, Kuala	0.2	0.9 <2	1.5 <4	1.7	1.8 <6	2.4 <8	2.9	2.7		
	Lawas, Kuala	0.3	0.8 <2	1.5 <4	1.5	1.6 <6	2.2 <8	2.7	2.4		
Sabah & Labuan	Labuan	0.1	0.8 <2	1.5 <4	1.5	1.6 <6	2.1 <8	2.8	2.7		
	Muara Harbour	0.0	0.6 <2	1.2 <4	1.3	1.5 <6	2.0 <8	2.7	2.7		
	Kota Kinabalu	-0.1	0.5 <2	1.1 <4	1.1	1.2 <6	1.7 <8	2.3	2.4		
	Sandakan	-0.1	0.4 <2	0.9 <4	1.1	1.2 <6	1.9 <8	2.7	2.8		
	Tawau	-0.3	0.1 <1	1.1 <3	1.5	1.8 <5	2.8 <7	3.0	3.3		

Note <1:MLWS, <2:MLLW, <3:MLWN <4:MLHW <5:MHWN <6:MHLW <7:MHWS <8:MHHW <9:usually diurnal

Abbrevations;

LAT : Lowest Astronomical Tide
MLLW : Mean Lower Low Water
MHLW : Mean Higher Low Water
MHWN : Mean High Water Neaps
MHWN : Mean High Water Springs
Hat : Highest Astronomical Tide
MLWS : Mean Low Water Springs
MLWN : Mean Low Water Neaps
MSL : Mean Sea Level
MLHW : Mean Lower High Water
MHHW : Mean Higher High Water
LSD : Land Survey Datum

Data Source : Tide Tables 1992

Table 2.4-1 SIZE OF RIVER BASIN

Class	Catchment Area (km2)			No. of River Basins in the Class
1		<	10	9
2	10	-	50	15
3	50	-	100	13
4	100	-	500	25
5	500	-	1,000	8
6	1,000	-	5,000	26
7	5,000	-	10,000	2
8	10,000	>		2

Table 2.4-2 STRETCH OF TIDAL INFLUENCE

Serial No.	River Mouth	Catchment Area (km2)	Stretch of Tidal Influence (km)
1	Perlis	600	15
5	Kedah	3,060	35
9	Muda	4,300	20
10	Perai	450	20
23	Selangor	1,820	25
25	Langat	1,815	90
30	Linggi	1,270	20
32	Melaka	500	5
36	Muar	6,160	130
39	Batu Pahat	2,230	40
44	Sedili Besar	1,445	70
46	Endau	4,740	80
48	Rompin	3,980	100
51	Pahang	29,140	25
53	Kuantan	1,710	25
55	Kemaman	1,775	25
59	Dungun	1,875	20
62	Terengganu	4,650	25
67	Kelantan	12,900	20
70	Kayan	1,020	65
78	Sadong	3,100	75
80	Oya	1,820	95
81	Mukah	2,150	80
82	Balingian	2,520	100
84	Tatau	4,780	45
86	Niah	1,270	30
87	Sibuti	830	20
88	Lawas	930	30

Source : National Water Resouces Study, 1982, JICA

Table 2.4-3 ANNUAL EROSION RATE BY MAJOR RIVER BASIN

Basin No.	Location / Name of Basin	Catchment Area(km2)	TASSL (ton/yr)	AASSL (ton/km2/yr)
	Peninsular Malaysia			
1	Perlis	790	277	351
2	Pulau Langkawi	475	85	179
3	Kedah	3,695	1,533	415
4	Merbok	520	326	627
5	Muda	4,300	1,928	448
6	Perai	895	815	911
7	Pulau Pinang	300	380	1,267
8	Kerian	1,420	1,428	1,006
9	Kurau	3,255	955	293
10	Perak	14,700	5,507	375
11	Bernam	3,335	1,299	390
12	Tengi	565	17	30
13	Selangor	1,820	1,320	725
14	Buloh	560	160	286
15	Kelang	1,425	578	406
16	Langat	1,815	1,535	846
17	Sepang	640	363	567
18	Linggi	1,420	373	263
19	Melaka	1,010	536	531
20	Kesang	705	255	362
21	Muar	6,595	3,385	513
22	Batu Pahat	2,600	1,157	445
23	Pontian Kechil	2,660	1,407	529
24	Johor	3,250	2,406	740
25	Sedili Besar	1,820	982	540
26	Mersing	880	171	194
27	Endau	4,740	1,357	286
28	Rompin	4,285	1,138	266
29	Bebar	1,895	15	8
30	Pahang	29,300	8,269	282
31	Kuantan	2,025	398	197
32	Kemaman	2,570	214	83
33	Paka	850	367	432
34	Dungun	1,875	259	138
35	Marang	760	320	421
36	Trengganu	4,650	2,042	439
37	Setiu	1,035	140	135
38	Besut	1,230	432	351
39	Kemasin	1,020	579	568
40	Kelantan	13,100	1,803	138
41	Golok	895	794	887
	Sub-total	131,680	47,305	359
	Sabah			
201	Pensiangan	5,971	550	92
202	Serudong	1,308	35	27
203	Kalabakan	1,371	553	403
204	Brantian	741	389	525
205	Umas Umas	553	308	557
206	Merutai Besar	558	526	943
207	Tawau	888	442	498
208	Kalumpang	2,792	1,203	431
209	Silabukan	2,714	2,329	858
210	Segama	5,558	1,840	331
211	Kinabatangan	16,755	6,718	401
212	Segalid	2,335	1,425	610
213	Labuk	6,829	3,525	516
214	Sugut	3,094	1,254	405
215	Paitan	1,474	1,279	868
216	Bengkoka	1,866	1,981	1,062
217	Bongan	2,126	3,777	1,777
218	Kadamaian	1,336	3,183	2,382
219	Tuaran	1,247	2,742	2,199
220	Putatan	629	553	879
221	Papar	805	31	39
222	Kimanis	607	38	63
223	Membakut	736	31	42
224	Padas	9,180	2,010	219
225	Labuan	86	82	953
226	Lakutan	1,291	331	256
	Sub-total	72,850	37,135	510
	Sarawak			
227	Lawas	1,080	1,327	1,229
228	Trusan	2,768	2,024	731
229	Limbang	3,920	6,092	1,554
230	Baram	22,325	15,681	702
231	Miri	788	1,573	1,996
232	Sibuti	935	2,893	3,094
233	Niah	1,345	2,269	1,687
234	Suai	1,440	816	567
235	Similajau	1,268	169	133
236	Kemana	6,000	8,633	1,439
237	Tatau	5,150	4,423	859
238	Balingian	2,518	3,678	1,461
239	Mukah	2,625	4,853	1,849
240	Oya	2,005	6,543	3,263
241	Rajang	51,053	63,516	1,244
242	Kerian	1,675	6,829	4,077
243	Saribas	1,900	5,501	2,895
244	Lupar	6,813	22,489	3,301
245	Sadong	3,645	10,335	2,835
246	Sarawak	3,358	13,542	4,033
247	Kayan	1,838	3,045	1,657
	Sub-total	124,449	186,231	1,496
	Total	328,979	270,671	823

Source : National Water Resources Study, 1982, JICA

Note TASSL : Total annual surface soil loss. AASSL : Average annual surface soil loss.

Table 2.6-1 LAND USE IN PENINSULAR MALAYSIA, 1966 AND 1974

Land Use Category	1966 Area (km2)	1966 Distribution	1974 Area (km2)	1974 Distribution	Increase or Decrease over 1966 (km2)
1. Settlement and associated non-agricultural lands	1,344.8	1.02%	2,002.7	1.51%	657.9
2. Horticultural lands (mainly miscellaneous cultivation including small areas of fruit trees)	1,999.4	1.51%	2,437.7	1.84%	438.3
3. Tree, palm and other permanent crops	20,939.7	15.84%	27,194.3	20.56%	6,254.7
Rubber	17,764.2	13.44%	19,399.3	14.67%	1,635.2
Oil palm	993.1	0.75%	4,850.5	3.67%	3,857.4
Coconut	1,763.1	1.33%	1,966.6	1.49%	203.5
Pineapple	173.2	0.13%	220.1	0.17%	46.9
Coffee	69.9	0.05%	79.3	0.06%	9.4
Cocoa	4.5	0.00%	130.7	0.10%	126.2
Sugarcane	0.0	0.00%	215.8	0.16%	215.8
Orchard	65.9	0.05%	198.9	0.15%	133.0
Sago	38.0	0.03%	62.3	0.05%	24.2
Other crops	67.7	0.05%	70.8	0.05%	3.1
4. Crop land	4,397.0	3.33%	5,036.8	3.81%	639.8
Padi	3,998.9	3.02%	4,283.1	3.24%	284.3
Diversified crops	319.0	0.24%	708.4	0.54%	389.4
Shifting cultivation	79.1	0.06%	45.2	0.03%	-33.8
5. Improved permanent crops	2.1	0.00%	39.0	0.03%	36.9
6. Grassland and forest	88,642.3	67.05%	79,686.3	60.25%	-8,956.1
Grasslands	4,053.5	3.07%	2,226.9	1.68%	-1,826.6
Forest	78,642.0	59.49%	72,415.9	54.75%	-6,226.2
Shrub forest	5,946.8	4.50%	5,043.5	3.81%	-903.3
7. Swampland	11,764.1	8.90%	10,675.1	8.07%	-1,089.0
8. Cleared land	1,153.0	0.87%	3,485.3	2.64%	2,332.3
9. Unused and unclassified land	1,957.4	1.48%	1,709.2	1.29%	-248.2
Total	132,199.7 *	100.00%	132,266.4 **	100.00%	

Source : The Present Land Use of Peninsular Malaysia, Ministry of Agriculture

Note * : Based on aerophotos taken in 1966.
**: Based on aerophotos taken in 1974.
(The total area of the Peninsula is 131,598 km2 in the Yearbook of Statistics, 1990)

Table 2.6-2 LAND USE IN THE STATE OF SARAWAK, 1966 AND 1976

Land Use Category	1966		1976		Increase or Decrease over 1966 (km2)
	Area (km2)	Distribution	Area (km2)	Distribution	
1. Settlement and associated non-agricultural lands	130.0	0.11%	151.8	0.12%	21.8
2. Horticultural lands (mainly miscellaneous cultivation including small areas of fruit trees)	80.0	0.06%	83.7	0.07%	3.7
3. Tree, palm and other permanent crops	3,765.1	3.05%	3,026.1	2.46%	-739.0
Rubber	3,184.4	2.58%	2,033.9	1.65%	-1,150.5
Oil palm	-	0.00%	189.3	0.15%	189.3
Coconut	250.7	0.20%	408.7	0.33%	158.0
Pepper	102.6	0.08%	236.5	0.19%	133.9
Sago	227.4	0.18%	157.7	0.13%	-69.7
4. Crop land	23,258.2	18.87%	28,945.6	23.48%	5,687.4
Wet padi	751.9	0.61%	417.0	0.34%	-334.9
Shifting cultivation	22,506.3	18.26%	28,528.6	23.15%	6,022.3
5. Unused land (secondary growth)	1,693.3	1.37%	724.2	0.59%	-969.1
6. Swamp forest	14,736.6	11.96%	13,837.1	11.23%	-899.5
Mixed swamp forest	11,741.0	9.53%	10,839.7	8.79%	-901.3
Alan	1,934.2	1.57%	2,409.0	1.95%	474.8
Padang paya	1,061.4	0.86%	588.4	0.48%	-473.0
7. Dry forest land	77,851.0	63.16%	74,801.9	60.69%	-3,049.1
Hill forest	74,016.0	60.05%	71,529.8	58.03%	-2,486.2
Kerangas forest	3,658.6	2.97%	2,973.8	2.41%	-684.8
Riverine forest	103.9	0.08%	289.8	0.24%	185.9
Beach forest	72.5	0.06%	8.5	0.01%	-64.0
8. Swamp (Paya) (including fresh and saltwater and mangrove and nipah)	1,738.7	1.41%	1,682.5	1.37%	-56.2
Total	123,252.9	100.00%	123,252.9	100.00%	

Source : Annual Statistics Bulletin, Sarawak, 1990

Note : The total area of Sarawak is 124,449.5 km2 in other statistical data.

Table 2.6-3 AGRICULTURAL LAND USE IN THE STATE OF SABAH, 1985-89

Unit : km2

Agricultural Land Use Category	1985	1986	1987	1988	1989
1. Wet padi	274.37	314.24	325.98	338.04	359.08
2. Dry padi	110.03	142.46	175.02	160.46	183.09
3. Rubber	847.46	859.68	870.26	884.25	901.56
4. Cocoa	1,727.13	1,844.77	1,969.44	2,044.66	2,052.60
5. Coconut	570.06	577.66	586.57	590.79	590.56
6. Oil palm	1,872.26	2,073.16	2,281.50	2,509.97	2,652.68
Total	5,401.31	5,811.97	6,208.77	6,528.17	6,739.57
% over the total state area *	7.34%	7.89%	8.43%	8.87%	9.15%

Source : Annual Bulletin of Statistics, Sabah, 1990

Note * : The total area of Sabah is 73,620 km2.

Table 2.7-1 ARRIVALS AND DEPARTURES OF OCEAN-GOING VESSELS ENGAGED IN FOREIGN TRADE AT PRINCIPAL PORTS, 1990

State/Port	Arrivals		Departures	
	Number	N.R.T.*1 (x1000)	Number	N.R.T.*1 (x1000)
Malaysia	16,253	81,995	16,311	81,623
Peninsular Malaysia	7,429	46,722	7,335	45,241
- Port Klang	3,333	21,310	3,329	21,356
- Port of Penang	1,823	8,408	1,790	8,357
- Port of Pasir Gudang	1,495	10,359	1,466	9,655
- Port Dickson	433	3,709	406	3,155
- Port of Kuantan	345	2,936	344	2,718
Sabah	3,363	14,324	3,397	15,014
- Port of Kota Kinabalu	918	2,654	925	2,669
- Port of Tawau	803	2,396	819	3,036
- Port of Federal Territory Labuan	777	6,488	777	6,488
- Port of Sandakan	865	2,786	876	2,821
Sarawak	5,461	20,949	5,579	21,368
- Port of Miri	1,747	5,892	1,888	6,214
- Rajang Ports *2	1,253	3,301	1,418	3,390
- Port of Kuching	1,182	1,719	924	1,433
- Port of Bintulu	1,279	10,037	1,349	10,331

Source : Yearbook of Statistics 1990, Department of Statistics

Note *1 : Net registered tonnage
*2 : Includes ports of Sibu, Bintangor, Sarikei and Tg. Mani.

