5.3 Dungcaan River Basin

5.3.1 Basin Conditions

(1) Natural Conditions

1) Existing River System and Structures

The Dungcaan River system is composed of three major rivers; Dungcaan River with a length of about 37.9 km (the principal drainage of this basin), the Pawonyan River with a length of 26.3 km (the right side main tributary), and the Tabayagon River with a length of 16.1km (the left side main tributary). The Dungcaan River Basin has the total area of 176 km^2. The riverbed gradient of Dungcaan River, ranging from 1/40 to 1/240, is relatively gentle compared with that of the Pawonyan (1/14 to 1/130) and Tabayagon River (1/8 to 1/80).

Dungcaan River flows through two channels in the downstream of the Baybay Bridge, the northern main stream and the southern sub-stream. The southern sub-stream was once closed with the concrete wall at the diversion point, and this concrete wall was broken in 2006. The existing river system of Dungcaan River is shown in Table 5.27 and Figure 5.10.

Table 5.27 Rivers in the Dungcaan River Basin

River	Catchment Area (km^2)	Length (m)	Remarks
Dungcaan	176	37,900*	* Excluding tributaries
Pawonyan	52	26,300	Tributary
Tabayagon	30	16,100	Tributary

The major river structures relating to flood control are, as follows:

- Concrete wall was constructed at the entrance of the southern sub-stream in the downstream of the Baybay Bridge. The purpose of this wall was prevention of flood damages to the Poblacion of Baybay from entering the floods into this sub-stream. However, this concrete wall was destroyed after continuous rainfall in December 2006.

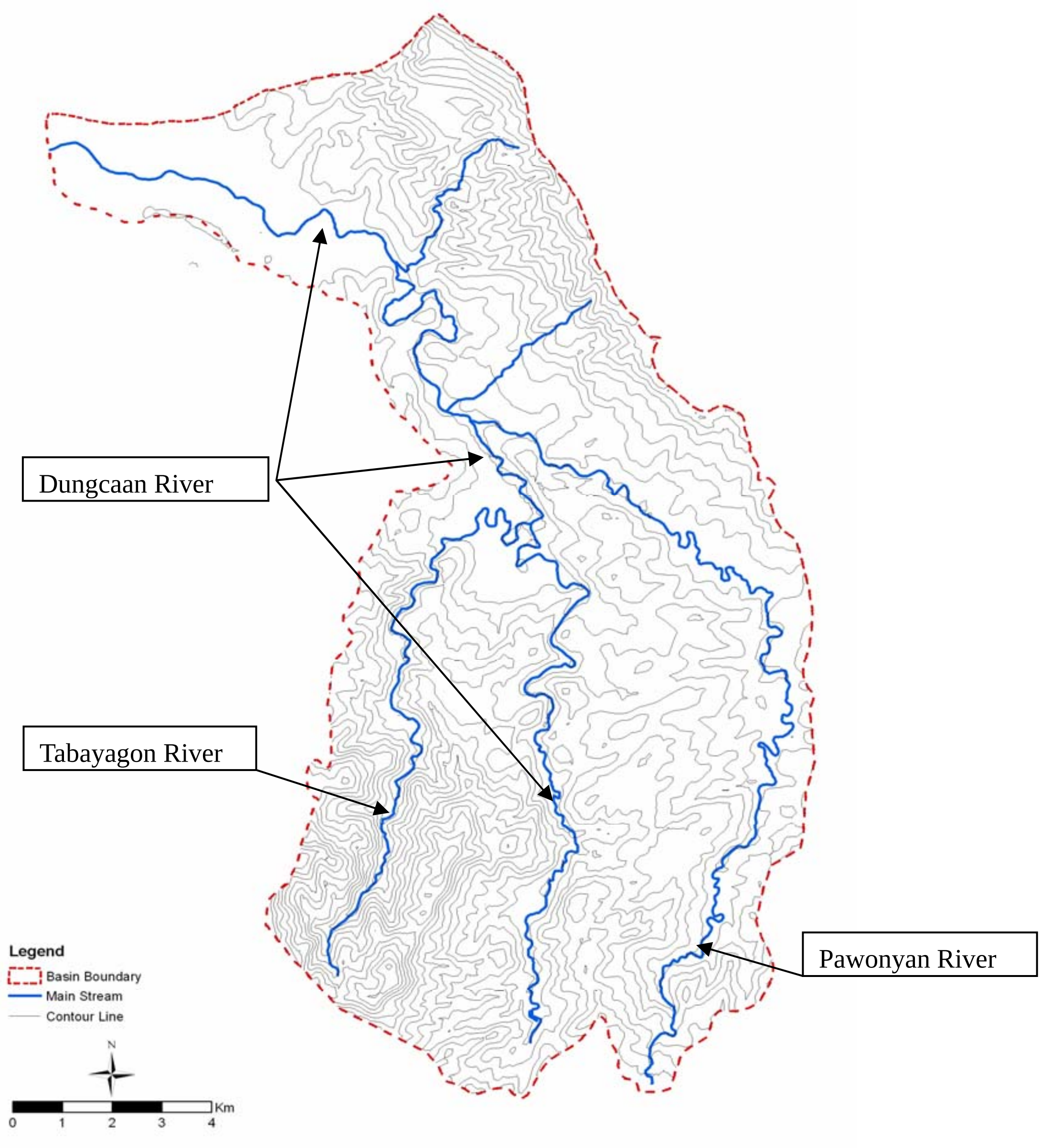


Figure 5.10 Topographic Map of the Dungcaan River Basin

2) Meteorology and Hydrology

The climate of the basin falls under Type IV of the modified Corona's climate classification, which is generally characterized as no dry season but with a pronounced maximum rainfall from September to January. For this type of climate, rainfall is more or less evenly distributed throughout the year.

The frequency of tropical cyclones are rated 7% for the area of Baybay. Monthly rainfall distribution at Baybay City is shown in Figure 5.11.

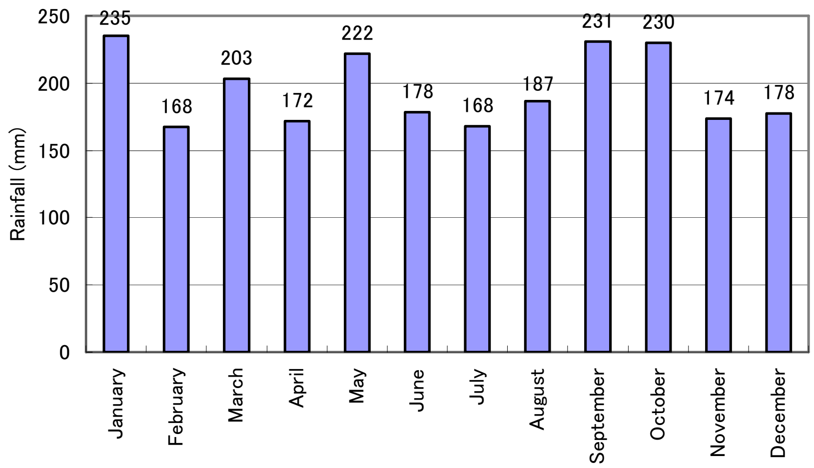


Figure 5.11 Monthly Rainfall Distributions at PAGASA, Baybay, 1994-2000

(2) Social and Economic Conditions

1) Population and its Growth

Based on the 2002 NCSO report, Baybay registered a total population of 99,689. Its Poblacion retains 17,391 in population. Population density of Baybay is 207.67 persons/km^2. On the other hand, the average annul growth rate from 1995 to 2000 is 2.10%. It is noteworthy that the increase in population from 1995 to 2000 is nearly three-fold of the increase from 1990 to 1995. It is not far-fetched to surmise that further acceleration in the growth of population will speed up considering the recent upgrading of Baybay from a 1st-Class City to a full-fledged city (January 2007).

2) Land Use

The City of Baybay covers a total land area of 46,050 ha. Nearly half of the land area is utilized for agriculture while more than two-fifths is considered forest areas. Land use projection is under preparation. Figure 5.12 shows the land use map of the basin. The details of the land use of the Baybay City are shown in Table 5.28.

