## 3.2 Basic Component of Pasig-Marikina River

To establish the flood control plan of the Pasig-Marikina River System, various plans or combination of plans are considered. Among them, the component which could be studied independently are herein discussed ahead, as follows:

### Effect of Shortcut of Pasig River

The shortcut in the stretch of the meandering portion from Sta. 8+295 (downstream of San Juan River confluence point) to Sta. 11+495 (upstream of San Juan River confluence point) was investigated by DMJM in 1975. It has been concluded that the reduction of water stage between with and without the shortcut is small and that the construction of the shortcut channel is not feasible.

To set up the framework plan of the Pasig-Marikina flood control, the effect of the above-proposed shortcut was herein reviewed again in the present study by non-uniform flow calculation, based on the following conditions, and the alignment of the proposed shortcut channel is shown in Fig. 4-3-3.

- Discharge : 500 and 1,000 $m^3/s$
- Manila Bay Tide : 11.30 m

The result of the calculation under these conditions are summarized in terms of the water stage in the following table.

| Point | Q = 500 $m^3/s$ | | Q = 1,000 $m^3/s$ | |
|---|---|---|---|---|
| | H1 | H2 | H1 | H2 |
| Sta. 8+295 * | 11.54 | 11.54 | 12.16 | 12.16 |
| Sta. 11+495 ** | 11.69 | 11.59 | 12.51 | 12.32 |
| Sta. 16+495 *** | 12.07 | 11.98 | 13.50 | 13.30 |

Notes:
- Q : Discharge ($m^3/s$)
- H1 : Water stage without shortcut (m)
- H2 : Water stage with shortcut (m)
- * : Starting section of shortcut
- ** : Ending section of shortcut
- *** : Napindan junction

From the above table, the effect of water stage reduction by the construction of a shortcut channel is not expected much. At the

Napindan junction, the water stage can be reduced only by about 9 cm to 20 cm for the discharge of 500 $m^3/s$ and 1,000 $m^3/s$, respectively.

Summarized below are the construction cost of the shortcut, the cost reduction for the upper stream improvement by shortcut (Sta. 8+295 to Sta. 11+495), and the number of house evacuation by shortcut construction.

| | | | |
|---|---|---|---|
| - Construction Cost | ($10^6$ ₱) | : | 279 |
| - Cost Reduction | ($10^6$ ₱) | : | 40 |
| - House Evacuation | (No.) | : | 100 |

The above indicates that the construction of a shortcut channel is not applicable from the hydraulic viewpoint.

Improvement of San Juan River

The existing flow capacity of the San Juan River is, less than 200 $m^3/s$, and the runoff discharge of a 100-year return period is, on the other hand, estimated at 900 $m^3/s$. The improvement of the San Juan River was studied first, with the following three (3) alternatives. (See Fig. 4-3-4.)

Alternative Plan 1: To confine the runoff discharge by expanding the present channel width and setting the high water level (HWL) at an approximate equivalent elevation as the present bank height.

Alternative Plan 2: To avoid house evacuation, improvement by applying an approximate equivalent width to the present channel without setting the high water level (HWL) even though the water stage becomes high.

Alternative Plan 3: To divert the runoff discharge of the upstream basin to Manila Bay and to confine the runoff discharge of the downstream basin in the river, with consideration on the avoidance of house evacuation by the channel improvement and lowering the water stage in the downstream of the San Juan River.

The design discharge distribution of each of the above plans is shown in Fig. 4-3-5. Plan 1 requires about 20 m for the expansion of the present channel width.

For the construction cost estimate of each alternative plan, the following conditions were applied for San Juan River improvement: (1) Longitudinal profile was set, considering the excavation to the maximum extent and the smooth connection to the Pasig River, (2) Cross section was set at 1:1 side slope with revetment for the common section and 1:0 (vertical) in the narrow section, and the closed box type culvert was considered for the diversion channel construction since the proposed route is densely populated. The high water level with its longitudinal profile is shown in Fig. 4-3-6, and the construction cost is summarized as follows, together with the required evacuation of houses.

| Item | Plan 1 | Plan 2 | Plan 3 |
|---|---|---|---|
| Construction Cost ($10^6$ ₱) | 896 | 472 | 2,227 |
| House Evacuation (No.) | 700 | 0 | 0 |

The most recommendable plan is Alternative Plan 2, because it has the lowest construction cost and no house evacuation is required although the high water level becomes 1.0 m on the average higher than the ground elevation along the river course.

Trans-Diversion of the Runoff Discharge of Baho River

The possibility of trans-diversion of the runoff discharge from the Baho River Basin into the Marikina River was studied comparatively on the following two alternatives. (See Fig. 4-3-7.)

Alternative Plan 1: To confine the design discharge by improvement of the existing channel and flow out to the Laguna Lake.

Alternative Plan 2: To trans-divert the runoff discharge of the upstream area of the Baho River, by constructing the diversion channel along the Marcos Highway and confluenced with the Marikina River at the Marcos Bridge point.

The design discharge distribution of both the alternative plans are shown in Fig. 4-3-8. According to the non-uniform flow calculation, the water stage of the improved Marikina River is at about 18.0 m at the Marcos Bridge point under the design discharge of 3,500 $m^3/s$ for the Marikina River. To divert the runoff discharge of the Baho River, the water stage of the Marikina River has to be less than about 18.5 m at the proposed confluence point with the Baho River. Therefore, it is available from the hydrological viewpoint.

The estimated construction cost for the above two alternative plans is as shown below, together with the required number of houses to be evacuated.

| I t e m | Plan 1 | Plan 2 |
|---|---|---|
| Construction Cost ($10^6$ ₱) | 709 | 824 |
| House Evacuation (No.) | 180 | 190 |

Alternative Plan 1 is deemed to be more recommendable than Alternative Plan 2, because the construction cost and the evacuation of houses in Alternative Plan 1 is less than Alternative Plan 2 by 16% and 6%, respectively. Also, Plan 1 shall have to be adopted for the flood control of the Baho River.

Modification of Rosario Weir, Mangahan Floodway

In the present flood control plan of the Pasig-Marikina River, the Marikina River diversion discharge through the Rosario Weir into the Mangahan Floodway is set at 2,400 $m^3/s$ for a 100-year return period flood (3,300 $m^3/s$). The drawing of the Rosario Weir is shown in Fig. 4-3-9. The high water level (HWL) of the floodway at the weir is 16.50 m, and the bottom elevation of the beam of the maintenance bridge is 17.70 m, as indicated in the detailed design drawings.

Taking the structural feature of the Rosario Weir into consideration, two modification methods to increase the diversion discharge are considerable.

The one is to reduce the beam thickness of the maintenance bridge from the 1,300 mm at present to 650 mm (half of the present height), keeping the elevation of the top of the bridge surface equal to the present without changing the maintenance convenience from the present condition. By applying this method, an increased diversion discharge of about 2,800 $m^3/s$, or an increase of 400 $m^3/s$ from the present design, could be secured.

The other is to raise the maintenance bridge, setting the elevation on the top of the bridge surface higher than the present, even though it will cause a somewhat inconvenience for maintenance activity. By applying this method, an increased diversion discharge of about 3,200 $m^3/s$, an increase of 800 $m^3/s$ from the present design, could be secured.

For both of the above modification works, the raising of the bank elevation of the floodway channel is needed.

The required total construction costs for the above modification works are estimated at 12 million peso for the former and 22 million peso for the latter.

Flood Flow Mitigation in the Pasig-Marikina River

To evaluate the flood mitigation in the lower reaches of the Pasig-Marikina River, the diversion effect through the Napindan Hydraulic Control Structure (NHCS) and the Mangahan Floodway was studied. The study was made on the following four (4) cases, considering not only the present condition but also the conditions before completion of either or both structures, so as to grasp the historical progress of the flooding conditions in the lower reaches.

Case 1: Before construction of NHCS and Mangahan Floodway (Natural Condition).

Case 2: Only NHCS is completed (Condition before 1987).

Case 3: The condition that both NHCS and Mangahan Floodway are completed (Present Condition).

Case 4: The existing NHCS is fully opened under the completion of Mangahan Floodway.

Case 4 was additionally studied to examine the flood flow mitigation in the Pasig River on the assumption that the existing NHCS is opened and flood diversion through the Napindan River to the Laguna Lake is allowed.

(1) Calculation Conditions

Calculation was made with the non-uniform flow calculation mehtod using the model shown in Fig. 4-3-10, incorporating the flood inundation conditions in the East and West Mangahan area in which the topographic feature was obtained from the 1:10,000 scaled map.

The other conditions are as given below.

| | | |
|---|---|---|
| - Flood Scale | : | 100-year and 50-year return period |
| - Calculation Pitch | : | $\Delta X$ = 200 m |
| - Manila Bay Tide | : | 11.30 m |
| - Laguna Lake Stage | : | 14.00 m |

(2) Results and Findings

From the study mentioned above, the discharge that will flow down the Pasig River and the diversion discharge through the Napindan River and the Mangahan Floodway are tabulated as follows, in case the Laguna Lake stage is at EL 14.00 m, for a 100-year return period flood in which the discharge at Sto. Niño is 3,500 $m^3/s$.

| Study Case | Flow Down Discharge to Pasig River | Diversion Discharge ($m^3/s$) | | |
|---|---|---|---|---|
| | | Napindan River | Mangahan Floodway | Total |
| Case 1 | 1,020 | 1,320 | 0 | 1,320 |
| Case 2 | 1,510 | 0 | 0 | 0 |
| Case 3 | 880 | 0 | 2,020 | 2,020 |
| Case 4 | 650 | 490 | 1,800 | 2,290 |

The findings of the study are summarized as follows.

Case 1: The discharge of a 100-year return period flood is diverted through the Napindan River to the Laguna Lake at 1,320 $m^3/s$. Correspondingly, the discharge that will flow down the Pasig River is estimated at 1,020 $m^3/s$. [Refer to Fig. 4-3-11(1/4)].

Since the flow capacity of the Pasig River is only about 500 $m^3/s$, inundation can be observed in almost the whole stretch of the river. The landside area along the Napindan River and the East and West Area of Mangahan Floodway are also inundated.

Gase 2: Inundation in the East and West Area of Mangahan Floodway is greater than in Case 1, and the flow down discharge to the Pasig River is estimated at 1,510 $m^3/s$. [Refer to Fig. 4-3-11(2/4)].

Case 3: Diversion discharge through the floodway is realized at 2,020 $m^3/s$ and the inundation in the East and West of Mangahan Floodway is far reduced from Case 1 and Case 2. However, inundation is somewhat observed along the Pasig River because the flow down discharge is 880 $m^3/s$. [Refer to Fig. 4-3-11(3/4)].

Case 4: The diversion discharge through the Napindan River can be realized at 490 $m^3/s$ in the case that lake stage is at EL 14.00 m. Correspondingly, the flow down discharge to the Pasig River decreases to 650 $m^3/s$. [Refer to Fig. 4-3-11(4/4)].

Inundation along the Pasig River is not observed, but the whole stretch of the landside area along the Napindan River, as well as the East and West Mangahan area, is inundated.

Discharge Allocation to Dam and River

The 100-year flood discharge at 3,500 $m^3/s$ was allocated to the Marikina Dam and the Pasig-Marikina River by the least cost method. The results are as shown in Table 4-3-12.

According to the above results, the optimum discharge distributions are as follows:

| Site | Discharge ($m^3/s$) |
|---|---|
| Marikina Dam | 600 $m^3/s$ dam cut |
| - Outflow | 1,500 |
| Sto. Niño | 2,900 |
| Mangahan Floodway (Diversion) | 2,400 |
| Pasig (MCGS to San Juan) | 500 |
| Pasig (San Juan to River Mouth) | 1,150 |

The breakdown of the estimated cost is shown in Table 4-3-2.

3.3 High Water Level of Laguna Lake

The high-water level of the Laguna Lake is determined as the one at which the water stage has increased from the calculated lake stage due to the flood discharge diversion into the Laguna Lake after regulation by the Napindan River and the Mangahan Floodway, under the condition that:

- Parañaque Spillway is not constructed.

- Pasig River is improved for the following discharges:

  River Mouth to San Juan
  (No. 0+000 to No. 8+735) : 1,150 $m^3/s$

  San Juan to Upstream of
  Napindan (No. 8+735 to No. 2+145) : 500 $m^3/s$

  Upstream of Napindan to MCGS
  (No. 2+145 to No. 5+145) : 500 $m^3/s$

- The calculation for the regulation of the lake stage was done with the variation pattern of the recorded maximum lake stage of 14.03 m in 1972, which corresponds to a 40-year return period.

- The Marikina Control Gate Structure is operated to minimize the design discharge of the river channel in the lower reach. The maximum diversion discharge to the Mangahan Floodway is 2,400 $m^3/s$. (Refer to Fig. 4-3-13.)

According to the study results, the following comments may be made:

- The recorded maximum lake stage of 14.03 m is reduced to the 13.63 m by regulation effects through the Napindan River and the Mangahan Floodway, after the river improvement of the Pasig River.

- By diverting the floodwater controlled by the MCGS in accordance with the above operation rule, the floodwater of about $140 \times 10^6$ $m^3$ are stored in the Lake, and the water stage increase by this storage is estimated at about 15.0 cm.

- From the above results, the high-water level of the Laguna Lake is determined at 13.78 m, which is lower by 25 cm compared with the recorded maximum lake stage of 14.03 m.

## 4. CONCEPT FOR PROJECT FORMULATION

### 4.1 General

Three plans are to be formulated in this study; namely, the Framework Plan, the Master Plan and the Priority Project. The main planning criteria and conditions include the target completion year, coverage area, land use conditions, design return period of flood, and financial conditions as shown below.

| | Planning Criteria | Framework Plan | Master Plan | Priority Project |
|---|---|---|---|---|
| (1) | Target Completion Year | Not specified, but far future. | Year of 2020 | Year of 2000 |
| (2) | Coverage Area | Metro Manila Area, Cainta and Taytay. | In principal, same as left. | Areas with top priority. |
| (3) | Land Use Condition | As of 2020. | As of 2020. | As of the present. |
| (4) | Design Return Period | River: 100-yr. Drainage: 10-yr. | To be set up by river based on financial condition. | To be set up for the selected areas in consideration of economic viability. |
| (5) | Financial Aspects | No consideration to financial aspect. | Within the limitation of funds available until the design period. | Within the limitation of financial sources obtainable until the design period. |

### 4.2 Framework Plan

The Framework Plan covers the whole area of Metro Manila and the municipalities of Cainta and Taytay. It presents the outline of the future comprehensive flood plain management for these areas after full urbanization is attained. This plan could serve as a guide in planning a master plan with a smaller scale.

The project scale adopted for entire stretches of rivers is a 100-year return period flood, while it is a 10-year return period flood for all the drainage systems. The runoff ratio for each sub-basin was estimated on the basis of land use conditions at the year 2020, which may be the most distant future possible to predict land use. Financial aspects were not considered and no definite design period was set.

### 4.3 Master Plan

Since the whole Framework Plan is may be impractical due to financial constraints, the Master Plan was formulated within the financial capacity of the organization concerned by applying a lower degree of safety from flooding or varying the design return period according to the river course and drainage area.

### 4.4 Feasibility Study on Priority Project

Within the frame of the Master Plan, priority projects will be formulated for river courses and/or drainage areas that are now very vulnerable to flood damage and thus require urgent countermeasures against flooding. The planning criteria for priority projects consist of, among others, the target completion year 2000 and the conditions of present land use for the benefit calculation.

In order not to duplicate the same kind of work, the degree of safety and design runoff discharge are, in principle, the same as those of the Master Plan that will be completed by 2020. The projects are expected to be implemented within the present financial limitations.

## 5. FRAMEWORK PLAN

### 5.1 Premises and Condition for the Study

In accordance with the study results on the existing and future conditions of the area, such as land use condition, hydrological and hydraulic characteristics, and financial availability, the premises and conditions were set as follows.

Target Completion Year

The target completion year for the Framework Plan is not specified, but it concerns the far future, because this plan presents the outline of the future comprehensive flood plain management for Metro Manila and some of its neighboring areas after full urbanization is attained.

Study Area

The Framework Plan is prepared for the following rivers.

(1) Pasig-Marikina River including San Juan River
(2) Malabon-Tullahan River
(3) Buli-Baho-Mahaba River
(4) South Parañaque-Las Piñas River

The study on the Meycauayan River and the Zapote River, which are located at the northern and the southern boundaries of Metro Manila, respectively, are not included in the scope of this study.

The Meycauayan river has frequently flooded the Malabon, Navotas and Valenzuela (MANAVA) area. Therefore, the drainage plan of the MANAVA area is to be formulated under the condition that the floodwaters of the Meycauayan River is controlled completely by the construction of a dike on the left bank.

The Zapote River causes flooding to the lowland area, but it is at present connected to a small river, the San Dionisio River. Since the drainage plan in the low land area could not be formulated without controlling the floodwaters of the Zapote River, the floodwater of the Zapote River is planned to be drained directly into the Manila Bay.

Land Use Condition

The land use conditions at the year 2020 is employed, since in the present study, the land use conditions at the year 2020 is the farthest that can be set.

Runoff Discharge

The design discharge for this study was calculated on the basis of the land use conditions at the year 2020. (Refer to Supporting Report II, Hydrology.)

Safety Degree and Design Discharge

To prepare the flood control plan of the river system in the Framework Plan, 100-year return period was adopted. This was determined from the review of the previous plans and studies, considering the importance of the metropolitan area with a high development potential. Flood control of rivers in the Philippines is mostly planned with a 100-year return period (refer to Table 4-5-1), even though there is no definite standard.

Definition of Existing Facilities

Existing facilities are defined as the structures and projects in the following stages.

- After completion
- Under construction
- With financial source for implementation

Hydraulic Boundary

The tide level of Manila Bay is set as follows in accordance with the results of the hydrological analysis.

(1) Manila Bay Tide

- River Flood Water Calculation: Mean Spring High Tide at 11.30 m

(2) Water Stage of Rivers

Adopted are the higher stage between the above Manila Bay tide level and the river water stage computed from non-uniform calculation with mean spring high tide at EL 11.30 m of Manila Bay.

Application Measures

The following measures were first taken into account in compliance with the topographic and hydrologic/hydraulic conditions of the Pasig-Marikina River System and other subjective river systems.

- River Channel Improvement
- Construction of Hydraulic Control Structure
- Construction of Dam
- Construction of Diversion Channel

## 5.2 Planning Criteria for Major Structures

As far as it is allowed by the topographic and hydraulic conditions, the flood control plan of the respective river system shall be prepared to attain the minimum construction cost, easy operation and maintenance, and limited house evacuation and land acquisition. Based on the above concept, the planning criteria were set as discussed hereinafter.

River Improvement

(1) Alignment

The proposed channel alignment is planned in such a way that it will not exceed the existing alignment and follow it as much as possible.

(2) Longitudinal Profile

(a) High Water Level

The design high-water level is set, in principle, to correspond with the average ground elevation along the river course. However, in the case where a number of house evacuation is required to set the design high-water level at the average elevation, height, the design high-water level is proposed at a slightly higher level than the average ground.

(b) Riverbed

The design riverbed is considered with a smooth gradient, to follow the mean elevation of the existing riverbed. In the case where the flow capacity of the channel is insufficient, expansion or deepening is applied with full consideration on the existing bed profile.

(3) Cross Section

In the stretches or rivers where land acquisition can be attained easily, a single cross section of 1:2 side slope without revetment is employed, and banking of the earth dike with a 1:2 side slope is also applied. (Refer to Fig. 4-5-1.)

On the other hand, since the widening of the existing channel width is deemed to be difficult from the viewpoint of land acquisition and house evacuation, the existing width is followed as much as practicable, with a single type revetted cross section having a 1:1 side slope with concrete block revetment. (Refer to Fig. 4-5-1.)

In case where the cross section designed by the above method is insufficient for the design discharge, the rectangular type with steel sheet piles is particularly applied. Also, a parapet with a height of less than 1.0 m, or a concrete river wall with a height of more than 1.0 m, is applied to the dike. (Refer to Fig. 4-5-2.)

(a) Freeboard and Crown Width of the Dike

The following values were applied to the freeboard of the dike.

- Discharge of less than 200 $m^3/s$ : 0.6 m
- Discharge of 200 to 500 $m^3/s$ : 0.8 m
- Discharge of 500 to 2,000 $m^3/s$ : 1.0 m
- Discharge of 2,000 to 5,000 $m^3/s$: 1.2 m

The height of the dike near the estuary was designed at EL 13.5 m, which was derived from the recorded highest tidal level of EL 11.77 m and the existing guideline of the DPWH.

The crown widths of the river dike were determined in accordance with the design flood discharge as follows.

- Discharge of less than 500 $m^3/s$ : 3 m
- Discharge of 500 to 2,000 $m^3/s$ : 4 m
- Discharge of 2,000 to 5,000 $m^3/s$: 5 m

In the backwater section of a tributary, the crown width of the river dike was designed at the same width as the main river.