Table 2.7-2 MARINE FISH LANDINGS, 1989 AND 1990

Unit : Metric Ton

State	1989	1990	% Change
Malaysia	882,492	951,307	7.8%
Peninsular Malaysia	746,884	819,903	9.8%
- Perlis	42,360	46,206	9.1%
- Kedah	75,615	86,408	14.3%
- Pulau Pinang	38,624	52,278	35.4%
- Perak	198,974	219,044	10.1%
- Selangor	112,646	86,966	-22.8%
- Negeri Sembilan	221	349	57.9%
- Melaka	1,989	2,363	18.8%
- West Johor	18,905	16,857	-10.8%
Sub-total (west coast)	489,334	510,471	4.3%
- Kelantan	32,982	31,557	-4.3%
- Terengganu	78,815	97,236	23.4%
- Pahang	68,730	105,370	53.3%
- East Johor	77,023	75,269	-2.3%
Sub-total (east coast)	257,550	309,432	20.1%
Sabah	44,000	44,760	1.7%
Sarawak	84,356	78,878	-6.5%
Labuan	7,252	7,766	7.1%

Source : Annual Fisheries Statistics 1990, Department of Fisheries

Table 2.7-3 NUMBER OF LICENSED FISHING BOATS AND FISHERMEN BY STATE, 1990

State	Number of Licensed Fishing Boats				Total Number of Fishermen	Number of Fishermen Per Boat
	Non-Powered	Outboard-Powered	Inboard-Powered	Total		
Malaysia	1,657	13,869	24,015	39,541	88,494	2.2
Peninsular Malaysia	779	7,029	15,326	23,134	59,801	2.6
- Perlis	0	174	601	775	4,223	5.4
- Kedah	11	918	1,371	2,300	7,403	3.2
- Pulau Pinang	49	1,226	876	2,151	4,484	2.1
- Perak	171	947	3,901	5,019	10,767	2.1
- Selangor	138	451	2,175	2,764	5,755	2.1
- Negeri Sembilan	18	151	51	220	447	2.0
- Melaka	78	560	236	874	1,557	1.8
- West Johor	212	1,607	1,072	2,891	4,418	1.5
Sub-total (west coast)	677	6,034	10,283	16,994	39,054	2.3
- Kelantan	9	236	932	1,177	3,784	3.2
- Terengganu	28	84	2,298	2,410	9,461	3.9
- Pahang	18	152	863	1,033	3,587	3.5
- East Johor	47	523	950	1,520	3,915	2.6
Sub-total (east coast)	102	995	5,043	6,140	20,747	3.4
Sabah	800	5,000	3,400	9,200	12,197	1.3
Sarawak	77	1,711	5,278	7,066	16,082	2.3
Labuan	1	129	11	141	414	2.9

Source : Annual Fisheries Statistics 1990, Department of Fisheries

Table 2.8-1 POPULATION AND ANNUAL AVERAGE GROWTH BY STATE

State	Population (thousand)				Annual Average Growth		
	1970	1980	1990 *3	2000	1970 - 1980	1980 - 1990	1990 - 2000
Malaysia	10,439	13,136	17,756	22,428	2.3%	3.1%	2.4%
Peninsular Malaysia	8,810	10,945	14,617	18,117	2.2%	2.9%	2.2%
- Johor	1,277	1,580	--	--	2.2%	--	--
- Kedah	955	1,078	--	--	1.2%	--	--
- Melaka	404	447	--	--	1.0%	--	--
- Negeri Sembilan	482	551	--	--	1.4%	--	--
- Pulau	776	901	--	--	1.5%	--	--
- Perak	1,569	1,744	--	--	1.1%	--	--
- Perlis	121	145	--	--	1.8%	--	--
- Selangor *1	1,630	2,346	--	--	3.7%	--	--
Sub-total (west coast)	7,215	8,792	--	--	2.0%	--	--
- Kelantan	685	859	--	--	2.3%	--	--
- Pahang	505	769	--	--	4.3%	--	--
- Terengganu	405	525	--	--	2.6%	--	--
Sub-total (east coast)	1,595	2,153	--	--	3.0%	--	--
Sabah *2	654	956	1,470	2,068	3.9%	4.4%	3.5%
Sarawak	976	1,236	1,669	2,243	2.4%	3.1%	3.0%

Source : Yearbook of Statistics 1990, Department of Statistics
Population Projection, Malaysia 1980-2000, Department of Statistics

Note *1 : Includes the Federal Territory, Kuala Lumpur.
(The population of Kuala Lumpur in 1980 is 919,610.)
*2 : Includes the Federal Territory of Labuan.
*3 : Provisional estimate.

Table 2.10-1 CONSUMER PRICE INDEX, 1986-90

Area/State	Consumer Price Index (1990=100)					Annual Increase
	1986	1987	1988	1989	1990	
Malaysia	91.4	92.1	94.4	97.0	100.0	2.27%
Peninsula	90.9	91.8	94.3	96.9	100.0	2.41%
Sabah	96.2	95.1	95.6	97.6	100.0	0.97%
Sarawak	91.9	92.4	94.5	97.5	100.0	2.13%

Source: Yearbook of Statistics 1990, Department of Statistics
Annual Bulletin of Statistics Sabah 1990, Department of Statistics
Annual Statistical Bulletin Sarawak 1990, Department of Statistics

Table 2.10-2 LABOR AND EMPLOYMENT, 1986-90

Unit : thousand persons

Item	1986	1987	1988	1989	1990	Annual Increase
Total Labor Force	6,222	6,409	6,622	6,834	7,047	3.2%
Participation Rate *	65.8%	65.9%	66.1%	66.3%	66.5%	0.3%
Employment	5,707	5,881	6,088	6,351	6,621	3.8%
Unemployment Rate	8.3%	8.2%	8.1%	7.1%	6.0%	---

Source: Economic Report 1991/92, Ministry of Finance

Note *: Total number of economically active people as a percentage of the total number of the working age population of 15 to 64 years old.

Table 2.10-3 FEDERAL GOVERNMENT CONSOLIDATED FINANCE

Unit : million RM

Item	1986	1987	1988	1989	1990
1. Revenue	19,518	18,143	21,967	25,273	29,521
(annual percentage changes)	-7.6%	-7.0%	21.1%	15.1%	16.8%
- Tax Revenue	14,683	12,473	14,708	16,674	21,244
- Non-Tax Revenue	4,355	5,134	6,623	7,497	6,946
- Non-Revenue Receipt	402	460	544	1,018	1,192
- Revenue from Federal Territory	78	75	92	85	138
2. Operating Expenditure	20,075	20,185	21,812	24,832	27,105
(annual percentage changes)	0.04%	0.5%	8.1%	13.8%	9.2%
2.1 Emoluments	6,454	6,504	7,964	7,381	7,966
2.2 Other Expenditure	13,621	13,681	13,848	17,450	19,139
3. Current Surplus/Deficit	-557	-2,042	155	442	2,416
4. Development Fund	7,559	4,741	5,231	7,696	10,689
(annual percentage changes)	5.8%	-37.3%	10.4%	47.1%	38.9%
4.1 Direct Expenditure	4,369	3,194	3,394	6,006	9,160
4.2 Gross Lending	3,190	1,547	1,837	1,690	1,529
5. Repayments	610	630	1,186	1,995	2,757
6. Net Lending (4.2 - 5.)	2,580	917	651	-305	-1,228
7. Total Expenditures (2.+ 4.1 + 6.)	27,024	24,296	25,857	30,532	35,037
(annual percentage changes)	0.8%	-10.1%	6.4%	18.1%	14.8%
8. Overall Deficit (1. - 7.)	-7,506	-6,153	-3,890	-5,260	-5,516
9. Source of Finance	6,278	6,255	4,759	1,458	3,026
9.1 Net External Borrowing	1,348	-2,438	-3,095	-1,016	-767
9.2 Net Domestic Borrowing	4,930	8,693	7,854	2,474	3,793
10. Change in Assets (8. + 9.)	-1,228	102	869	-3,802	-2,490

Source : Economic Report 1991/92, Ministry of Finance
Yearbook of Statistics 1990, Department of Statistics

Table 2.10-4 DEVELOPMENT EXPENDITURE FOR RELATED WORKS

Unit : million RM

Item	1986	1987	1988	1989	1990	Total/ Ave. %
1. Federal Gov't Development Fund	6,949	4,111	4,045	5,701	7,932	28,737
1.1 Direct Expenditure	4,369	3,194	3,394	6,006	9,160	26,122
1.2 Net Lending	2,580	917	651	-305	-1,228	2,615
2. Development Expenditure of MOA	644	515	481	563	601	2,804
3. Percentage of 2. to the Federal Gov't Development Fund (2./1.)	9.3%	12.5%	11.9%	9.9%	7.6%	9.8%
4. Development Expenditure of DID	80.7	66.4	65.8	76.5	96.8	386.2
4.1 Irrigation	19.8	13.5	7.8	10.3	8.2	59.6
4.2 Agriculture Drainage	26.3	18.0	19.3	11.1	13.3	88.0
4.3 Flood Mitigation	31.0	29.6	32.2	49.8	67.2	209.9
4.4 Hydrology & Water Resources Dev't.	0.4	0.3	0.4	0.5	0.4	2.0
4.5 Coastal Erosion Protection	0.0	0.0	0.0	0.0	1.8	1.8
4.6 Other Works	3.1	5.1	6.1	4.8	5.8	24.9
5. Percentage of 4. to the MOA Development Expenditure (4./2.)	12.5%	12.9%	13.7%	13.6%	16.1%	13.8%
6. Percentage of 4. to the Federal Gov't Development Fund (4./1.)	1.2%	1.6%	1.6%	1.3%	1.2%	1.3%

Source : Economic Report 1991/1992, Ministry of Finance
Belanjawan Persekutuan, 1988 - 1992
DID Headquarters

Table 2.10-5 DID EXPENDITURE FOR DREDGING WORKS IN THE FIFTH MALAYSIA PLAN

Unit : million M$

State	River	Project Cost	Revised Budget in the 5th MP	Actual Expenditure	Achievement (%)
Selangor	Semenyih	2.200	2.200	2.134	97.0%
Negeri Sembilan	Setol	0.698	0.698	0.668	95.7%
Negeri Sembilan	Bukit Melintang	0.042	0.042	0.042	100.0%
Pahang	Bertam, Cameron Highlands	2.500	2.100	2.148	102.3%
Kelantan	Kuala Besar	1.700	0.798	0.785	98.4%
Kelantan	Jajahang Mechang	5.000	2.477	2.362	95.4%
Kelantan	Kuala Geting & Pak Amat	2.000	0.930	0.812	87.3%
Sabah	Moyong & Renahan	4.093	0.177	0.177	99.8%
Total		18.233	9.422	9.128	96.9%

Source : DID Headquarters

Table 3.1-1(1/2) DATA ON RIVER MOUTH PROBLEM

Serial	Name	Flood Problem	Commercial Navigation Problem	No. of Commercial Boat	Complaint from Fishermen	No. of Fishing Boat	Population of Fishermen
1	Perlis*	-	yes	20	yes	432	(2333)
2	Baru	-	-	-	yes**	104	(561)
3	Sanglang	-	-	-	-	238	(762)
4	Jerlun	-	-	-	-	63	(202)
5	Kedah*	-	yes	77	yes	536	(1716)
6	Yan	-	-	-	yes**	154	(493)
7	Melaka	-	-	-	-	3	(10)
8	Cenang	-	-	-	yes**	44	(141)
9	Muda*	-	-	-	yes**	201	(504)
10	Perai	-	-	16	-	(26)	50
11	Kerian	yes	-	-	yes**	245	693
12	Pinang	-	-	-	yes**	182	700
13	Bayan Lepas	-	-	-	yes	122	50
14	Tg. Piandang	-	-	-	yes**	486	1042
15	Gula	-	-	-	yes	216	308
16	Sangga	-	-	-	yes	39	76
17	Larut	-	-	-	yes	752	140
18	Terong	-	-	-	-	5	166
19	Beruas*	-	-	-	yes**	(655)	1595
20	Batu	-	-	-	yes**	16	21
21	Dinding*	-	-	***	-	40	83
22	Lekir	-	-	-	-	26	(55)
23	Selangor	-	-	-	yes**	189	(397)
24	Kapar Besar	-	-	-	-	77	(67)
25	Langat	-	-	-	yes**	34	(158)
26	Sepan Kecil	-	-	-	yes**	23	(26)
27	Sepang	-	-	-	-	105	(95)
28	Lukut	-	-	-	-	35	79
29	Raya	-	-	-	-	(5)	(10)
30	Linggi	-	-	-	-	63	(20)
31	Baru	-	-	-	yes**	92	170
32	Melaka	-	-	***	yes**	111	311
33	Duyong	-	-	-	yes	32	95
34	Umbai	-	-	-	yes	38	62
35	Merlimau	-	-	-	yes	35	69
36	Muar	-	-	-	-	167	(251)
37	Parit Jawa	-	-	-	-	117	(176)
38	Sarang Buaya	-	-	-	-	35	(53)
39	Batu Pahat	-	-	-	-	64	(96)
40	Senggarang	-	-	-	yes	35	(53)
41	Rengit	-	-	-	yes	57	(86)
42	Benut	-	-	-	-	61	(92)
43	Pontian Kecil	-	-	-	-	247	(370)
44	Sedili Besar	-	-	-	-	311	(467)
45	Mersing*	-	yes	154	yes	290	(435)
46	Endau	-	-	-	-	218	(327)
47	Pontian	-	-	-	-	17	28
48	Rompin	-	-	-	-	107	405
49	Merchong	-	-	-	-	4	11
50	Nenasi	-	-	-	-	75	228

Source: DID, MD and Investigation Survey Results
Note: * Dredging has been conducted or is scheduled.
** Complaint is very strong.
*** Data is not available.
Figures in parenthesis are estimated value based on interview survey or statistical data.

Table 3.1-1(2/2) DATA ON RIVER MOUTH PROBLEM

Serial	Name	Flood Problem	Commercial Navigation Problem	No. of Commercial Boat	Complaint from Fishermen	No. of Fishing Boat	Population of Fishermen
51	Pahang	-	-	-	-	164	666
52	Terus	-	-	-	-	(34)	86
53	Kuantan	-	-	45	-	163	(570)
54	Beserah	-	-	-	-	6	(21)
55	Kemaman	yes	-	8	-	97	1338
56	Kemasik	-	-	-	yes	42	175
57	Kerteh*	-	-	23	yes	53	140
58	Paka	-	-	-	-	83	267
59	Dungun*	-	-	***	-	66	848
60	Mercang*	yes	-	-	yes	23	50
61	Marang*	-	-	-	yes**	188	715
62	Terengganu*	yes	yes	161	yes	107	(417)
63	Merang*	-	-	-	-	34	66
64	Keluang	-	-	-	-	(10)	(39)
65	Gali	-	-	-	-	(8)	15
66	Pak Amat*	yes	-	-	yes**	28	30
67	Kelantan*	yes	-	***	-	208	(666)
68	Rulah	-	-	-	-	(15)	35
69	Sematan	-	-	-	-	4	97
70	Kayan	-	-	-	-	(45)	(104)
71	Sempadi	-	-	-	-	7	49
72	Rambungun	-	-	-	-	0	27
73	Sibu Laut	-	-	-	-	0	47
74	Salak	-	-	-	-	8	54
75	Santubong	-	-	-	-	0	50
76	Buntal	-	-	-	-	5	122
77	Bako	-	-	-	-	(92)	93
78	Sadong	-	-	-	-	(867)	751
79	Kabong	-	-	***	-	(207)	239
80	Oya	-	-	-	-	(104)	292
81	Mukah	-	-	-	-	(199)	556
82	Balingian	-	-	-	-	(33)	92
83	Serupadi	-	-	-	-	(3)	(7)
84	Tatau	-	-	-	-	(43)	142
85	Suai	-	-	-	-	(4)	12
86	Niah	-	-	-	-	(4)	12
87	Sibuti	-	-	-	-	(31)	99
88	Lawas	-	-	-	-	(161)	167
89	Padas	yes	-	-	-	400	509
90	Papar	yes	-	-	yes	123	34
91	Inanam	-	-	-	-	21	50
92	Tuaran	-	-	-	-	120	120
93	Bandau	-	-	-	-	54	54
94	Bongan	-	-	-	-	47	42
95	Sugut	-	-	-	-	211	211
96	Segama	-	-	***	-	26	28
97	Kalumpang	-	-	-	-	10	105
98	Tawau	-	-	-	-	60	400
99	Umas-umas	-	-	***	-	15	60
100	Kalabakan	-	-	***	-	5	98

Source: DID, MD and Investigation Survey Results
Note: * Dredging has been conducted or is scheduled.
** Complaint is very strong.
*** Data is not available.
Figures in parenthesis are estimated value based on interview survey or statistical data.