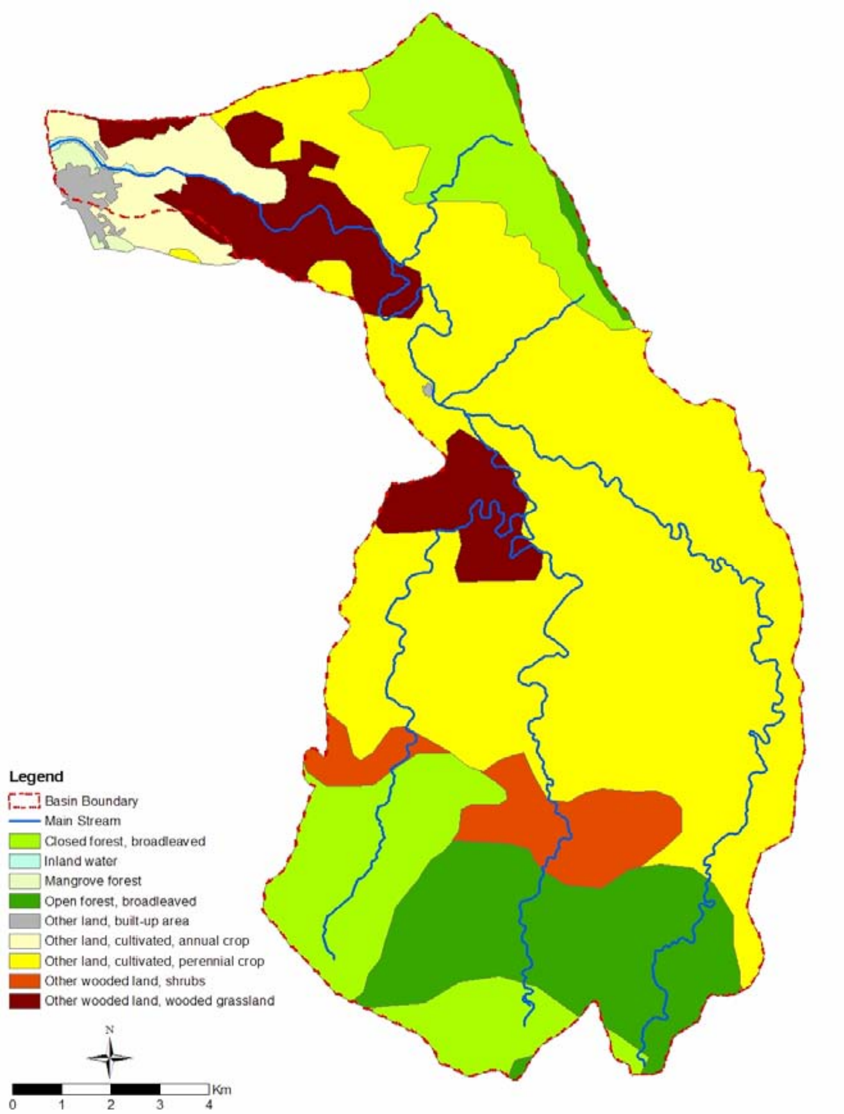


Figure 5.12 Existing Land Use in the Dungcaan River Basin

Table 5.28 Existing Land Use in Baybay City

Land Use	Land Area (has)	Percent of Total (%)
Built-up	352	0.8
Agriculture	22,412	48.7
Forest	21,790	47.3
Fishponds/ Swamps/ Mangroves	47	0.1
Grassland/ Pastureland	180	0.4
Agri-industrial (rice and corn mills, etc.)	167	0.4
Institutional	1,053	2.3
Roads/ Bridges	30	0.7
Open Water Space	13	0.0
Dump Site	1	0.0
Cemetery/ Burial Ground	6	0.0

3) Local Economy

a) Agriculture

Agriculture is one of the most important economic activities in the Baybay City. Coconut farming occupies the largest area of agricultural land with 16,176 ha, followed by irrigated rice farming with 1,540 ha, rainfed rice with 441 ha and corn with 250 ha.

b) Commerce and Trade

There is a Central Business District in the Poblacion of the City where most of the commercial establishments are located. More than 700 establishments operate in the Poblacion. Commercial activities include the wholesale and sari-sari, eatery, rice and corn retailer, cold/snack bar/refreshment, hollow block makers and others.

c) Industry

The City of Baybay is basically agricultural town. Hence, the industries in the City are mostly agri-base operating at the Poblacion and in outlying rural barangays. Various cottage industries can also be found in the City such as bamboo and rattan craft, ceramics, dress making, fiber craft food preservation, metal craft and other related activities.

(3) Floods and Flood Damage

1) Floods and Flood Damage

The Dungcaan River Basin experienced severe floods in 1972, 1994 and 2006. In the 1972 floods, the flood depth was 1-2 m and the flood duration was from 3 hr to 1 day. On the other hand, in the 1994 floods, the flood depth was around 1.5 m and the flood duration was from 6 hr to 2 days. The flood flows were very fast with thousand of up rooted coconut trees including heavy sediment discharges. Severe bank erosion is observed in the downstream of Dungcaan River.

In the 1972 flood, thousand of up rooted coconut trees caused damming at the upstream and at the Baybay Bridge, and they breached. As a result, the floodwater flowed into the Poblacion and remarkable damages were occurred, i.e., number of affected people was around 10,000 persons and the number of completely damaged houses was 250 (based on the questionnaire survey). The 2006 flood was caused by continuous rainfall, and the concrete wall at the entrance of the southern sub-stream was destroyed as fore mentioned.

2) Major Causes of Floods

Heavy rainfall in the upstream of the basin causes overflow in the lower reaches in where the river is lack of flow capacity. In addition, severe bank erosion is observed especially in the lower reaches of Dungcaan River. Rapid change in land use seems not to be the major cause of floods in the basin. However, rapid increase of the population in the Poblacion of Baybay contributes to the increase of flood damages.

(4) Previous Related Study

The City of Baybay is preparing land use plan, etc. at present.

5.3.2 Hydrologic Analysis

(1) Specific Discharge Formula

The design discharge of Dungcaan River is computed with the Specific Discharge Formula, as follows:

$$q = c \cdot A^{(A^{-0.048}-1)}$$

Where, q = specific discharge ($m^3/s/km^2$)

c = constant (11.59, decided by region and return period)

A = catchment area (km^2)

(2) Design Discharge Distribution

Distribution of design discharge for 20-year return period is shown in Figure 5.13.

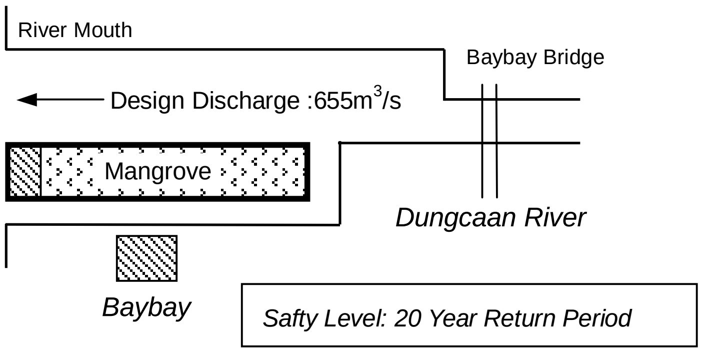


Figure 5.13 Design Discharge Distribution in the Dungcaan River Basin

5.3.3 Flood Inundation Analysis

(1) Flow Capacity

The flow capacity of the existing river channel is analyzed with HEC-RAS using the river cross sections newly obtained in the survey. The flow capacity of Dungcaan River at the Bridge is estimated as shown below.

Table 5.29 Flow Capacity of Existing River Channel in the Dungcaan River Basin

Location of Calculation	Flow Capacity (m^3/sec)
Dungcaan River (Baybay Bridge)	290

(2) Flood Inundation Area

Flood inundation area is analyzed with HEC-RAS and HEC-GeoRAS using the river cross sections newly obtained. In the analysis, the altitude data of SRTM is adjusted by comparison with the river cross sectional survey data. As a result, the flood inundation area consists of mangrove forest, built-up area of the Baybay City at the downstream of the Baybay Bridge, and annual crop area at the upstream of the Baybay Bridge. The total inundation area is estimated at around 173 ha with 20-year return period flood, as shown in the table below. The flood inundation map is shown in Figure 5.14.