(b) Maintenance Pathway

The maintenance pathway is necessary for the inspection of the river, flood prevention activities on the occasion of flood, etc. When the river dike is provided, the pathway is designed on the crest. When the concrete parapet wall or the river wall is provided, this indicates that it is very difficult to provide a maintenance pathway in the congested area. As far as practicable, however, a maintenance pathway with a width of at least 1.0 m shall be provided, though a width of 3.0 m or more is more appropriate.

Hydraulic Control Structure

THE MCGS is to be constructed at just downstream of the confluence with the Mangahan Floodway to divert the flood discharge.

| | | |
|---|---|---|
| Location | : | Downstream of confluence with Mangahan Floodway (Sta. 5+425) |
| Type of Gate | : | Roller Gated Weir |
| Height | : | 15 m |

Dam

The possibility of dam construction is only in the upper reach of the Marikina River, known as the Marikina Dam as previously proposed. The designing principles were considered as follows.

| | | |
|---|---|---|
| Purpose of Dam | : | Flood Control |
| Dam Site | : | Montalban Gorge |

| | | |
|---|---|---|
| Dam Type | : | Concrete Gravity Type |
| Discharge Regulation Method | : | In this study, the natural discharge regulation without artificial operation by gate was considered. Thus, a flood control gate is not provided at the outlet. |

Diversion Channel and Shortcut Channel

(1) Channel Route

Selection of the channel route was made based mainly on the 1/10,000 scaled topographic map.

(2) Longitudinal and Cross Sectional Feature

The longitudinal profile of the channel was planned in consideration of the elevation of the intake and outlet points. The design high water level was set to correspond with the average ground elevation along the channel, considering the avoidance of the problem of draining inland water.

The channel is basically proposed as an open channel with a riveted single type of cross section having a 1:1 side slope. The box culvert was considered only in the area where the open channel is not applicable from the topographical and land use conditions.

## 5.3 Alternative Plan Study

Pasig-Marikina River

(1) Alternative Plans

The alternative plans to conduct the framework plan study for the flood control of the Pasig-Marikina River were prepared in consideration of the following basic factors.

- Increment of Flow Capacity of the Present Pasig River

  In general, it is essential to convey flood water to the sea through a river channel without overtopping. In this connection, increase of the flow capacity in the downstream is one of the most critical factors in planning flood control plans.

- Utilization of the Laguna Lake as Retarding Basin

  According to the present flood control plan fo the Pasig-Marikina River, the diversion discharge into the Laguna Lake is set at 2,400 $m^3/s$ which raises the lake water stage by about 7.0 cm. Even if the diversion discharge is increased to 3,000 $m^3/s$, the rise of lake state is estimated at only 12.9 cm. Therefore, the utilization of the Laguna Lake as a retarding pond is important to consider in the flood control plan of the Pasig-Marikina River.

Based on the above two factors, the alternative plans for the flood control of the Pasig-Marikina River were prepared as follows:

| Alternative Plan | Pasig River | Diversion to Laguna Lake | Marikina River |
|---|---|---|---|
| Plan 1 | Channel improvement at 1,150 $m^3/s$ from the mouth to San Juan R. confluence point, and some channel modification at 500 $m^3/s$ in the upper reaches. | Diverison through Mangahan Floodway at 3,000 $m^3/s$ by construction of MCGS and modifying Rosario Weir. | Channel improvement at 3,500 $m^3/s$. |
| Plan 2 | - ditto - | Diversion through Mangahan Floodway at 2,250 $m^3/s$ and Napindan R. at 750 $m^3/s$, by construction of PCGS (tentatively named). | - ditto - |

| | | | |
|---|---|---|---|
| Plan 3 | - ditto - | Diversion only through Mangahan Floodway at 2,400 $m^3/s$, by construction of MCGS. | Channel improvement at 2,900 $m^3/s$, and regulate 600 $m^3/s$ by Marikina Dam. |
| Plan 4 | Channel improvement at 1,350 $m^3/s$ from the mouth to San Juan R. confluence point, and some channel modification at 700 $m^3/s$ in the upper reaches. | Diversion through Mangahan Floodway at 2,800 $m^3/s$, by construction of MCGS and modifying Rosario Weir. | Channel improvement at 3,500 $m^3/s$. |
| Plan 5 | - ditto - | Diversion through Mangahan Floodway at 2,250 $m^3/s$ and Napindan R. at 550 $m^3/s$, by construction of PCGS (tentatively named). | - ditto - |
| Plan 6 | - ditto - | Diversion through Mangahan Floodway at 2,400 $m^3/s$, by construction of MCGS. | Channel improvement at 3,100 $m^3/s$, and regulate 400 $m^3/s$ by Marikina Dam. |
| Plan 7 | Channel improvement at 1,550 $m^3/s$ from the mouth to San Juan R. confluence point, and also improvement at 1,100 $m^3/s$ in the upper reaches. | Diversion only through Mangahan Floodway at 2,400 $m^3/s$, by construction of MCGS. | Channel improvement at 3,500 $m^3/s$. |
| Plan 8 | Channel improvement at 1,300 $m^3/s$ from the mouth to San Juan R. confluence point, and also improvement at 900 $m^3/s$ in the upper reaches. | Diversion only through Mangahan Floodway at 1,100 $m^3/s$, by natural diversion (w/o construction of MCGS). | Channel improvement at 2,000 $m^3/s$, and regulate 1,500 $m^3/s$ by Marikina Dam. |

The design discharge distribution and the facilities' layout are shown in Figs. 4-5-3 and 4-5-4, respectively.

Among the above alternative plans, Alternative Plans 1, 2 and 3 were prepared based on the following two (2) concepts, by setting the Pasig River discharge at 1,150 $m^3/s$. One is by diverting the surplus flood discharge into the Laguna Lake for Alternative Plans 1 and 2, and the other is by maintaining the present diversion discharge through the Mangahan Floodway with discharge regulation by a dam for the Alternative Plan 3.

Alternative Plans 4, 5 and 6 were prepared based on the same concepts as the above, by setting the Pasig River discharge at 1,350 $m^3/s$.

Alternative Plan 7 was prepared to be attained mainly by the channel improvement, following the present diversion discharge through Mangahan Floodway at 2,400 $m^3/s$ which is attained by construction of MCGS.

Alternative Plan 8 was prepared to be attained mainly by the regulation by Marikina reservoir for the purpose of reduction of the inflow to the lake, keeping the natural diversion through Mangahan Floodway.

(2) Findings of the Study

The required construction cost and the house evacuation of the above alternative plans are summarized as follows:

| Alternative Plan | Construction Cost (million pesos) | House Evacuation (No.) |
|---|---|---|
| Plan 1 | 3,887 | 30 |
| Plan 2 | 5,737 | 210 |
| Plan 3 | 4,413 | 30 |
| Plan 4 | 4,694 | 30 |
| Plan 5 | 5,717 | 190 |
| Plan 6 | 5,234 | 30 |
| Plan 7 | 5,414 | 30 |
| Plan 8 | 5,315 | 30 |

(3) Optimum Plan

From the above findings, Alternative Plans 1 and 3 are considered to be recommendable for the following reasons:

(a) For Alternative Plan 1:

- The required construction cost is the lowest among all the alternative plans considered.

- The diversion discharge into the Laguna Lake is set at 3,000 $m^3/s$ which exceeds the present diversion discharge of 2,400 $m^3/s$, but the increased diversion discharge of 600 $m^3/s$ will not affect so much to the Laguna Lake because the rise of the lake stage by increased diversion discharge is estimated only at 5.9 cm.

(b) For Alternative Plan 3:

- The diversion discharge into the Laguna Lake is set at 2,400 $m^3/s$, same as the present one, and the plan deems acceptable from the social viewpoint.

- The required construction cost is the second lowest among all of the alternative plans considered, and the difference from Alternative Plan 1 is at 532 million pesos.

- The construction cost of the proposed Marikina Dam is estimated on the basis that the dam will construct only for the flood control purpose. If the proposed Marikina Dam is considered to be developed as a multipurpose dam for not only flood but also water supply and other water utilization purpose, the total construction cost of Alternative Plan 3 may become the lowest, because an allocated cost for flood control of the multipurpose dam will become lower than that of the dam which will be constructed aiming the flood control purpose only.

Among the above two recommendable plans, Alternative Plan 3 was finally selected as the optimum plan taking into consideration the future affordability of the Marikina Dam and not to exceed the present diversion capacity of Mangahan Floodway which was completed in 1987.

Other River Systems

(1) Malabon-Tullahan River

Since the basin of this river has been well developed, it is practically difficult to construct flood regulation facilities such as reservoir, retarding basin, etc. in the upper reaches. River channel improvement in the upper and middle stretches is the only practical measure.

To discharge the design flow of the river safely into the sea in the downstream area, the following two alternatives were prepared. The design discharge distribution and layout are as presented in Figs. 4-5-5 and 4-5-6, respectively.

Alternative Plan 1: River Improvement and Diversion Channel.
This is a plan to provide a shortcut to the Malabon (Tenejeros) River between the Tenejeros Bridge and the Tang area. The design discharge will be continued by both newly proposed diversion channel and improvement of the existing channel. The river section above the Tenejeros Bridge will be improved mainly by dredging.

Alternative Plan 2: River Improvement.
The design discharge is confined by river improvement of the existing channel by expanding the channel width, since excavation is not effective hydrologically in relation with the tidal stage. The channel to be improved is the stretch between the river mouth and the North Diversion Highway Road Bridge.

The two alternative plans were compared to each other as to the number of houses to be evacuated and their construction cost, as follows:

| Alternative Plan | Construction Cost (million pesos) | House Evacuation (No.) |
|---|---|---|
| Plan 1 | 682 | 280 |
| Plan 2 | 593 | 570 |

The above results show, from the viewpoint of only river improvement, that Alternative Plan 2 has a lesser construction cost but Alternative 1 has a lesser house evacuation. On the other hand, taking into consideration the drainage plan in this area (refer to Supporting Report V, Drainage Improvement), the inland water along the river is planned to be drained into the Malabon River and Alternative Plan 1 was deleted and the river improvement of Plan 2 was adopted.

(2) Buli-Baho-Mahaba River

There are three rivers that flow into the Laguna Lake through the drainage channel provided along the left side of the Mangahan Floodway to the lake, namely, the Buli River, the Baho River, and the Mahaba River. The flow capacity of their river channels is extremely small, and the channels run through the densely populated urban area.

As for the flood control of Baho River, trans-diversion of the runoff discharge to the Marikina River, is not viable as aforementioned in the Basic Study and Analysis. Therefore, channel improvement by expanding the existing channel width and excavation/dredging of channel bed was herein adopted as the most viable measure. In this case, short-cut from the Baho River to Buli River was employed because of apparently less cost and house evacuation than the improvement works for the Baho River which runs through the densely populated areas.

Judging from the aforementioned flow capacity and the design discharge distribution diagram in Fig. 4-3-8, all the rivers require extensive improvement. To drain the flood water to Laguna Lake or

Mangahan Floodway, two methods such as the construction of the backwater levee and pump drainage are considered. The total design discharge of these three rivers amounts to more than 600 $m^3/s$, so that the pump drainage method deems not viable because the backwater levee is quite low in its construction cost. Therefore, the following two alternative plans were studies with construction of backwater levee as shown in Fig. 4-3-9.

Alternative Plan 1: Drainage into the Mangahan Floodway.
The three rivers are directly connected to the Mangahan Floodway and dike are construced along the river courses to confine the backwater in the floodway during the flood time.

Alternative Plan 2: Drainage into the Laguna Lake.
A channel is provided along the Mangahan Floodway, and the three rivers are connected to this channel to drain the design discharge into the Laguna Lake. Dikes are also provided to prevent the backwater from the Laguna Lake from flowing into the channel.

The number of houses to be evacuated and the construction cost are estimated for these two plans, as follows:

| Plan | Construction Cost (million pesos) | House Evacuation (No.) |
| --- | --- | --- |
| Plan 1 | 290 | 0 |
| Plan 2 | 280 | 5 |

Although the above comparative study shows only a little difference in the construction cost and the number of house evacuations, Alternative Plan 2 is considered to be more applicable for the reason that Alternative Plan 1 may cause a considerable scouring at the confluence points between the rivers and the floodway.

(3) South Parañaque-Las Piñas River System

The upstream of the rivers included in this area is already urbanized, especially recently, and flood control by reservoir and/or retarding pond are not considerable, and there may not be alternative plans. The optimum way is to drain the runoff discharge from the upstream hilly land or mountain area into the Manila Bay directly by the channel improvement and the construction of the diversion channel, in view of the topographic characteristic. (See Fig. 4-5-7.)

## 5.4 Proposed Features of the Plan

The main features of the proposed structures are as follows. The construction cost of the optimum plan is summerized in Table 4-5-2, and the details are discussed in Supporting Report VI, Construction Planning and Cost Estimate.

Pasig-Marikina River

The main features of the proposed structures are as follows.

(1) River Improvement

| River Stretch | Design Discharge ($m^3/s$) | Length (m) | Width (m) | X-Section | Proposed Structures |
|---|---|---|---|---|---|
| River Mouth/ San Juan R. Confluence | 1,150 | 8,735 | 250-80 | Single (Rectangular/ Trapezoidal) | °Sheet Piles<br>°Parapet Wall |
| San Juan R. Confluence Napindan R. Confluence | 500 | 9,760 | 80-110 | - ditto - | °Sheet Piles<br>°Revetment<br>°Parapet Wall |
| Napindan R. Confluence/ MCGS | 500 | 5,580 | 110-100 | Single (Trapezoidal) | °Revetment<br>°River Wall |
| MCGS/Mangahan F. Confluence | 500 | 1,210 | 100-130 | - ditto - | °Revetment<br>°River Wall |

| | | | | | |
|---|---|---|---|---|---|
| Mangahan F. Confluence/ Marikina Bridge | 2,900 | 6,425 | 130-150 | - ditto - | °Revetment<br>°River Wall<br>°Embankment |
| Marikina Bridge/Nangka R. Confluence | 2,900 | 5,560 | 350-300 | Compound | °Revetment<br>°River Wall |
| Nangka R. Confluence/ Rodriguez Bridge | 2,600 | 8,580 | 300-170 | - ditto - | °Embankment |
| San Juan R. | 900 | 10,653 | 40 | Single (Rectangular/ Trapezoidal) | °Sheet Piles<br>°Revetment<br>°Parapet Wall |

(2) Marikina Control Gate Structure (MCGS)

The MCGS as shown in Fig. 4-8-4 is to be constructed just downstream of the confluence with the Mangahan Floodway to divert the discharge of 2,400 $m^3/s$ into the floodway.

Location : Downstream of confluence with Mangahan Floodway (Sta. 5+425)

Type of Gate : Roller Gated Weir

Height : 15 m

(3) Marikina Dam (See Fig. 4-8-5)

Dam construction is possible only in the upper reach of the Marikina River. In this study, the natural discharge regulation method without artificial operation by gate is considered to avoid a man-made flood. The dam will be known as the Marikina Dam as previously proposed.

Location : Montalban Gorge (100 m downstream of the existing Wawa Dam)

Type of Dam : Concrete Gravity Type

Height : 70 m

Premises of Structural Application

The Framework Plan was formulated without considering financial restrictions. On the contrary, the Master Plan is to formulate the flood control and drainage project that could be realized by the year 2020 within the financial availability up to that year.

Discharge

(1) Runoff Discharge

The design discharge for this study was calculated on the basis of land use conditions at the year 2020. (Refer to Supporting Report II, Hydrology.)

(2) Diversion Discharge through Mangahan Floodway

The maximum diversion discharge of Mangahan Floodway is set at 2,400 $m^3/s$.

Hydraulic Boundary

The tide level of Manila Bay and the water stage of the Laguna Lake were set as follows in accordance with the results of the hydrological analysis.

- Manila Bay Tide : Mean Spring High Tide at 11.30 m.
- Laguna Lake Stage : 12.50 m, to avoid double accounting of damage due to inland water inundation and flood water inundation or river.

## 6.2 Planning Criteria of Applicable Structural Measures

The structural measures for the Master Plan of the river improvement works, have been studied on the same planning criteria as the Framework Plan.

## 6.3 Alternative Study Cases

For the flood control of rivers and inland water drainage, the study on the Master Plan was done under the following alternative cases.

Flood Control of Rivers

For each of the following rivers, the improvement scale of structures and facilities was considered in five alternative cases; namely, 10, 20, 30, 50 and 100-year return periods.

- Pasig-Marikina River (including San Juan River)
- Malabon-Tullahan River
- Baho-Buli-Mahaba River
- South Parañaque-Las Piñas River

## 6.4 Flood Inundation Analysis

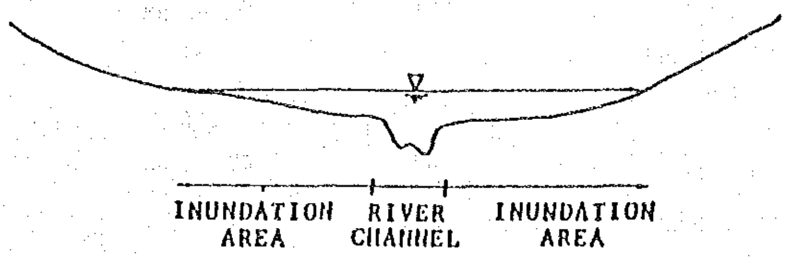
Basic Approach and Analysis

(1) Inundation Condition and Model

The pattern of flood inundation by rivers in Metro Manila is classified into the following three groups, according to the flood inundation survey for the flood of September 1986 (refer to Fig. 5-6-1.

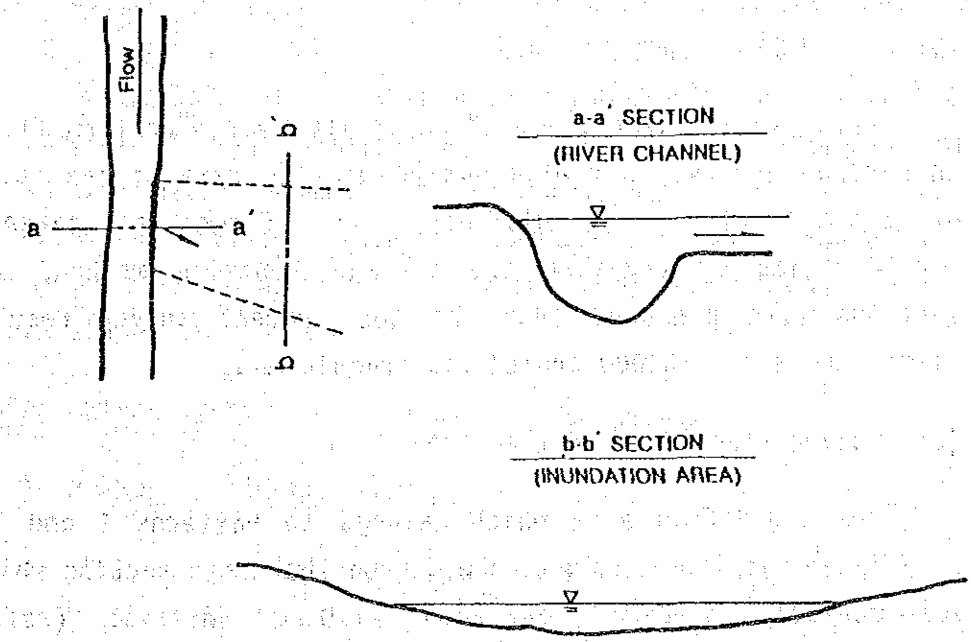
(a) Pattern I

Floodwater overflows the river bank but flows down along the river, without flowing out to the other basin, inundating on the riverine areas.



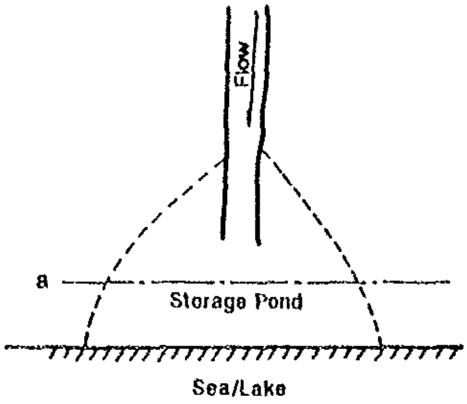

(b) Pattern II

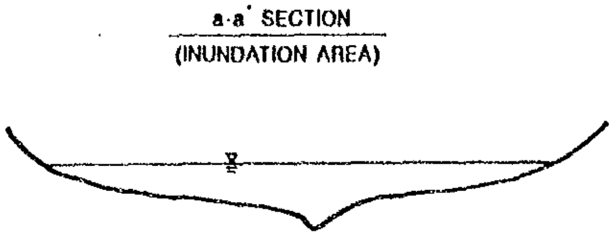
Floodwater overtops the riverbank and flows out into a riparian area. Usually, the flood water flows down towards other river basins.




(c) Pattern III

Floodwater overflows the river bank and is retained in a low-lying area (storage pond) near to the shoreline of sea/ lake. The retained floodwater is once stored in the low-lying area and gradually drained to the sea/lake.