Table 3.2-1(1/2) RECORD OF DREDGING WORKS

Serial	Name	DID	Marine Department*1
1	Perlis	-	1986, '87, '90, '91, ('92)
2	Baru	-	-
3	Sanglang	-	-
4	Jerlun	-	-
5	Kedah	-	(1992)
6	Yan	-	-
7	Melaka	-	-
8	Cenang	-	-
9	Muda	1986	-
10	Perai	-	-
11	Kerian	-	-
12	Pinang	-	-
13	Bayan Lepas	-	-
14	Tg. Piandang	-	-
15	Gula	-	-
16	Sangga	-	-
17	Larut	-	-
18	Terong	-	-
19	Beruas	1988-90	-
20	Batu	-	-
21	Dinding	-	1986
22	Lekir	-	-
23	Selangor	-	-
24	Kapar Besar	-	-
25	Langkat	-	-
26	Sepan Kecil	-	-
27	Sepang	-	-
28	Lukut	-	-
29	Raya	-	-
30	Linggi	-	-
31	Baru	-	-
32	Melaka	-	-
33	Duyong	-	-
34	Umbai	-	-
35	Merlimau	-	-
36	Muar	-	-
37	Parit Jawa	-	-
38	Sarang Buaya	-	-
39	Batu Pahat	-	-
40	Senggarang	-	-
41	Rengit	-	-
42	Benut	-	-
43	Pontian Kecil	-	-
44	Sedili Besar	-	-
45	Mersing	-	1981, ('92)
46	Endau	-	-
47	Pontian	-	-
48	Rompin	-	-
49	Merchong	-	-
50	Nenasi	-	-

Note: *1 Figures in parenthesis show scheduled year of dredging works.
Source: DID, MD

Table 3.2-1(2/2) RECORD OF DREDGING WORKS

Serial	Name	DID	Marine Department*1
51	Pahang	-	-
52	Terus	(1993)	-
53	Kuantan	-	-
54	Beserah	-	-
55	Kemaman	-	-
56	Kemasik	-	-
57	Kerteh	1991	-
58	Paka	-	-
59	Dungun	-	1989, '90
60	Mercang	1991	-
61	Marang	1979	-
62	Terengganu	-	1976, '87, '88, '91, ('92)
63	Merang	1975, '76, '77	-
64	Keluang	-	-
65	Gali	-	-
66	Pak Amat	1991	
67	Kelantan	1991	1986, '88, '89, ('92)
68	Rulah	-	-
69	Semantan	-	-
70	Kayan	-	-
71	Sempadi	-	-
72	Rambungun	-	-
73	Sibu Laut	-	-
74	Salak	-	-
75	Santubong	-	-
76	Buntal	-	-
77	Bako	-	-
78	Sadong	-	-
79	Kabong	-	-
80	Oya	-	-
81	Mukah	-	-
82	Balingian	-	-
83	Serupadi	-	-
84	Tatau	-	-
85	Suai	-	-
86	Niah	-	-
87	Sibuti	-	-
88	Lawas	-	-
89	Padas	-	-
90	Papar	-	-
91	Inanam	-	-
92	Tuaran	-	-
93	Bandau	-	-
94	Bongan	-	-
95	Sugut	-	-
96	Segama	-	-
97	Kalumpang	-	-
98	Tawau	-	-
99	Umas-umas	-	-
100	Kalabakan	-	-

Note: *1 Figures in parenthesis show scheduled year of dredging works.
Source: DID, MD

Table 3.2-2 RIVER MOUTH IMPROVEMENT AND RELATED STRUCTURES

Serial	Name	Structures for River Mouth Improvement *1	Related Structures *2
1	Perlis	-	DM
2	Baru	-	TG
3	Sanglang	-	TG
4	Jerlun	-	TG
5	Kedah	-	TG, DM
6	Yan	-	TG
7	Melaka	-	-
8	Cenang	BW	TG
9	Muda	-	TG
10	Perai	-	TG
11	Kerian	-	TG
12	Pinang	-	-
13	Bayan Lepas	-	-
14	Tg. Piandang	-	TG
15	Gula	-	-
16	Sangga	-	-
17	Larut	-	-
18	Terong	-	-
19	Beruas	-	-
20	Batu	-	-
21	Dinding	-	-
22	Lekir	-	-
23	Selangor	-	-
24	Kapar Besar	-	-
25	Langkat	-	-
26	Sepan Kecil	-	-
27	Sepang	-	-
28	Lukut	-	TG
29	Raya	-	TG
30	Linggi	-	TG
31	Baru	-	-
32	Melaka	BW	DM
33	Duyong	-	TG
34	Umbai	-	TG
35	Merlimau	-	-
36	Muar	-	-
37	Parit Jawa	-	TG
38	Sarang Buaya	-	TG
39	Batu Pahat	-	DM
40	Senggarang	-	TG
41	Rengit	-	TG
42	Benut	-	DM
43	Pontian Keci	-	-
44	Sedili Besar	-	-
45	Mersing	-	-
46	Endau	-	DM
47	Pontian	-	DM
48	Rompin	-	-
49	Merchong	-	-
50	Nenasi	-	-
51	Pahang	-	DM, GR, RV
52	Terus	-	-
53	Kuantan	-	-
54	Beserah	-	-
55	Kemaman	JT	-
56	Kemasik	TL	-
57	Kerteh	-	-
58	Paka	-	DM
59	Dungun	-	DM, RV
60	Mercang	-	-
61	Marang	-	-
62	Terengganu	RV	DM
63	Merang	-	-
64	Keluang	-	-
65	Gali	BW	-
66	Pak Amat	-	-
67	Kelantan	-	DM, RV, GR
68	Rulah	-	-
69	Semantan	-	-
70	Kayan	-	-
71	Sempadi	-	-
72	Rambungun	-	-
73	Sibu Laut	-	-
74	Salak	-	-
75	Santubong	-	-
76	Buntal	-	-
77	Bako	-	-
78	Sadong	-	-
79	Kabong	-	-
80	Oya	-	-
81	Mukah	-	-
82	Balingian	-	-
83	Serupadi	-	-
84	Tatau	-	-
85	Suai	-	-
86	Niah	-	-
87	Sibuti	-	-
88	Lawas	-	-
89	Padas	-	-
90	Papar	-	-
91	Inanam	-	RV
92	Tuaran	-	-
93	Bandau	-	-
94	Bongan	-	-
95	Sugut	-	-
96	Segama	-	-
97	Kalumpang	-	-
98	Tawau	-	-
99	Umas-umas	-	-
100	Kalabakan	-	-

Note: *1 BW: Breakwater JT: Jetty TL: Training Levee RV: Revetment
*2 TG: Tidal Gate GR: Groyne RV: Revetment DM: Dam

Table 4.1-1 (1/3) CLASSIFICATION OF 100 RIVER MOUTHS BASED ON NATURAL CONDITION

Serial	River Mouth	Coastal Geomorphology *1	Wave *2	Tide *3	Catchment Area of the River *4	River Course Pattern *5	Shoreline Formation *6	Coastal Material *7	River Mouth Condition *8
1	Perlis	SC	LW	LP	LC	MD	ST	SM	OP
2	Baru	SC	LW	SP	MC	SR	ST	MU	OP
3	Sanglang	SC	LW	SP	MC	SR	ST	MU	OP
4	Jerlun	SC	LW	SP	MC	SR	ST	MS	OP
5	Kedah	PR	LW	LP	LC	MD	CV	MU	OP
6	Yan	SI	LW	SP	MC	MD	ST	SM	OP
7	Melaka	HL	LW	SP	MC	MD	CV	SA	PC
8	Cenang	SI	LW	SP	MC	MD	ST	SA	PC
9	Muda	PR	LW	LP	LC	MD	ST	SA	PC
10	Perai	PR, SI	LW	LP	LC	MD	ST	MU	OP
11	Kerian	ES	LW	LP	LC	MD	CC	MU	OP
12	Pinang	SC	LW	SP	MC	SR	ST	MU	OP
13	Bayan Lepas	HL	LW	SP	MC	SR	ST	SM	OP
14	Tg. Piandang	PR	LW	SP	LC	SR	ST	MU	OP
15	Gula	EB	LW	LP	MC	MD	CC	MU	OP
16	Sangga	ES	LW	LP	LC	MD	CC	MU	OP
17	Larut	ES	LW	LP	LC	MD	CC	MU	OP
18	Terong	ES	LW	LP	MC	MD	CC	MU	OP
19	Beruas	HL	LW	LP	LC	MD	CC	MU	OP
20	Batu	HL	LW	SP	MC	MD	ST	MU	OP
21	Dinding	HL, SI	LW	LP	LC	SR	ST	SA	OP
22	Lekir	SC	LW	SP	MC	SR	ST	MU	OP
23	Selangor	SC	LW	LP	LC	MD	CC	MU	OP
24	Kapar Besar	SI	LW	SP	LC	SR	ST	MU	OP
25	Langat	SC	LW	LP	LC	MD	ST	MS	OP
26	Sepan Kecil	SC	LW	SP	MC	MD	ST	MU	SS
27	Sepang	SC	LW	SP	MC	MD	ST	SM	PC
28	Lukut	HL	LW	SP	LC	MD	ST	MU	OP
29	Raya	HL	LW	SP	MC	SR	ST	MU	SS
30	Linggi	HL	LW	LP	LC	SR	ST	MU	SS
31	Baru	SC	LW	SP	MC	SR	ST	SA	PC
32	Melaka	SC	LW	SP	LC	SR	CV	MS	OP
33	Duyong	SC	LW	SP	MC	MD	ST	MU	OP
34	Umbai	SC	LW	SP	MC	MD	ST	MU	OP
35	Merlimau	SC	LW	SP	MC	MD	ST	MU	OP
36	Muar	ES	LW	LP	LC	MD	CC	MU	OP
37	Parit Jawa	SC	LW	SP	MC	SR	ST	MU	OP
38	Sarang Buaya	SC	LW	SP	LC	SR	ST	MU	OP
39	Batu Pahat	ES, HL	LW	LP	LC	MD	CC	MU	OP
40	Senggarang	SC	LW	SP	MC	SR	ST	MU	OP

Note is in the last page, Table 4.1-1(3/3).

Table 4.1-1 (2/3) CLASSIFICATION OF 100 RIVER MOUTHS BASED ON NATURAL CONDITION

Serial	River Mouth	Coastal Geomorphology *1	Wave *2	Tide *3	Catchment Area of the River *4	River Course Pattern *5	Shoreline Formation *6	Coastal Material *7	River Mouth Condition *8
41	Rengit	SC	LW	SP	LC	SR	ST	MU	OP
42	Benut	SC	LW	SP	LC	SR	ST	MU	OP
43	Pontian Kecil	SC	LW	SP	MC	MD	ST	MU	OP
44	Sedili Besar	HL	WO	LP	LC	MD	OB	SA	PC
45	Mersing	SI	WO	LP	LC	MD	ST	SA	SS
46	Endau	HL	WO	LP	LC	MD	ST	SA	SS
47	Pontian	SC	WS	SP	LC	MD	OB	SA	SS
48	Rompin	SC	WS	LP	LC	MD	OB	SA	SS
49	Merchong	PT	WO	SP	LC	MD	OB	SA	PC
50	Nenasi	PT	WO	LP	LC	MD	OB	SM	PC
51	Pahang	DL	WS	LP	LC	MD	OB	SA	PC
52	Terus	PT	WO	LP	MC	MD	OB	SA	CL
53	Kuantan	HL	WO	LP	LC	MD	OB	SA	SS
54	Beserah	PT	WO	SP	MC	MD	OB	SA	SS
55	Kemaman	HL	WO	LP	LC	MD	OB	SA	SS
56	Kemasik	SI	WO	SP	MC	MD	OB	SA	PC
57	Kerteh	HL	WO	SP	MC	MD	OB	SA	CL
58	Paka	HL, PT	WO	LP	LC	MD	OB	SA	SS
59	Dungun	HL	WO	LP	LC	MD	OB	SA	SS
60	Mercang	PT	WO	LP	LC	MD	ST	SA	CL
61	Marang	SC	WS	LP	LC	MD	ST	SA	PC
62	Terengganu	PR	WS	LP	LC	MD	OB	SA	PC
63	Merang	PR	WO	SP	LC	MD	ST	SA	CL
64	Keluang	HL	WO	LP	MC	MD	ST	SA	OP
65	Gali	SC	WS	SP	MC	SR	ST	SA	OP
66	Pak Amat	SC	WO	SP	MC	MD	ST	SA	CL
67	Kelantan	DL	WO	LP	LC	MD	CV	SA	PC
68	Rulah	DL, PT	WO	SP	MC	MD	OB	SM	PC
69	Sematan	ES	WO	LP	LC	MD	OB	SM	PC
70	Kayan	ES	WO	LP	LC	MD	OB	SM	PC
71	Sempadi	ES	WO	LP	MC	MD	CC	SM	OP
72	Rambunban	ES	WS	LP	LC	MD	CC	SM	OP
73	Sibu Laut	ES	WS	LP	LC	MD	CC	SM	OP
74	Salak	ES, HL	LW	LP	MC	MD	CC	SM	OP
75	Santubong	ES, HL	LW	LP	MC	MD	CC	SM	OP
76	Buntal	ES, HL	LW	LP	MC	MD	CC	MU	OP
77	Bako	ES, HL	LW	LP	MC	MD	CC	MU	OP
78	Sadong	ES	LW	LP	LC	MD	CC	SM	OP
79	Kabong	ES	LW	LP	LC	MD	CC	SM	OP
80	Oya	SC	WO	LP	LC	MD	CC	SA	OP

Note is in the last page, Table 4.1-1(3/3).