Table 5.30 Area of Flood Inundation of the Dungcaan River Basin

(Unit: ha)

Land Use	Flood Scale (Return Period)
	20-year
Built-up Area	13.0
Fishpond	0.0
Cultivated, Annual Crop	89.1
Other	70.5
Total	172.6

5.3.4 Basic Layout of Main Structural Measures

(1) Applicable Structural Measures

The flood type of the Dungcaan River Basin is O+B (Group 2). Comparing with the flood type of this basin, the following structural measures are considered as the applicable ones:

Table 5.31 Basic Applicable Structural Measures for Flood Type in the Dungcaan River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir and/or Sabo dam	Retarding Basin	Diversion Channel	Drainage Facilities
Over Flow (O)	O	O	O	O	O
Bank Erosion (B)	O				

Judging from the river basin conditions, retarding basin, diversion channel and drainage facilities are not applicable considering the topographic and land use conditions. Hence, applicable measures are river channel improvement and dam and reservoir as described below.

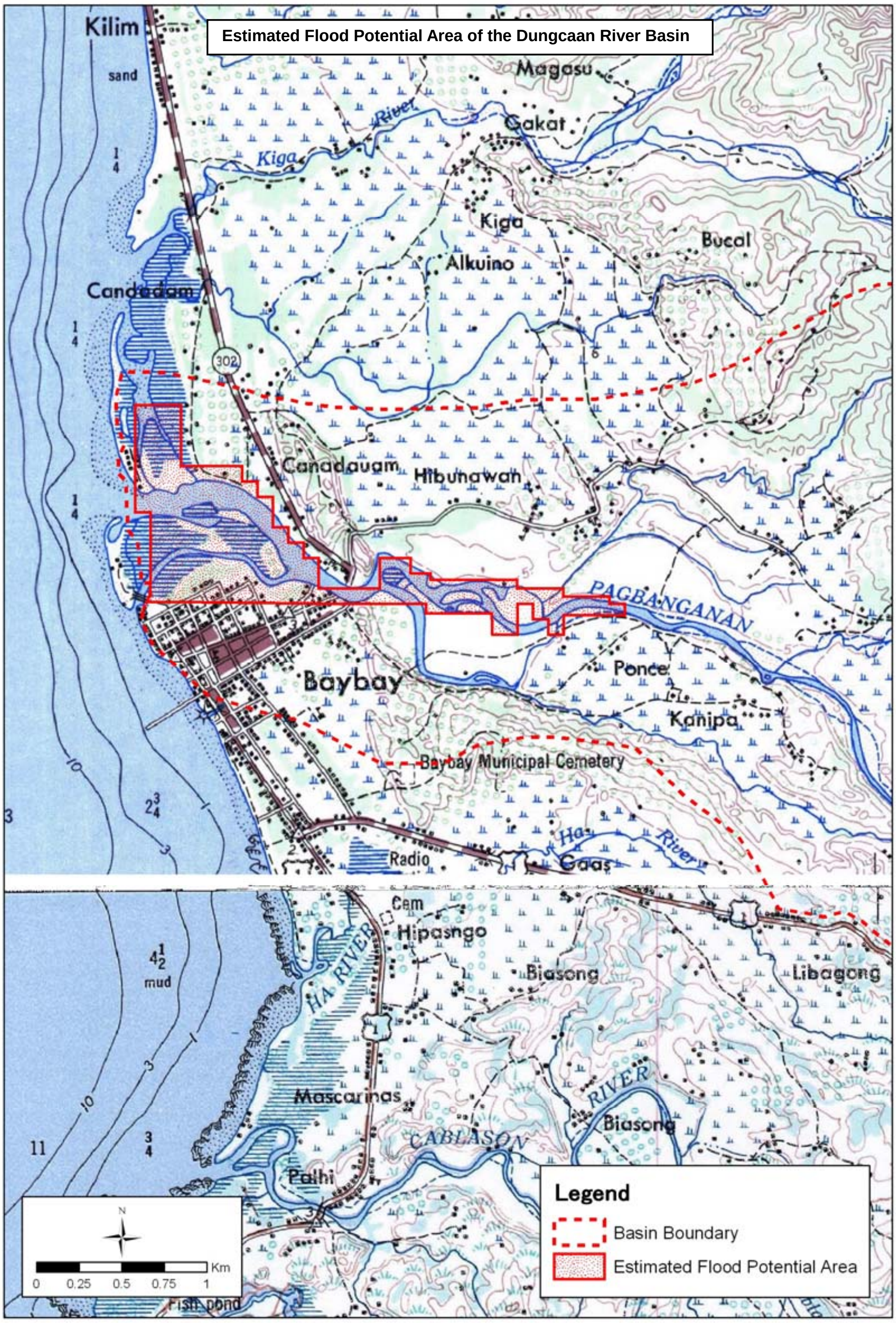


Figure 5.14 Flood Inundation Area of the Dungcaan River Basin

1) River Channel Improvement

River channel improvement is applicable for this river. However, for the downstream of the Baybay Bridge, its alignment should be studied considering the socio-environmental conditions, especially mangrove and resettlement.

2) Dam and Reservoir

Observing the geological conditions, several dam sites are surveyed around the following places:

- Along Dungcaan River, between the confluences with the tributaries, the Tabayagon and Pawonyan Rivers;
- Along Pawonyan Rivers, around 1.8 km upstream of the confluence; and
- Along the Tabayagon Rivers, around 7.0 km upstream of the confluence.

As a result, the Pawonyan River site is preliminarily selected for the dam, considering its geological condition, location and storage capacity, etc. This dam is planned as a multi-purpose dam for flood control and irrigation.

As a result, the applicable structural measures are recommended as summarized below.

Table 5.32 Applicable Structural Measures in the Dungcaan River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir	Retarding Basin	Diversion Channel	Drainage Facilities
O+B	O	O			

(2) Target Area of Flood Mitigation

Target area of flood mitigation is the downstream reach of Dungcaan River, in which built-up area of Baybay exists in the right side of the river.

(3) Basic Idea of Layout

The basic layout of the river channel improvement is studied for the downstream and upstream portions of the Baybay Bridge as described below.

1) Upstream of the Baybay Bridge

The river channel improvement is planned until around 300 m upstream from the Baybay Bridge against the overflow and bank erosion. There is a bend portion at around 300 m upstream of the Baybay Bridge. For this portion, a series of spur dikes (right bank) and dredging (left bank) is planned to stabilize the channel and make the channel straighter.

2) Downstream of the Baybay Bridge

The river channel improvement is planned for the downstream of the Baybay Bridge against the overflow and bank erosion. For the planned alignment of the dike, there are two alternatives regarding the socio-environment consideration, as follows:

<u>Channel alignment along the northern main stream for the right bank and the southern sub-stream for the left bank</u>

In this case, the mangrove area is positioned inside the river area. Hence, following impacts are expected:

- Negligible impacts on the mangrove; and
- Possibility of resettlement for about 20 families, who are dwelling near the seashore. However, the impacts of this resettlement can be mitigated when near resettlement site is found.

<u>Channel alignment along the northern main stream</u>

In this case, the major portion of the mangrove area is positioned outside the river area. Hence, following impacts are expected:

- Probability of negative impacts on the mangrove because of the change of water flows. In this case, reforestation of the mangrove forest is required; and
- No necessity of resettlement for about 20 families.

(4) Possible Alternative Cases

Corresponding to the above idea, five alternative cases are conceivable, as follows:

(1) River channel improvement only (alignment along the northern main stream and the southern sub-stream);
(2) River channel improvement only (alignment along the northern main stream);
(3) Dam and reservoir only;
(4) Combination of river channel improvement (above (1)) and dam and reservoir; and
(5) Combination of river channel improvement (above (2)) and dam and reservoir.