(2) Premises and Conditions of Calculation

(a) Discharge for Inundation Analysis

The flood discharge applied to the analysis were those of 2, 5, 10, 20, 30, 50 and 100-year return periods.

(b) Flood Stage Calculation

Flood stages were computed basically by non-uniform flow with an average interval set at about 200 m. In case of the retarding or storage effect is distinct, its effect was taken into consideration by applying the storage function method. Cross sections were prepared from the most recent survey results of rivers and the 1/10,000 scaled topographic map.

(c) Delineation of Inundation Area

The inundation area which belongs to Patterns I and II was deliniated with the inundation width on the cross section which was fundamentally prepared at about 1.0 km interval (refer to Fig. 4-6-2).

The inundation area of Pattern III was deliniated with the area which was obtained from the stage-area-volume relationship of the low-lying storage pond.

(d) Roughness Coefficient

In the computation of non-uniform flow, the roughness coefficients were determined based on the recent investigation results, as follows:

- Denuded Land : N = 0.1
- Poor Grassland : N = 0.2
- River Channel : N = 0.03

Model Application

There are four river systems to which the aforementioned inundation models were applied, namely the Pasig-Marikina, the Malabon-Tullahan, the Buli-Baho-Mahaba and the South Parañaque-Las Pinas River Systems.

(1) Pasig-Marikina River System

Based on the topographic characteristics and the paste experience of flooding, the Pasig-Marikina River is classified as the combined type of Patterns I and II. Thus, the model was prepared with four effluent points, incorporating the two inundation areas by overtopping of the floodwater, and the flood stage was obtained by non-uniform computation (refer to Fig. 4-6-3). As for the tributary San Juan River, the model of Pattern I was utilized since the inundation occurs topographically in the riverine area along the channel, applying the non-uniform flow for the flood stage computation.

(2) Other River Systems

(a) Malabon-Tullahan River

Through the elevation on flow capacity and topographic survey, the flooding in this river is characterized by two types; one is the flood retarding along the channel from the bridge of North Diversion Road until the PNR bridge and the other is the storage type in the lower reach from the PNR bridge to the river mouth.

Thus the model was prepared as the combined type of Pattern I and Pattern III as shown in Fig. 4-6-3. Flood stage was obtained considering the retarding and storage effect, applying the storage function method.

(b) Buli-Baho-Mahaba River

East side area of the Mangahan Floodway is a chronical flood inundation area receiving floods from the said three rivers. The three rivers have all flooding along their channels due to poor flow capacities. Moreoever, floods in the upstream of the Baho River have been retained by the Marcos Highway, so the upper area bordered by the highway can be treated as another storage area.

The model of this river system was prepared as combined type of Pattern I and Pattern III as shown in Fig. 4-6-3. Flood stage was obtained considering the retarding and storage effect, applying the storage function method.

(c) South Parañaque-Las Piñas River

The coastal lowland area in Parañaque is topographically situated as a storage pond which is suffering from the chronical inundation. Three rivers flow into the pond with retarding and inundated in the low-lying storage pond in the lower reach.

Thus, the model was prepared as the combined type of Pattern I and Pattern III as shown in Fig. 4-6-3. Flood stage was also obtained by storage function method.

Verification of Model

Three models were applied for the calculation and these are needed to be verified. However, the verification by comparison of the calculation results with the actual survey was made only for the Pasig-Marikina River which belongs to Pattern I and Pattern II, because the actual survey data in other river systems are inappropriate to be utilized for the verification since the applied methods and procedures of analysis in other river systems are the ones just commonly utilized and there is no way to realize the flooding condition. Thus, the above-mentioned model was utilized.

Calculation Results

By using the method and model mentioned in the above, the inundation by the floodwater of rivers was calculated for the 2, 5, 10, 20, 30, 50 and 100 year floods. The obtained inundation water stages of the respective river system are as tabulated in Tables 4-6-1 to 4-6-4.

## 6.5 Economic Efficiency of the Alternative Study Case

As discussed in Section 5.3, set up are five study cases for four river systems and four cases for nine drainage areas, or a total of 56 alternative study cases. Cost-Benefit ratio was verified to confirm the economic efficiency for each study case on the following assumptions.

- Construction period is five years at equal annual disbursements;
- Economic construction cost is 80% of the estimated cost;
- Annual OMR cost is as estimated;
- Project life is 40 years after construction; and
- Discount rate is 15% per annum.

Details of the project cost are described in Supporting Report VII, Construction Planning and Cost Estimate, and the annual average benefit was estimated as discussed in Supporting Report X, Economic Evaluation. The estimated cost-benefit ratios are presented in Table 4-6-5.

## 6.6 Formulation of the Master Plan

### 6.6.1 Proposed Plan

The optimum structural measures for the Master Plan were selected through the following studies.

Proposed Structural Measure

The optimum structural measures are proposed in consideration of the following conditions.

(1) Grouping of River Courses/Drainage Areas

The Framework Plan has been formulated to protect Metro Manila from flooding/inundation of 100-year and 10-year return periods for the river course and drainage area, respectively. However, it is financially infeasible to put this plan into implementation. In formulating the Master Plan, therefore, financial capacity is one of the planning criteria. This can be attained by applying a lower degree of safety from flooding or varying the design return period according to the river course/drainage area.

The safety degree of applicable structures and facilities for flood control is determined depending on the economic viability and social significance of each river course/drainage area. However, there are four river courses and nine drainage areas and some of them show a very similar economic viability and social significance. Determination of the safety degree for each river course/drainage area is so difficult that it is proposed to classify them into several groups as follows.

(a) River System

Economical viability is almost the same for all the rivers, although economic viability for the Pasig-Marikina River is relatively higher than those of the other rivers. Considering that the Pasig-Marikina River runs through the heart of Metro Manila which is the political, economic and social center of the Philippines, the degree of safety for this river system is likewise set higher than the other rivers. Thus, the objective river systems were classified into the following two groups.

| | | |
|---|---|---|
| Group A<br>(Most Important) | : | Pasig-Marikina River<br>(including San Juan River) |
| Group B<br>(Important) | : | Buli-Baho-Mahaba River<br>Malabon-Tullahan River; and<br>South Parañaque-Las Piñas River |

(b) Drainage System

In North and South Manila, the drainage facilities are already set with a certain degree of safety, and will be improved under the 14th OECF Loan. In other areas, however, no countermeasure is provided, or that the facilities are inappropriate. These areas will be classified into two groups, one group with the B/C ratio of more than 2.0 and the other with the B/C ratio of less than 2.0. Thus, drainage areas will be classified into the following three groups. (The areal division and the drainage system are referred to in SUPPORTING REPORT, VI. DRAINAGE IMPROVEMENT.)

| | | |
|---|---|---|
| Group A (Most Important) | : | Manila and Suburbs |
| Group B (More Important) | : | West of Mangahan;<br>East of Mangahan; and<br>Malabon-Navotas |
| Group C (Important) | : | San Juan;<br>Mandaluyong-Pasig;<br>Parañaque-Las Piñas; and<br>Valenzuela |

(2) Alternative Combinations and Selection of Optimum Plan

Based on the above grouping of drainage area, alternative combinations are set up in terms of the project scale expressed in return period on the following considerations.

- To rank the groups according to their economic viability and social significance; and

- To place a higher safety degree on the higher ranked groups.

Alternative combinations are thus suggested below with the maximum safety degree of 100-year and 10-year return periods for the river course and drainage area, respectively.

| Alternative | River | | Drainage | | |
|---|---|---|---|---|---|
| | Group A | Group B | Group A | Group B | Group C |
| Case 1 | 1/100 | 1/50 | 1/10 | 1/10 | 1/5 |
| Case 2 | 1/100 | 1/30 | Existing** | 1/5 | 1/3 |
| Case 3 | 1/30* | 1/30 | Existing** | 1/5 | 1/3 |
| Case 4 | 1/30* | 1/20 | Existing** | 1/3 | 1/2 |
| Case 5 | 1/100 | - | 1/10 | 1/10 | - |
| Case 6 | 1/30* | - | Existing** | 1/5 | - |

[Note] * With respect to the flood control of the Pasig-Marikina River, the 100-year flood is controlled with a dam and river channel improvement works. The most economical allocation between them is a 30-year return period for the river channel. Therefore, the maximum safety degree without a dam is considered at a 30-year return period.

** Under the condition that the 14th OECF Loan Project has been executed.

The total construction cost required for the above alternative cases are as follows. The breakdown of cost is in Table 4-6-6.

| | | | |
|---|---|---|---|
| Case 1 | : 17,009 | million | pesos |
| Case 2 | : 13,523 | " | " |
| Case 3 | : 12,884 | " | " |
| Case 4 | : 12,015 | " | " |
| Case 5 | : 10,751 | " | " |
| Case 6 | : 7,250 | " | " |

Case 2 is selected as the optimum plan on the ground that the required project cost corresponds to the accumulated amount of public investment on the flood control and drainage sector by the year 2020 that could be attained by the potential economic growth rate of 4% in the future Philippine economy. The location of the optimum plan is shown in Fig. 4-6-5.

### 6.6.2 Features of Proposed Structural Measures

The proposed structures and facilities are as indicated in Figs. 4-6-7 and 4-6-8, while the discharge distrubution of river flood control works is as shown in Fig. 4-6-6. The plan for the respective rivers is explained as follows.

Pasig-Marikina River

The area in the lower reach of the Pasig River is the most urbanized area of Metro Manila. Widening of the channel width is difficult because the landside is densely populated. Channel improvement will be done by dredging the channel bed to make it lower and the construction or river walls on both banks. As to the San Juan River, the biggest tributary, the same improvement system as the Pasig River will be applied.

Along the channel of the Marikina River, earth dike will be constructed to avoid flood inundation to the landside areas of both banks, and lowering of the channel bed will also be undertaken. To control the diversion water to the Mangahan Floodway, the Marikina Control Gate Structure (MCGS) will be constructed at the downstream of the floodway in Marikina River. The Marikina Dam will be constructed in the upper reach of the Marikina River to regulate the floodwaters. After completion of the proposed works, the flood of less than a 100-year return period will be safely controlled.

The principal features of proposed structures are as follows.

(1) River Improvement

| River Stretch | Design Discharge ($m^3/s$) | Length (m) | Width (m) | X-Section | Proposed Structures |
|---|---|---|---|---|---|
| River Mouth/ San Juan R. Confluence | 1,150 | 8,735 | 250-80 | Single (Rectangular/ Trapezoidal) | °Sheet Piles<br>°Parapet Wall |
| San Juan R. Confluence Napindan R. Confluence | 500 | 9,760 | 80-110 | - ditto - | °Sheet Piles<br>°Revetment<br>°Parapet Wall |
| Napindan R. Confluence/ MCGS | 500 | 5,580 | 110-100 | Single (Trapezoidal) | °Revetment<br>°River Wall |
| MCGS/Mangahan F. Confluence | 500 | 1,210 | 100-130 | - ditto - | °Revetment<br>°River Wall |

| | | | | | |
|---|---|---|---|---|---|
| Mangahan F. Confluence/ Marikina Bridge | 2,900 | 6,425 | 130-150 | - ditto - | °Revetment<br>°River Wall<br>°Embankment |
| Marikina Bridge/Nangka R. Confluence | 2,900 | 5,560 | 350-300 | Compound | °Revetment<br>°River Wall |
| Nangka R. Confluence/ Rodriguez Bridge | 2,600 | 8,580 | 300-170 | - ditto - | °Embankment |
| San Juan R. | 900 | 10,653 | 40 | Single (Rectangular/ Trapezoidal) | °Sheet Piles<br>°Revetment<br>°Parapet Wall |

(2) Marikina Control Gate Structure (MCGS)

Location : Downstream of Rosario Weir (Sta. 5+425)

Type of Gate : Roller Gated Weir

Height : 15 m

(3) Marikina Dam

Location : Montalban Gorge
(100 m downstream of the existing Wawa Dam)

Type of Dam : Concrete Gravity Type

Height : 70 m

Discharge Regulations : Natural discharge regulation without artificial operation by gate

Malabon-Tullahan River

The scale of the design flood is 30-uear return priod. River channel improvement consisting mainly of dredging in the upper and middle reaches is the only practical measure. Although the shortcut plan of the Malabon (Tenejeros) River is recommended in the Framework Plan, dredging of the existing river course is adopted in the Master Plan, judging from the project scale of 30-year return period. The main features are summarized as follows.

| River Stretch | Design Discharge ($m^3/s$) | Length (m) | Width (m) | X-Section | Proposed Structures |
|---|---|---|---|---|---|
| Malabon River | 500-450 | 5,430 | 80-70 | Single (Trapezoidal) | °Revetment<br>°Parapet Wall<br>°Embankment |
| Tullahan River | 420-210 | 20,500 | 80-15 | - ditto - | °Revetment<br>°Parapet Wall<br>°Embankment |

Buli-Baho-Mahaba River

The scale of the design flood for each river is 30-year return period. For the Baho and Buli rivers, channel improvement by expanding the existing channel width, dredging of the channel bed and diking are adopted. In this case, a short-cut from the Baho River to the Buli River is also employed.

As to the Mahaba river, river channel improvement is applied by expanding the existing channel width, dredging the channel bed and diking. The features of the rivers are as follows.

| River Stretch | Design Discharge ($m^3/s$) | Length (m) | Width (m) | X-Section | Proposed Structures |
|---|---|---|---|---|---|
| Mahaba River | 160 | 5,000 | 45-20 | Single (Trapezoidal) | °Embankment |
| Baho River | 275-230 | 7,450 | 45-35 | - ditto - | - ditto - |
| Buli River (incl. tributaries) | 270-50 | 19,900 | 45-5 | - ditto - | - ditto - |
| Mangahan Diversion | 470-280 | 3,800 | 80-55 | - ditto - | - ditto - |

Construction cost of the above optimum plan of the respective river is as summerized in Table 4-6-7, and the details are described in Supporting Report VI, Construction Planning and Cost Estimate.

South Parañaque-Las Piñas River

The scale of the design flood is 30-year return period. Three rivers were considered in the study; namely, the South Parañaque River, the Las Piñas River, and the Dongalo River. Since the upstream of these rivers are already urbanized, channel improvement by expanding the existing channel width, dredging of the channelbed and diking are adopted only to drain the floodwaters to the Manila Bay. The principal features of river improvement works are described as follows.

| River Stretch | Design Discharge ($m^3/s$) | Length (m) | Width (m) | X-Section | Proposed Structures |
|---|---|---|---|---|---|
| Las Piñas River | 210-180 | 6,395 | 45-25 | Single (Trapezoidal) | °Revetment<br>°Parapet Wall<br>°Embankment |
| South Parañaque River (incl. Dongalo River | 520-170 | 6,500 | 60-25 | - ditto - | - ditto - |

## 7. FEASIBILITY STUDY ON PASIG-MARIKINA RIVER

### 7.1 Target Stretch

The Pasig-Marikina River including its tributary, the San Juan River, was selected in the Master Plan Study as one of the highest priority projects. However, the target stretch for the Feasibility Study is herein limited to the most significant portion of the river, i.e., Pasig River from the river mouth to the Napindan Junction and Lower Marikina River from the Napindan Junction to the effluent point of Mangahan Floodway, considering the flood control effect and the social significance that the river is passing through the core of Metro Manila.

## 7.2 Present Condition of Target Stretch

### Topographic Features

The area is topographically located in the Manila deltaic plain and Guadalupe formation.

Manila deltaic plain is almost flat and its elevation ranges from about 1.0 m in the Manila Bay side and about 5.0 m in Sta. Mesa and Makati area. This plain consists of sand, pebbly gravel, silt and clay.

Guadalupe formation is the bedrock of the Manila deltaic plain, and the elevation is about 40 m from Guadalupe to near Camp Aguinaldo and 50 m to 70 m in the Quezon City area.

### River Utilization

Since the landside area of the target stretch is highly developed and densely populated as a core of Metro Manila, there exist many factories, markets, churches and other administrative offices (refer to Fig. 4-7-1 and Table 4-7-1), and the river channel of the Pasig River is highly utilized as the navigation purposes to transport the products and materials and for the traffic communication of the residencials.

Since the fishing and fish culture are briskly conducted in the lake and along the lake shore, a brisk navigation through the lock of Napindan Hydraulic Control Structure is observed. Also, Marikina River and Mangahan Floodway is partly utilized for "Kangkong" cultivation in addition to the above nagivation purposes.

### Channel and Related Structures

Although the rectangular type cross section with sheet pile exist in some sections, the trapezoidal type cross section with concrete or riprap revetment is provided from the river mouth to the Napindan Junction, changing the channel width at about 300 m to 80 m in the lower reach and at about 80 m in the middle reach. As for the upper reach of the Napindan Junction, no revetment is observed and the channel width is about 100 to 110 m. (Refer to Fig. 4-7-2.)

The longitudinal gradient of channel bed is very mild, i.e. about 1/33,000 from the river mouth to the confluence point of the San Juan River, about 1/16,000 from the confluence point of the San Juan River to the Napindan Junction and about 1/13,000 from the Napindan Junction to Rosario.

Along the target stretch of the Pasig-Marikina River, there exist many related structures such as bridges crossing the river, parapet wall/river wall, drainage facilities, i.e. pumping stations, flood gates and other small drainage facilities. Those updated locations and elevations are as shown in Fig. 4-2-4, based on the most recent survey results.

## 7.3 Planning Condition

### Target Completion Year

The year 2000 is set as the target completion year by which the project formulated in the Feasibility Study should be completed.

### Runoff Discharge

The design discharge for the Feasibility Study was set on the basis of the runoff calculation results of the Master Plan study of which the discharge was obtained including Marikina Dam and Marikina Control Gate Structure (MCGS), setting the land use conditions at the year 2020.

### Design Scale

The design scale is 30-year return period, since the Marikina Dam is not included in the Feasibility Study.

### Diversion Discharge through Mangahan Floodway

The maximum diversion discharge through Mangahan Floodway is at 2,400 $m^3/s$, which has already been accepted.

Hydraulic Boundary Condition

To calculate the water stage of the river by non-uniform calculation, the Manila Bay tide level was set at the mean spring high tide of EL 11.30 m and the Laguna Lake stage at EL 12.50 m, with the Manning's roughness coefficient at 0.030 for the whole stretch of the river.

Criteria for River Improvement

- The alignment of the channel is planned in such a way that it will not exceed the existing alignment and follow it as much as possible.
- The design riverbed gradient is set not to change so steeply (variation of the bed gradient is to be within approximately 50 percent at the variation point), considering the existing profile.
- Single trapezoidal cross section with a side slope of 1:1 is fundamentally applied, following the existing features as much as possible.
- At the river mouth, the bed elevation is set to be connected to the seabed, which was obtained from the 1:10,000 topographic map.

## 7.4 Establishment of High Water Level

To confine the design discharge in the existing river channel, the water stage is generally obliged to be higher than the ground level due to the poor flow capacity of the channel. Once the design high water level is set higher than the ground level, a high levee will be required on both banks along the river course. This will present several inconveniences and it increases the damage potential. The most recommendable improvement is to confine the design discharge in the river channel with a water stage lower than the present ground level.

Since the target stretch is highly developed and densely populated, it is impractical to widen the river channel to confine the design discharge. Therefore, dredging of the bed is the only method to increase the flow capacity. However, this generally requires a huge amount of excavation volume and as a result, a big amount of construction cost.

Considering the above aspects, the adequacy of the design high water level was clarified as follows, setting the design high water level in almost equal elevation as the existing ground level. (Refer to Fig. 4-7-3.)

(a) Justification from River Utilization

There exist many factories on both banks of the Pasig River (refer to Fig. 4-7-1), and the banks are utilized as quay or wharf for the transportation of industrial materials and products. Thus, high dike construction with a higher design high water level on both banks will bring several problems and difficulties for the utilization of reparian facilities and could not be recommended from practical viewpoints.

(b) Justification from Riparian Structures

There exist many riparian structures such as bridges crossing the river, revetment and drainage facilities, i.e., pumping stations, flood gate and other small drainage sluices.

As for the bridges, only one bridge, the Pandacan Bridge, has no appropriate clearance for the design high water level and needs reconstruction (refer to Fig. 4-2-4). To avoid reconstruction of this bridge, the design high water level should be considerably lowered in height from the proposed one. This could not be recommended not only from the economical viewpoint due to the higher construction cost by excavation but also from the technical viewpoint because the stability of the river channel is difficult to maintain due to the lower bed height in the river mouth.

Concrete revetment is provided in almost all stretches of the Pasig River and Lower Marikina River. About 20% of the stretches are either destroyed or superanuated but others are still functional, though it is necessary to reconstruct them in the future. From this, making the design high water stage much lower than the existing ground level will result in higher construction cost because of the big volume of excavation.

The invert elevations of the drainage facilities such as pumping stations, flood gates and drainage channels are appropriately higher than the existing riverbed as shown in Fig. 4-2-4. All of the facilities are not affected by the design high water level.

From the above justifications, the design high water level has been determined as indicated in Fig. 4-7-3. By the adoption of this high water level, a river wall with an approximate height of 0.5 m to 1.0 m will be provided as a freeboard for almost all stretches, and this will not cause serious problems since a river wall exists already in the present condition.