Table 4.1-1 (3/3) CLASSIFICATION OF 100 RIVER MOUTHS BASED ON NATURAL CONDITION

Serial	River Mouth	Coastal Geomor-phology *1	Wave *2	Tide *3	Catchment Area of the River *4	River Course Pattern *5	Shoreline Formation *6	Coastal Material *7	River Mouth Condition *8
81	Mukah	SC	WS	LP	LC	MD	CC	SA	OP
82	Balingian	SC	WS	LP	LC	MD	CC	SA	OP
83	Serupadi	SC	WS	SP	LC	SR	CC	SA	OP
84	Tatau	SC	WS	LP	LC	MD	OB	SA	PC
85	Suai	SC	WO	SP	LC	MD	OB	SA	PC
86	Niah	SC	WO	SP	LC	MD	OB	SA	PC
87	Sibuti	SC	WO	SP	LC	MD	OB	SA	PC
88	Lawas	PR	LW	LP	LC	MD	CV	SA	OP
89	Padas	ES	LW	LP	LC	MD	ST	SM	OP
90	Papar	PR, PT	WO	SP	LC	MD	OB	SA	PC
91	Inanam	EB	WO	SP	MC	MD	ST	SA	OP
92	Tuaran	SC	WO	LP	LC	MD	ST	SA	OP
93	Bandau	EB	LW	SP	LC	MD	ST	MU	OP
94	Bongan	EB	LW	SP	LC	MD	ST	MU	OP
95	Sugut	PR	WS	LP	LC	MD	ST	MS	OP
96	Segama	ES	WO	LP	LC	MD	ST	MS	OP
97	Kalumpang	ES	LW	LP	LC	MD	CC	MS	OP
98	Tawau	SI	LW	SP	LC	MD	ST	SA	PC
99	Umas-umas	EB	LW	LP	LC	MD	ST	MU	OP
100	Kalabakan	EB	LW	LP	LC	MD	CC	MU	OP

Note:

*1 SC: Straight Coast, PR: Protruding Coast, EB: Embayed Coast
ES: Estuary, HL: Headland, SI: Sheltered by Island
DL: Delta Formation, PT: Sand Spit

*2 WS: High Straight Wave, WO: High Oblique Wave, LW: Low Wave

*3 LP: Large Tidal Prism, SP: Small Tidal Prism

*4 LC: Large Catchment Area, MC: Small Catchment Area

*5 SR: Straight River, MD: Meandering River

*6 CV: Convex Shoreline, ST: Straight Shoreline, CC: Concave Shoreline
OB: One Side Bar

*7 SA: Sandy, MU: Muddy, SM: Mixed (Sand is predominant)
MS: Mixed (Mud is predominant)

*8 CL: Completely Closed by Sand Bar, PC: Partially Closed by Sand Bar
SS: Shallowed by Submerged Bar, OP: Open to the Sea

Table 4.1-2(1/2) CLASSIFICATION OF 100 RIVER MOUTHS BASED ON SOCIOECONOMIC CONDITION

Serial	Name	Land Use Condition *1	Navigation Condition *2
1	Perlis	UR, VI, AG	F, C
2	Baru	VI, AG	F
3	Sanglang	VI, AG	F
4	Jerlun	VI, AG	F
5	Kedah	UR, VI, AG	F, C
6	Yan	VI, AG	F
7	Melaka	VI, AG	F
8	Cenang	VI, AG	F
9	Muda	VI, SW, AG	F
10	Perai	UR, SW, AG	F, C
11	Kerian	VI, SW, AG	F
12	Pinang	UR, VI, AG	F
13	Bayan Lepas	VI, AG	F
14	Tg. Piandang	VI, AG, SW	F
15	Gula	VI, SW, AG	F
16	Sangga	VI, SW	F
17	Larut	VI, SW	F
18	Terong	VI, SW	F
19	Beruas	UR, SW, AG	F
20	Batu	VI, SW	F
21	Dinding	VI, SW, AG	F, C
22	Lekir	VI, SW, AG	F
23	Selangor	UR, SW, AG	F
24	Kapar Besar	VI, SW, AG	F
25	Langkat	VI, SW	F
26	Sepan Kecil	VI, FO, AG	F
27	Sepang	VI,FO, AG	F
28	Lukut	VI, FO	F
29	Raya	VI, SW, AG	F
30	Linggi	VI, SW	F
31	Baru	VI, AG	F
32	Melaka	UR	F, C
33	Duyong	VI, SW, AG	F
34	Umbai	VI, SW, AG	F
35	Merlimau	VI, SW, AG	F
36	Muar	UR, SW, AG	F
37	Parit Jawa	VI, AG	F
38	Sarang Buaya	VI, SW, AG	F
39	Batu Pahat	UR, SW, AG	F
40	Senggarang	VI, AG	F
41	Rengit	VI, SW, AG	F
42	Benut	VI, SW, AG	F
43	Pontian Kecil	VI, SW, AG	F
44	Sedili Besar	VI, SW	F
45	Mersing	UR, SW, AG	F, C
46	Endau	VI, SW, AG	F
47	Pontian	VI, SW, AG	F
48	Rompin	VI, SW, AG	F
49	Merchong	VI, SW	F
50	Nenasi	VI, SW	F

Note: *1 UR: Urban Area VI: Village AG: Agriculture FO: Forest
SW: Swampy Area UN: Unused Land
*2 F: Fishing Boat Only F,C: Fishing and Commercial Boat

Table 4.1-2(2/2) CLASSIFICATION OF 100 RIVER MOUTHS BASED ON SOCIOECONOMIC CONDITION

Serial	Name	Land Use Condition *1	Navigation Condition *2
51	Pahang	UR, SW, AG	F
52	Terus	VI, SW	F
53	Kuantan	UR, SW	F, C
54	Beserah	VI	F
55	Kemaman	UR, SW	F, C
56	Kemasik	VI, SW	F
57	Kerteh	VI, SW	F, C
58	Paka	VI, SW	F
59	Dungun	UR, SW, AG	F, C
60	Mercang	VI	F
61	Marang	VI	F
62	Terengganu	UR, AG	F, C
63	Merang	VI, FO	F
64	Keluang	VI, SW, FO	F
65	Gali	VI, FO	F
66	Pak Amat	VI, AG	F
67	Kelantan	UR, FO, AG	F, C
68	Rulah	VI, AG	F
69	Semantan	VI, SW	F
70	Kayan	VI, SW	F
71	Sempadi	VI, SW	F
72	Rambungun	VI, SW	F
73	Sibu Laut	VI, SW	F
74	Salak	VI, SW	F
75	Santubong	VI, SW	F
76	Buntal	VI, SW	F
77	Bako	VI, SW	F
78	Sadong	VI, SW	F
79	Kabong	VI, SW	F, C
80	Oya	VI, SW	F
81	Mukah	VI, SW	F
82	Balingian	VI, FO	F
83	Serupadi	VI, FO, AG	F
84	Tatau	VI, FO, AG	F
85	Suai	VI	F
86	Niah	VI, SW, AG	F
87	Sibuti	VI, FO, AG	F
88	Lawas	VI, SW, FO	F
89	Padas	VI, SW	F
90	Papar	VI, SW	F
91	Inanam	VI, UN	F
92	Tuaran	VI, SW, UN	F
93	Bandau	VI, SW	F
94	Bongan	SW	F
95	Sugut	SW	F
96	Segama	SW	F, C
97	Kalumpang	SW	F
98	Tawau	UR	F
99	Umas-umas	SW	F, C
100	Kalabakan	SW	F, C

Note: *1 UR: Urban Area VI: Village AG: Agriculture FO: Forest
SW: Swampy Area UN: Unused Land
*2 F: Fishing Boat Only F,C: Fishing and Commercial Boat

Table 4.2-1 DRAFT OF BOAT BY SIZE

Size of Boat	Displacement Tonnage (ton)	Draft (m)
Small	less than 10	1.0
Medium	10 - 25	1.5
	25 - 40	1.9
Large	40 - 70	2.5
	more than 70	3.0 or more

Source: DID

Table 4.2-2 CRITERIA TO JUDGE SERIOUSNESS OF NAVIGATION

Seriousness of Navigation	Size of Major Boat	River Mouth Depth
Very Serious	Large	less than 3.0m
	Medium	less than 2.0m
	Small	less than 1.0m
Serious	Large	3.0m - 4.0m
	Medium	2.0m - 3.0m
	Small	1.0m - 2.0m
Fair	Large	more than 4.0m
	Medium	more than 3.0m
	Small	more than 2.0m

Table 4.2-3(1/2) PHYSICAL CONDITION AT RIVER MOUTHS

Serial	Name	River Width at River Mouth (m)	Observed Water Depth (m)	Expected Minimum Depth (m)	Size of Boat *1	Physical Condition *2
1	Perlis	513	1.8	0.6	L	VS
2	Baru	100	0.3	0.2	L	VS
3	Sanglang	120	1.0	0.8	L	VS
4	Jerlun	130	1.4	1.1	M	VS
5	Kedah	1,220	2.3	1.8	L	VS
6	Yan	13	0.4	0.1	M	VS
7	Melaka	70	0.0	0.0	M	VS
8	Cenang	23	0.0	0.0	M	VS
9	Muda	200	3.2	1.0	M	VS
10	Perai	210	2.9	2.3	M	SE
11	Kerian	780	2.2	1.8	L	VS
12	Pinang	52	0.0	0.0	M	VS
13	Bayan Lepas	30	0.0	0.3	L	VS
14	Tg. Piandang	300	0.2	0.2	M	VS
15	Gula	379	1.4	1.1	M	VS
16	Sangga	915	2.0	1.6	M	VS
17	Larut	120	1.5	1.2	L	VS
18	Terong	265	3.6	2.9	M	SE
19	Beruas	140	1.1	0.9	L	VS
20	Batu	5	0.1	0.1	S	VS
21	Dinding	1,105	12.3	3.9	M	FA
22	Lekir	70	0.0	0.0	M	VS
23	Selangor	483	1.5	1.2	M	VS
24	Kapar Besar	571	0.0	0.0	M	VS
25	Langat	473	2.7	2.2	M	SE
26	Sepan Kecil	162	2.3	1.8	S	SE
27	Sepang	141	8.0	2.6	M	SE
28	Lukut	30	0.0	0.0	M	VS
29	Raya	10	0.6	0.5	M	VS
30	Linggi	320	0.0	0.0	M	VS
31	Baru	115	0.1	0.0	M	VS
32	Melaka	85	1.5	1.2	L	VS
33	Duyong	45	0.7	0.6	M	VS
34	Umbai	25	0.6	0.5	M	VS
35	Merlimau	10	0.5	0.4	M	VS
36	Muar	1,780	2.6	2.1	M	SE
37	Parit Jawa	100	0.6	0.5	M	VS
38	Sarang Buaya	150	1.4	1.1	M	VS
39	Batu Pahat	2,120	1.3	1.0	M	VS
40	Senggarang	70	0.7	0.6	M	VS
41	Rengit	120	0.6	0.5	M	VS
42	Benut	300	1.0	0.8	M	VS
43	Pontian Kecil	120	1.2	1.0	M	VS
44	Sedili Besar	210	5.5	1.8	M	VS
45	Mersing	122	2.5	0.8	L	VS
46	Endau	850	4.2	1.3	L	VS
47	Pontian	255	2.8	0.9	M	VS
48	Rompin	607	5.4	1.7	L	VS
49	Merchong	115	2.3	0.7	M	VS
50	Nenasi	45	5.2	1.7	L	VS

Note: *1 L: Large Size Boat with displacement tonnage of more than 40 and with inboard en
M: Medium Size Boat with displacement tonnage of less than 40 and with inboard e
S: Small Size Boat; boats with outboard engines.
*2 VS: Very Serious SE: Serious FA: Fair

Table 4.2-3(2/2) PHYSICAL CONDITION AT RIVER MOUTHS

Serial	Name	River Width at River Mouth (m)	Observed Water Depth (m)	Expected Minimum Depth (m)	Size of Boat *1	Physical Condition *2
51	Pahang	415	5.7	1.8	L	VS
52	Terus	570	1.1	0.4	S	VS
53	Kuantan	284	8.0	2.6	L	VS
54	Beserah	4	0.0	0.0	M	VS
55	Kemaman	575	9.6	1.9	L	VS
56	Kemasik	15	0.1	0.0	M	VS
57	Kerteh	54	1.7	0.5	M	VS
58	Paka	161	4.9	1.6	M	VS
59	Dungun	428	4.1	1.3	L	VS
60	Mercang	46	0.6	0.2	M	VS
61	Marang	244	1.6	0.5	M	VS
62	Terengganu	141	10.2	3.3	L	SE
63	Merang	440	0.7	0.2	M	VS
64	Keluang	146	2.0	0.6	S	VS
65	Gali	86	1.2	0.4	S	VS
66	Pak Amat	113	0.4	0.1	L	VS
67	Kelantan	367	5.2	1.7	L	VS
68	Rulah	468	1.2	0.4	M	VS
69	Sematan	633	4.6	1.5	M	VS
70	Kayan	1,650	5.3	1.7	M	VS
71	Sempadi	730	1.6	0.5	M	VS
72	Rambungun	676	10.9	3.5	S	FA
73	Sibu Laut	1,209	16.2	5.2	S	FA
74	Salak	1,362	6.0	1.9	S	FA
75	Santubong	869	6.5	2.1	S	SE
76	Buntal	556	0.7	0.6	L	VS
77	Bako	1,834	1.5	1.2	S	SE
78	Sadong	4,500	4.4	1.4	M	VS
79	Kabong	919	10.4	3.3	M	FA
80	Oya	1,399	3.6	1.2	M	VS
81	Mukah	272	3.7	1.2	M	VS
82	Balingian	780	2.9	0.9	M	VS
83	Serupadi	59	2.5	0.8	S	VS
84	Tatau	334	3.7	1.2	L	VS
85	Suai	135	4.7	1.5	S	SE
86	Niah	305	3.2	1.0	M	VS
87	Sibuti	112	4.9	1.6	L	VS
88	Lawas	541	3.2	1.0	M	VS
89	Padas	190	2.4	0.8	M	VS
90	Papar	100	2.0	0.6	M	VS
91	Inanam	360	1.1	0.4	M	VS
92	Tuaran	470	1.7	0.5	M	VS
93	Bandau	1,020	3.9	3.1	M	FA
94	Bongan	200	0.6	0.5	M	VS
95	Sugut	130	3.2	2.6	M	SE
96	Segama	1,170	5.6	4.5	M	FA
97	Kalumpang	390	8.0	6.4	M	FA
98	Tawau	30	0.0	0.0	M	VS
99	Umas-umas	450	6.3	2.5	L	VS
100	Kalabakan	900	5.4	2.2	M	SE

Note: *1 L: Large Size Boat with displacement tonnage of more than 40 and with inboard en
M: Medium Size Boat with displacement tonnage of less than 40 and with inboard e
S: Small Size Boat; boats with outboard engines.
*2 VS: Very Serious SE: Serious FA: Fair

Table 4.2-4 COMBINATION OF SERIOUSNESS IN EACH ASPECT FOR CATEGORIZATION

Category	Combination	Physical Aspect	Economic Aspect	Social Aspect
Category 1 (Critical)	Combination-1	Very Serious	Very Serious	Any
	Combination-2	Very Serious	Serious	Very Serious
	Combination-3	Serious	Very Serious	Very Serious or Serious
Category 2* (Significant)	Combination-1	Very Serous or Serious	Very Serous or Serious	Any
	Combination-2	Very Serious	Fair	Very Serious or Serious
	Combinaiton-3	Fair	Very Serious or Serious	Very Serious or Serious
Category 3 (Acceptable)		The Other River Mouth		

Note: * Combination is applied to river mouths excluding those in Category 1.