In the case of (3) dam and reservoir only, flood damage still occurs even the dam regulates all the flood discharge from the upstream. Thus, this case is eliminated.

In this regard, the dam size is preliminary designed as shown below, and its construction cost is roughly estimated at 443 million pesos. Based on the storage capacity for flood control and irrigation, the allocated cost for flood control is estimated at 221.5 million pesos. On the other hand, the cost for the river channel improvement only is roughly estimated at below this allocated cost. Hence, the cases (4) and (5) are eliminated, because the river channel improvement cost is added to this allocated dam cost. In addition to this, its land acquisition for the dam construction is expected to be problematic during its implementation.

Table 5.33 Preliminary Design of Dam

Item	Dimension, etc.
Dam Type	Rockfill
Peak Discharge Cut at Dam Site (m^3/s)	280 (All cut at the dam site)
Total Storage Capacity (MCM) - Flood Control - Irrigation (400-450 ha) - Dead Water	12.0 4.4 4.4 3.2
Dam Height (m)	41.0
Dam Lengthy (m)	160

Consequently, the possible alternative cases are formulated as shown in Table 5.34 and Figure 5.15.

Table 5.34 Alternative Cases in the Dungcaan River Basin

Alternative Cases	Basic Layout of Main Structural Measures
Case-1	• For the downstream of the Baybay Bridge, river channel improvement with its alignment along the northern main stream and the southern sub-stream • For the upstream of the Baybay Bridge, river channel improvement of about 300 m, and spur dikes, dredging and bank protection works
Case-2	• For the downstream of the Baybay Bridge, river channel improvement with its alignment along the northern main stream • For the upstream of the Baybay Bridge, the same layout to the above

(5) Recommended Structural Measures

1) Optimum Case

The optimum case for the Dungcaan River Basin is studied from the socio-environmental and economic aspects, as follows:

<u>Socio-environmental Aspect</u>

These plans were discussed and explained in the workshop and interview survey, and the following opinions were observed:

- There were opinions about the conservation of the mangrove forest; and
- There observed no strong objection on the resettlement. The resettlement would not be problematic if compensation and resettlement are assured on favorable conditions.

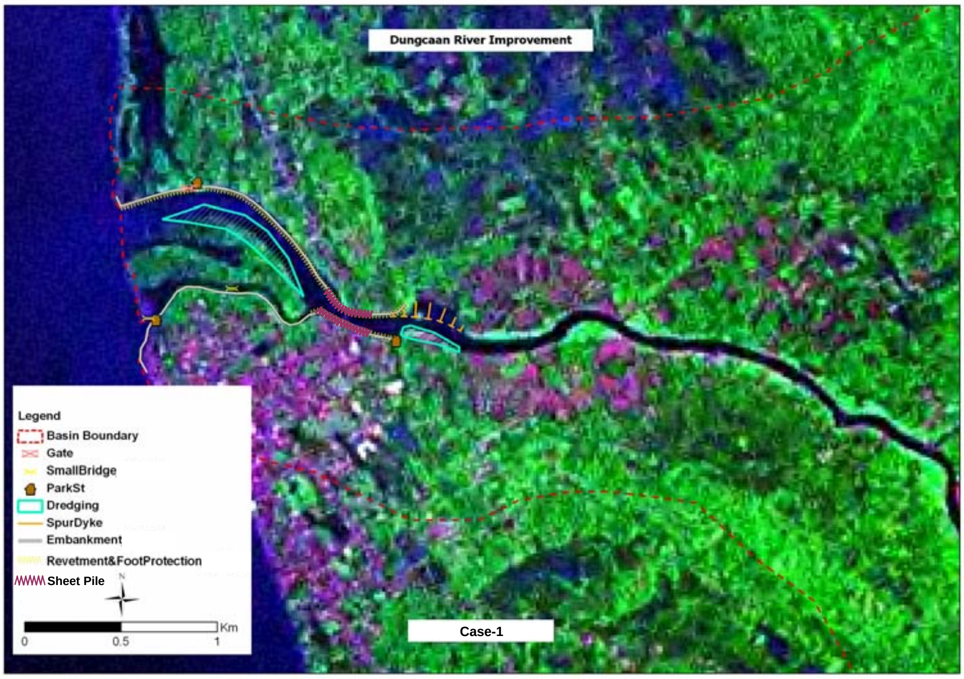
<u>Economic Aspect</u>

The results of the cost comparison are shown in Table 5.35. Case-1 shows lower cost. However, there is no big difference between both alternatives.

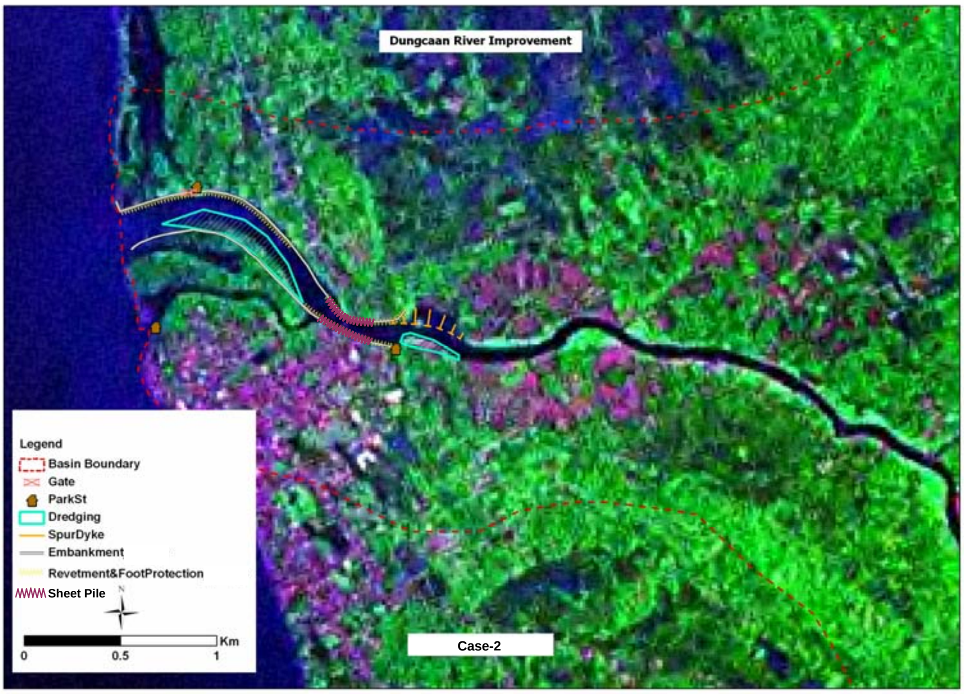
Table 5.35 Result of Cost Comparison of Alternative Cases in the Dungcaan River Basin

Alternative Cases	Cost (mil. Pesos)
Case-1	211.1
Case-2	264.0

Based on the above, Case-1 is preliminarily selected for the time being as the structural measures, which are the river channel improvement with the alignment along the northern main stream and the southern sub-stream. However, further study is necessary for this selection of the optimum case.



Case-1



Case-2

Figure 5.15 Comparison of Alternative Cases in the Dungcaan River Basin

With the recommended structural measures, the design discharge of 20-year return period will be distributed as shown in Figure 5.16.

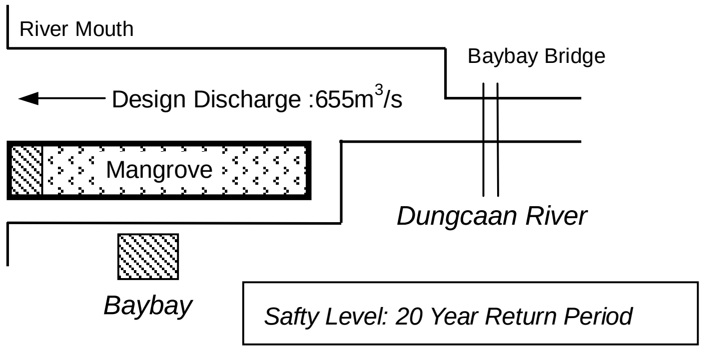


Figure 5.16 Design Discharge Distribution with Optimum Structural Measures in the Dungcaan River Basin

2) Preliminary Design of Main Structural Measures

The preliminary design of the river channel improvement is presented below.

a) River Channel Improvement

The improvement works will be required for the following river in order to attain the flood mitigation against the project scale of 20-year return period. The length and section for the improvement are tabulated in Table 5.36. On the other hand, longitudinal profile and typical cross sections of the improvement are shown in Fig.5-2.