In the lower reaches, both banks are utilized as quays or wharves in many places, but the construction of wall with a lower height will not bring new social problems so seriously since a low wall already exists at present.

In the upper reaches, some portions require the construction of a river wall with a height of more than 1.0 m, but this will not present any problem since the river utilization facilities are not so densely distributed as in the lower reaches and hilly land is close to the riverbank. (Refer to Fig. 4-7-1 and Table 4-7-1.

## 7.5 Confirmation of Necessity for MCGS

In the study for the Master Plan, the flood control plan was formulated by the combination of the channel improvement and the construction of the Marikina Control Gate Structure (MCGS). To clarify the necessity of the MCGS, more detailed study was conducted as below.

## Study Case

The following three alternative cases were prepared for the comparative study, considering the existing condition of the river channel and riparian structures such as the Mangahan Floodway and the Napindan Hydraulic Control Structure (NHCS).

Alternative Case 1: Natural Diversion through Mangahan Floodway (Without construction of MCGS and without allowing the flood diversion into the Napindan River)

Alternative Case 2: Natural Diversion through Mangahan Floodway and Napindan River
(Without construction of MCGS and with flood diversion into the Napindan River)

Alternative Case 3: Diversion through Mangahan Floodway (With construction of MCGS and without diversion into the Napindan River)

## Improvement Plan and Construction Cost

### (1) Improvement Work of Each Study Case

The design discharge distribution for the above cases is indicated in Fig. 4-7-4. In the figure, the discharge distribution of Case 1 and Case 2 cannot be strictly obtained without unsteady flow analysis, but it was herein calculated by non-uniform flow analysis, considering the runoff time lag of the peak discharge of the Upper Marikina River at Sto. Niño and the San Juan River at the river mouth.

The features of the improvement plan such as longitudinal profile and cross section for the above three cases are as indicated in Fig. 4-7-5.

(2) Required Construction Cost

The required construction costs for the thre study cases are presented in the following table. The cost breakdown of the optimum case in in Table 4-7-2.

| Alternative Case | Construction Cost (in million pesos) |
|---|---|
| 1 | 2,457 |
| 2 | 2,242 |
| 3 | 1,809 |

Advantage of MCGS

The advantage of above plans could be judged by the least construction cost, since all of these plans were prepared under the same benefit.

According to the estimation results, the cost of Case 3 is far lower than the other cases. Aside from the construction cost, Case 1 and Case 2 are deemed to be difficult to ensure the successful diversion without the control gate. Also, since the design discharge in the lower reach from San Juan confluence is bigger than the upper reach because of the runoff discharge from the San Juan River, the design bed was set at a low elevation, especially Case 1, and the maintenance of the river bed is deemed difficult after completion.

From the above consideration, Case 3 was selected as the most viable improvement plan.

7.6 Proposed River Improvement Work

The most viable plan consists of the river channel improvement together with the construction of MCGS. The features of the plan are summarized as follows.

Design Discharge

The design discharge distributions with a 100-year return period are as follows. (Refer to Fig. 4-7-4.)

| Stretch | Discharge |
|---|---|
| River Mouth to San Juan (No. 0+000 to No. 8+735) | 1,150 $m^3/s$ |
| San Juan to Napindan (No. 8+735 to No. 18+495) | 500 $m^3/s$ |
| Napindan to MCGS (No. 18+495 to No. 5+415) | 500 $m^3/s$ |

Alignment

The alignment was set as shown in Fig. 4-7-6 by following the existing one without expanding the existing channel width. In the meandering portion in the upper reach of the San Juan River confluent, a shortcut plan was deleted based on the study results of the Framework Plan that the shortcut plan is not effective in the backwater reach for lowering the water stage of the river.

River embankment is to be provided for about 3 km in the upper stretches where the backwater by the MCGS is affected. Also, since the river mouth of the San Juan River is affected by the backwater of the Pasig River, about 3 km stretch will be improved.

Longitudinal Profile

The longitudinal profile was determined in accordance with the planning conditions discussed in Subsection 6.4.2 as presented in Fig. 4-7-7.

In the upper stretches of the Marikina River from the Marikina Control Gate Structure (MCGS), a large quantity of the Marikina floodwater will be diverted through the Mangahan Floodway to the Laguna Lake by heightening the Marikina water stage with the cosntruction of the MCGS, and the discharge to the Pasig River will be reduced much. In addition, a big amount of discharge from the San Juan River will join the Pasig River. As a result, the stability of the channel is deemed difficult to maintain, and the maintenance of the channel may become one of the important matters for consideration after completion, especially at the river mouth. Though the bed elevation was set at 5.00 m considering the smooth connection to the sea, maintenance dredging is needed to ensure the channel flow capacity because of the sand sedimentation in the estuary.

The design bed gradients are as follows:

| Stretch | Existing Channel | Designed Channel |
|---|---|---|
| River Mouth to San Juan (No. 0+000 to No. 8+735) | 1/33,000 | 1/29,000 |
| San Juan to Napindan Junction (No. 8+735 to No. 18+495) | 1/16,000 | 1/15,500 |
| Napindan to MCGS (No. 18+495 to No. 5+415) | 1/13,000 | 1/10,000 |

As for the channel bed stability of the above, it is very difficult to predict it since a large quantity of the Marikina floodwater is controlled by the Marikina Control Gate Structure and a big amount of discharge from the San Juan River will join the Pasig River. Therefore, the dynamic equilibrium of the bed is difficult to discuss. As a result, the periodical maintenance work by dreding is, from the practical viewpoint, needed to be ensured after completion, though the designed bed is set at 5.00 m in the river mouth considering the smooth connection to the sea without changing much the existing profile.

Cross Section

The cross sectional feature was set with a trapezoidal type section with 1:1 side slope for all stretches, providing a concrete revetment together with parapet wall or river wall.

At the river mouth, about 1.9 km stretch from No. 0+000 to No. 1+900 in which the revetment is not provided, trapezoidal section with 1:2 side slope was adopted.

Structural Features

The main work items and structural features of the proposed river improvement works are summarized as follows:

| Work Item/Structure | Quantity | Description |
|---|---|---|
| Excavation (dredging) | 2,884,000 $m^3$ | Mainly in the lower stretch of the river |
| Revetment (concrete block) | 114,000 $m^2$ | 5,000 m in total length |
| Parapet Wall (river wall) | 17,000 $m^3$ | Heightening of existing wall by 1.0 m |
| Bridge Reconstruction | | |
| - Pandacan Bridge | 137.6 m in span length | PNR Truss Bridge |
| - Marikina Control Gate Structure (MCGS) | Roller Gate 2 units x 17.5 m wide x 10.1 m high | Fixed & Movable Combined Type Weir |

8. PRELIMINARY STRUCTURAL DESIGN

8.1 Framework Plan

In the Framework Plan, the 100-year return period is adopted for the safety degree and design discharge of river works.

### 8.1.1 River System

Pasig-Marikina River Improvement

The river improvement works comprise improvement works for the Pasig, Marikina and San Juan rivers, and construction works of the Marikina Control Gate Structure and the Marikina Dam.

(1) Improved River Cross Section

From the river mouth to Sta. 7+425 upstream of Mangahan, the same design concept as the Feasibility Study in Section 8.3 was applied. Typical cross sections are presented in Fig. 4-8-1.

As for the upper stretch of the Marikina River from Sta. 7+425 upstream of Mangahan, dredging and diking with compound cross section area is proposed as shown in Fig. 4-8-2. For the San Juan river course, dredging and river wall construction are proposed. Fig. 4-8-3 shows the improved typical cross section of the San Juan River.

(2) Marikina Control Gate Structure (MCGS)

The same design concept as the Feasibility Study in Section 8.3 is adopted. A general drawing is presented in Fig. 4-8-4.

(3) Marikina Dam

The Marikina Dam is preliminarily designed based on the previously investigated data. The main design features of the Marikina Dam are as follows and the general features are shown in Fig. 4-8-5.

(a) Dam

| | | |
|---|---|---|
| Type | : | Concrete Gravity Type |
| Height | : | 70 m |
| Crest Length | : | 85 m |
| Spillway | : | Orifice Type (natural discharge regulation) |
| | | 4.7 m in width x 4.75 m in height x 3 units |

(b) Reservoir

Catchment Area : 280 $km^2$

Gross Storage Capacity : 25,000,000 $m^3$

Flood Control Capacity : 21,000,000 $m^3$

(c) Seepage Protection Works

To prevent seepage failure, concrete filling works at about 50,000 $m^2$ of the reservoir inside area will be required, since limestone foundation with many cracks and joints is distributed around the damsite.

Malabon-Tullahan River Improvement

Dredging and diking with 1:2 side slope are provided. Typical cross sections are shown in Fig. 4-8-6.

As for the Tullahan River, similar works as the Malabon River are required except for the upper stretch which has a relatively large natural flow capacity. (Refer to Fig. 4-3-2.)

Buli-Baho-Mahaba River Improvement

Since the existing flow capacity of these rivers are extremely small, a huge volume of excavation/dredging is required. Moreover, a channel (tentatively called Mangahan Diversion Channel) is provided along the Mangahan Floodway, and the three rivers of Buli, Baho and Mahaba are connected to this channel to drain the design discharge into the Laguna Lake. In the low-lying area near the lakeside, diking is provided. Both slopes of cut and embankment are at 1:2. Typical cross section of these rivers are shown in Fig. 4-8-7.

South Parañaque and Las Piñas River Improvement

Dredging and diking with 1:2 side slope are provided along the existing river courses. Their typical cross sections are presented in Fig. 4-8-8.

### 8.1.2 Laguna Lake System

Paranaque Spillway

The preliminary design features of the Parañaque Spillway are summarized as follows (refer to Fig. 4-8-9):

| | | |
|---|---|---|
| Type of Spillway | : | Trapezoidal Type Open Channel (Bottom Width: 60 m) |
| Length of Spillway | : | 9.2 km (incl. connecting river course) |
| Tide Control Gate | : | 1 site |

Longitudinal profile and typical cross sections are shown in Fig. 4-8-10.

Lakeshore Dike

A lakeshore dike is provided along the north Laguna lakeshore line. The design features of the lakeshore dike are as follows:

| | | |
|---|---|---|
| Shape of Dike | : | Earth dike with 1:2 revetted side slope |
| | | EL 14.2m; 9.1 m in width; 2.9 m in height incl. 1.7 m freeboard |
| Length of Dike | : | 10.7 km |

The location and typical cross section of the lakeshore dike are illustrated in Fig. 4-8-11.

## 8.2 Master Plan

In the master plan, the design discharge of a 100-year return period is also applied for the Pasig-Marikina river improvement. For the other rivers such as the Malabon-Tullahan River, the Buli-Baho-Mahaba River, and the South Parañaque-Las Piñas River, a 30-year return period is employed as the design discharge.

Pasig-Marikina River Improvement

The same structural design as the Framework Plan is adopted for all river courses.

Malabon-Tullahan River Improvement

Although the same design concept as the Framework Plan is basically applied for the existing river course, for the lower stretch of the Malabon River, rehabilitation works such as raising and reinforcing of existing river structures are provided in addition to the improvement works in the Framework Plan. Improved typical river cross sections are presented in Fig. 4-8-12.

Buli-Baho-Mahaba River Improvement

The same design concept as the Framework Plan is applied. However, the quantity of excavation/dredging works is reduced in accordance with the difference of design discharge, although there is a little difference between the quantities of diking in the two plans. Fig. 4-8-13 presents the improved typical cross sections of these rivers.

South Parañaque-Las Piñas River Improvement

The same design concept as the Framework Plan is applied. As for quantities of civil works, the same situation as the Buli-Baho-Mahaba River Improvement is recognized. Improved typical cross sections are shown in Fig. 4-8-14.

## 8.3 Priority Project

River improvement works of the Pasig-Marikina downstream of Mangahan is selected as a priority project for the feasibility study. The works comprise dredging, rehabilitation works for existing river wall, construction of the Marikina Control Gate Structure and reconstruction of the Pandacan Bridge (PNR).

Improved River Cross Section

Design cross section is set as a trapezoidal type with 1:1 side slope concrete revetment, parapet wall or river wall for all stretches in general. However, if the present river cross section has sufficient width to flow down the design discharge, only dredging of the riverbed or heightening of the existing parapet wall or river wall is provided.

As a result, improvement pattern of each river stretch becomes as follows (refer to Fig. 4-8-1).

| Stretch | Improvement Pattern |
|---|---|
| River mouth to San Juan (Sta. 0+000 to Sta. 8+735) | Dredging, raising of existing river wall or parapet wall and rehabilitation of bank protection.<br>Design bed width 450 m - 75 m, Trapezoidal section with 1:1 side slope. |
| San Juan to Napindan (Sta. 8+735 to Sta. 18+495) | Raising of existing river wall or parapet wall and rehabilitation of bank protection. |
| Napindan to MCGS (Sta. 18+495 to Sta. 5+425) | Principally no improvement and river wall or parapet wall for low elevation only. |
| MCGS to Mangahan Floodway (Sta. 5+425 to Sta. 6+375) | Dredging, providing new parapet wall or river wall and new bank protection.<br>Design bed width 75 m, Trapezoidal section with 1:1 side slope. |
| Upstream of Mangahan Floodway (Sta. 6+375 to Sta. 7+425) | Dredging, providing new parapet wall or river wall and new bank protection.<br>Design bed width 114 m, Trapezoidal section with 1:1 side slope. |

Marikina Control Gate Structure

(1) Design Condition

| | | | |
|---|---|---|---|
| Design discharge | : | 500 $m^3/s$ (same as design discharge of the Lower Marikina River) | |
| Design water level | : | EL 16.50 m (upstream side)<br>EL 14.20 m (downstream side) | |
| Design river section: | | Bed width | 75.00 m |
| | | Bank slope | 1:1 |
| | | Bed elevation | EL 6.50 m |

(2) Design of Gate

Japanese standard is applied in designing MCGS. The concept of the least construction cost is also applied. Design feature of MCGS is set as follows (refer to Fig. 5.2-2).

| | | |
|---|---|---|
| Gate span | : | 2 nos. and 20.00 m each width including piers |
| Gate height | : | 10.10 m |
| Gate type | : | Roller gate |

Gate span of 20.00 m is the required minimum width of gate in Japanese standards. Two gates are required to make the safe operation of MCGS in case one gate becomes inoperable during flood flow of the Marikina River. Roller gate is commonly used in other weirs such as Napindan HCGS and Rosario weir. As for the foundation, direct foundation is adopted as the design river bed is composed of lapilli tuff which has adequate bearing capacity for gate structure.

In order to pass 500 $m^3/s$ through MCGS, it is necessary to open the two gates of MCGS partially (3.0 m). If the two gates are fully opened and upstream and downstream water level of MCGS are fixed at the design water level, capacity of MCGS becomes about 1,550 $m^3/s$.

Reconstruction of Bridge

Design feature of the new Pandacan Bridge is as follows (refer to Fig. 4-8-15).

| | | |
|---|---|---|
| Length | : | 137.60 m |
| Width of railway | : | 5.40 m |
| Type | : | Steel plate girder |
| No. of spans | : | 3 spans (45.20 m each) |

In the Philippine standard, type of superstructure of railway bridge must be steel bridge and its span must be 9.00 m - 30.00 m. But to make the obstruction rate by the piers of the flow area to be less than 4.0%, it is necessary to make the span length to be more than 45.20 m. So, this span length is adopted. From the economical comparison study, steel plate girder bridge is considered as suitable type for the superstructure. Pile foundation of steel sheet pile with about 20 m in length is provided, so that it can reach the stiff layer of Guadalupe Formation which has enough bearing capacity.

# TABLES

Table 4-2-1 FEATURES OF MAIN RIVERS IN THE STUDY AREA

| River Basin/ Area | River/Channel | Length (km) | Catchment Area ($km^2$) | Remarks |
|---|---|---|---|---|
| 1. Pasig-Marikina River Basin | Pasig River | 18 | 13.0 | Discharge into Manila Bay |
| | Marikina River | 60 | 530.0 | Join Pasig River |
| | San Juan River | 14 | 91.4 | Join Pasig River |
| | Napindan Channel | 8 | 21.7 | Connect Pasig River and Laguna Lake |
| | Mangahan Floodway | 9 | - | Connect Marikina River and Laguna Lake |
| 2. Meycauayan River Basin | Meycauayan River | 40 | 168.7 | Discharge into Manila Bay |
| 3. Malabon-Tullahan River Basin | Malabon-Tullahan River | 26 | 69.2 | Discharge into Manila Bay |
| | Navotas River | 7 | 30.1 | Discharge into Manila Bay |
| 4. Baho and Buli River Basins | Buli River | 2 | 4.5 | Discharge into Laguna Lake |
| | Baho River | 14 | 59.4 | Discharge into Mangahan Floodway |
| | Mahaba River | 9 | 10.5 | Discharge into Laguna Lake |
| 5. Parañaque and Las Piñas River Basins | Parañaque River | 4 | 8.8 | Discharge into Manila Bay |
| | Dongalo River | 5 | 14.9 | Join South Parañaque River |
| | South Parañaque River | 10 | 19.2 | Discharge into Manila Bay |
| | San Dionisio River | 4 | 6.6 | Connect South Parañaque River and Las Piñas River |
| | Las Piñas River | 12 | 16.0 | Discharge into Manila Bay |
| | Zapote River | 16 | 45.2 | Discharge into Manila Bay |

Table 4-3-1 ESTIMATED FLOW CAPACITY OF MAIN RIVERS IN THE STUDY AREA (EXCEPT PASIG-MARIKINA RIVER)

(Unit: $m^3/s$)

| River | Initial Water Stage for Non-Uniform Calculation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sea Level | | | | Laguna Lake Stage | | | |
| | Mean Spring High Tide (Ho = 11.30) | | Mean Sea Level (Ho = 10.46) | | Recorded Highest Stage (Ho = 14.00) | | Mean Annual Highest Stage (Ho = 12.50) | |
| | Lower Reach | Middle Reach | Lower Reach | Middle Reach | Lower Reach | Middle Reach | Lower Reach | Middle Reach |
| Meycauayan | 0 | 0 | 0 | 200 | - | - | - | - |
| Malabon-Tullahan | 0 | 50 | 30 | 100 | - | - | - | - |
| Navotas | 0 | - | 100 | - | - | - | - | - |
| Buli | - | - | - | - | 0 | 5 | 30 | 10 |
| Baho | - | - | - | - | 0 | 10 | 50 | 20 |
| Mahaba | - | - | - | - | 0 | 3 | 5 | 5 |
| Parañaque | 0 | - | 50 | - | - | - | - | - |
| Dongalo | 0 | 0 | 50 | 50 | - | - | - | - |
| South Parañaque | 20 | 0 | 70 | 50 | - | - | - | - |
| San Dionisio | 0 | 0 | 5 | - | - | - | - | - |
| Las Piñas | 0 | 10 | 30 | 30 | - | - | - | - |
| Zapote | 0 | 10 | 50 | 50 | - | - | - | - |

Table 4-3-2 COST ALLOCATION BETWEEN MARIKINA DAM AND RIVER IMPROVEMENT

PASIG-MARIKINA RIVER (100-Yr)

| Section | Stretch | Length (M) | Design Discharge Q(1) (m3/s) | Cost (mill.p) | Design Discharge Q(2) (m3/s) | Cost (mill.p) | Design Discharge Q(3) (m3/s) | Cost (mill.p) | Design Discharge Q(4) (m3/s) | Cost (mill.p) | Design Discharge Q(5) (m3/s) | Cost (mill.p) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Pasig River-Lower Marikina River | | | | | | | | | | | | |
| River Mouth/San Juan c. | Sta. 0+000/ 8+735 | 8,735 | 1550 | 1,136 | 1350 | 814 | 1150 | 706 | 1000 | 633 | 1000 | 633 |
| San Juan c./Napindan c. | Sta. 8+735/18+495 | 9,760 | 1100 | 359 | 750 | 296 | 500 | 257 | 350 | 243 | 0 | 122 |
| Napindan c./M.C.G.S. | Sta.18+495/ 5+425 | 5,580 | 1100 | 84 | 750 | 73 | 500 | 63 | 350 | 59 | 0 | 10 |
| M.C.G.S. /Mangahan C. | Sta. 5+425/ 6+635 | 1,210 | 1100 | 56 | 750 | 48 | 500 | 42 | 350 | 40 | 0 | 10 |
| Mangahan C./Sta.7+425 | Sta. 6+635/ 7+425 | 790 | 3500 | 51 | 3150 | 44 | 2900 | 38 | 2750 | 36 | 2400 | 30 |
| M.C.G.S. | | | 1100 | 294 | 750 | 251 | 500 | 184 | 350 | 178 | 0 | 123 |
| San Juan River | Sta. 0+000/10+653 | 10,653 | 900 | 757 | 900 | 757 | 900 | 757 | 900 | 757 | 900 | 757 |
| Sub-total | | 36,728 | | 2,739 | | 2,284 | | 2,047 | | 1,946 | | 1,685 |
| 2 Upper Marikina River | | | | | | | | | | | | |
| Sta. 7+425 /Nangka c. | Sta. 7+425/18+620 | 11,195 | 3500 | 1,226 | 3150 | 1,041 | 2900 | 831 | 2750 | 785 | 2400 | 649 |
| Nangka c. /Rodorigez B. | Sta.18+620/27+200 | 8,580 | 3050 | 986 | 2800 | 847 | 2600 | 735 | 2400 | 694 | 2050 | 568 |
| Sub-total | | 19,775 | | 2,212 | | 1,888 | | 1,566 | | 1,478 | | 1,217 |
| Total (1+2) | | 56,503 | | 4,951 | | 4,172 | | 3,613 | | 3,424 | | 2,901 |
| 3 Marikina Dam | Design Discharge=Dam Cut | | 0 | 0 | 350 | 420 | 600 | 800 | 750 | 1,100 | 1100 | 1,950 |
| G.Total (1+2+3) | | | | 4,951 | | 4,592 | | 4,413 | | 4,524 | | 4,851 |