Table 4.2-5(1/2) CATEGORIZATION OF RIVER MOUTH

Serial	Name	Record of Dredging	Physical Aspect *1	Economic Aspect *1	Social Aspect *1	Compehensive Evaluation (Category) *2
1	Perlis	yes	VS	VS	SE	1
2	Baru	-	VS	VS	VS	1
3	Sanglang	-	VS	VS	FA	1
4	Jerlun	-	VS	VS	FA	1
5	Kedah	yes	VS	VS	SE	1
6	Yan	-	VS	VS	VS	1
7	Melaka	-	VS	FA	FA	3
8	Cenang	-	VS	SE	VS	1
9	Muda	yes	VS	SE	VS	1
10	Perai	-	SE	FA	FA	3
11	Kerian	-	VS	VS	VS	1
12	Pinang	-	VS	VS	VS	1
13	Bayan Lepas	-	VS	FA	SE	2
14	Tg. Piandang	-	VS	VS	VS	1
15	Gula	-	VS	VS	SE	1
16	Sangga	-	VS	SE	SE	2
17	Larut	-	VS	SE	SE	2
18	Terong	-	SE	SE	FA	2
19	Beruas	yes	VS	VS	VS	1
20	Batu	-	VS	FA	VS	2
21	Dinding	yes	FA	SE	FA	3
22	Lekir	-	VS	SE	FA	2
23	Selangor	-	VS	VS	VS	1
24	Kapar Besar	-	VS	SE	FA	2
25	Langat	-	SE	SE	VS	2
26	Sepan Kecil	-	SE	FA	VS	2
27	Sepang	-	SE	SE	FA	2
28	Lukut	-	VS	SE	SE	2
29	Raya	-	VS	FA	FA	3
30	Linggi	-	VS	FA	FA	3
31	Baru	-	VS	SE	VS	1
32	Melaka	-	VS	VS	VS	1
33	Duyong	-	VS	SE	SE	2
34	Umbai	-	VS	SE	SE	2
35	Merlimau	-	VS	SE	SE	2
36	Muar	-	SE	VS	FA	2
37	Parit Jawa	-	VS	SE	FA	2
38	Sarang Buaya	-	VS	SE	FA	2
39	Batu Pahat	-	VS	SE	FA	2
40	Senggarang	-	VS	SE	SE	2
41	Rengit	-	VS	SE	SE	2
42	Benut	-	VS	SE	FA	2
43	Pontian Kecil	-	VS	VS	SE	1
44	Sedili Besar	-	VS	VS	FA	1
45	Mersing	yes	VS	VS	SE	1
46	Endau	-	VS	VS	FA	1
47	Pontian	-	VS	FA	FA	3
48	Rompin	-	VS	VS	FA	1
49	Merchong	-	VS	FA	FA	3
50	Nenasi	-	VS	VS	FA	1

Note: *1 VS: Very Serious SE: Serious FA: Fair
*2 1: Critical 2: Significant 3: Acceptable

Table 4.2-5(2/2) CATEGORIZATION OF RIVER MOUTH

Serial	Name	Record of Dredging	Physical Aspect *1	Economic Aspect *1	Social Aspect *1	Compehensive Evaluation (Category) *2
51	Pahang	-	VS	VS	FA	1
52	Terus	-	VS	SE	FA	2
53	Kuantan	-	VS	VS	VS	1
54	Beserah	-	VS	FA	FA	3
55	Kemaman	-	VS	VS	FA	1
56	Kemasik	-	VS	SE	SE	2
57	Kerteh	yes	VS	SE	SE	2
58	Paka	-	VS	VS	FA	1
59	Dungun	yes	VS	VS	FA	1
60	Mercang	yes	VS	FA	SE	2
61	Marang	yes	VS	VS	VS	1
62	Terengganu	yes	SE	VS	SE	1
63	Merang	yes	VS	SE	FA	2
64	Keluang	-	VS	FA	FA	3
65	Gali	-	VS	FA	FA	3
66	Pak Amat	yes	VS	FA	VS	2
67	Kelantan	yes	VS	VS	FA	1
68	Rulah	-	VS	FA	FA	3
69	Sematan	-	VS	SE	FA	2
70	Kayan	-	VS	SE	FA	2
71	Sempadi	-	VS	FA	FA	3
72	Rambungun	-	FA	FA	FA	3
73	Sibu Laut	-	FA	FA	FA	3
74	Salak	-	FA	SE	FA	3
75	Santubong	-	SE	FA	FA	3
76	Buntal	-	VS	SE	FA	2
77	Bako	-	SE	SE	FA	2
78	Sadong	-	VS	VS	FA	1
79	Kabong	-	FA	VS	FA	3
80	Oya	-	VS	VS	FA	1
81	Mukah	-	VS	VS	FA	1
82	Balingian	-	VS	SE	FA	2
83	Serupadi	-	VS	FA	FA	3
84	Tatau	-	VS	SE	FA	2
85	Suai	-	SE	FA	FA	3
86	Niah	-	VS	FA	FA	3
87	Sibuti	-	VS	SE	FA	2
88	Lawas	-	VS	SE	FA	2
89	Padas	-	VS	VS	FA	1
90	Papar	-	VS	FA	SE	2
91	Inanam	-	VS	FA	FA	3
92	Tuaran	-	VS	SE	FA	2
93	Bandau	-	FA	SE	FA	3
94	Bongan	-	VS	FA	FA	3
95	Sugut	-	SE	VS	FA	2
96	Segama	-	FA	FA	FA	3
97	Kalumpang	-	FA	SE	FA	3
98	Tawau	-	VS	VS	FA	1
99	Umas-umas	-	VS	SE	FA	2
100	Kalabakan	-	SE	SE	FA	2

Note: *1 VS: Very Serious SE: Serious FA: Fair
*2 1: Critical 2: Significant 3: Acceptable

Table 4.2-6(1/3) LIST OF RIVER MOUTHS BY CATEGORY
(Category-1 : Critical)

Serial	Name	Physical Condition *2	Economic Condition *2	Social Condition *2
1	Perlis*1	VS	VS	SE
2	Baru	VS	VS	VS
3	Sanglang	VS	VS	FA
4	Jerlun	VS	VS	FA
5	Kedah*1	VS	VS	SE
6	Yan	VS	VS	VS
8	Cenang	VS	SE	VS
9	Muda*1	VS	SE	VS
11	Kerian	VS	VS	VS
12	Pinang	VS	VS	VS
14	Tg. Piandang	VS	VS	VS
15	Gula	VS	VS	SE
19	Beruas*1	VS	VS	VS
23	Selangor	VS	VS	VS
31	Baru	VS	SE	VS
32	Melaka	VS	VS	VS
43	Pontian Kecil	VS	VS	SE
44	Sedili Be.	VS	VS	FA
45	Mersing*1	VS	VS	SE
46	Endau	VS	VS	FA
48	Rompin	VS	VS	FA
50	Nenasi	VS	VS	FA
51	Pahang	VS	VS	FA
53	Kuantan	VS	VS	SE
55	Kemaman	VS	VS	FA
58	Paka	VS	VS	FA
59	Dungun*	VS	VS	FA
61	Marang*1	VS	VS	VS
62	Terengganu*1	SE	VS	SE
67	Kelantan*1	VS	VS	FA
78	Sadong	VS	VS	FA
80	Oya	VS	VS	FA
81	Mukah	VS	VS	FA
89	Padas	VS	VS	FA
98	Tawau	VS	VS	FA

Note: *1 Dredging has been conducted
*2 VS: Very Serious SE: Serious FA: Fair

Table 4.2-6(2/3) LIST OF RIVER MOUTHS BY CATEGORY
(Category-2 : Significant)

Serial	Name	Physical Condition *2	Economic Condition *2	Social Condition *2
13	Bayan Lepas	VS	FA	SE
16	Sangga	VS	SE	SE
17	Larut	VS	SE	SE
18	Terong	SE	SE	FA
20	Batu	VS	FA	VS
22	Lekir	VS	SE	FA
24	Kapar Besar	VS	SE	FA
25	Langkat	SE	SE	VS
26	Sepan Ke.	SE	FA	VS
27	Sepang	SE	SE	FA
28	Lukut	VS	SE	SE
33	Duyong	VS	SE	SE
34	Umbai	VS	SE	SE
35	Merlimau	VS	SE	SE
36	Muar	SE	VS	FA
37	Parit Jawa	VS	SE	FA
38	Sarang Buaya	VS	SE	FA
39	Batu Pahat	VS	SE	FA
40	Senggarang	VS	SE	SE
41	Rengit	VS	SE	SE
42	Benut	VS	SE	FA
52	Terus	VS	SE	FA
56	Kemasik	VS	SE	SE
57	Kerteh	VS	SE	SE
60	Mercang	VS	FA	SE
63	Merang	VS	SE	FA
66	Pak Amat	VS	FA	VS
69	Sematan	VS	SE	FA
70	Kayan	VS	SE	FA
76	Buntal	VS	SE	FA
77	Bako	SE	SE	FA
82	Balingian	VS	SE	FA
84	Tatau	VS	SE	FA
87	Sibuti	VS	SE	FA
88	Lawas	VS	SE	FA
90	Papar	VS	FA	SE
92	Tuaran	VS	SE	FA
95	Sugut	SE	VS	FA
99	Umas-umas	VS	SE	FA
100	Kalabakan	SE	SE	FA

Note: *1 Dredging has been conducted
*2 VS: Very Serious SE: Serious FA: Fair

Table 4.2-6(3/3) LIST OF RIVER MOUTHS BY CATEGORY
(Category-3 : Acceptable)

Serial	Name	Physical Condition *2	Economic Condition *2	Social Condition *2
7	Melaka	VS	FA	FA
10	Perai	SE	FA	FA
21	Dingding*1	FA	SE	FA
29	Raya	VS	FA	FA
30	Linggi	VS	FA	FA
47	Pontian	VS	FA	FA
49	Merchong	VS	FA	FA
54	Beserah	VS	FA	FA
64	Keluang	VS	FA	FA
65	Gali	VS	FA	FA
68	Rulah	VS	FA	FA
71	Sempadi	VS	FA	FA
72	Rambungun	FA	FA	FA
73	Sibu Laut	FA	FA	FA
74	Salak	FA	SE	FA
75	Santubong	SE	FA	FA
79	Kabong	FA	VS	FA
83	Serupadi	VS	FA	FA
85	Suai	SE	FA	FA
86	Niah	VS	FA	FA
91	Inanam	VS	FA	FA
93	Bandau	FA	SE	FA
94	Bongan	VS	FA	FA
96	Segama	FA	FA	FA
97	Kalumpang	FA	SE	FA

Note: *1 Dredging has been conducted
*2 VS: Very Serious SE: Serious FA: Fair

Table 5.2-1 DESIGN BOAT SIZE FOR OBJECTIVE RIVER MOUTHS OF THE MASTER PLAN

No.	River Mouth No.	Name		Design Boat Size (GRT)
1	1	Perlis	*	150
2	2	Baru		40
3	3	Sanglang		40
4	4	Jerlun		40
5	5	Kedah	*	150
6	6	Yan		40
7	8	Cenang		40
8	9	Muda		40
9	11	Kerian		40
10	12	Pinang		40
11	13	Bayan Lepas		40
12	14	Tg. Piandang	*	40
13	15	Gula		70
14	16	Sangga		40
15	17	Larut		40
16	18	Terong		40
17	19	Beruas	*	100
18	20	Batu		40
19	22	Lekir		40
20	23	Selangor		40
21	24	Kapar Besar		40
22	25	Langat		40
23	26	Sepan Kecil		40
24	27	Sepang		40
25	28	Lukut		40
26	31	Baru		40
27	32	Melaka		40
28	33	Duyong		40
29	34	Umbai		40
30	35	Merlimau		40
31	36	Muar		40
32	37	Parit Jawa		40
33	38	Sarang Buaya		40
34	39	Batu Pahat		40
35	40	Senggarang		40
36	41	Rengit		40
37	42	Benut		40
38	43	Pontian Kecil		40
39	44	Sedili Besar		150
40	45	Mersing		150
41	46	Endau		200
42	48	Rompin		70
43	50	Nenasi		70
44	51	Pahang		70
45	52	Terus		40
46	53	Kuantan	*	200
47	55	Kemaman		100
48	56	Kemasik		40
49	57	Kerteh	*	40
50	58	Paka		40
51	59	Dungun		100
52	60	Mercang		40
53	61	Marang	*	40
54	62	Terengganu	*	150
55	63	Merang		40
56	66	Pak Amat		40
57	67	Kelantan		100
58	69	Sematan		40
59	70	Kayan		40
60	76	Buntal		40
61	77	Bako		40
62	78	Sadong		40
63	80	Oya	*	40
64	81	Mukah		70
65	82	Balingian		40
66	84	Tatau		40
67	87	Sibuti		40
68	88	Lawas		40
69	89	Padas		40
70	90	Papar	*	40
71	92	Tuaran		40
72	95	Sugut		40
73	98	Tawau		40
74	99	Umas-umas		40
75	100	Kalabakan		40

Note * : Representative river mouths.

Table 6.1-1(1/2) GROUPING OF RIVER MOUTHS FOR THE MASTER PLAN

No.	Geo -morphology	Wave	Tidal Prism	River Mouth			
				Numbers	Serial	Name	State
1	Straight	High/Straight	Large	6	45	Mersing	Johor
					48	Rompin	Pahang
					61	Marang	Terengganu
					81	Mukah	Sarawak
					82	Balingian	Sarawak
					84	Tatau	Sarawak
2	Straight	High/Oblique	Large	10	44	Sedili Besar	Johor
					46	Endau	Johor
					50	Nenasi	Pahang
					52	Terus	Pahang
					53	Kuantan	Pahang
					55	Kemaman	Terengganu
					58	Paka	Terengganu
					59	Dungun	Terengganu
					60	Mercang	Terengganu
					92	Tuaran	Sabah
3	Straight	High/Oblique	Small	3	56	Kemasik	Terengganu
					57	Kerteh	Terengganu
					87	Sibuti	Sarawak
4	Straight	Low	Large	4	1	Perlis	Perlis
					21	Dinding	Perak
					25	Langat	Selangor
					99	Umas-Umas	Sabah
5	Straight	Low	Small	26	2	Baru	Perlis
					3	Sanglang	Kedah
					4	Jerlun	Kedah
					6	Yan	Kedah
					7	Melaka	Kedah
					8	Cenang	Kedah
					12	Pinang	P. Pinang
					13	Bayan Lepas	P. Pinang
					14	Tg. Piandang	Perak
					20	Batu	Perak
					22	Lekir	Perak
					24	Kapar Besar	Selangor
					26	Sepang Kecil	Selangor
					27	Sepang	Selangor
					28	Lukut	N. Sembilian
					31	Baru	Melaka
					32	Melaka	Melaka
					33	Duyong	Melaka
					34	Umbai	Melaka
					35	Merlimau	Melaka
					37	Parit Jawa	Johor
					40	Senggarang	Johor
					41	Rengit	Johor
					42	Benut	Johor
					43	Pontian Kecil	Johor
					98	Tawau	Sabah