Table 5.36 Improvement Plan of Dungcaan River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)
	From	To			
1	0	0.2	655	0.2	125
2	0.2	1.4	655	1.2	115
3	1.4	1.6	655	0.2	70
4	1.6	1.8	655	0.2	115
Total				1.8	

Based on the above design, the basic layout of the main structure is presented in Figure 5.17.

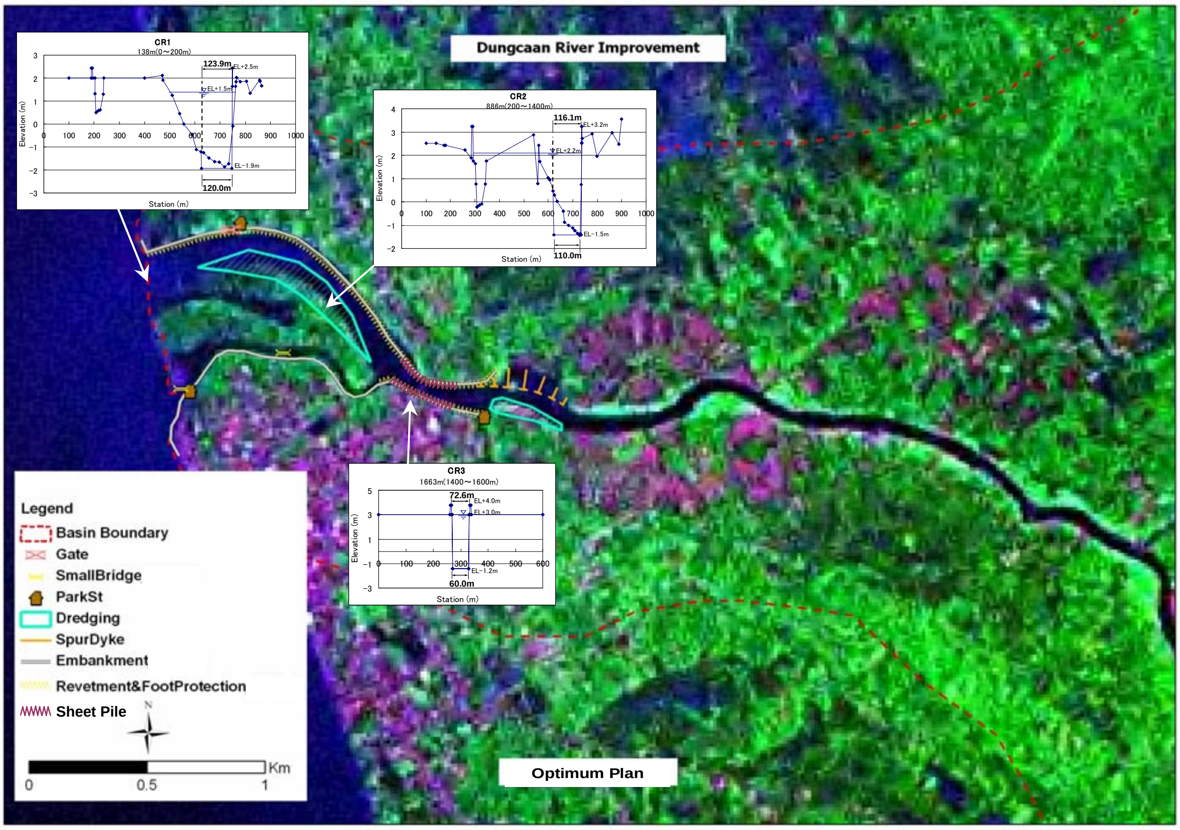


Figure 5.17 Proposed Works of the Optimum Plan of the Dungcaan River Basin

(6) Estimation of Cost for Structural Measures

1) Construction Cost of Structural Measures

The construction cost of the recommended structural measures is estimated at 139.6 million pesos as shown below.

Table 5.37 Main Construction Cost for Structural Measures of the Dungcaan River Basin

No.	Work Item	Unit	Quantity	Unit Cost (Pesos)	Amount (thousand Pesos)
1	Clearing and Grubbing	m^2	33,830	350	11,840
2	Channel Excavation	m^3	84,789	150	12,718
3	Channel Backfill	m^3	32,954	130	4,284
4	Revetment	m^2	8,516	1,100	9,368
5	Sheet Pile	m	13,500	3,000	40,500
6	Embankment	m^3	7,886	130	1,025
7	Sodding	m^2	8,987	30	270
8	Spur Dike (Gabion)	m^3	1,605	3,200	5,136
9	Foot Protection	m^3	985	3,350	3,300
10	Park Station	station	6	2,200,000	13,200
11	Bridge (3m x 10m x 2)	m^2	40	40,000	1,600
12	Gate(5m x 7m)	m^2	35	1,040,000	36,400
	Total				139,641

2) Project Cost

The project cost of the recommended structural measures is estimated at 211.1 million pesos in total as shown below.

Table 5.38 Project Cost for Structural Measures of the Dungcaan River Basin

No.	Description	Amount (thousand Pesos)
1	Construction Cost	160,587
(1)	Preparatory Works	20,946
(2)	Main Construction Cost	139,641
2	Administration Cost	4,818
3	Engineering Services	25,694
4	Compensation Cost	800
5	Physical Contingency	19,190
	Total	211,088

3) Economic Cost

The economic project cost is estimated as shown below.

Table 5.39 Financial and Economic Costs of the Project of the Dungcaan River Basin

	Financial (mil.Pesos)	Economic (mil.Pesos)
Project Cost	211.1	154.1

(7) Estimation of Benefit of Structural Measures

1) Estimation of Flood Damage

Inundation areas under the project scale are calculated in the flood inundation analysis, and are applied to estimate the flood damage. The flood damage is estimated considering with and without project conditions as shown below.

Table 5.40 Flood Damage in the Dungcaan River Basin

Item		Area Inundated (ha)	Assets Inundated (mil. Pesos)	Flood Damage (mil. Pesos)
I.	Direct Damage			46.2
	Built-up Area	13.0	118.3	35.5
	Infrastructure			10.7
II.	Indirect Damage			9.2
III.	Total			55.4

2) Annual Average Benefit

Based on the estimated flood damage, the annual average benefit under present condition is computed at 21.1 million pesos. The future benefit is shown in Tab.5-3.

5.3.5 Non-Structural Measures

(1) General

Non-structural measures are examined on the basis of filed survey and preliminary studies on flood warning system and soil loss related to reforestation. The methodology and detailed results of the study are described in Supporting Report H. It should be reminded that the Study is preliminary level because of limited time frame and resources. The Study concentrated to discuss general direction of flood mitigation using currently available information. Further detailed study toward implementation of flood mitigation measures is recommended at the next stage such as feasibility study. The recommended non-structural measures at this stage are summarized below.

(2) Recommendation on Non-Structural Measures

1) Recommended Flood Warning System

Community Based Flood Early Warning System (CBFEWS), which PAGASA is now introducing, is recommended. PAGASA is now introducing CBFEWS in Southern Leyte. Almost same scheme can be applied into the Dungcaan River Basin. Because time of concentration of flood wave is small, it is very difficult to get benefit by reduction of tangible damage by introducing the flood warning system. Disaster management should consider more on "response" including information dissemination and evacuation than "forecast" in order to reduce causality when the flood warning system is introduced.

Park stations, which are proposed as one of other measures shown below, can be utilized also for the monitoring station for the flood warning system.

After initial introduction of the warning system, it is recommended to refine the system every 3 years using the accumulated data and knowledge. Equipment introduced should also be checked at the same time.