Table 4-5-1. FEATURES OF FLOOD CONTROL PLANS FOR MAJOR RIVERS IN THE PHILIPPINES

| RIVER | RIVER BASIN CONDITIONS | | | | | | FLOOD CONTROL PLAN | | |
|---|---|---|---|---|---|---|---|---|---|
| | LOCATION | RIVER LENGTH (km) | BASIN AREA (km2) | POPULATION (x1000) | MAJOR LAND USE | PROVINCIAL CAPITAL | RETURN PERIOD | DESIGN DISCHARGE (m3/s) | SPECIFIC DISCHARGE (m3/s/km2) |
| 1. Tagoloan | N. Mindanao | 106 | 1,778 | 135 | Coconut & Industry | --- | 50-yr. | 3,840 | 2.16 |
| 2. Agusan | N. Mindanao | 350 | 11,700 | 995 | Paddy, Corn & Marsh | Butuan | 100-yr. | 8,000 | 0.68 |
| 3. Mindanao | W. Mindanao | 373 | 20,260 | 1,763 | Paddy, Corn & Marsh | Cotabato | 100-yr. | 8,000 | 0.12 |
| 4. Laoag | N. Luzon | 73 | 1,353 | 156 | Paddy | Laog | 50-yr. | 10,500 | 7.76 |
| 5. Amnay | W. Mindanao | 58 | 993 | 38 | Paddy | --- | 50-yr. | 4,460 | 4.49 |
| 6. Agno | C. Luzon | 206 | 5,697 | 1,737 | Paddy | --- | 100-yr. | 17,800 | 3.12 |
| 7. Cagayan | N. Luzon | 505 | 27,280 | 2,194 | Paddy | Tuguegarao | 100-yr. | 21,750 | 0.79 |
| 8. Panay | N. Panay | 152 | 2,068 | 387 | Paddy & Sugarcane | Capiz | 100-yr. | 3,950 | 1.91 |
| 9. Pampanga | C. Luzon | 260 | 10,503 | 4,054 | Paddy | San Fernando | 100-yr. | 7,900 | 0.75 |
| 10. Bicol | S. Luzon | 136 | 3,132 | 821 | Paddy | Naga | 100-yr. | 4,580 | 1.46 |
| 11. Jalaur | S. Panay | 123 | 1,742 | 394 | Paddy & Sugarcane | --- | 100-yr. | 3,780 | 2.17 |
| 12. Ilog | W. Negros | 124 | 2,104 | 227 | Sugarcane | --- | 50-yr. | 3,640 | 1.73 |

Table 4-5-2(1/3) CONSTRUCTION COST OF FRAMEWORK PLAN

PASIG-MARIKINA RIVER IMPROVEMENT (100-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| River Mouth/San Juan C. | Sta. 0+000/ 8+735 | 8,735 | 1150 | 2,334 | 0 | 40 | 3 | 0 | 1 | 20 | 546 | 60 | 706 |
| San Juan C./Napindan C. | Sta. 8+735/18+495 | 9,760 | 500 | 300 | 0 | 60 | 10 | 0 | 0 | 15 | 212 | 45 | 257 |
| Napindan C./M.C.G.S. | Sta.18+495/ 5+425 | 5,580 | 500 | 100 | 10 | 10 | 1 | 0 | 0 | 8 | 39 | 24 | 63 |
| M.C.G.S. /Mangahan C. | Sta. 5+425/ 6+635 | 1,210 | 500 | 100 | 0 | 2 | 1 | 0 | 0 | 15 | 24 | 18 | 42 |
| Mangahan C./Sta.7+425 | Sta. 6+635/ 7+425 | 790 | 2900 | 50 | 5 | 2 | 2 | 0 | 0 | 10 | 26 | 12 | 38 |
| M.C.G.S. | | | 500 | 30 | 6 | 0 | 22 | 300 | 0 | 1 | 183 | 1 | 184 |
| San Juan River | Sta. 0+000/10+653 | 10,653 | 900 | 1,820 | 0 | 175 | 43 | 0 | 4 | 50 | 580 | 177 | 757 |
| | Sub-Total | 36,728 | | 4,734 | 21 | 289 | 82 | 300 | 5 | 119 | 1,710 | 337 | 2,047 |
| Sta.7+425 /Nangka C. | Sta. 7+425/18+620 | 11,195 | 2900 | 2,493 | 555 | 109 | 46 | 0 | 0 | 950 | 497 | 334 | 831 |
| Nangka C. /Rodorigez B. | Sta.18+620/27+200 | 8,580 | 2600 | 1,596 | 692 | 0 | 0 | 0 | 0 | 1,753 | 218 | 517 | 735 |
| Marikina Dam (Qcut=600m3/s) | | | 2100 | 40 | 0 | 0 | 120 | 0 | 0 | 2,500 | 675 | 125 | 800 |
| | Sub-Total | 19,775 | | 4,129 | 1,246 | 109 | 166 | 0 | 0 | 5,203 | 1,390 | 976 | 2,366 |
| | Total | 56,503 | | 8,863 | 1,267 | 398 | 248 | 300 | 5 | 5,322 | 3,100 | 1,313 | 4,413 |
| Paranaque Spillway(C. Bottom Width : 60m) | | 9,000 | | 7,600 | 45 | 30 | 50 | 590 | 5 | 580 | 3,476 | 524 | 4,000 |
| | G.Total | 56,503 | | 16,463 | 1,312 | 428 | 298 | 890 | 10 | 5,902 | 6,576 | 1,837 | 8,413 |

Table 4-5-2(2/3) CONSTRUCTION COST OF FRAMEWORK PLAN

BAHO BULI MAHABA RIVER IMPROVEMENT (100-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mahaba River | Sta. 0+000/ 5+000 | 5,000 | 190 | 475 | 43 | 0 | 0 | 0 | 6 | 210 | 78 | 159 | 237 |
| | Sta. 5+000/ 6+000 | 1,000 | 190 | 12 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 4 |
| | Sub-Total | 6,000 | | 487 | 43 | 0 | 0 | 0 | 6 | 213 | 79 | 162 | 241 |
| Baho River | Sta. 0+000/ 5+500 | 5,500 | 335 | 682 | 37 | 0 | 0 | 0 | 7 | 209 | 112 | 146 | 258 |
| | Sta.A0+000/A2+000 | 2,000 | 280 | 231 | 4 | 0 | 0 | 0 | 3 | 63 | 35 | 19 | 54 |
| | Sta.A2+000/A3+000 | 1,000 | 280 | 49 | 0 | 0 | 0 | 0 | 0 | 10 | 5 | 3 | 8 |
| | Sub-Total | 8,500 | | 962 | 41 | 0 | 0 | 0 | 10 | 282 | 152 | 168 | 320 |
| Buli River | Sta. 0+000/6A+200 | 3,100 | 330 | 292 | 44 | 0 | 0 | 0 | 4 | 98 | 82 | 86 | 168 |
| | Sta.6A+200/8A+200 | 2,000 | 280 | 304 | 6 | 0 | 0 | 0 | 3 | 73 | 45 | 22 | 67 |
| | Sta.8A+200/9A+830 | 1,630 | 280 | 207 | 16 | 0 | 0 | 0 | 1 | 74 | 40 | 22 | 62 |
| | Sta.9A+830/10+480 | 650 | 280 | 85 | 7 | 0 | 0 | 0 | 1 | 32 | 14 | 38 | 52 |
| | Sta.10+480/14+000 | 2,520 | 200 | 317 | 20 | 0 | 0 | 0 | 3 | 113 | 57 | 135 | 192 |
| | Sta.14+000/15+000 | 1,000 | 200 | 73 | 0 | 0 | 0 | 0 | 1 | 19 | 21 | 23 | 44 |
| | Sub-Total | 10,900 | | 1,278 | 93 | 0 | 0 | 0 | 13 | 409 | 259 | 326 | 585 |
| Tributary-B | Sta. 0+000/ 5+000 | 5,000 | 110 | 414 | 13 | 0 | 0 | 0 | 3 | 144 | 70 | 43 | 113 |
| | Sta. 5+000/ 6+000 | 1,000 | 110 | 24 | 2 | 0 | 0 | 0 | 2 | 14 | 7 | 4 | 11 |
| | Sub-Total | 6,000 | | 438 | 15 | 0 | 0 | 0 | 5 | 158 | 77 | 47 | 124 |
| Tributary-C | Sta. 0+000/ 4+000 | 4,000 | 80 | 170 | 4 | 0 | 0 | 0 | 3 | 60 | 30 | 52 | 82 |
| | Sta. 4+000/ 5+000 | 1,000 | 80 | 183 | 0 | 0 | 0 | 0 | 0 | 5 | 2 | 2 | 4 |
| | Sub-Total | 5,000 | | 353 | 4 | 0 | 0 | 0 | 3 | 65 | 32 | 54 | 86 |
| Mangahan Diversion | Sta. 6+800/ 6+100 | 700 | 570 | 1,059 | 18 | 0 | 0 | 0 | 0 | 219 | 159 | 65 | 224 |
| | Sta. 6+100/ 4+500 | 1,600 | 520 | 1,023 | 0 | 0 | 0 | 0 | 0 | 170 | 156 | 51 | 207 |
| | Sta. 4+500/ 3+000 | 1,500 | 340 | 499 | 29 | 0 | 0 | 0 | 0 | 114 | 56 | 34 | 90 |
| | Sub-Total | 3,800 | | 2,581 | 47 | 0 | 0 | 0 | 0 | 503 | 371 | 150 | 521 |
| | Total | 40,200 | | 6,100 | 242 | 0 | 0 | 0 | 37 | 1,630 | 970 | 907 | 1,877 |

Table 4-5-2(3/3) CONSTRUCTION COST OF FRAMEWORK PLAN

MALABON-TULLAHAN RIVER IMPROVEMENT (100-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Malabon River | Sta. 0+000/ 2+835 | 2,835 | 570 | 1,132 | 140 | 68 | 0 | 0 | 3 | 75 | 156 | 90 | 246 |
| | Sta. 2+835/ 4+377 | 1,542 | 550 | 198 | 59 | 20 | 0 | 0 | 0 | 42 | 36 | 50 | 87 |
| | Sta. 4+377/ 5+427 | 1,050 | 520 | 77 | 91 | 11 | 0 | 0 | 3 | 15 | 94 | 18 | 112 |
| | Sub-Total | 5,427 | | 1,407 | 289 | 99 | 0 | 0 | 6 | 132 | 287 | 158 | 445 |
| Tullahan River | Sta. 0+000/ 4+800 | 4,800 | 480 | 452 | 160 | 0 | 0 | 0 | 0 | 87 | 280 | 104 | 384 |
| | Sta. 4+800/18+000 | 13,200 | 330 | 23 | 0 | 0 | 0 | 0 | 0 | 26 | 47 | 31 | 78 |
| | Sta.18+000/20+500 | 2,500 | 240 | 11 | 24 | 0 | 0 | 0 | 0 | 7 | 16 | 8 | 24 |
| | Sta.20+500/21+500 | 1,000 | 240 | 11 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 2 | 7 |
| | Sub-Total | 21,500 | | 497 | 184 | 0 | 0 | 0 | 0 | 122 | 347 | 146 | 493 |
| | Total | 26,927 | | 1,904 | 473 | 99 | 0 | 0 | 6 | 254 | 634 | 305 | 938 |

SOUTH PARANAQUE LAS PINAS RIVER IMPROVEMENT (100-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Las Pinas River | Sta. 0+000/ 1+780 | 1,780 | 250 | 227 | 100 | 3 | 0 | 0 | 2 | 32 | 132 | 38 | 171 |
| | Sta. 1+780/ 6+395 | 4,615 | 220 | 624 | 118 | 25 | 0 | 0 | 2 | 135 | 151 | 162 | 313 |
| | Sta. 6+395/ 7+395 | 1,000 | 130 | 38 | 0 | 7 | 0 | 0 | 0 | 4 | 15 | 5 | 20 |
| | Sub-Total | 7,395 | | 889 | 218 | 35 | 0 | 0 | 4 | 171 | 298 | 205 | 503 |
| South Paranaque River | Sta. 0+000/ 0+560 | 560 | 630 | 95 | 12 | 4 | 0 | 0 | 0 | 5 | 26 | 6 | 32 |
| | Sta.D0+000/D0+400 | 400 | 630 | 95 | 24 | 0 | 0 | 0 | 0 | 2 | 64 | 2 | 67 |
| | Sta.D0+400/S0+000 | 400 | 430 | 113 | 18 | 0 | 0 | 0 | 0 | 11 | 14 | 13 | 27 |
| | Sta.S0+000/S1+200 | 1,200 | 430 | 302 | 86 | 0 | 0 | 0 | 0 | 46 | 45 | 37 | 82 |
| | Sta.S1+200/S2+600 | 1,400 | 370 | 340 | 39 | 0 | 0 | 0 | 0 | 72 | 53 | 58 | 110 |
| | Sta.S2+600/S3+600 | 1,000 | 370 | 113 | 3 | 0 | 0 | 0 | 0 | 20 | 13 | 16 | 29 |
| | Sub-Total | 4,960 | | 1,060 | 183 | 4 | 0 | 0 | 0 | 156 | 214 | 132 | 346 |
| Dongalo River | Sta. 0+000/ 2+600 | 2,600 | 200 | 265 | 48 | 16 | 0 | 0 | 0 | 30 | 80 | 24 | 104 |
| | Sta. 2+600/ 3+600 | 1,000 | 200 | 38 | 2 | 7 | 0 | 0 | 0 | 8 | 16 | 6 | 23 |
| | Sub-Total | 3,600 | | 302 | 50 | 23 | 0 | 0 | 0 | 38 | 97 | 30 | 127 |
| | Total | 15,955 | | 2,251 | 451 | 62 | 0 | 0 | 4 | 365 | 609 | 368 | 977 |

Table 4-6-1(1/2) FLOODING WATER STAGE OF RIVERS
(Pasig-Marikina River)

| Name of Station | Station No. | Inundation Water Stage (El.m) 100-yr. | 50-yr. | 30-yr | 20-yr. | 10-yr. | 5-yr. | 2-yr. |
|---|---|---|---|---|---|---|---|---|
| Pasig-Marikina River | | | | | | | | |
| (Pasig River) | | | | | | | | |
| P-1 | 1+900 | 11.73 | 11.69 | 11.65 | 11.64 | 11.60 | 11.55 | 11.49 |
| P-2 | 2+980 | 12.24 | 12.16 | 12.07 | 12.06 | 11.97 | 11.86 | 11.71 |
| P-3 | 3+935 | 12.47 | 12.38 | 12.27 | 12.25 | 12.14 | 12.01 | 11.83 |
| P-4 | 4+695 | 12.58 | 12.47 | 12.36 | 12.34 | 12.22 | 12.08 | 11.88 |
| P-5 | 5+605 | 12.85 | 12.73 | 12.60 | 12.58 | 12.44 | 12.28 | 12.04 |
| P-6 | 6+480 | 13.08 | 12.95 | 12.81 | 12.78 | 12.63 | 12.45 | 12.18 |
| P-7 | 7+295 | 13.32 | 13.18 | 13.02 | 12.99 | 12.82 | 12.61 | 12.31 |
| P-8 | 8+095 | 13.37 | 13.23 | 13.08 | 13.05 | 12.88 | 12.67 | 12.37 |
| P-9 | 9+695 | 13.85 | 13.69 | 13.51 | 13.47 | 13.28 | 13.02 | 12.65 |
| P-10 | 10+745 | 13.92 | 13.77 | 13.59 | 13.51 | 13.36 | 13.09 | 12.70 |
| P-11 | 11+495 | 14.02 | 13.86 | 13.68 | 13.64 | 13.45 | 13.17 | 12.76 |
| P-12 | 12+315 | 13.14 | 13.99 | 13.81 | 13.77 | 13.58 | 13.28 | 12.84 |
| P-13 | 13+295 | 14.30 | 14.15 | 13.97 | 13.93 | 13.73 | 13.41 | 12.94 |
| P-14 | 14+290 | 14.38 | 14.23 | 14.06 | 14.01 | 13.82 | 13.49 | 13.01 |
| P-15 | 15+295 | 14.62 | 14.48 | 14.31 | 14.26 | 14.07 | 13.71 | 13.18 |
| P-16 | 16+315 | 14.84 | 14.70 | 14.53 | 14.48 | 14.29 | 13.91 | 13.34 |
| P-17 | 17+185 | 14.99 | 14.85 | 14.67 | 14.62 | 14.43 | 14.03 | 13.44 |
| P-18 | 18+165 | 15.10 | 14.96 | 14.79 | 14.73 | 14.54 | 14.13 | 13.52 |
| P-19 | 18+495 | 15.17 | 15.03 | 14.85 | 14.80 | 14.60 | 14.19 | 13.56 |
| (Marikina River) | | | | | | | | |
| M-1 | 0+980 | 15.23 | 15.09 | 14.92 | 14.86 | 14.67 | 14.25 | 13.61 |
| M-2 | 1+780 | 15.27 | 15.13 | 14.96 | 14.90 | 14.70 | 14.28 | 13.64 |
| M-3 | 2+710 | 15.34 | 15.20 | 15.02 | 14.96 | 14.76 | 14.33 | 13.68 |
| M-4 | 3+700 | 15.41 | 15.26 | 15.09 | 15.02 | 14.82 | 14.38 | 13.72 |
| M-5 | 4+660 | 15.52 | 15.36 | 15.18 | 15.12 | 14.90 | 14.46 | 13.79 |
| M-6 | 5+595 | 15.71 | 15.55 | 15.35 | 15.28 | 15.05 | 14.61 | 13.92 |
| M-7 | 6+635 | 15.21 | 16.03 | 15.83 | 15.75 | 15.49 | 15.03 | 14.32 |
| M-8 | 7+615 | 18.09 | 17.82 | 17.52 | 17.41 | 17.03 | 16.43 | 15.58 |
| M-9 | 8+575 | 18.93 | 18.65 | 18.34 | 18.22 | 17.83 | 17.19 | 16.29 |
| M-10 | 9+465 | 19.43 | 19.15 | 18.83 | 18.72 | 18.31 | 17.66 | 16.74 |
| M-11 | 10+410 | 19.69 | 19.42 | 19.11 | 19.00 | 18.61 | 17.98 | 17.09 |
| M-12 | 11+175 | 20.10 | 19.83 | 19.52 | 19.41 | 19.02 | 18.38 | 17.46 |
| M-13 | 12+125 | 20.90 | 20.60 | 20.27 | 20.15 | 19.73 | 19.04 | 18.06 |
| M-14 | 13+120 | 21.32 | 21.01 | 20.66 | 20.54 | 20.07 | 19.39 | 18.43 |
| M-15 | 14+120 | 21.67 | 21.34 | 20.98 | 20.84 | 20.33 | 19.65 | 18.68 |
| M-16 | 15+120 | 22.86 | 22.45 | 22.02 | 21.86 | 21.22 | 20.47 | 19.43 |
| M-17 | 16+120 | 23.31 | 22.86 | 22.39 | 22.21 | 21.52 | 20.76 | 19.70 |
| M-18 | 17+120 | 23.44 | 23.00 | 22.54 | 22.38 | 21.72 | 21.00 | 20.08 |
| M-19 | 18+120 | 23.76 | 23.33 | 22.89 | 22.73 | 22.10 | 21.46 | 20.68 |
| M-20 | 19+220 | 23.95 | 23.53 | 23.08 | 22.93 | 22.30 | 21.67 | 20.90 |
| M-21 | 19+850 | 24.00 | 23.58 | 23.14 | 22.98 | 22.36 | 21.74 | 20.97 |
| M-22 | 20+600 | 24.17 | 23.77 | 23.37 | 22.21 | 22.68 | 22.16 | 21.60 |
| M-23 | 21+400 | 24.78 | 24.46 | 24.15 | 24.01 | 23.52 | 23.09 | 22.77 |
| M-24 | 22+150 | 25.44 | 25.18 | 24.93 | 24.79 | 24.22 | 23.72 | 23.36 |
| M-25 | 23+080 | 26.11 | 25.86 | 25.62 | 25.48 | 25.09 | 24.74 | 24.39 |