Table 6.1-1(2/2) GROUPING OF RIVER MOUTHS FOR THE MASTER PLAN

No.	Geo -morphology	Wave	Tidal Prism	River Mouth Numbers	Serial	Name	State
6	Estuary	High/Oblique	Large	3	69	Sematan	Sarawak
					70	Kayan	Sarawak
					80	Oya	Sarawak
7	Estuary	Low	Large	14	11	Kerian	P. Pinang
					15	Gula	Perak
					16	Sangga	Perak
					17	Larut	Perak
					18	Terong	Perak
					19	Beruas	Perak
					23	Selangor	Selangor
					36	Muar	Johor
					39	Batu Pahat	Johor
					76	Buntal	Sarawak
					77	Bako	Sarawak
					78	Sadong	Sarawak
					89	Padas	Sabah
					100	Kalabakan	Sabah
8	Protruding	High/Straight	Large	4	51	Pahang	Pahang
					62	Terengganu	Terengganu
					67	Kelantan	Kelantan
					95	Sugut	Sabah
9	Protruding	High/Oblique	Small	3	63	Merang	Terengganu
					66	Pak Amat	Kelantan
					90	Papar	Sabah
10	Protruding	Low	Large	3	5	Kedah	Kedah
					9	Muda	P. Pinang
					88	Lawas	Sarawak
			Total	76			

Table 6.1-2(1/2) AVAILABILITY OF PRINCIPAL DATA BY RIVER MOUTH

Serial	Name	State	Detailed Topo-map	Available Nos. of Aerophoto	Bathym. Survey Results	LEO Prog. Applica-bility	Discharge (Q) and Sediment(S)	River Survey	Bed Material Data	No. of Avail. Data
1	Perlis	Perlis	-	4	'92	R01	Q / S	-	-	4
2	Baru	Perlis	-	4	-	-	-	-	-	1
3	Sanglang	Kedah	-	4	-	-	-	-	-	1
4	Jerlun	Kedah	-	4	-	-	-	-	-	1
5	Kedah	Kedah	-	4	'90-91	K01	-	-	-	3
6	Yan	Kedah	-	3	-	-	-	-	-	1
7	Melaka	Kedah	-	3	-	-	-	-	-	1
8	Cenang	Kedah	-	3	-	-	-	-	-	1
9	Muda	P.Pinang	-	4	-	-	Q / S	-	-	2
10	Perai	P.Pinang	-	4	-	SP1	-	'87-'88	-	3
11	Kerian	P.Pinang	-	4	-	-	Q / S	'88 *1	-	3
12	Pinang	P.Pinang	-	3	-	-	-	-	-	1
13	Bayan Lepas	P.Pinang	-	3	-	-	-	-	-	1
14	Tg. Piandang	Perak	-	4	-	-	-	-	-	1
15	Gula	Perak	-	4	-	-	-	-	-	1
16	Sangga	Perak	-	3	-	-	-	-	-	1
17	Larut	Perak	-	3	-	-	-	-	-	1
18	Terong	Perak	-	2	-	-	-	-	-	1
19	Beraus	Perak	-	3	-	-	-	-	-	1
20	Batu	Perak	-	3	-	-	-	-	-	1
21	Dinding	Perak	-	3	-	-	-	-	-	1
22	Lekir	Perak	-	3	-	-	-	-	-	1
23	Selangor	Selangor	-	4	-	-	Q / S	-	-	2
24	Kapar Besar	Selangor	-	3	-	-	-	-	-	1
25	Langat	Selangor	-	3	-	-	Q / S	-	-	2
26	Sepan Kecil	Selangor	-	3	-	-	-	-	-	1
27	Sepang	Selangor	-	3	-	-	-	-	-	1
28	Lukut	N.Sembilan	-	3	-	-	-	-	-	1
29	Raya	N.Sembilan	-	3	-	-	-	-	-	1
30	Linggi	N.Sembilan	-	3	-	-	Q	-	-	2
31	Baru	Melaka	-	3	-	-	-	-	-	1
32	Melaka	Melaka	-	3	-	M01	Q / S	-	-	3
33	Duyong	Melaka	-	3	-	-	-	-	-	1
34	Umbai	Melaka	-	3	-	-	-	-	-	1
35	Merlimau	Melaka	-	3	-	-	-	-	-	1
36	Muar	Johor	-	3	-	-	Q	-	-	2
37	Parit Jawa	Johor	-	3	-	-	-	-	-	1
38	Sarang Buaya	Johor	-	3	-	-	-	-	-	1
39	Batu Pahat	Johor	-	3	-	-	Q / S	-	-	2
40	Senggarang	Johor	-	3	-	-	-	-	-	1
41	Rengit	Johor	-	3	-	J03	-	-	-	2
42	Benut	Johor	-	3	-	-	Q	-	-	2
43	Pontian Kecil	Johor	-	3	-	J02	-	-	-	2
44	Sedili Besar	Johor	-	3	-	-	-	-	-	1
45	Mersing	Johor	-	3	'91	J01	-	-	'84 *2	4
46	Endau	Johor	-	3	-	-	Q	-	-	2
47	Pontian	Pahang	-	3	-	-	-	-	-	1
48	Rompin	Pahang	-	3	-	-	-	-	-	1
49	Merchong	Pahang	-	3	-	-	-	-	-	1
50	Nenasi	Pahang	-	3	'82 *3	-	-	-	-	2

Note: *1 F/S on Flood Mitigation and Agricultural Development Projects in the Kerian River Basin, Dec. 1988
*2 Report on Mission to Malaysia, 26 March to 11 April 1984, ESCAP
*3 Hydrographic Survey for the Approaches to Kuala Bebar, Nenasi, Pekan, Pahang; Bathymetric map 1/2,000, Nov.-Dec., 1982, JPT

Table 6.1-2(2/2) AVAILABILITY OF PRINCIPAL DATA BY RIVER MOUTH

Serial	Name	State	Detailed Topo-map	Available Nos. of Aerophoto	Bathym. Survey Results	LEO Prog. Applica-bility	Discharge (Q) and Sediment(S)	River Survey	Bed Material Data	No. of Avail. Data
51	Pahang	Pahang	-	3	-	-	Q / S	-	-	2
52	Terus	Pahang	-	3	-	-	-	-	-	1
53	Kuantan	Pahang	-	3	'90	-	Q	'90	Yes *4	5
54	Beserah	Pahang	-	3	-	C01	-	-	-	2
55	Kemaman	Terengganu	-	3	'89 *5	-	Q / S	-	-	3
56	Kemasik	Terengganu	1/4000 '86	3	-	-	-	Yes	-	3
57	Kerteh	Terengganu	1/4000 '86	3	-	-	-	Yes	-	3
58	Paka	Terengganu	-	3	-	-	-	-	-	1
59	Dungun	Terengganu	-	3	'88-90	-	Q / S	-	-	3
60	Mercang	Terengganu	-	3	-	-	-	-	-	1
61	Marang	Terengganu	-	3	'89 *5	-	-	-	-	2
62	Terengganu	Terengganu	-	3	'89-90	T01	Q	-	-	4
63	Merang	Terengganu	-	3	-	-	-	-	-	1
64	Keluang	Terengganu	-	3	-	-	-	-	-	1
65	Gali	Kelantan	-	4	Yes	-	-	Yes	-	3
66	Pak Amat	Kelantan	-	4	-	-	-	-	-	1
67	Kelantan	Kelantan	-	4	'89-90	D02	Q / S	Yes	-	5
68	Rulah	Kelantan	-	4	-	D01	-	-	-	2
69	Semantan	Sarawak	-	10	-	-	-	-	-	1
70	Kayan	Sarawak	-	11	-	-	-	-	-	1
71	Sempadi	Sarawak	-	8	-	-	-	-	-	1
72	Rambungun	Sarawak	-	8	-	-	-	-	-	1
73	Sibu Laut	Sarawak	-	8	-	-	-	-	-	1
74	Salak	Sarawak	-	9	-	-	-	-	-	1
75	Santubong	Sarawak	-	10	-	-	-	-	-	1
76	Buntal	Sarawak	-	10	-	-	-	-	-	1
77	Bako	Sarawak	-	6	-	-	-	-	-	1
78	Sadong	Sarawak	-	7	-	-	Q	-	-	2
79	Kabong	Sarawak	-	8	-	-	Q	-	-	2
80	Oya	Sarawak	-	5	-	-	-	-	-	1
81	Mukah	Sarawak	-	8	-	-	-	-	-	1
82	Balingian	Sarawak	-	3	-	-	-	-	-	1
83	Serupadi	Sarawak	-	3	-	-	-	-	-	1
84	Tatau	Sarawak	-	5	-	-	-	-	-	1
85	Suai	Sarawak	-	6	-	-	-	-	-	1
86	Niah	Sarawak	-	5	-	-	-	-	-	1
87	Sibuti	Sarawak	-	5	-	-	-	-	-	1
88	Lawas	Sabah	-	8	-	-	-	-	-	1
89	Padas	Sabah	-	2	-	-	Q	-	-	2
90	Papar	Sabah	-	2	-	-	Q	-	-	2
91	Inanam	Sabah	-	2	-	-	-	-	-	1
92	Tuaran	Sabah	-	2	-	-	Q	-	-	2
93	Bandau	Sabah	-	2	-	-	-	-	-	1
94	Bongan	Sabah	-	2	-	-	-	-	-	1
95	Sugut	Sabah	-	2	-	-	Q	-	-	2
96	Segama	Sabah	-	2	-	-	Q	-	-	2
97	Kalumpang	Sabah	-	2	-	-	-	-	-	1
98	Tawau	Sabah	-	2	-	-	-	-	-	1
99	Umas-umas	Sabah	-	2	-	-	-	-	-	1
100	Kalabakan	Sabah	-	2	-	-	-	-	-	1

Note: *4 Proposal for Maintenance Dredging of Fishing Ports and River Mouths in Peninsular Malaysia
*5 Hydrographic Survey and Data Collection Work at Kuala Kemaman and Kuala Marang, Terengganu; Bathymetric map, Feb. 1989, JPT

Table 6.1-3(1/2) SELECTION OF REPRESENTATIVE RIVER MOUTHS

Group and Definition				River Mouth						
No.	Geomor-phology	Wave	Tidal Prism	Serial	Name	State	Cate-gory	High Priority *1	Avail. Data *2	Representative *3
1	Straight	High /Straight	Large	45	Mersing	Johor	1	*	4	
				48	Rompin	Pahang	2		1	
				61	Marang	Terengganu	1	*	2	Representative
				81	Mukah	Sarawak	2		1	
				82	Balingian	Sarawak	2		1	
				84	Tatau	Sarawak	2		1	
2	Straight	High /Oblique	Large	44	Sedili Besar	Johor	2		1	
				46	Endau	Johor	2		2	
				50	Nenasi	Pahang	2		2	
				52	Terus	Pahang	2		1	
				53	Kuantan	Pahang	1	*	5	Representative
				55	Kemaman	Terengganu	2		3	
				58	Paka	Terengganu	2		1	
				59	Dungun	Terengganu	1		3	
				60	Mercang	Terengganu	1		1	
				92	Tuaran	Sabah	2		2	
3	Straight	High /Oblique	Small	56	Kemasik	Terengganu	2		3	
				57	Kerteh	Terengganu	1		3	Representative
				87	Sibuti	Sarawak	2		1	
4	Straight	Low	Large	1	Perlis	Perlis	1	*	4	Representative
				21	Dinding	Perak	1		1	
				25	Langat	Selangor	1		2	
				99	Umas-Umas	Sabah	2		1	
5	Straight	Low	Small	2	Baru	Perlis	1	*	1	
				3	Sanglang	Kedah	2		1	
				4	Jerlun	Kedah	2		1	
				6	Yan	Kedah	1		1	
				7	Melaka	Kedah	2		1	
				8	Cenang	Kedah	1		1	
				12	Pinang	P. Pinang	1		1	
				13	Bayan Lepas	P. Pinang	2		1	
				14	Tg. Piandang	Perak	1		1	Representative
				20	Batu	Perak	1		1	
				22	Lekir	Perak	2		1	
				24	Kapar Besar	Selangor	2		1	
				26	Sepang Kecil	Selangor	1		1	
				27	Sepang	Selangor	2		1	
				28	Lukut	N. Sembilian	2		1	
				31	Baru	Melaka	1		1	
				32	Melaka	Melaka	1	*	3	
				33	Duyong	Melaka	2		1	
				34	Umbai	Melaka	2		1	
				35	Merlimau	Melaka	2		1	
				37	Parit Jawa	Johor	2		1	
				40	Senggarang	Johor	2		1	
				41	Rengit	Johor	2		2	
				42	Benut	Johor	2		2	
				43	Pontian Kecil	Johor	1		2	
				98	Tawau	Sabah	2		1	

Note: *1 The river mouth with "*" mark is given high priority in the State.
*2 Number of available data (see Table 6.1-2).
*3 The representative river mouth has been selected on the basis of the contents of Category, Priority and Available Data as presented in the left columns, as well as considering the physical representativeness of the river mouth in the group.

Table 6.1-3(2/2) SELECTION OF REPRESENTATIVE RIVER MOUTHS

Group and Definition				River Mouth						
No.	Geomor-phology	Wave	Tidal Prism	Serial	Name	State	Cate-gory	High Priority *1	Avail. Data *2	Representative *3
6	Estuary	High /Oblique	Large	69	Sematan	Sarawak	2		1	
				70	Kayan	Sarawak	2		1	
				80	Oya	Sarawak	2		1	Representative
7	Estuary	Low	Large	11	Kerian	P. Pinang	1		3	
				15	Gula	Perak	1		1	
				16	Sangga	Perak	2		1	
				17	Larut	Perak	2		1	
				18	Terong	Perak	2		1	
				19	Beruas	Perak	1	*	1	Representative
				23	Selangor	Selangor	1	*	2	
				36	Muar	Johor	2		2	
				39	Batu Pahat	Johor	2		2	
				76	Buntal	Sarawak	2		1	
				77	Bako	Sarawak	2		1	
				78	Sadong	Sarawak	2		2	
				89	Padas	Sabah	2		2	
				100	Kalabakan	Sabah	2		1	
8	Protrudg.	High /Straight	Large	51	Pahang	Pahang	2		2	
				62	Terengganu	Terengganu	1	*	4	Representative
				67	Kelantan	Kelantan	1	*	5	
				95	Sugut	Sabah	2		2	
9	Protrudg.	High /Oblique	Small	63	Merang	Terengganu	1		1	
				66	Pak Amat	Kelantan	1		1	
				90	Papar	Sabah	2		2	Representative
10	Protrudg.	Low	Large	5	Kedah	Kedah	1	*	3	Representative
				9	Muda	P. Pinang	1	*	2	
				88	Lawas	Sarawak	2		1	

Note: *1 The river mouth with "*" mark is given high priority in the State.
*2 Number of available data (see Table 6.1-2).
*3 The representative river mouth has been selected on the basis of the contents of Category, Priority and Available Data as presented in the left columns, as well as considering the physical representativeness of the river mouth in the group.