2) Recommendation on Baseline Activities on Watershed Management

Watershed management includes many aspects than flood mitigation. In the present Study, it is recommended that at least minimum necessary activities related to flood mitigation be implemented as baseline activities on watershed management. The following activities are recommended.

- To prepare watershed characterization and watershed management plan
  - There is no watershed characterization and management plan in the Dungcaan River Basin. However, a devastating flood caused by accumulation of woody debris at Dungcaan Bridge occurred previously. There is a potential danger the similar woody debris happens. As a first step of watershed management, watershed characterization and watershed management plan should be prepared. Then, critical location should be identified and monitored.
  - The watershed characterization and watershed management plan should be reviewed and revised every 5 years to reflect the watershed situation properly.
- Reforestation with at least same rate as current national average
  - In order to keep at least current condition of watershed so that sediment load from catchment will not increase drastically in future, reforestation should be continued with at least same rate as current national average, e.g., reforestation of grass land (Total area in 26 years = 5.7% of land without forest in the basin).
- Supporting of River Basin Council
  - To enhance more communication within a basin, it is recommended to prepare budget to support activities of river basin council.

3) Recommendation on Other Measures

Issues and recommendations for further improvement for disaster management activity for the Dungcaan River Basin based on the result of field survey are summarized.

General recommendations are, as follows:

- Enhancement of disaster management activities at community level;
- Necessity of periodical refinement of disaster management plan; and
- Necessity of preparation and dissemination of hazard map for excess flood after completion of structural measures.

Recommended other measures for the Dungcaan River Basin are, as follows:

- Enhancement of evacuation system
  - People living in wet land, who meet inundation almost every year, are get used to evacuate. Because structural measures may not give significant improvement of flood condition in the wet land area, enhancement of evacuation system should be considered.

- To place park stations to be utilized not only for sight seeing for mangrove area but also temporal evacuation center and stock yard during flood is proposed. It may give more ensured evacuation in the wet land area.

- Information & education campaign
  - People who live along river bank and are threatened by bank erosion do not want to evacuate. The proposed structural measures can reduce the risk of bank erosion. However, people should recognize that they are living in potentially dangerous area.
  - Information Education Campaign for those people is required. Furthermore, the constructed structure should be properly maintained. It is desirable for the residents living nearby to corporate to the activity of maintenance of the structure.

(3) Rough Estimation of Cost and Benefit for Reference

As a reference, rough cost estimation is made for the flood warning system and the baseline activity on watershed management.

Cost for flood warning system is roughly estimated as follows. O&M cost for 26 years includes 1) cost for refinement of the system every 3 years and 2) cost for observer.

Table 5.41 Rough Cost Estimation for Flood Warning System for 26 years in the Dungcaan River Basin (2009 to 2034)

Cost for Initial Setting (mil. Pesos)	Total Cost for O&M for 26 years (mil. Pesos)	Total Cost for 26 years (mil. Pesos)
0.3	1.2	1.5

Cost for recommended baseline activities on watershed management for 26 years (2009 to 2034) is roughly estimated as shown in the following table.

Table 5.42 Rough Cost Estimation for Recommended Baseline Activities on Watershed Management for 26 years in the Dungcaan River Basin (2009 to 2034)

Cost			
Preparation of Watershed Characterization & Watershed Management Plan (mil. Pesos)	Reforestation (mil. Pesos)	Supporting of River Basin Council (mil. Pesos)	Total Cost (mil. Pesos)
3.00	3.42	2.6	9.02

The breakdown of the estimated costs is shown in Supporting Report H.

Possible benefit by flood forecasting and warning system is preliminary estimated to examine appropriate flood forecasting and warning system in this river basin. Based on it, the above-mentioned flood warning system is recommended. The detail discussion is presented in Supporting Report H.

5.3.6 Initial Environmental Examination

(1) Result of the IEE

The IEE for the structural measures was carried out based on the information and data collected during this Study and consultation with concerned government and stakeholders.

In the Matrix (refer to Tab.5-4), the major environmental resources are shown in the horizontal line, and the activities for implementation of the proposed plan are shown in the vertical line. The assessment of impacts was made in terms of magnitude (e.g., significant, moderate, and negligible) of the negative or positive affecting the environmental elements.

Positive impacts are not considered in the cumulative quantification of the environmental impact score for each alternative since they would not lead to any hindrance in decisions of whether or not to proceed with the project. On the other hand, negative environmental impacts remain critical in so far as decisions in the proper selection of project alternatives.

Table 5.43 Activities for Each Project Phase in the Dungcaan River Basin

Phase	Project Activity
Pre-construction Phase	Resettlement of Project affected Persons/Families
	Land Acquisition
	Project Mobilization
Construction Phase	Construction of Concrete Dike with Access Road
	Bank Erosion Protection Work (revetment and foot protection)
	Construction of the Spur Dike
	Construction of the Multi-Purpose Reservoir
	Construction of Small Bridge and Mini Park within the Mangrove/Wetland Area
	Dredging and Excavation
O & M Phase	Dredging and Excavation
	Watershed Management
	Installation of Flood Warning System

As the result of the assessment, it is evaluated that the implementation of the multi-purpose dam and the river channel improvement along the main channel of Dungcaan River is considered to cause the potential adverse impact for this area. The particular evaluations for these impacts are described below (for details, refer to Supporting Report I).

1) Social Environment

a) Resettlement

In the pre-construction phase, resettlement of PAPs/PAFs which are mostly residential households is inevitable since it is necessary to clear the area for the dam and to give way for the road level to be increased due to the construction of the dike. The number of PAFs was estimated as more than 20 at the dam site and some 114 families in Sitio Brandy Island and more than 20 families in Sitio Paradise Island for the implementation of river channel improvement and dam and reservoir. In terms of implementing alternative Case-1 or Case-2, some 114 families in Sitio Brandy Island and more than 20 families in Barangay Sto. Rosario will be displaced to facilitate the river improvement works.

This number of potentially displaced PAFs requires extensive public consultations/hearings and depending on the experiences/professional judgment of the DENR-EMB (as determined by the EIA review committee) this may lead to full-scale EIS. Based on the WB guidelines on involuntary resettlement, once the number of PAPs reached 200 or more, a full resettlement action plan (RAP) is required.

2) Natural Environment

a) Mangrove and faunal communities

The damage on the mangrove as well as other faunal communities whose habitat may be found in the mangrove sites will be the most significant impacts by the proposed activities. When the project is implemented, the study shall be submitted to the DENR and it shall include the proposed action plans (replanting of cut mangroves, etc.) consistent with the concept of forest management systems within mangrove areas. Although the extent of mangrove removal is not towards clear cutting operations, the implementing agency should consider re-vegetation of mangroves along coastlines as prescribed under Section 43 of the revised forestry code of the Philippines (RA 7161) and Section 12 of DENR AO 1990-15.

3) Public Hazard

a) Disposal of dredge materials and spoils

The extent and magnitude of the proposed river improvement works has a high potential for indiscriminate disposal of dredge materials. If left unmanaged and with the absence of an acceptable disposal site, the dredge materials may end up in vacant lots and agricultural lands resulting to irreversible negative aesthetic impacts. Hence, it is a primordial concern to identify, procure and prepare the land for ultimate disposal prior to the start of the construction works.

Environmental impacts from dredging activities may be controlled and reduced by performing environmentally-dredging activities which minimize adversely environmental and social impacts. At least, water volume of the river should be taken into consideration for mitigation.

b) Deterioration of the water quality

The possible deterioration of the water quality in Dungcaan River will be temporary and can still be reversed or restored to existing river quality. Among the potential changes in water quality are increased in suspended solids, turbidity, discoloration, presence of inorganic substance such as oils, etc. Such changes in the water quality may significantly cause adverse impacts to the existing aquatic biota in the water bodies, especially the estuarine ecosystem composed of mangroves and small fishes at the mouth of Dungcaan River. The extent of environmental impact may be treated as negative but short-term.