Table 4-6-1(2/2) FLOODING WATER STAGE OF RIVERS
(Pasig-Marikina River)

| Name of Station | Station No. | Inundation Water Stage (El.m) 100-yr. | 50-yr. | 30-yr | 20-yr. | 10-yr. | 5-yr. | 2-yr. |
|---|---|---|---|---|---|---|---|---|
| (Marikina River, Cont'd) | | | | | | | | |
| M-26 | 24+910 | 27.00 | 26.75 | 26.49 | 26.33 | 25.96 | 25.55 | 25.12 |
| M-27 | 25+910 | 27.52 | 27.25 | 26.97 | 26.81 | 26.42 | 25.99 | 25.51 |
| M-28 | 26+780 | 27.87 | 27.59 | 27.31 | 27.13 | 26.74 | 26.28 | 25.78 |
| M-29 | 27+200 | 27.85 | 27.58 | 27.30 | 27.13 | 26.75 | 26.31 | 25.81 |
| (Inundation Area: East Side Lowland of Mangahan) | | | | | | | | |
| E-1 | 0+000 | 13.35 | 13.15 | 12.95 | 12.88 | --- | --- | --- |
| E-2 | 0+900 | 15.12 | 14.65 | 14.16 | 13.99 | --- | --- | --- |
| E-3 | 1+800 | 16.24 | 15.90 | 15.57 | 15.45 | --- | --- | --- |
| E-4 | 2+500 | 16.96 | 16.66 | 16.38 | 16.29 | --- | --- | --- |
| E-5 | 3+300 | 17.11 | 16.77 | 16.44 | 16.34 | --- | --- | --- |
| E-6 | 4+250 | 17.21 | 16.85 | 16.51 | 16.40 | --- | --- | --- |
| E-7 | 5+100 | 17.36 | 16.99 | 16.62 | 16.50 | --- | --- | --- |
| E-8 | 6+100 | 17.85 | 17.55 | 17.26 | 17.17 | --- | --- | --- |
| E-9 | 7+300 | 18.82 | 18.56 | 18.30 | 18.22 | --- | --- | --- |
| E-10 | 8+300 | 19.58 | 19.32 | 19.03 | 18.90 | --- | --- | --- |
| E-11 | 9+300 | 20.25 | 19.99 | 19.72 | 19.60 | --- | --- | --- |
| E-12 | 10+200 | 20.83 | 20.54 | 20.12 | 20.09 | --- | --- | --- |
| (Inundation Area: West Side Lowland of Mangahan) | | | | | | | | |
| W-1 | 0+000 | 12.57 | 12.54 | 12.52 | 12.51 | --- | --- | --- |
| W-2 | 1+000 | 12.77 | 12.66 | 12.58 | 12.56 | --- | --- | --- |
| W-3 | 2+000 | 13.32 | 13.18 | 13.04 | 13.00 | --- | --- | --- |
| W-4 | 3+000 | 13.94 | 13.75 | 13.56 | 13.49 | --- | --- | --- |
| W-5 | 4+000 | 14.08 | 13.87 | 13.64 | 13.57 | --- | --- | --- |
| W-6 | 5+000 | 14.59 | 14.44 | 14.26 | 14.20 | --- | --- | --- |
| W-7 | 5+800 | 15.27 | 15.13 | 14.96 | 14.90 | --- | --- | --- |
| (San Juan River) | | | | | | | | |
| S-1 | 0+000 | 13.60 | 13.45 | 13.30 | 13.25 | 13.10 | 12.85 | 12.50 |
| S-2 | 1+000 | 14.18 | 14.02 | 13.90 | 13.81 | 13.61 | 13.37 | 13.02 |
| S-3 | 2+000 | 14.56 | 14.40 | 14.29 | 14.19 | 13.96 | 13.74 | 13.40 |
| S-4 | 2+975 | 15.31 | 15.16 | 15.09 | 14.96 | 14.71 | 14.52 | 14.20 |
| S-5 | 4+130 | 16.32 | 16.15 | 16.10 | 15.94 | 15.64 | 15.44 | 15.09 |
| S-6 | 5+130 | 16.79 | 16.63 | 16.57 | 16.41 | 16.12 | 15.93 | 15.59 |
| S-7 | 6+000 | 17.25 | 17.10 | 17.04 | 16.89 | 16.62 | 16.44 | 16.12 |
| S-8 | 7+000 | 18.06 | 17.91 | 17.85 | 17.70 | 17.43 | 17.25 | 16.93 |
| S-9 | 7+690 | 18.61 | 18.45 | 18.39 | 18.23 | 17.96 | 17.78 | 17.50 |

Table 4-6-2 FLOODING WATER STAGE OF RIVERS
(Buli-Baho-Mahaba River)

| Name of Station | Station No. | Inundation Water Stage (El.m) 100-yr. | 50-yr. | 30-yr | 20-yr. | 10-yr. | 5-yr. | 2-yr. |
|---|---|---|---|---|---|---|---|---|
| (Buli River) | | | | | | | | |
| Bu-1 | 1+000 | 15.30 | 15.10 | 14.80 | 14.45 | 14.20 | 14.10 | 14.00 |
| Bu-2 | 2+000 | 16.75 | 16.68 | 16.62 | 16.61 | 16.58 | 16.53 | 16.46 |
| (Baho River) | | | | | | | | |
| Ba-1 | 3+000 | 16.10 | 15.80 | 15.60 | 15.40 | 15.30 | 15.10 | 15.00 |
| Ba-2 | 4+000 | 17.42 | 17.34 | 17.27 | 17.25 | 17.19 | 17.11 | 17.02 |
| Ba-3 | 5+000 | 19.42 | 19.20 | 19.01 | 18.94 | 18.79 | 18.54 | 18.22 |
| Ba-4 | 6+000 | 17.70 | 17.57 | 17.44 | 17.38 | 17.27 | 17.06 | 16.63 |
| Ba-5 | 7+000 | 18.56 | 18.43 | 18.32 | 18.27 | 18.20 | 17.99 | 17.51 |
| Ba-6 | 8+000 | 19.75 | 19.57 | 19.40 | 19.34 | 19.24 | 18.91 | 18.09 |
| Ba-7 | 9+000 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 |
| (Mahaba River) | | | | | | | | |
| Ma-1 | 3+000 | 16.90 | 16.70 | 16.50 | 16.20 | 16.10 | 15.90 | 15.70 |
| Ma-2 | 4+000 | 19.19 | 19.05 | 18.96 | 18.93 | 18.83 | 18.71 | 18.59 |
| Ma-3 | 5+000 | 21.68 | 21.56 | 21.46 | 21.43 | 21.39 | 21.34 | 21.26 |
| Pond-1 | | 19.36 | 19.33 | 19.32 | 19.31 | 19.30 | 19.27 | 19.20 |
| Pond-2 | | 14.42 | 14.30 | 14.20 | 14.16 | 14.05 | 13.93 | 13.78 |

Table 4-6-3 FLOODING WATER STAGE OF RIVERS
(Malabon-Tullahan River)

| Name of Station | Station No. | Inundation Water Stage (El.m) 100-yr. | 50-yr. | 30-yr | 20-yr. | 10-yr. | 5-yr. | 2-yr. |
|---|---|---|---|---|---|---|---|---|
| (Tullahan River) | | | | | | | | |
| T-1 | 1+000 | 12.95 | 12.75 | 12.66 | 12.53 | 12.32 | 12.18 | 11.97 |
| T-2 | 2+000 | 13.64 | 13.48 | 13.40 | 13.28 | 13.11 | 12.92 | 12.62 |
| T-3 | 3+000 | 14.91 | 14.62 | 14.49 | 14.29 | 13.95 | 13.70 | 13.24 |
| T-4 | 4+000 | 15.60 | 15.40 | 15.20 | 15.10 | 14.80 | 14.60 | 14.10 |
| T-5 | 5+000 | 17.20 | 17.10 | 17.00 | 16.80 | 16.50 | 16.30 | 15.80 |
| Pond-3 | | 12.97 | 12.83 | 12.76 | 12.67 | 12.52 | 12.38 | 11.93 |

Table 4-6-4 FLOODING WATER STAGE OF RIVERS
(South Paranaque-Las Pinas River)

| Name of Station | Station No. | Inundation Water Stage (El.m) 100-yr. | 50-yr. | 30-yr | 20-yr. | 10-yr. | 5-yr. | 2-yr. |
|---|---|---|---|---|---|---|---|---|
| (Dongaro River) | | | | | | | | |
| D-1 | | | | | | | | |
| D-2 | 2+000 | 13.55 | 13.34 | 13.27 | 13.21 | 13.12 | 13.01 | 12.84 |
| D-3 | 3+000 | 15.96 | 15.75 | 15.62 | 15.53 | 15.39 | 15.23 | 15.03 |
| (South Paranaque River) | | | | | | | | |
| S-1 | 3+200 | 14.50 | 14.40 | 14.20 | 14.10 | 14.00 | 13.80 | 13.60 |
| (Las Pinas River) | | | | | | | | |
| L-1 | | | | | | | | |
| L-2 | 5+000 | 17.04 | 16.91 | 16.81 | 16.74 | 16.59 | 16.41 | 16.22 |
| L-3 | 6+000 | 18.81 | 18.60 | 18.52 | 18.44 | 18.33 | 18.24 | 18.14 |
| Pond-4 | | 12.19 | 12.06 | 11.95 | 11.91 | 11.85 | 11.78 | 11.69 |

TABLE 4-6-5 BENEFIT/COST RATIOS OF ALTERNATIVE CASES ON THE 2020-YEAR LAND USE CONDITIONS

| RIVER SYSTEM | BENEFIT/COST RATIOS | | | | |
|---|---|---|---|---|---|
| | 100-YR | 50-YR | 30-YR | 20-YR | 10-YR |
| PASIG MARIKINA | 1.32 | 1.38 | 1.38 | 1.35 | 1.28 |
| BULI BAHO MAHABA | 0.73 | 0.82 | 0.84 | 0.83 | 0.78 |
| MALABON TULLAHAN | 0.73 | 0.88 | 0.98 | 1.04 | 1.14 |
| S.PARANAQUE LAS PINAS | 0.98 | 1.07 | 1.13 | 1.16 | 1.19 |

| DRAINAGE AREA | BENEFIT/COST RATIOS | | | |
|---|---|---|---|---|
| | 10-YR | 5-YR | 3-YR | 2-YR |
| MANILA | 1.17 | --- | --- | --- |
| MALABON NAVOTAS | 2.40 | 2.49 | 2.50 | 2.29 |
| EAST OF MANGAHAN | 1.77 | 1.89 | 1.94 | 1.88 |
| WEST OF MANGAHAN | 1.97 | 2.19 | 2.38 | 2.57 |
| SAN JUAN | 0.81 | 0.83 | 0.79 | 0.69 |
| MANDALUYONG PASIG | 1.36 | 1.42 | 1.45 | 1.65 |
| MARIKINA | 1.40 | 1.52 | 1.61 | 1.69 |
| PARANAQUE LAS PINAS | 0.97 | 1.08 | 1.23 | 1.37 |
| VALENZUELA | 1.59 | 1.61 | 1.39 | 0.98 |

Table 4-6-6 PROJECT SCALES AND INVESTMENT COST

| RIVER SYSTEM / DRAINAGE AREA | CASE 1 | | CASE 2 | | CASE 3 | | CASE 4 | | CASE 5 | | CASE 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PROJECT SCALE | INVEST. (MIL.P) | PROJECT SCALE | INVEST. (MIL.P) | PROJECT SCALE | INVEST. (MIL.P) | PROJECT SCALE | INVEST. (MIL.P) | PROJECT SCALE | INVEST. (MIL.P) | PROJECT SCALE | INVEST. (MIL.P) |
| 1. PASIG-MARIKINA RIVER | 100-Yr. | 4,413 | 100-Yr. | 4,413 | 30-Yr. | 3,774 | 30-Yr. | 3,774 | 100-Yr. | 4,413 | 30-Yr. | 3,774 |
| 2. BAHO BULI MAHABA RIVERS | 50-Yr. | 1,652 | 30-Yr. | 1,542 | 30-Yr. | 1,542 | 20-Yr. | 1,494 | --- | | --- | |
| 3. MALABON-TULLAHAN RIVER | 50-Yr. | 759 | 30-Yr. | 655 | 30-Yr. | 655 | 20-Yr. | 589 | --- | | --- | |
| 4. S. PARANAQUE L. PINAS RIVERS | 50-Yr. | 869 | 30-Yr. | 780 | 30-Yr. | 780 | 20-Yr. | 715 | --- | | --- | |
| SUB-TOTAL | | 7,693 | | 7,390 | | 6,751 | | 6,572 | | 4,413 | | 3,774 |
| 1. MANILA | 10-Yr. | 2,431 | --- | | --- | | --- | | 10-Yr. | 2,431 | --- | |
| 2. MALABON NAVOTAS | 10-Yr. | 1,294 | 5-Yr. | 1,151 | 5-Yr. | 1,151 | 3-Yr. | 1,004 | 10-Yr. | 1,294 | 5-Yr. | 1,151 |
| 3. EAST OF MANGAHAN | 10-Yr. | 286 | 5-Yr. | 249 | 5-Yr. | 249 | 3-Yr. | 218 | 10-Yr. | 286 | 5-Yr. | 249 |
| 4. WEST OF MANGAHAN | 10-Yr. | 2,327 | 5-Yr. | 2,076 | 5-Yr. | 2,076 | 3-Yr. | 1,893 | 10-Yr. | 2,327 | 5-Yr. | 2,076 |
| 5. SAN JUAN | 5-Yr. | 1,066 | 3-Yr. | 962 | 3-Yr. | 962 | 2-Yr. | 867 | --- | | --- | |
| 6. MANDALUYONG PASIG | 5-Yr. | 790 | 3-Yr. | 721 | 3-Yr. | 721 | 2-Yr. | 579 | --- | | --- | |
| 7. MARIKINA | 5-Yr. | 200 | 3-Yr. | 184 | 3-Yr. | 184 | 2-Yr. | 168 | --- | | --- | |
| 8. PARANAQUE LASPINAS | 5-Yr. | 658 | 3-Yr. | 573 | 3-Yr. | 573 | 2-Yr. | 504 | --- | | --- | |
| 9. VALENZUELA | 5-Yr. | 265 | 3-Yr. | 217 | 3-Yr. | 217 | 2-Yr. | 211 | --- | | --- | |
| SUB-TOTAL | | 9,316 | | 6,133 | | 6,133 | | 5,443 | | 6,338 | | 3,476 |
| TOTAL INVESTMENT | | 17,009 | | 13,523 | | 12,884 | | 12,015 | | 10,751 | | 7,250 |

Table 4-6-7(1/4) CONSTRUCTION COST OF PROPOSED SCHEMES

PASIG-MARIKINA RIVER IMPROVEMENT (100-Yr)

| River | Stretch | Length | Design Discharge | Required Works | | | | | | | Construction Cost | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (M) | (m3/s) | Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
| River Mouth/San Juan C. | Sta. 0+000/ 8+735 | 8,735 | 1150 | 2,334 | 0 | 40 | 3 | 0 | 1 | 20 | 645 | 60 | 706 |
| San Juan C./Napindan C. | Sta. 8+735/18+495 | 9,760 | 500 | 300 | 0 | 60 | 10 | 0 | 0 | 15 | 212 | 45 | 257 |
| Napindan C./M.C.G.S. | Sta.18+495/ 5+425 | 5,580 | 500 | 100 | 10 | 10 | 1 | 0 | 0 | 8 | 39 | 24 | 63 |
| M.C.G.S. /Mangahan C. | Sta. 5+425/ 6+635 | 1,210 | 500 | 100 | 5 | 2 | 1 | 0 | 0 | 15 | 24 | 18 | 42 |
| Mangahan C./Sta.7+425 | Sta. 6+635/ 7+425 | 790 | 2900 | 50 | 5 | 2 | 2 | 0 | 0 | 10 | 26 | 12 | 38 |
| M.C.G.S. | | | 500 | 30 | 6 | 0 | 22 | 300 | 0 | 1 | 183 | 1 | 184 |
| San Juan River | Sta. 0+000/10+653 | 10,653 | 900 | 1,820 | 0 | 175 | 43 | 0 | 4 | 50 | 580 | 177 | 757 |
| | Sub-Total | 36,728 | | 4,734 | 26 | 289 | 82 | 300 | 5 | 119 | 1,710 | 337 | 2,047 |
| Mangahan C./Nangka C. | Sta. 7+425/18+620 | 11,195 | 2900 | 2,493 | 555 | 109 | 46 | 0 | 0 | 950 | 497 | 334 | 831 |
| Nangka C. /Rodorigez B. | Sta.18+620/27+200 | 8,580 | 2600 | 1,596 | 692 | 0 | 0 | 0 | 0 | 1,753 | 218 | 517 | 735 |
| Marikina Dam (Qcut=600m3/s) | | | 2100 | 40 | 0 | 0 | 120 | 0 | 0 | 2,500 | 675 | 125 | 800 |
| | Sub-Total | 19,775 | | 4,129 | 1,246 | 109 | 166 | 0 | 0 | 5,203 | 1,390 | 976 | 2,366 |
| | Total | 56,503 | | 8,863 | 1,272 | 398 | 248 | 300 | 5 | 5,322 | 3,100 | 1,313 | 4,413 |

Table 4-6-7(2/4) CONSTRUCTION COST OF PROPOSED SCHEMES

BAHO BULI MAHABA RIVER IMPROVEMENT (30-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mahaba River | Sta. 0+000/ 5+000 | 5,000 | 160 | 390 | 35 | 0 | 0 | 0 | 6 | 173 | 64 | 130 | 194 |
| | Sta. 5+000/ 6+000 | 1,000 | 160 | 10 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 4 |
| | Sub-Total | 6,000 | | 400 | 35 | 0 | 0 | 0 | 6 | 176 | 65 | 133 | 198 |
| Baho River | Sta. 0+000/ 5+500 | 5,500 | 275 | 560 | 30 | 0 | 0 | 0 | 7 | 172 | 92 | 120 | 212 |
| | Sta.A0+000/A2+000 | 2,000 | 230 | 190 | 3 | 0 | 0 | 0 | 3 | 52 | 29 | 16 | 45 |
| | Sta.A2+000/A3+000 | 1,000 | 230 | 40 | 0 | 0 | 0 | 0 | 0 | 9 | 4 | 3 | 7 |
| | Sub-Total | 8,500 | | 790 | 33 | 0 | 0 | 0 | 10 | 233 | 125 | 139 | 264 |
| Buli River | Sta. 0+000/6A+200 | 3,100 | 270 | 240 | 36 | 0 | 0 | 0 | 4 | 81 | 67 | 71 | 138 |
| | Sta.6A+200/8A+200 | 2,000 | 230 | 250 | 5 | 0 | 0 | 0 | 3 | 60 | 37 | 18 | 55 |
| | Sta.8A+200/9A+830 | 1,630 | 230 | 170 | 13 | 0 | 0 | 0 | 1 | 61 | 32 | 18 | 51 |
| | Sta.9A+830/10+480 | 650 | 230 | 70 | 6 | 0 | 0 | 0 | 1 | 26 | 12 | 31 | 43 |
| | Sta.10+480/14+000 | 2,520 | 180 | 260 | 16 | 0 | 0 | 0 | 3 | 93 | 46 | 111 | 158 |
| | Sta.14+000/15+000 | 1,000 | 180 | 60 | 0 | 0 | 0 | 0 | 1 | 16 | 18 | 19 | 36 |
| | Sub-Total | 10,900 | | 1,050 | 76 | 0 | 0 | 0 | 13 | 337 | 212 | 269 | 480 |
| Tributary-B | Sta. 0+000/ 5+000 | 5,000 | 95 | 340 | 11 | 0 | 0 | 0 | 3 | 118 | 57 | 35 | 92 |
| | Sta. 5+000/ 6+000 | 1,000 | 95 | 20 | 2 | 0 | 0 | 0 | 2 | 12 | 5 | 3 | 9 |
| | Sub-Total | 6,000 | | 360 | 13 | 0 | 0 | 0 | 5 | 130 | 62 | 39 | 101 |
| Tributary-C | Sta. 0+000/ 4+000 | 4,000 | 50 | 140 | 3 | 0 | 0 | 0 | 3 | 49 | 25 | 43 | 67 |
| | Sta. 4+000/ 5+000 | 1,000 | 50 | 150 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 2 | 3 |
| | Sub-Total | 5,000 | | 290 | 3 | 0 | 0 | 0 | 3 | 54 | 26 | 45 | 71 |
| Mangahan Diversion | Sta. 6+800/ 6+100 | 700 | 470 | 870 | 15 | 0 | 0 | 0 | 0 | 180 | 131 | 53 | 184 |
| | Sta. 6+100/ 4+500 | 1,600 | 435 | 840 | 0 | 0 | 0 | 0 | 0 | 140 | 128 | 42 | 170 |
| | Sta. 4+500/ 3+000 | 1,500 | 280 | 410 | 24 | 0 | 0 | 0 | 0 | 93 | 47 | 28 | 75 |
| | Sub-Total | 3,800 | | 2,120 | 39 | 0 | 0 | 0 | 0 | 413 | 306 | 123 | 429 |
| | Total | 40,200 | | 5,010 | 199 | 0 | 0 | 0 | 37 | 1,343 | 796 | 747 | 1,542 |