Table 6.2-1 OBSERVED MONTHLY MEAN DISCHARGE AND SUSPENDED LOAD

Serial	River Mouth	Catchment Area (km2)	Station No.	Station Name	River	Catchment Area (km2)	Upper : Monthly Mean Discharge (m3/s) Lower : Monthly Mean Suspended Load (ton/day)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual	
1	Perlis	600	6502432	Titi Baru	Tasoh	126		0.1	0.1	0.1	1.0	1.1	0.4	1.0	1.4	1.8	2.5	2.0	1.6	1.1	<1
									5.4	1.3	3.5	11.1	1.4	0.4	9.7	5.7	5.3	37.8	8.1	8.2	<1
53	Kuantan	1,710	3930401	Bukit Keneu	Kuantan	582		27.2	11.2	53.3	29.5	28.3	20.1	15.7	15.1	24.2	30.9	33.6	83.1	31.0	<1
								506.9	733.2	1260.5	688	591.2	398.2	296.9	265.8	467.5	706.7	865	1764.6	712	<1
62	Terengganu	4,650	5130432	Kg. Tanggol	Terengganu	3,340		405.4	244.1	151.8	198.9	133.8	170.1	196.2	181.4	214.1	237.7	302.6	579.9	251.3	<2
								8284	1747.3	815.5	873.3	658.1	1162.4	1623.8	1313.3	2749.1	2410	4473.1	22943.9	4087.8	<2
90	Papar	770	5760401	Kagopan	Papar	536		84.6	62.6	52.8	67.4	91.9	77.3	66.4	59.6	80.9	97.7	102.7	78.7	76.9	<1
																				115.1	<3

Data Source : <1 ; Streamflow and River Suspended Sediment Records 1981 - 1985, DID
<2 ; Streamflow and River Suspended Sediment Records 1986 - 1990, DID
<3 ; National Water Resources Study, 1982, JICA

Table 6.3-1 TIDAL LEVELS OF REPRESENTATIVE RIVER MOUTHS

(1) Semi-diurnal Tide

Serial	River Mouth	Tidal Levels (m above LSD)							Tidal Station referred to
		LAT	MLWS	MLWN	MSL	MHWN	MHWS	HAT	
1	Perlis	-1.9	-1.3	-0.3	0.0	0.3	1.3	1.9	Pulau Langkawi,Kedah
5	Kedah	-1.9	-1.3	-0.3	0.0	0.3	1.3	1.9	ditto
14	Tg.Piandang	-1.5	-1.0	-0.1	0.1	0.3	1.0	1.7	Kedah Pier,Penang
19	Beruas	-1.5	-1.0	-0.2	0.2	0.6	1.3	1.9	Lumut,Perak
80	Oya	-1.7	-0.8	-0.1 <1	0.0	0.3 <2	0.6	1.0	Mukah,Sarawak <3

Note;

<1 : MHLW, <2: MLHW

<3: Tidal levels are reduced to LSD by assuming MSL is equal to LSD.

(2) Diurnal Tide

Serial	River Mouth	Tidal Levels (m above LSD)							Tidal Station referred to
		LAT	MLLW	MLW	MSL	MHW	MHHW	HAT	
53	Kuantan	-1.7	-1.1	-0.3	0.3	0.8	1.6	2.2	Tanjung Gelang,Kuantan
57	Kerteh	-1.7	-1.1	-0.3	0.3	0.8	1.6	2.2	ditto
61	Marang	-1.3	-0.8	-0.1	0.3	0.6	1.3	2.0	Chendaring,Terengganu
62	Terengganu	-1.3	-0.8	-0.1	0.3	0.6	1.3	2.0	ditto
90	Papar	-1.2	-0.9	-0.3	0.0	0.2	0.9	1.2	Kota Kinabalu,Sabah

Abbrevations;

LAT : Lowest Astronomical Tide
MLWS: Mean Low Water Springs
MLWN: Mean Low Water Neaps
MHWN: Mean High Water Neaps
MHWS: Mean High Water Springs
HAT : Highest Astronomical Tide
MLLW: Mean Lower Low Water
MLW : Mean Low Water
MHLW: Mean Higher Low Water
MSL : Mean Sea Level
MLHW: Mean Lower High Water
MHW : Mean High Water
MHHW: Mean Higher High Water

Data Source;

1) Tidal Observation Records 1990, DSM
2) Tide Tables 1992, RMN

Table 6.3-2 (1/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (PERLIS)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
180	6.0	194.8	0.901	0.955	0.860	200.9	0.853	0.981	0.837	205.7	0.840	1.024	0.860	210.7	0.836	1.104	0.923	215.2	0.829	1.188	0.985
	8.0	203.0	0.824	1.068	0.880	207.7	0.811	1.112	0.902	211.1	0.807	1.177	0.950	215.0	0.800	1.283	1.026	218.0	0.794	1.370	1.088
	10.0	210.7	0.735	1.198	0.881	214.3	0.736	1.253	0.922	215.7	0.735	1.330	0.978	218.8	0.730	1.462	1.067	221.0	0.727	1.556	1.131
210	6.0	221.7	0.877	0.947	0.831	223.6	0.859	0.973	0.836	225.3	0.854	1.019	0.870	225.4	0.855	1.097	0.938	227.4	0.856	1.175	1.006
	8.0	221.9	0.821	1.070	0.878	222.5	0.800	1.112	0.890	222.2	0.790	1.174	0.927	223.9	0.780	1.282	1.000	225.8	0.774	1.377	1.066
	10.0	221.0	0.797	1.208	0.963	219.3	0.778	1.264	0.983	218.3	0.764	1.348	1.030	220.2	0.753	1.476	1.111	221.8	0.747	1.558	1.164
240	6.0	235.2	0.538	0.994	0.535	236.2	0.525	1.021	0.536	238.0	0.514	1.064	0.547	241.3	0.500	1.148	0.574	243.2	0.489	1.318	0.645
	8.0	235.3	0.772	1.110	0.857	238.1	0.760	1.158	0.880	241.0	0.747	1.227	0.917	241.8	0.736	1.334	0.982	242.2	0.730	1.438	1.050
	10.0	232.5	0.751	1.207	0.906	235.9	0.736	1.266	0.932	238.3	0.725	1.343	0.974	241.8	0.713	1.476	1.052	243.4	0.706	1.577	1.113

Table 6.3-2 (2/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (KEDAH)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
180	6.0	201.5	0.257	0.976	0.251	204.0	0.254	1.005	0.255	206.3	0.251	1.043	0.262	211.9	0.248	1.127	0.279	230.3	0.240	1.292	0.310
	8.0	213.0	0.730	1.102	0.804	214.3	0.730	1.141	0.833	215.9	0.731	1.214	0.887	217.6	0.731	1.313	0.960	226.0	0.728	1.427	1.039
	10.0	213.6	0.717	1.211	0.868	215.9	0.713	1.277	0.911	218.4	0.709	1.351	0.958	222.2	0.704	1.493	1.051	224.1	0.701	1.588	1.113
210	6.0	219.3	1.026	0.954	0.979	219.9	1.027	0.978	1.004	220.8	1.029	1.026	1.056	221.6	1.030	1.099	1.132	0.0	0.000	0.000	0.000
	8.0	225.7	1.145	1.088	1.245	227.7	1.153	1.125	1.296	229.7	1.162	1.197	1.390	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000
	10.0	236.9	0.914	1.212	1.108	239.7	0.909	1.273	1.157	241.1	0.907	1.348	1.223	0.0	0.000	0.000	0.000	0.0	0.000	0.000	0.000
240	6.0	240.9	0.976	0.949	0.926	241.4	0.974	0.971	0.945	242.4	0.972	1.013	0.984	244.2	0.970	1.088	1.055	245.4	0.969	1.148	1.112
	8.0	248.6	0.842	1.061	0.892	248.4	0.838	1.110	0.930	247.5	0.835	1.173	0.979	245.5	0.831	1.279	1.062	243.9	0.829	1.356	1.123
	10.0	246.5	0.828	1.216	1.007	245.7	0.826	1.254	1.036	244.6	0.823	1.332	1.096	243.5	0.820	1.466	1.202	243.5	0.820	1.466	1.202
270	6.0	264.7	0.963	0.947	0.912	264.3	0.964	0.971	0.936	264.0	0.965	1.019	0.983	264.0	0.966	1.089	1.052	264.2	0.967	1.149	1.111
	8.0	258.7	0.851	1.069	0.910	258.9	0.850	1.108	0.942	259.3	0.850	1.180	1.003	260.0	0.851	1.277	1.087	260.6	0.852	1.349	1.149
	10.0	258.9	0.808	1.201	0.970	259.4	0.805	1.269	1.022	260.4	0.804	1.347	1.083	262.6	0.803	1.472	1.182	262.6	0.803	1.472	1.182

Table 6.3-2(3/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (TG.PIANDANG)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
210	6.0	242.0	0.629	0.948	0.596	243.8	0.624	0.968	0.604	247.2	0.616	1.015	0.625	252.0	0.603	1.087	0.655	263.5	0.582	1.261	0.734
	8.0	249.0	0.517	1.032	0.534	250.5	0.514	1.070	0.550	252.5	0.511	1.131	0.578	256.0	0.508	1.233	0.626	262.1	0.505	1.436	0.725
	10.0	250.8	0.705	1.033	0.728	251.5	0.699	1.074	0.751	252.9	0.692	1.132	0.783	254.4	0.680	1.235	0.840	260.8	0.657	1.455	0.956
240	6.0	250.1	0.611	1.033	0.631	249.4	0.607	1.072	0.650	247.8	0.602	1.132	0.681	247.3	0.594	1.234	0.733	241.5	0.581	1.446	0.840
	8.0	254.8	0.756	1.152	0.871	252.6	0.753	1.217	0.916	250.7	0.751	1.297	0.974	250.7	0.751	1.412	1.060	247.4	0.751	1.650	1.239
	10.0	257.1	0.761	1.173	0.893	259.1	0.756	1.218	0.921	261.5	0.749	1.300	0.974	265.0	0.741	1.420	1.052	270.0	0.716	1.669	1.195
270	6.0	265.3	0.759	1.163	0.882	264.0	0.755	1.218	0.919	261.3	0.750	1.299	0.974	258.0	0.746	1.416	1.056	249.6	0.734	1.660	1.217
	8.0	264.3	0.889	0.948	0.843	263.1	0.888	0.965	0.857	263.6	0.888	1.006	0.893	266.6	0.827	1.083	0.896	271.2	0.826	1.262	1.042
	10.0	270.1	0.867	1.033	0.896	267.2	0.865	1.074	0.929	259.8	0.862	1.136	0.979	259.8	0.862	1.136	0.979	259.8	0.797	1.449	1.155
300	6.0	281.3	0.879	1.166	1.025	276.6	0.876	1.223	1.071	277.1	0.873	1.297	1.132	277.9	0.870	1.423	1.238	284.1	0.866	1.662	1.439
	8.0	298.7	0.883	0.950	0.839	294.2	0.880	0.969	0.853	286.7	0.876	1.013	0.887	276.7	0.873	1.082	0.945	261.7	0.867	1.274	1.105
	10.0	303.5	0.850	1.059	0.900	302.2	0.848	1.090	0.924	298.0	0.845	1.154	0.975	290.3	0.842	1.267	1.067	276.0	0.838	1.504	1.260

Table 6.3-2(4/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (BERUAS)

Ocean Wave Characteristics		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
240	6.0	250.0	0.844	0.942	ERR	252.0	0.836	0.971	0.812	254.6	0.830	1.008	0.837	256.8	0.826	1.043	0.862	252.3	0.793	1.250	0.991
	8.0	253.0	0.802	1.029	0.825	254.5	0.795	1.065	0.847	257.4	0.788	1.133	0.893	258.9	0.785	1.168	0.917	260.2	0.773	1.433	1.108
	10.0	253.2	0.837	1.147	0.960	255.0	0.831	1.201	0.998	258.0	0.825	1.282	1.058	259.0	0.700	1.343	0.940	261.3	0.690	1.470	1.014
270	6.0	270.3	0.858	0.943	0.809	234.3	0.853	0.969	0.827	271.0	0.849	1.015	0.862	271.5	0.848	1.038	0.880	272.5	0.830	1.223	1.015
	8.0	268.6	0.803	1.035	0.831	268.9	0.797	1.078	0.859	270.0	0.793	1.138	0.902	270.6	0.792	1.171	0.927	271.0	0.780	1.439	1.122
	10.0	271.3	0.694	1.161	0.806	271.3	0.686	1.222	0.838	272.2	0.681	1.297	0.883	273.0	0.679	1.349	0.916	274.2	0.661	1.500	0.992
300	6.0	274.5	0.817	0.944	0.771	268.6	0.795	0.971	0.772	249.0	0.712	1.011	0.720	251.1	0.628	1.086	0.682	252.0	0.605	1.235	0.747
	8.0	280.8	0.649	1.031	0.669	279.8	0.641	1.076	0.690	279.4	0.638	1.130	0.721	279.7	0.635	1.218	0.773	280.1	0.622	1.399	0.870
	10.0	261.8	0.469	1.163	0.545	258.1	0.453	1.216	0.551	256.7	0.443	1.296	0.574	256.3	0.433	1.417	0.614	256.9	0.420	1.498	0.629

Table 6.3-2(5/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (KUANTAN)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
30	6.0	71.8	0.586	0.969	0.568	79.8	0.544	0.997	0.542	83.0	0.512	1.036	0.530	96.9	0.396	1.118	0.442	107.4	0.338	1.302	0.440
	8.0	73.5	0.533	1.088	0.580	80.7	0.504	1.127	0.568	86.7	0.468	1.193	0.558	98.6	0.409	1.300	0.532	102.3	0.391	1.521	0.595
	10.0	72.9	0.712	1.209	0.861	80.3	0.672	1.255	0.843	86.3	0.619	1.340	0.830	100.1	0.513	1.469	0.754	102.5	0.477	1.730	0.824
60	6.0	77.9	0.702	0.957	0.671	83.7	0.663	0.982	0.651	88.1	0.612	1.024	0.627	100.6	0.558	1.105	0.617	103.4	0.486	1.280	0.622
	8.0	85.0	0.736	1.085	0.798	91.7	0.693	1.134	0.786	96.7	0.624	1.200	0.749	97.3	0.580	1.295	0.751	87.7	0.680	1.507	1.024
	10.0	85.3	0.490	1.210	0.592	92.2	0.461	1.274	0.587	97.2	0.417	1.356	0.565	98.2	0.387	1.470	0.569	84.9	0.280	1.760	0.493
90	6.0	92.1	0.739	0.979	0.723	94.4	0.731	1.001	0.732	98.7	0.692	1.047	0.724	101.2	0.663	1.125	0.747	93.1	0.453	1.328	0.602
	8.0	88.5	0.763	1.106	0.844	93.4	0.759	1.160	0.880	94.8	0.767	1.223	0.938	107.5	0.786	1.321	1.038	112.3	0.806	1.588	1.279
	10.0	81.4	0.707	1.206	0.852	87.1	0.702	1.261	0.885	92.3	0.688	1.350	0.929	97.0	0.627	1.479	0.928	107.5	0.588	1.744	1.026
120	6.0	121.9	0.733	0.956	0.701	123.7	0.732	0.982	0.719	124.5	0.727	1.032	0.751	122.3	0.697	1.105	0.770	108.9	0.662	1.284	0.850
	8.0	122.0	0.476	1.088	0.517	124.0	0.474	1.133	0.537	124.8	0.471	1.209	0.570	122.5	0.446	1.308	0.583	108.8	0.420	1.539	0.646
	10.0	103.6	0.432	1.221	0.528	105.2	0.430	1.273	0.547	107.4	0.427	1.345	0.575	113.5	0.405	1.469	0.594	103.4	0.390	1.727	0.673
150	6.0	123.2	0.494	1.008	0.498	123.4	0.494	1.021	0.504	124.5	0.491	1.076	0.528	123.9	0.438	1.155	0.506	112.3	0.410	1.322	0.542
	8.0	120.1	0.374	1.102	0.412	122.3	0.373	1.149	0.429	123.8	0.371	1.227	0.456	126.4	0.358	1.329	0.476	111.2	0.339	1.574	0.533
	10.0	118.2	0.364	1.187	0.432	120.7	0.364	1.245	0.453	122.4	0.363	1.340	0.486	121.0	0.352	1.469	0.518	121.3	0.343	1.745	0.598