Dredging activities would make suspended solids increase visibly and high turbidity as well as discoloration in water might adversely affect biological activities taking place in the river system. Hence photosynthetic activities would slow down affecting largely the primary consumers like nektons (fish) and other aquatic organisms dependent on photosynthesis for survival. In order to mitigate these impacts, collecting dredged materials properly should be planned and dispersion of the operation's debris should be controlled and kept to a minimum. Engineering intervention does not necessarily work if a small amount of dredged materials is expected to disperse.

(2) Management/Mitigation Plan

Overall, environmental management and mitigation plan shall be closely exercised during the development phase of these major project components in order to minimize if not totally eradicated the negative environmental impacts. Several potential adverse impacts identified in the evaluation were concluded that the Environmental Impact Assessment (EIA) is required in the succeeding study period. Especially, the construction of the multi-purpose reservoir may also trigger (if the final design height of the dam will inundate > 25 hectares of land) the DENR-EMB to classify the project as major flood control project whose primary requirement in the issuance of an Environmental Compliance Certificate (ECC).

5.3.7 Project Evaluation

(1) Technical Feasibility

The Philippines has experienced the construction of river channel improvement many times. Thus, no difficulty would be encountered in the actual construction of the river channel improvement. The recommended non-structural measures have also been experienced in the country. This project is, therefore, evaluated to have a technical feasibility.

(2) Economical Viability

The economic viability is assessed based on the economic cost and benefit stream of the proposed structural measures. As for the assessment of the non-structural measures, this is not carried out based on the situation as discussed before.

Tab. 5-3 shows the economic cost and benefit stream. As the results, the economic viability is figured out as follows:

Table 5.44 Economic Viability of the Optimum Plan in the Dungcaan River Basin

Viability Index	
EIRR (%)	18.8
NPV (mil. Pesos)	26.0
B/C	1.29

Based on the above results, EIRR becomes higher than the opportunity cost of capital of 15%. Therefore, the project is evaluated to have an adequate economic viability.

(3) Environmental and Social Acceptance

As the social environmental impacts, the resettlement due to the construction of dike is unavoidable. Therefore, the resettlement framework will be needed to satisfy the achievement of the social acceptability. At this stage, it is understood that social acceptance can be obtainable by providing the satisfactory resettlement framework carefully arranged through further discussion. As the natural environmental impacts, the removal of a part of mangrove in the river mouth is expected even though the bank alignment is provided behind the mangrove area. Regarding this matter, it is concluded at this study stage that the situation can be accepted by stakeholders through provision of the action plan on the forest management to minimize the damage to the mangrove area. As the public hazard, the disposal of dredge materials and spoils are expected. Preparation of the appropriate disposal site will be needed prior to construction work.

Overall, environmental management and mitigation plan shall be closely exercised during the development phase of these major project components in order to minimize if not totally eradicated the negative environmental impacts.

The project plan was explained and discussed with the stakeholders through the stakeholder meetings at each end of the field survey and workshop in the site. Through these experiences and activities, it is concluded that, at this stage, implementation of this project is socially and environmentally accepted by the stakeholders.

5.4 Meycauayan River Basin

5.4.1 Basin Conditions

(1) Natural Conditions

1) Existing River System and Structures

The Meycauayan River Basin has total catchment area of about 201km^2, excluding the catchment area of the Bulacan River. The Meycauayan River consists of the main stream and several tributaries. The biggest tributary is Marilao River, which merges to Meycauayan River at around 9km from the river mouth. The Bulacan River also merges to Meycauayan River at around the river mouth. In the present Study, it is decided not to include the Bulacan River Basin, which has much wider watershed area than the Meycauayan River Basin.

Malabon River originates from Quezon City, and is connected to Meycauayan River through Polo area. However, in the on-going flood control project in KAMANAVA area, flood flow from Malabon River is planned to be drained through KAMANAVA area. Therefore, the discharge from the catchment area of Malabon River is not considered in the present Study.

The gradient of the main stream and Marilao River is shown in Table 5.45. The topographic map of the basin is shown in Figure 5.18.

Table 5.45 River Gradient of Meycauayan River

Reach	Slope
0 - 9km	1/2,500
9 - 16 km	1/1,000
16 - 32 km	1/450
32 - 45 km	1/250
45 - 49 km	1/30
49 - 52 km	1/150

Up to around 10km, tidal effect is governing the river condition. In this reach, once flood occurs, flood flow diffuses the surrounding low land area, which makes the area widely inundated. In addition to the overflow from the river, inland flood caused by high tide and heavy rainfall can often happen in this area. The VOM (Valenzuela - Obando - Meycauayan) project by DPWH has been conducted at F/S level to reduce the damage by the inland flood.

On the other hand, the middle and upper reach of the river has relatively steep gradient of the riverbed. The river shape is basically trench type, which is referred as an incised channel and has less flood plain area.

The existing structures relating to flood control are, as follows:

- Dike along the Meycauayan River and Marilao River;
- Coastal dike in Municipality of Obando; and
- Pumps and flood gates.

However, it is said that height of the dikes are often low compared to flood water level and many pumps and gates have been deteriorated.

There is an irrigation weir at the middle reach of Marilao River. However, it is said that it is not functioning.

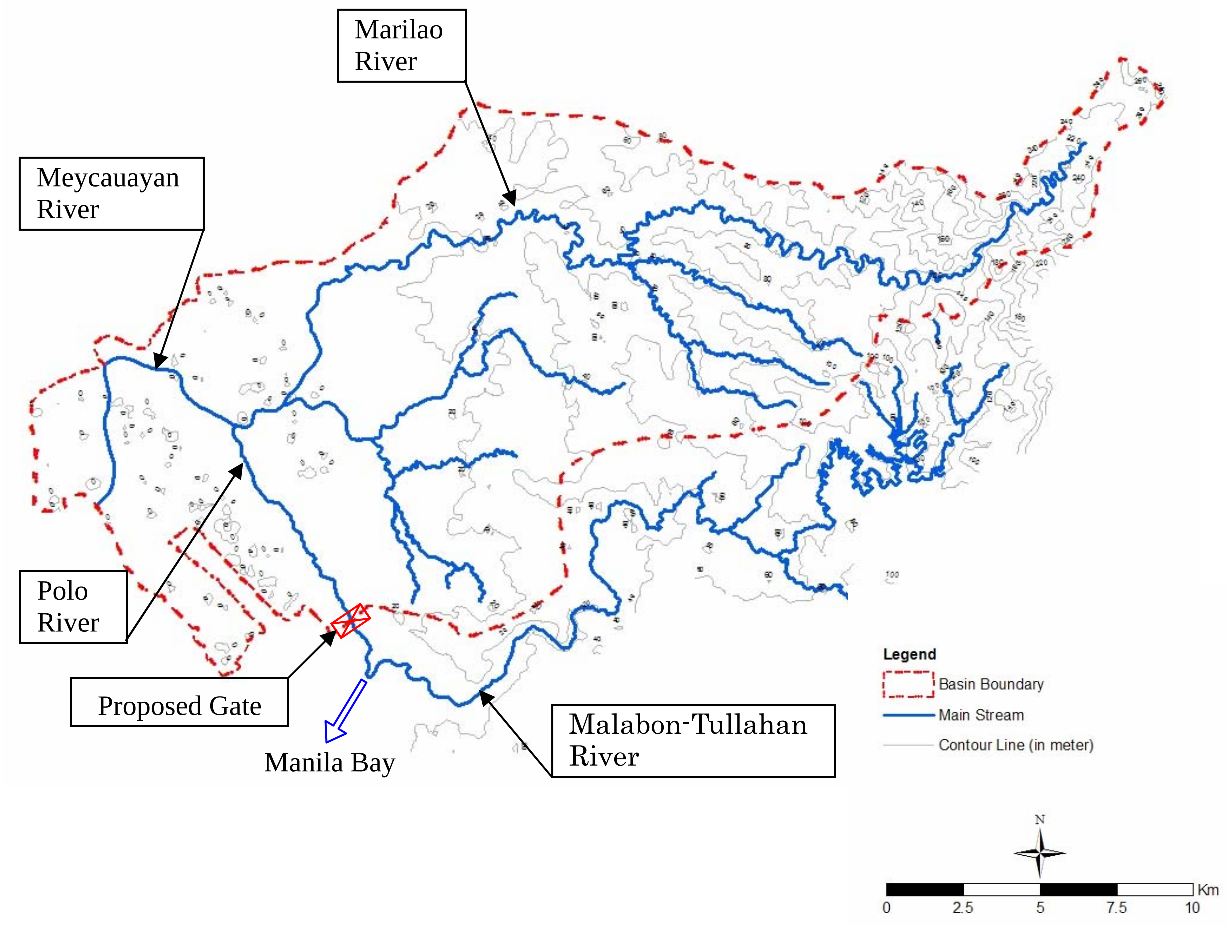


Figure 5.18 Topographic Map of the Meycauayan River Basin

2) Meteorology and Hydrology

The Meycauayan River Basin falls under Type I of the modified Corona's climate classification. In this climatic region, there are two pronounced seasons, one is dry season from November to April, and another is wet season during the rest in which about 80% of the annual rainfall occurs. In this region, there are regular occurrences of tropical cyclones.