Table 4-6-7(3/4) CONSTRUCTION COST OF PROPOSED SCHEMES

MALABON-TULLAHAN RIVER IMPROVEMENT (30-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Malabon River | Sta. 0+000/ 2+835 | 2,835 | 500 | 970 | 112 | 68 | 0 | 0 | 3 | 64 | 122 | 77 | 199 |
| | Sta. 2+835/ 4+377 | 1,542 | 480 | 170 | 55 | 20 | 0 | 0 | 0 | 33 | 37 | 40 | 77 |
| | Sta. 4+377/ 5+427 | 1,050 | 450 | 70 | 82 | 10 | 0 | 0 | 3 | 13 | 40 | 16 | 56 |
| | Sub-Total | 5,427 | | 1,210 | 250 | 98 | 0 | 0 | 6 | 110 | 199 | 133 | 332 |
| Tullahan River | Sta. 0+000/ 4+800 | 4,800 | 420 | 400 | 141 | 0 | 0 | 0 | 0 | 80 | 163 | 96 | 259 |
| | Sta. 4+800/18+000 | 13,200 | 290 | 20 | 0 | 0 | 0 | 0 | 0 | 19 | 23 | 23 | 46 |
| | Sta.18+000/20+500 | 2,500 | 210 | 10 | 21 | 0 | 0 | 0 | 0 | 5 | 8 | 6 | 14 |
| | Sta.20+500/21+500 | 1,000 | 210 | 10 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 4 |
| | Sub-Total | 21,500 | | 440 | 163 | 0 | 0 | 0 | 0 | 105 | 197 | 126 | 323 |
| | Total | 26,927 | | 1,650 | 413 | 98 | 0 | 0 | 6 | 215 | 397 | 259 | 655 |

SOUTH PARANAQUE LAS PINAS RIVER IMPROVEMENT (30-Yr)

| River | Stretch | Length (M) | Design Discharge (m3/s) | Required Works: Exca. (1000m3) | Embank. (1000m3) | Revet. (1000m2) | Concrete (1000m3) | Gate (ton) | Re.Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | L.A./Compen. (mil.Peso) | Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Las Pinas River | Sta. 0+000/ 1+780 | 1,780 | 210 | 181 | 80 | 3 | 0 | 0 | 2 | 21 | 111 | 25 | 136 |
| | Sta. 1+780/ 6+395 | 4,615 | 180 | 498 | 94 | 20 | 0 | 0 | 2 | 86 | 149 | 104 | 253 |
| | Sta. 6+395/ 7+395 | 1,000 | 110 | 30 | 0 | 5 | 0 | 0 | 0 | 3 | 11 | 4 | 15 |
| | Sub-Total | 7,395 | | 710 | 173 | 28 | 0 | 0 | 4 | 110 | 271 | 133 | 404 |
| South Paranaque River | Sta. 0+000/ 0+560 | 560 | 520 | 76 | 10 | 3 | 0 | 0 | 0 | 4 | 21 | 5 | 26 |
| | Sta.D0+000/D0+400 | 400 | 520 | 76 | 19 | 0 | 0 | 0 | 0 | 2 | 51 | 2 | 53 |
| | Sta.D0+400/S0+000 | 400 | 350 | 91 | 14 | 0 | 0 | 0 | 0 | 9 | 10 | 11 | 21 |
| | Sta.S0+000/S1+200 | 1,200 | 350 | 242 | 68 | 0 | 0 | 0 | 0 | 37 | 20 | 44 | 65 |
| | Sta.S1+200/S2+600 | 1,400 | 300 | 272 | 31 | 0 | 0 | 0 | 0 | 46 | 32 | 55 | 88 |
| | Sta.S2+600/S3+600 | 1,000 | 300 | 91 | 2 | 0 | 0 | 0 | 0 | 16 | 3 | 19 | 23 |
| | Sub-Total | 4,960 | | 846 | 144 | 3 | 0 | 0 | 0 | 114 | 138 | 137 | 275 |
| Dongalo River | Sta. 0+000/ 2+600 | 2,600 | 170 | 211 | 38 | 13 | 0 | 0 | 0 | 24 | 54 | 29 | 83 |
| | Sta. 2+600/ 3+600 | 1,000 | 170 | 30 | 1 | 5 | 0 | 0 | 0 | 6 | 11 | 7 | 18 |
| | Sub-Total | 3,600 | | 242 | 39 | 18 | 0 | 0 | 0 | 30 | 65 | 36 | 101 |
| | Total | 15,955 | | 1,797 | 357 | 49 | 0 | 0 | 4 | 254 | 475 | 305 | 780 |

Table 4-6-7(4/4) CONSTRUCTION COST OF PROPOSED SCHEMES

DRAINAGE IMPROVEMENT

| Drainage Area | Area (km2) | Pump Station (site) | Pump Station (m3/s) | Gate (site) | Gate (ton) | Channel Impvt. (m) | Open Cha. Const. (m) | Closed Cha. Const. (m) | Ring Dike/ Lake Dike (m) | Regulating Pond (site) | Regulating Pond (1000m3) | Reconst. Bridge (place) | Land Acq. (1000m2) | Construction Cost: Civil Works (mil.Peso) | Construction Cost: L.A./Compen. (mil.Peso) | Construction Cost: Total (mil.Peso) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Scale (5-Yr) | | | | | | | | | | | | | | | | |
| Malabon-Navotas | 24.9 | 8 | 62.1 | 16 | 405 | 5,100 | 5,600 | 800 | 22,000 | 0 | 0 | 11 | 106 | 1,108 | 43 | 1,151 |
| East of Mangahan | 8.8 | 4 | 27.0 | 4 | 84 | 1,100 | 7,300 | 0 | 1,800 | 2 | 51 | 2 | 62 | 211 | 38 | 249 |
| West of Mangahan | 38.1 | 5 | 129.3 | 10 | 342 | 34,100 | 11,000 | 1,450 | 8,900 | 4 | 642 | 26 | 237 | 1,910 | 166 | 2,076 |
| Sub-Total | 71.8 | 17 | 218.4 | 30 | 831 | 40,300 | 23,900 | 2,250 | 32,700 | 6 | 693 | 39 | 405 | 3,229 | 247 | 3,476 |
| Project Scale (3-Yr) | | | | | | | | | | | | | | | | |
| San Juan | 12.7 | 9 | 31.0 | 13 | 103 | 1,300 | 0 | 12,300 | 3,400 | 0 | 0 | 8 | 6 | 960 | 2 | 962 |
| Mandaluyong Pasig | 15.9 | 3 | 14.5 | 3 | 40 | 2,500 | 0 | 8,800 | 0 | 0 | 0 | 5 | 8 | 713 | 8 | 721 |
| Marikina | 13.0 | 0 | 0.0 | 1 | 7 | 0 | 1,000 | 2,600 | 0 | 0 | 0 | 2 | 20 | 169 | 15 | 184 |
| Paranaque Laspinas | 15.4 | 2 | 12.5 | 8 | 175 | 4,800 | 650 | 0 | 0 | 0 | 0 | 3 | 36 | 559 | 14 | 573 |
| Valenzuela | 18.4 | 0 | 0.0 | 1 | 10 | 12,900 | 500 | 0 | 8,000 | 0 | 0 | 4 | 29 | 205 | 12 | 217 |
| Sub-Total | 75.4 | 14 | 58.0 | 26 | 335 | 21,500 | 2,150 | 23,700 | 11,400 | 0 | 0 | 22 | 99 | 2,606 | 51 | 2,657 |
| Total | 147.2 | 31 | 276.4 | 56 | 1,166 | 61,800 | 26,050 | 25,950 | 44,100 | 6 | 693 | 61 | 504 | 5,835 | 298 | 6,133 |

Table 4-7-1 (1/3). CONDITION OF LAND SIDE AREA UTILIZATION AND TOPOGRAPHY (AT THE LOW BANK ELEVATION SECTIONS)

| Station No. | | Existing Elevation | | Designed Elevation | | | Condition of Land Side | |
|---|---|---|---|---|---|---|---|---|
| | | (1) Bank (m) | (2) Ground (m) | (3) H.W.L. (m) | (4) Wall (m) | (5) 4-1 (m) | Utilization | Topography |
| No. 5+005 | R | 10.90 | 11.20 | 12.07 | 13.07 | 2.17 | Office compound (Min. of budget) | Flat land |
| | L | 11.50 | 11.50 | 12.07 | 13.07 | 1.57 | Factory compound | Flat land |
| No. 5+195 | R | 11.50 | 11.60 | 12.08 | 13.08 | 1.58 | Hospital compound | Flat land |
| | L | 12.20 | 12.50 | | 13.08 | 0.88 | Factory compound | Flat land |
| No. 5+395 | R | 11.70 | 12.10 | 12.09 | 13.09 | 1.39 | Hospital compound | Flat land |
| | L | 12.10 | 12.20 | | 13.09 | 0.99 | Factory compound | Flat land |
| No. 5+605 | R | 12.30 | 11.90 | 12.28 | 13.28 | 0.98 | Malacanang Palace | Flat land |
| | L | 12.10 | 12.30 | 12.28 | 13.28 | 1.18 | Santa Banez Flood Gate | Flat land |
| No. 6+195 | R | 11.90 | 11.80 | 12.46 | 13.46 | 1.56 | Malacanang Palace | Flat land |
| | L | 12.70 | 12.30 | 12.46 | 13.46 | 0.76 | Malacanang Park (Open space) | Flat land |
| No. 6+360 | R | 11.90 | 11.90 | 12.50 | 13.50 | 1.60 | Malacanang Administration Office | Flat land |
| | L | 12.90 | 12.50 | 12.50 | 13.50 | 0.60 | Malacanang Park (Open space) | Flat land |
| No. 6+480 | R | 11.50 | 11.50 | 12.54 | 13.54 | 2.04 | Aviles Pump. Station (Residential area) | Flood land |
| | L | 12.00 | 12.10 | 12.54 | 13.54 | 1.54 | Malacanang Park (Open space) | Flood land |
| No. 6+650 | R | 13.00 | 11.40 | 12.58 | 13.58 | 0.58 | Factory compound | Flat land |
| | L | 13.00 | 13.80 | 12.58 | 13.58 | 0.58 | Malacanang Park (Open space) | Flat land |
| No. 6+790 | R | 13.20 | 13.90 | 12.63 | 13.63 | 0.43 | Factory compound | Flat land |
| | L | 12.20 | 12.40 | 12.63 | 13.63 | 1.43 | Office compound (City Engineer's Office) | Flat land |
| No. 6+895 | R | 12.90 | 13.70 | 12.67 | 13.67 | 0.77 | Factory compound | Flat land |
| | L | 12.60 | 12.60 | 12.67 | 13.67 | 1.07 | Office compound (Open space) | Flat land |
| No. 7+095 | R | 12.50 | 12.90 | 12.72 | 13.72 | 1.22 | - Unknown - | Flat land |
| | L | 12.50 | 12.40 | 12.72 | 13.72 | 1.22 | Factory compound (PNOC) | Flat land |
| No. 7+295 | R | 12.30 | 13.00 | 12.76 | 13.76 | 1.46 | - Unknown - | Flat land |
| | L | 12.70 | 12.50 | 12.76 | 13.76 | 1.06 | Factory compound | Flat land |
| No. 7+470 | R | 13.00 | 13.80 | 12.83 | 13.83 | 0.83 | PUP compound | Flat land |
| | L | 12.40 | 12.40 | 12.83 | 13.83 | 1.43 | Factory (Philippine Shell) compound | Flat land |
| No. 7+615 | R | 12.60 | 13.20 | 12.90 | 13.90 | 1.30 | PUP compound | Flat land |
| | L | 11.70 | 11.80 | 12.90 | 13.90 | 2.20 | Factory (Philippine Shell) compound | Flat land |
| No. 7+845 | R | 12.20 | 13.00 | 12.97 | 13.97 | 1.77 | Petron Terminal | Flat land |
| | L | 13.00 | 12.40 | 12.97 | 13.97 | 0.97 | Factory compound | Flat land |

Table 4-7-1 (2/3). CONDITION OF LAND SIDE AREA UTILIZATION AND TOPOGRAPHY (AT THE LOW BANK ELEVATION SECTIONS)

| Station No. | | Existing Elevation | | Designed Elevation | | | Condition of Land Side | |
|---|---|---|---|---|---|---|---|---|
| | | (1) Bank (m) | (2) Ground (m) | (3) H.W.L. (m) | (4) Wall (m) | (5) 4-1 (m) | Utilization | Topography |
| No. 8+910 | R | 12.10 | 12.70 | 13.21 | 14.21 | 2.11 | Housing area | Hilly land |
| | L | 13.20 | 13.20 | 13.21 | 14.21 | 1.01 | Petron Terminal | Flat land |
| No. 9+075 | R | 12.00 | 12.70 | 13.23 | 14.23 | 2.23 | Housing area | Flat land |
| | L | 13.20 | 13.40 | 13.23 | 14.23 | 1.03 | Petron Terminal | Flat land |
| No. 9+225 | R | 12.00 | 12.70 | 13.24 | 14.24 | 2.24 | Housing area | Flat land |
| | L | 13.00 | 13.40 | 13.24 | 14.24 | 1.24 | Factory compound | Flat land |
| No. 9+475 | R | 12.40 | 13.00 | 13.25 | 14.25 | 1.85 | Factory compound | Flat land |
| | L | 12.60 | 13.40 | 13.25 | 14.25 | 1.65 | Factory compound | Flat land |
| No. 9+695 | R | 13.20 | 12.50 | 13.27 | 14.27 | 1.07 | Factory compound (Harcere Steel) | Flat land |
| | L | 13.40 | 13.30 | 13.27 | 14.27 | 0.87 | Housing area | Flat land |
| No. 10+495 | R | 13.80 | 13.80 | 13.33 | 14.33 | 0.53 | Housing area | Flat land |
| | L | 12.90 | 12.30 | 13.33 | 14.33 | 2.03 | Market area (Sta Ana Market) | Flat land |
| No. 10+745 | R | 12.80 | 13.80 | 13.35 | 14.35 | 1.55 | Housing area | Flat land |
| | L | 11.80 | 11.80 | 13.35 | 14.35 | 2.55 | Housing area | Flat land |
| No. 10+965 | R | 13.00 | 13.30 | 13.36 | 14.46 | 1.46 | Factory compound (Philmco Industry) | Flat land |
| | L | 13.90 | 13.90 | 13.36 | 14.46 | 0.56 | Housing area | Flat land |
| No. 11+165 | R | 11.60 | 12.30 | 13.38 | 14.38 | 2.78 | High school compound | Flat land |
| | L | 12.90 | 12.90 | 13.38 | 14.38 | 1.48 | Housing area | Flat land |
| No. 15+095 | R | 14.20 | 14.30 | 13.66 | 14.66 | 0.46 | Factory compound | Hilly land |
| | L | 13.10 | 13.70 | 13.66 | 14.66 | 1.56 | Factory compound (Colgate) | Hilly land |
| No. 15+295 | R | 14.20 | 14.20 | 13.67 | 14.67 | 0.47 | Congested housing area | Hilly land |
| | L | 13.10 | 13.90 | 13.67 | 14.67 | 1.57 | Congested housing area | Hilly land |
| No. 15+495 | R | 14.40 | 15.10 | 13.68 | 14.68 | 0.28 | Congested housing area | Hilly land |
| | L | 12.30 | 13.70 | 13.68 | 14.68 | 2.38 | Factory compound | Hilly land |
| No. 0+590 | R | 12.70 | 12.70 | 13.94 | 14.94 | 2.24 | Factory compound | Hilly land |
| | L | 12.90 | 13.40 | 13.94 | 14.94 | 2.04 | Congested housing area | Flat land |
| No. 0+780 | R | 13.10 | 13.10 | 13.95 | 14.95 | 1.85 | Open space | Hilly land |
| | L | 13.20 | 13.10 | 13.95 | 14.95 | 1.75 | Office compound (Pasig Manpower) | Flat land |
| No. 0+980 | R | 12.10 | 12.30 | 13.96 | 14.95 | 2.85 | Factory compound | Hilly land |
| | L | 13.20 | 13.10 | 13.96 | 14.95 | 1.75 | Housing area | Flat land |

## Table 4-7-1 (3/3). CONDITION OF LAND SIDE AREA UTILIZATION AND TOPOGRAPHY (AT THE LOW BANK ELEVATION SECTIONS)

| Station No. | | Existing Elevation | | Designed Elevation | | | Condition of Land Side | |
|---|---|---|---|---|---|---|---|---|
| | | (1) Bank (m) | (2) Ground (m) | (3) H.W.L. (m) | (4) Wall (m) | (5) 4-1 (m) | Utilization | Topography |
| No. 1+180 | R | 12.50 | 12.50 | 13.97 | 14.97 | 2.47 | Housing area | Hilly land |
| | L | 15.70 | 15.60 | 13.97 | 14.97 | - | Housing area | Flat land |
| No. 2+145 | R | 15.80 | 15.70 | 14.02 | 15.02 | - | Factory compound | Hilly land |
| | L | 12.30 | 12.50 | 14.02 | 15.02 | 2.72 | Factory compound | Flat land |
| No. 2+320 | R | 15.00 | 15.30 | 14.03 | 15.03 | 0.03 | Open space | Hilly land |
| | L | 13.40 | 13.40 | 14.03 | 15.03 | 1.63 | Factory compound | Flat land |
| No. 2+510 | R | 13.00 | 13.00 | 14.04 | 15.04 | 2.04 | Factory compound | Hilly land |
| | L | 14.10 | 14.10 | 14.04 | 15.04 | 0.94 | Housing area | Flat land |
| No. 2+710 | R | 14.70 | 14.80 | 14.05 | 15.05 | 0.35 | Housing area | Hilly land |
| | L | 15.40 | 15.40 | 14.05 | 15.05 | - | Housing area | Flat land |
| No. 2+910 | R | 12.70 | 13.20 | 14.07 | 15.07 | 2.37 | Housing area | Hilly land |
| | L | 14.30 | 14.40 | 14.07 | 15.07 | 0.77 | Housing area | Flat land |
| No. 3+100 | R | 13.00 | 13.10 | 14.08 | 15.08 | 2.08 | Housing area | Hilly land |
| | L | 15.00 | 15.00 | 14.08 | 15.08 | 0.08 | Housing area | Flat land |
| No. 4+080 | R | 14.00 | 14.20 | 14.13 | 13.13 | - | Open space | Hilly land |
| | L | 12.40 | 12.30 | 14.13 | 13.13 | 0.73 | Housing area | Flat land |
| No. 4+280 | R | 16.50 | 13.50 | 14.14 | 15.14 | - | Housing area | Hilly land |
| | L | 16.50 | 12.70 | 14.14 | 15.14 | - | Housing area | Flat land |
| No. 4+470 | R | 12.00 | 12.00 | 14.15 | 15.15 | 3.15 | Factory compound | Hilly land |
| | L | 16.10 | 16.20 | 14.15 | 15.15 | - | Factory compound | Flat land |