Table 6.3-2(6/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (KERTEH)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
30	6.0	65.8	0.636	0.942	0.599	67.7	0.600	0.962	0.577	71.2	0.532	1.006	0.535	80.1	0.432	1.084	0.468	99.8	0.377	1.242	0.469
	8.0	69.9	0.698	1.010	0.706	73.0	0.641	1.051	0.674	79.6	0.553	1.118	0.618	90.0	0.459	1.211	0.556	114.6	0.352	1.416	0.499
	10.0	76.3	0.600	1.114	0.668	83.9	0.538	1.160	0.624	87.4	0.491	1.244	0.611	92.9	0.419	1.357	0.569	105.9	0.361	1.605	0.580
60	6.0	75.7	0.871	0.948	0.825	76.9	0.846	0.969	0.819	79.0	0.777	1.016	0.790	87.2	0.680	1.086	0.738	99.2	0.476	1.271	0.605
	8.0	79.0	0.836	1.017	0.850	81.1	0.813	1.061	0.863	85.6	0.788	1.121	0.883	92.4	0.741	1.222	0.905	95.7	0.734	1.431	1.051
	10.0	87.1	1.016	1.148	1.166	87.6	1.062	1.206	1.280	93.2	1.105	1.287	1.423	96.8	1.146	1.408	1.614	116.3	1.024	1.651	1.691
90	6.0	94.9	0.944	0.946	0.893	93.9	0.921	0.967	0.890	96.7	0.877	1.009	0.885	103.6	0.831	1.086	0.902	115.3	0.745	1.258	0.938
	8.0	94.7	0.873	1.039	0.907	93.6	0.845	1.072	0.905	96.8	0.796	1.133	0.902	103.9	0.744	1.234	0.918	116.0	0.651	1.450	0.944
	10.0	94.3	0.801	1.175	0.941	93.1	0.774	1.215	0.940	97.3	0.732	1.293	0.946	105.9	0.677	1.432	0.970	116.6	0.595	1.675	0.997
120	6.0	118.7	0.968	0.946	0.916	120.0	0.973	0.973	0.947	119.0	0.998	1.018	1.015	119.0	1.029	1.091	1.123	130.4	1.021	1.271	1.298
	8.0	112.8	0.893	1.044	0.933	115.4	0.900	1.090	0.981	117.1	0.931	1.154	1.075	118.0	0.973	1.260	1.226	117.0	1.053	1.458	1.535
	10.0	109.1	1.031	1.182	1.219	110.6	1.042	1.244	1.297	109.4	1.094	1.326	1.450	114.9	1.134	1.452	1.647	119.2	1.187	1.693	2.009
150	6.0	127.5	0.811	0.957	0.776	128.0	0.810	0.978	0.792	128.5	0.801	1.018	0.815	128.6	0.795	1.096	0.871	128.7	0.766	1.271	0.974
	8.0	123.4	0.900	1.074	0.966	122.9	0.897	1.110	0.996	117.5	0.881	1.178	1.038	120.1	0.865	1.286	1.112	122.4	0.828	1.499	1.240
	10.0	113.8	0.716	1.244	0.891	114.5	0.715	1.274	0.911	107.2	0.724	1.347	0.976	107.5	0.729	1.476	1.077	127.6	0.696	1.758	1.223

Table6.3-2(7/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (MARANG)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
0	6.0	23.3	0.823	0.937	0.771	24.4	0.817	0.968	0.791	23.9	0.817	1.005	0.822	26.2	0.798	1.085	0.866	31.3	0.724	1.249	0.905
	8.0	33.4	0.803	1.047	0.840	33.5	0.797	1.076	0.857	35.8	0.775	1.146	0.888	40.2	0.724	1.244	0.901	41.8	0.820	1.441	1.182
	10.0	34.7	0.805	1.173	0.944	34.7	0.805	1.231	0.991	34.6	0.806	1.307	1.054	42.1	0.548	1.280	0.702	44.5	0.509	1.508	0.767
30	6.0	33.0	0.988	0.941	0.930	33.2	0.986	0.960	0.946	31.9	0.979	1.001	0.980	31.5	0.897	1.085	0.974	33.0	0.883	1.258	1.110
	8.0	37.2	1.022	1.035	1.058	42.3	1.020	1.088	1.110	45.8	1.019	1.148	1.170	42.6	1.029	1.246	1.282	40.0	1.000	1.452	1.453
	10.0	39.1	1.017	1.175	1.195	38.6	1.021	1.237	1.263	36.8	1.027	1.311	1.346	44.7	1.027	1.437	1.476	47.0	1.027	1.764	1.812
60	6.0	61.8	0.995	0.945	0.940	64.2	0.994	0.967	0.961	67.7	0.992	1.002	0.994	71.4	0.945	1.086	1.026	58.3	0.913	1.252	1.144
	8.0	61.6	0.983	1.028	1.010	64.9	0.983	1.082	1.064	68.4	0.982	1.138	1.117	63.7	0.963	1.241	1.195	52.7	0.953	1.472	1.402
	10.0	60.8	0.975	1.155	1.126	60.3	0.975	1.229	1.198	60.4	0.975	1.297	1.265	56.4	0.972	1.420	1.380	55.7	0.970	1.676	1.626
90	6.0	80.5	0.963	0.941	0.907	78.6	0.959	0.968	0.929	78.3	0.957	1.015	0.971	82.8	0.956	1.088	1.039	75.2	0.955	1.255	1.198
	8.0	70.5	0.845	1.041	0.879	69.2	0.840	1.079	0.906	69.4	0.837	1.151	0.963	73.1	0.821	1.236	1.015	67.5	0.811	1.469	1.192
	10.0	69.9	0.862	1.172	1.010	69.5	0.857	1.217	1.043	68.2	0.852	1.302	1.109	65.4	0.838	1.426	1.195	62.9	0.834	1.651	1.376
120	6.0	96.3	0.971	0.942	0.915	92.0	0.971	0.970	0.942	88.8	0.975	1.020	0.994	87.5	0.940	1.091	1.025	67.6	0.870	1.262	1.098
	8.0	84.8	0.762	1.045	0.796	83.6	0.753	1.090	0.821	84.5	0.747	1.153	0.861	83.7	0.675	1.254	0.847	68.6	0.615	1.475	0.907
	10.0	85.5	0.754	1.179	0.889	82.5	0.740	1.244	0.921	81.3	0.733	1.335	0.979	82.5	0.713	1.454	1.036	73.8	0.699	1.724	1.204

Table 6.3-2(8/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (TERENGGANU)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
0	6.0	17.1	0.863	0.951	0.821	18.1	0.864	0.972	0.840	18.5	0.867	1.020	0.885	22.2	0.847	1.096	0.928	31.0	0.818	1.261	1.032
	8.0	30.1	0.817	1.033	0.843	33.9	0.820	1.072	0.879	34.4	0.831	1.137	0.944	35.7	0.852	1.232	1.049	39.9	0.864	1.435	1.240
	10.0	37.0	0.942	1.149	1.082	40.4	0.938	1.196	1.122	42.0	0.938	1.283	1.203	43.2	0.907	1.406	1.276	46.1	0.881	1.665	1.466
30	6.0	40.8	1.009	0.960	0.968	43.0	1.009	0.982	0.991	43.9	1.014	1.028	1.042	42.2	1.024	1.106	1.132	51.9	1.025	1.279	1.311
	8.0	37.8	0.980	1.032	1.011	35.6	0.982	1.070	1.050	39.2	0.988	1.133	1.119	40.9	0.997	1.232	1.229	62.3	0.982	1.445	1.419
	10.0	46.9	1.066	1.147	1.223	47.1	1.072	1.208	1.295	45.0	1.086	1.280	1.391	37.6	1.112	1.403	1.560	43.0	1.165	1.674	1.950
60	6.0	58.1	0.997	0.937	0.935	57.5	0.997	0.964	0.961	58.7	0.996	1.003	0.999	62.8	0.980	1.078	1.056	82.9	0.965	1.243	1.200
	8.0	57.6	0.978	1.042	1.019	57.6	0.977	1.086	1.061	60.9	0.976	1.143	1.116	65.6	0.960	1.244	1.195	84.4	0.953	1.442	1.374
	10.0	57.7	0.951	1.182	1.124	57.9	0.951	1.240	1.179	61.0	0.950	1.310	1.245	66.2	0.935	1.435	1.342	85.2	0.930	1.681	1.563
90	6.0	83.0	1.052	0.943	0.992	82.5	1.056	0.964	1.018	80.9	1.060	1.011	1.072	77.0	1.055	1.082	1.141	79.6	1.068	1.236	1.321
	8.0	78.9	1.107	1.034	1.145	78.9	1.119	1.075	1.203	79.7	1.130	1.116	1.261	75.0	1.210	1.230	1.488	71.0	1.171	1.484	1.737
	10.0	76.5	0.990	1.142	1.130	74.8	0.986	1.198	1.182	72.1	0.993	1.277	1.268	69.8	0.981	1.396	1.370	62.5	0.980	1.637	1.605
120	6.0	93.7	0.915	0.942	0.861	87.1	0.898	0.968	0.869	76.5	0.897	1.011	0.907	71.1	0.941	1.088	1.024	47.6	0.948	1.266	1.200
	8.0	90.0	0.902	1.035	0.933	89.0	0.902	1.069	0.964	86.5	0.901	1.131	1.019	81.4	0.891	1.226	1.092	79.1	0.893	1.416	1.265
	10.0	85.5	0.932	1.155	1.076	84.2	0.934	1.203	1.124	84.1	0.922	1.286	1.185	83.8	0.868	1.405	1.219	74.8	0.846	1.657	1.402

Table 6.3-2(9/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (OYA)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
300	6.0	320.1	0.935	0.949	0.887	324.1	0.929	0.973	0.904	329.8	0.909	1.017	0.925	335.5	0.870	1.096	0.953	349.5	0.832	1.275	1.061
	8.0	328.0	0.997	1.099	1.096	332.5	1.006	1.147	1.154	336.1	0.991	1.213	1.202	339.8	0.990	1.314	1.301	345.5	0.973	1.554	1.512
	10.0	334.7	0.978	1.219	1.192	335.7	0.966	1.272	1.229	335.4	0.964	1.354	1.305	338.1	0.967	1.484	1.435	327.0	1.022	1.753	1.792
330	6.0	339.4	0.988	0.945	0.934	341.9	0.994	0.940	0.935	345.9	0.962	1.013	0.975	356.6	0.907	1.096	0.994	7.0	0.888	1.266	1.125
	8.0	340.6	0.983	1.072	1.054	342.7	0.991	1.116	1.106	348.4	0.972	1.178	1.146	354.4	0.977	1.279	1.250	1.5	0.977	1.489	1.455
	10.0	339.7	0.980	1.192	1.168	342.0	0.989	1.249	1.235	347.5	0.963	1.329	1.280	358.5	0.921	1.450	1.336	4.6	0.910	1.699	1.546
0	6.0	358.2	0.999	0.958	0.957	359.5	0.998	0.983	0.981	359.8	0.996	1.025	1.021	359.5	0.994	1.098	1.091	5.0	0.992	1.271	1.261
	8.0	357.3	0.999	1.090	1.089	358.8	0.998	1.132	1.130	359.6	0.997	1.198	1.195	7.2	0.980	1.297	1.271	5.2	0.973	1.518	1.477
	10.0	357.3	0.999	1.202	1.201	358.9	0.998	1.254	1.251	359.5	0.997	1.335	1.331	7.1	0.981	1.453	1.426	5.1	0.974	1.712	1.668
30	6.0	21.0	0.958	0.952	0.912	20.4	0.963	0.977	0.941	19.2	0.968	1.021	0.988	16.7	0.973	1.098	1.069	3.3	0.958	1.282	1.228
	8.0	11.4	0.890	1.080	0.961	11.0	0.888	1.123	0.997	9.8	0.884	1.189	1.051	5.7	0.877	1.294	1.135	5.9	0.873	1.521	1.328
	10.0	7.2	0.907	1.210	1.097	7.0	0.910	1.261	1.147	6.4	0.912	1.335	1.218	5.6	0.915	1.466	1.342	4.6	0.915	1.711	1.566
60	6.0	36.1	0.797	0.968	0.771	34.2	0.784	0.994	0.779	30.4	0.739	1.037	0.766	29.8	0.715	1.118	0.800	37.4	0.733	1.296	0.950
	8.0	25.5	0.892	1.104	0.985	24.5	0.886	1.150	1.019	21.5	0.873	1.217	1.063	21.6	0.875	1.320	1.155	34.3	0.903	1.549	1.399
	10.0	19.1	1.016	1.211	1.230	18.8	1.012	1.267	1.282	17.8	0.991	1.344	1.332	15.8	0.976	1.469	1.434	4.8	0.959	1.715	1.645

Table 6.3-2(10/10) WAVE HEIGHT COEFFICIENTS FOR REFRACTED DEEPWATER WAVES (PAPAR)

Ocean Wave Characteristic		Depth = 5 m				Depth = 4 m				Depth = 3 m				Depth = 2 m				Depth = 1 m			
Direction °N	Period (sec)	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks	Direction °N	Kr	Ks	K=Kr*Ks
300	6.0	295.5	0.985	0.946	0.932	298.4	0.983	0.971	0.954	300.4	0.986	1.004	0.990	302.6	0.987	1.091	1.077	306.9	0.984	1.304	1.283
	8.0	297.7	1.046	1.058	1.106	297.2	1.080	1.097	1.185	294.9	1.105	1.173	1.297	294.7	1.114	1.271	1.417	296.3	1.109	1.474	1.635
	10.0	296.8	0.995	1.192	1.186	299.7	0.983	1.249	1.228	300.6	0.989	1.310	1.295	299.8	1.004	1.434	1.439	289.6	1.034	1.709	1.766
330	6.0	327.9	0.984	0.947	0.932	329.3	0.984	0.971	0.955	333.6	0.983	1.015	0.998	333.4	0.983	1.091	1.072	331.7	0.982	1.258	1.235
	8.0	324.9	0.919	1.036	0.953	326.6	0.918	1.074	0.986	330.5	0.917	1.153	1.057	337.3	0.916	1.245	1.141	347.5	0.882	1.450	1.279
	10.0	323.6	0.952	1.166	1.110	325.9	0.949	1.221	1.159	333.8	0.946	1.304	1.233	339.2	0.938	1.409	1.322	354.8	0.748	1.668	1.248
0	6.0	349.4	0.876	0.946	0.829	350.8	0.858	0.974	0.836	354.9	0.866	1.018	0.881	359.4	0.871	1.096	0.955	355.9	0.866	1.260	1.091
	8.0	346.0	0.930	1.044	0.971	347.9	0.914	1.091	0.998	351.2	0.917	1.145	1.050	355.7	0.926	1.254	1.161	356.8	0.939	1.491	1.399
	10.0	346.4	0.949	1.180	1.120	348.6	0.929	1.241	1.152	350.5	0.929	1.307	1.213	354.1	0.927	1.435	1.331	356.8	0.909	1.691	1.537