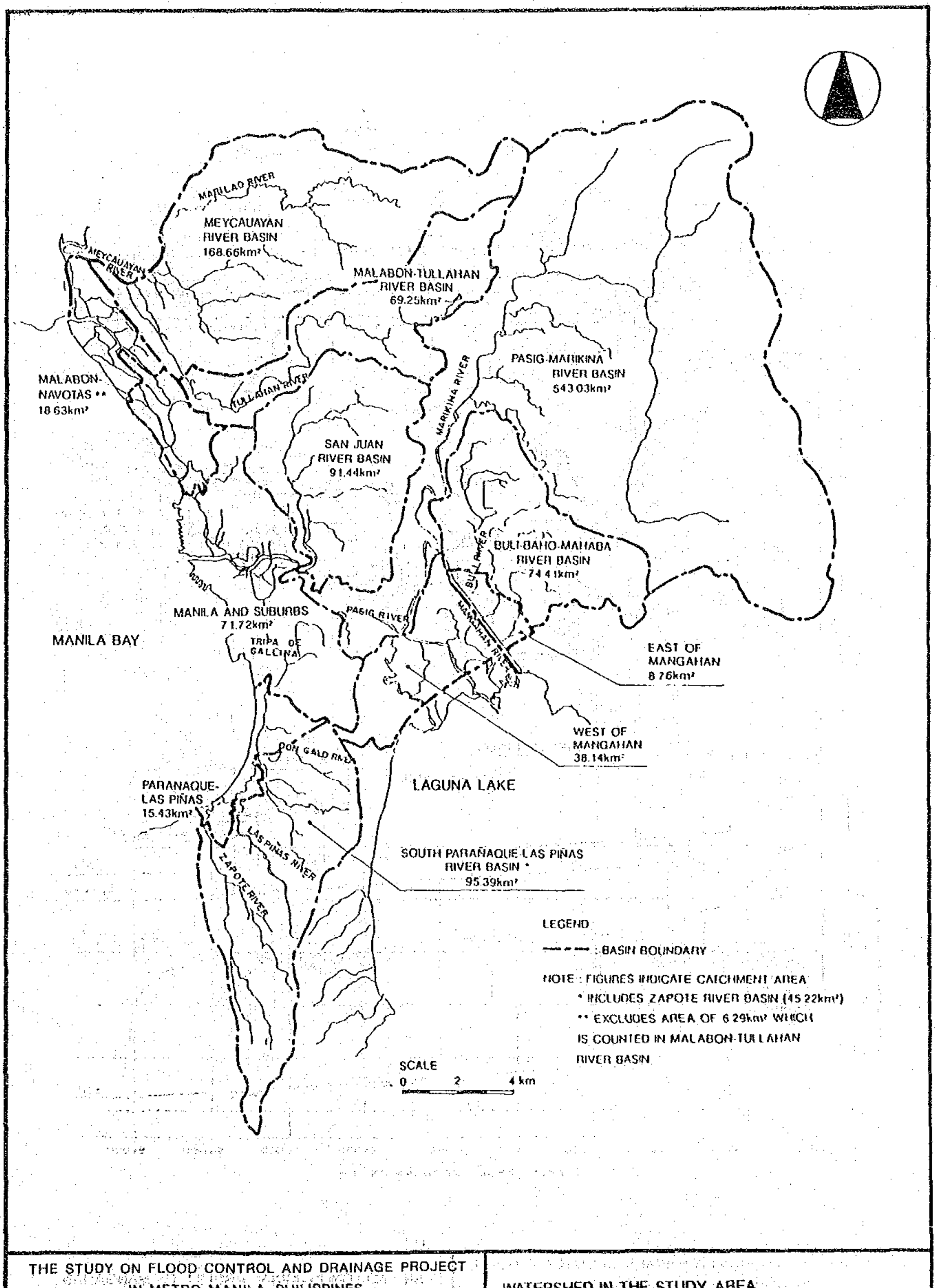
Table 4-7-2 COST BREAKDOWN OF THE OPTIMUM PLAN FOR PASIG-MARIKINA RIVER IMPROVEMENT PROJECT

1US$=132Yen=21.3Peso

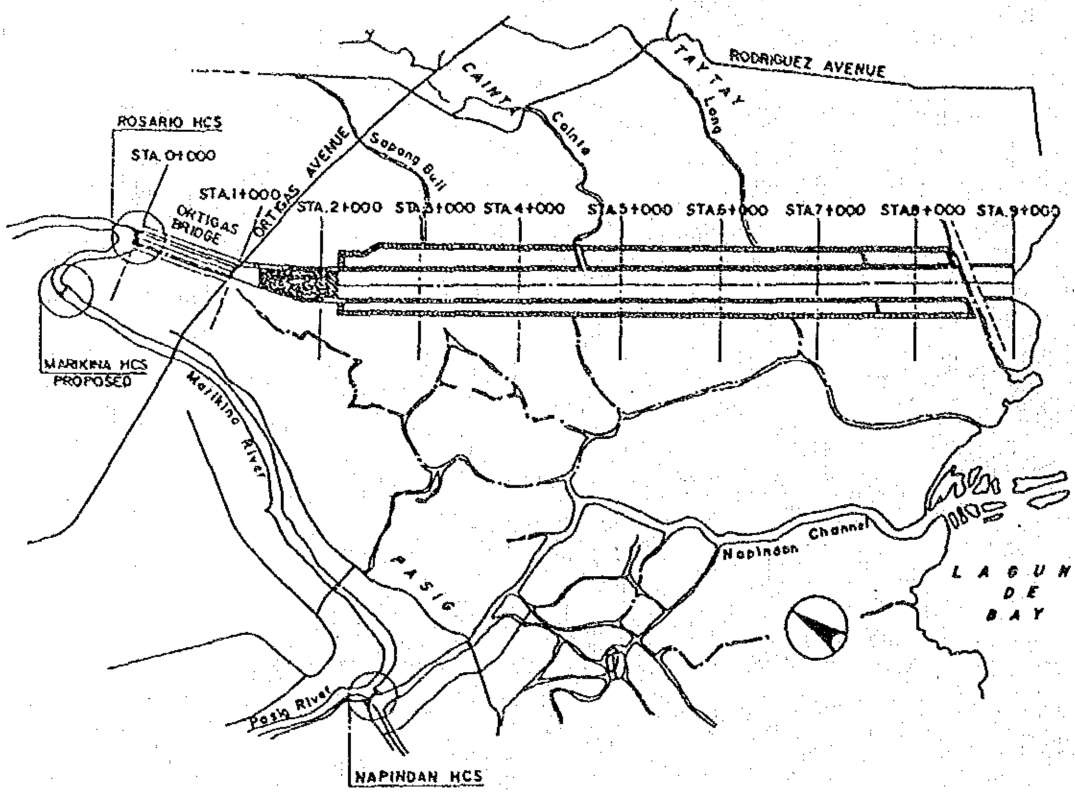
| Work Item | Feature | Unit | Quantity | Total (1000P) | Foreign Currency (1000P) | Local Currency (1000P) |
|---|---|---|---|---|---|---|
| 1 River Improvement | | | | 718,313 | 611,645 | 106,668 |
| River Mouth/San Juan C. | L=8735m | | | 494,093 | 418,307 | 75,786 |
| Preparatory Works | | l/s | 1 | 117,679 | 99,629 | 18,050 |
| Excavation | | cu.m | 2,334,000 | 305,754 | 259,891 | 45,863 |
| Parapet wall/River wall | | cu.m | 3,000 | 9,000 | 7,650 | 1,350 |
| Revetment | | sq.m | 40,000 | 24,000 | 20,400 | 3,600 |
| Steel sheet | | sq.m | 5,000 | 17,500 | 16,625 | 875 |
| Reconst. Pandacan bridge | L=140m | sq.m | 840 | 20,160 | 14,112 | 6,048 |
| San Juan C./Napindan C. | L=9760m | | | 159,750 | 137,259 | 22,491 |
| Preparatory Works | | l/s | 1 | 45,750 | 39,309 | 6,441 |
| Excavation | | cu.m | 300,000 | 37,500 | 31,875 | 5,625 |
| Parapet wall/River wall | | cu.m | 10,000 | 30,000 | 25,500 | 4,500 |
| Revetment | | sq.m | 60,000 | 36,000 | 30,600 | 5,400 |
| Steel sheet | | sq.m | 3,000 | 10,500 | 9,975 | 525 |
| Napindan C./M.C.G.S. | L=5580m | | | 28,170 | 24,385 | 3,785 |
| Preparatory Works | | l/s | 1 | 5,770 | 4,995 | 775 |
| Excavation | | cu.m | 100,000 | 9,500 | 8,075 | 1,425 |
| Embankment | | cu.m | 10,000 | 400 | 340 | 60 |
| Parapet wall/River wall | | cu.m | 1,000 | 3,000 | 2,550 | 450 |
| Revetment | | sq.m | 10,000 | 6,000 | 5,100 | 900 |
| Steel sheet | | sq.m | 1,000 | 3,500 | 3,325 | 175 |
| M.C.G.S. /Mangahan C. | L=1210m | | | 17,520 | 15,312 | 2,208 |
| Preparatory Works | | l/s | 1 | 2,920 | 2,552 | 368 |
| Excavation | | cu.m | 100,000 | 6,900 | 5,865 | 1,035 |
| Parapet wall/River wall | | cu.m | 1,000 | 3,000 | 2,550 | 450 |
| Revetment | | sq.m | 2,000 | 1,200 | 1,020 | 180 |
| Steel sheet | | sq.m | 1,000 | 3,500 | 3,325 | 175 |
| Mangahan C./STA.7+425 | L=790m | | | 18,780 | 16,383 | 2,397 |
| Preparatory Works | | l/s | 1 | 3,130 | 2,731 | 400 |
| Excavation | | cu.m | 50,000 | 4,750 | 4,038 | 713 |
| Embankment | | cu.m | 5,000 | 200 | 170 | 30 |
| Parapet wall/River wall | | cu.m | 2,000 | 6,000 | 5,100 | 900 |
| Revetment | | sq.m | 2,000 | 1,200 | 1,020 | 180 |
| Steel sheet | | sq.m | 1,000 | 3,500 | 3,325 | 175 |
| 2 Marikina Control Gate Structure | | | | 138,600 | 116,147 | 22,453 |
| Preparatory Works | | l/s | 1 | 23,100 | 19,358 | 3,742 |
| Excavation | | cu.m | 30,000 | 7,000 | 5,950 | 1,050 |
| Embankment | | cu.m | 6,000 | 300 | 255 | 45 |
| Concrete | | cu.m | 22,000 | 62,000 | 52,700 | 9,300 |
| Gate (10.1m*17.5m*2no.) | | ton | 300 | 46,200 | 37,884 | 8,316 |
| Sub-Total(1+2) | | | | 856,913 | 727,792 | 129,121 |
| 3 Administration *1) | | l/s | 1 | 42,846 | 0 | 42,846 |
| 4 Engineering Services | | l/s | 1 | 127,800 | 115,020 | 12,780 |
| 5 Physical Cotingency *2) | | l/s | 1 | 102,756 | 84,281 | 18,475 |
| 6 Land Acquisition & Compensation | | ha | 7 | 160,000 | 0 | 160,000 |
| Total(1+2+3+4+5+6) | | | | 1,290,315 | 927,093 | 363,222 |
| 7 Price Cotingency *3) | | | | 110,675 | 0 | 110,675 |
| 8 Grand Total | | | | 1,400,990 | 927,093 | 473,896 |

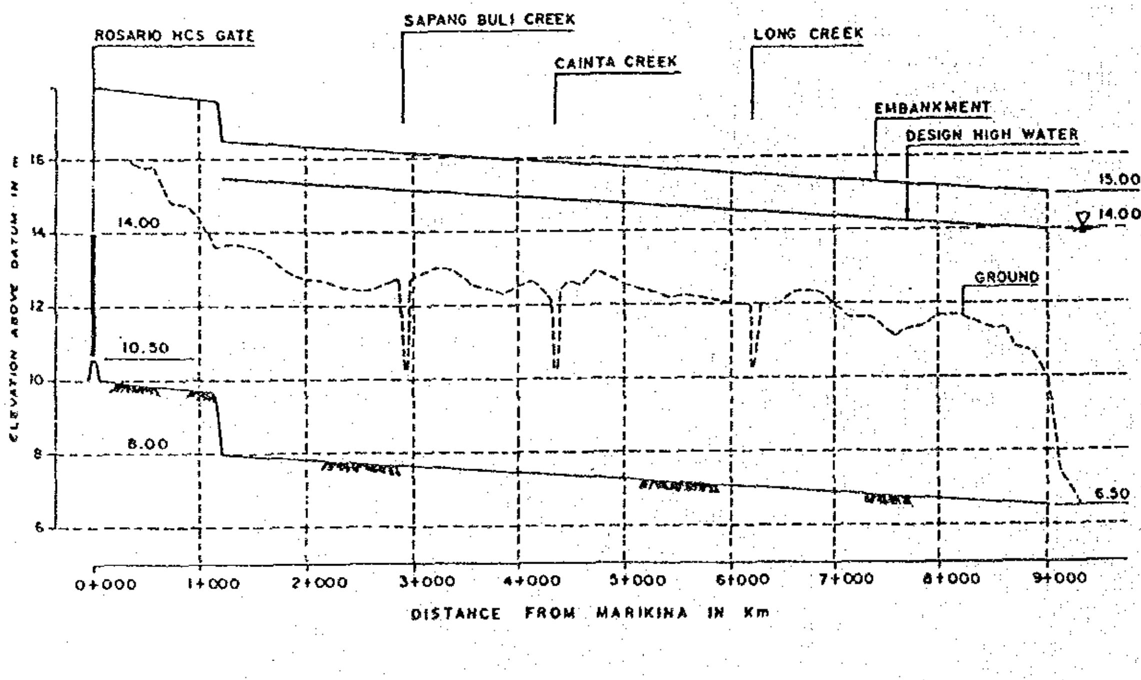
Notes;
1); 5% of main civil works(1+2)
2);10% of (1+2+3+4)
3); 0% for foreign currecy and 6% for local currency

FIGURES

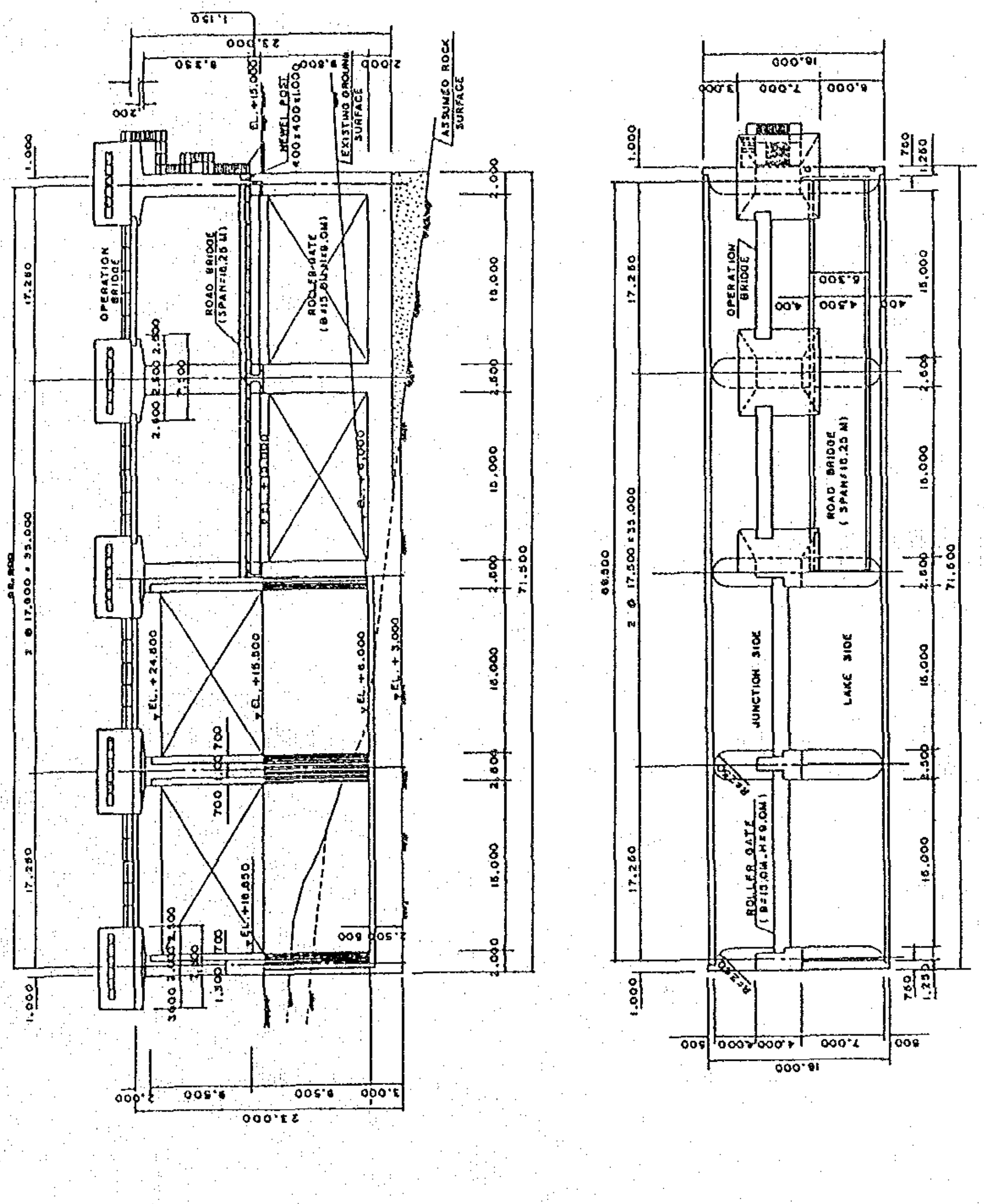



| THE STUDY ON FLOOD CONTROL AND DRAINAGE PROJECT IN METRO MANILA, PHILIPPINES | WATERSHED IN THE STUDY AREA |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | Fig. 4-2-1 |

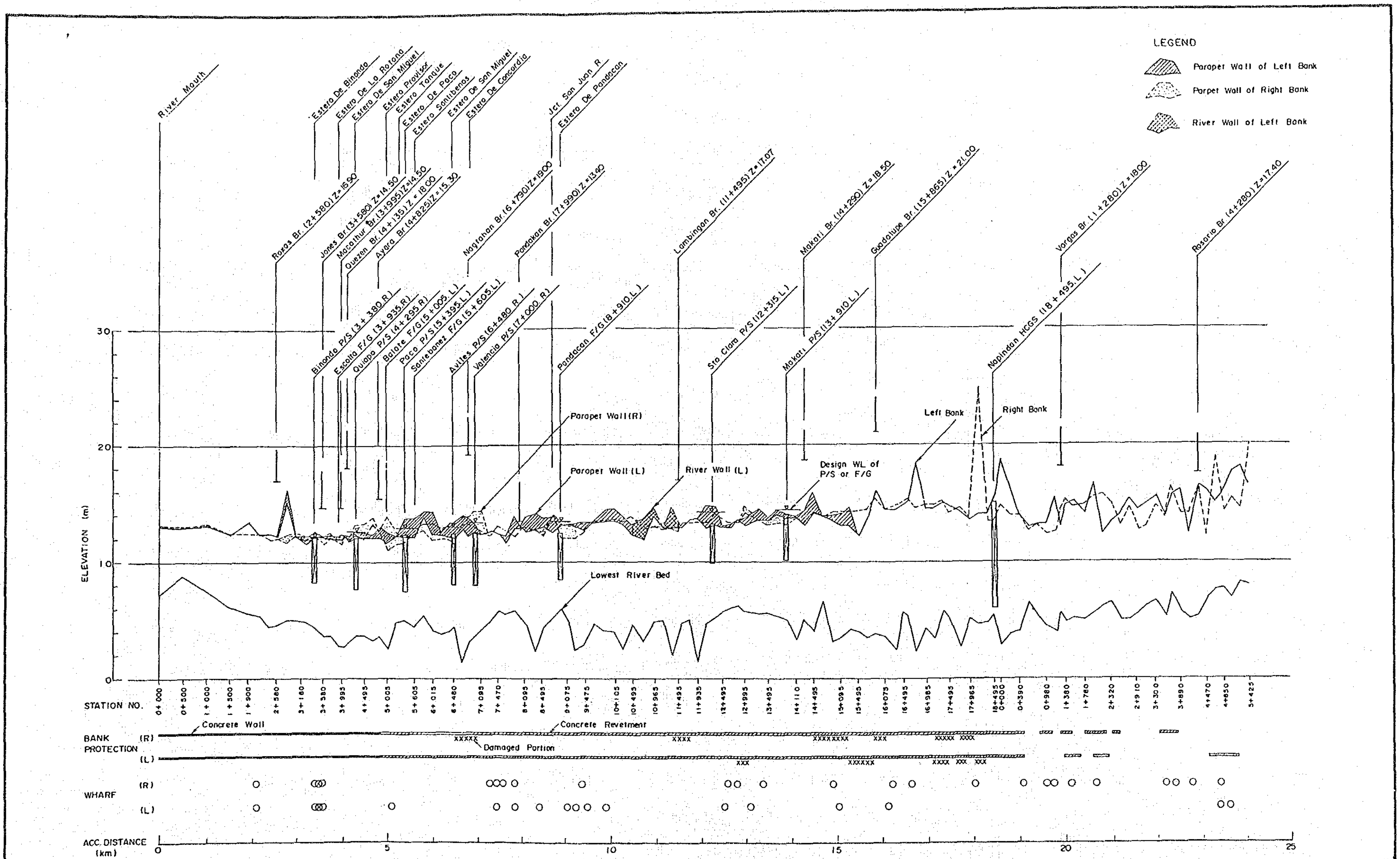



| THE STUDY ON FLOOD CONTROL AND DRAINAGE PROJECT IN METRO MANILA, PHILIPPINES | PLAN AND LONGITUDINAL PROFILE OF MANGAHAN FLOODWAY |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | Fig. 4-2-2 |



| | |
|---|---|
| THE STUDY ON FLOOD CONTROL AND DRAINAGE PROJECT IN METRO MANILA, PHILIPPINES | PLAN AND SIDE VIEW OF NAPINDAN HYDRAULIC CONTROL STRUCTURE |
| JAPAN INTERNATIONAL COOPERATION AGENCY | Fig. 4-2-3 |




THE STUDY ON FLOOD CONTROL AND DRAINAGE PROJECT IN METRO MANILA, PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

EXISTING RIPARIAN STRUCTURE ALONG PASIG RIVER

Fig. 4-2-4