Time of concentration of flood wave at the confluence of the Meycauayan and Marilao River is estimated at about 6 hours. This hydrological characteristic could allow some preparation time for flood. Hence, flood forecasting and warning may reduce damage in the lower reach of the basin. On the other hand, in the middle and upper reach, time of concentration of flood wave is much shorter, which can cause flash flood.

Because many areas of the Meycauayan River Basin have already been highly urbanized and it is expected that the urbanization proceeds more in future, the time of concentration of flood wave may become shorter, which results in the increase of the risk for flash flood more.

(2) Social and Economic Conditions

1) Population and its Growth

The total population and its density of cities and municipalities located in the lower reach of the Meycauayan River Basin, which is flood prone area, is shown in Table 5.46. Based on the F/S for the VOM area, it is said that population in the VOM area is expected to be double by 2020.

Table 5.46 Population in the Meycauayan River Basin

City / Municipality	Population	Land Area (ha)	Population Density (Head/ha)	Source
Meycauayan City	199,040	3,210	62	Municipality Profile 2005
Municipality of Marilao	114,794	2,625	44	Municipality Profile 2004
Municipality of Obando	60,333	1,592	38	Municipality Profile 2005
Valenzuela City	562,000	4,460	126	Year 2000, VOM F/S Report

There are some informal settlers along the Meycauayan and Marilao Rivers with shelter/living structures affixed underneath a bridge similar to those found in the Metropolitan Manila.

2) Land Use

Figure 5.19 shows the land use map of the basin (2002/03). Share of each land use is calculated based on the above map and is shown in Table 5.47. In the Meycauayan River Basin, almost half of the total catchment area is covered by built-up area. The fish ponds shares about 20%, which is located at the most downstream reach, especially for the right bank of Meycauayan River.

In the right bank of the middle reach of Marilao River, there are many newly developing sub-divisions to be used for residential area. On the other hand, in the left bank of the middle reach of Marilao River, there is resettlement project area by National Housing Authority in Caloocan City. Based on the Provincial Environment and Natural Resources Office, DENR Bulacan (PENRO), almost all of the river basin is already alienable and disposable lands.

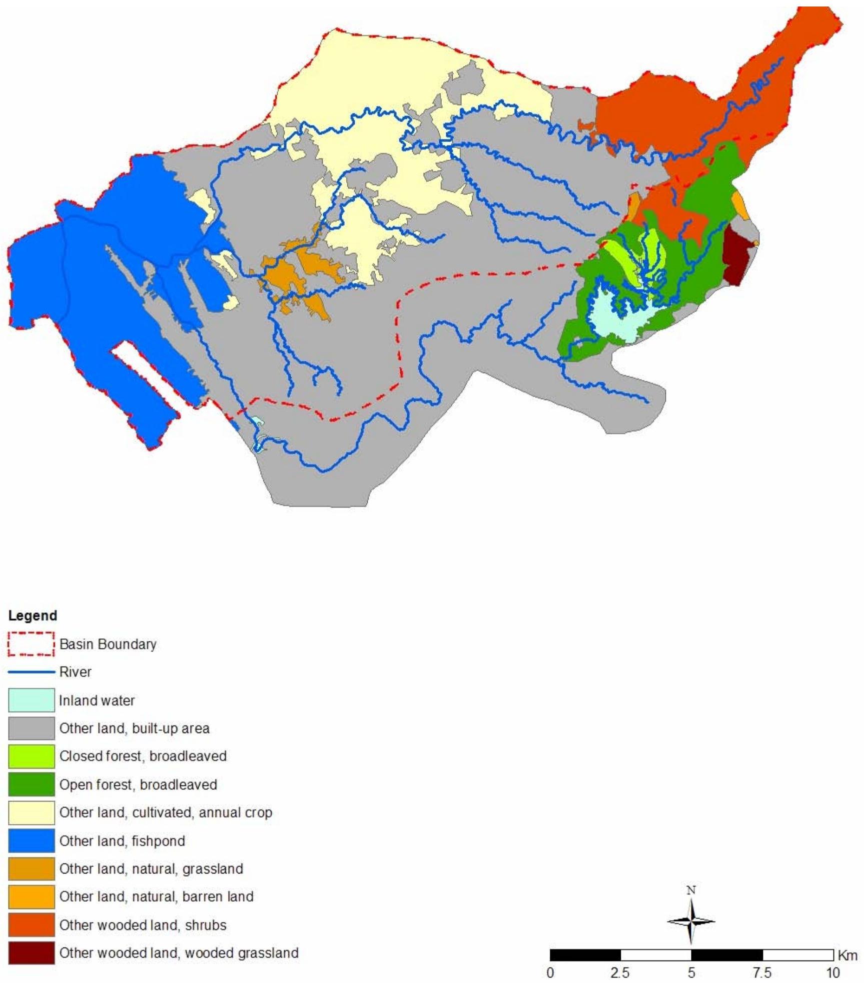


Figure 5.19 Existing Land Use in the Meycauayan River Basin

Table 5.47 Share of Land Use in the Meycauayan River Basin

Class	Area (km^2)	Percentage
Closed forest, broadleaved	0.02	0.0
Forest plantation, broadleaved	0.00	0.0
Inland water	0.00	0.0
Mangrove forest	0.00	0.0
Open forest, broadleaved	0.31	0.2
Other land, built-up area	96.39	47.9
Other land, cultivated, annual crop	38.32	19.1
Other land, cultivated, perennial crop	0.00	0.0
Other land, fishpond	41.48	20.6
Other land, natural, barren land	0.00	0.0
Other land, natural, grassland	3.75	1.9
Other wooded land, shrubs	20.77	10.3
Other wooded land, wooded grassland	0.00	0.0
Total	201.05	100.0

3) Local Economy

In this river basin, there is a preponderance of fishponds, which is a major source of business and personal income, as well as employment, although recently on a dwindling trend. Meanwhile, agriculture is dramatically decreasing in terms of both agricultural produce and income. Further, in the fishpond and agricultural areas, commercial establishments are increasing, which are mostly service-oriented companies. Moreover, the City of Meycauayan is noted for its jewelry industries and leather-crafts, etc.

(3) Floods and Flood Damage

1) Floods and Flood Damage

The lowest reach of the Meycauayan River Basin is subjected to inland flooding caused by high tide and heavy rainfall. It can occur almost every year. Almost all territory of Municipality of Obando is flood prone area, especially for the inland flooding. A part of Valenzuela City, which is in the VOM area, is also flood prone area. In Meycauayan City and Municipality of Marilao, downstream portion from North Luzon Highway, especially for downstream portion from McArther Highway is generally considered as flood prone area. Damage in the basin is rather concentrated to asset damage. Based on the data by Provincial Disaster Coordinating Council, number of causality is relatively small.

2) Major Causes of Floods

There are two major causes of flood in the Meycauayan River Basin.

One is high tide and heavy rainfall in the low-lying area located at the most downstream reach of the Meycauayan River Basin. This can be seen in the VOM area, the area along right bank of the reach downstream from the confluence of Meycauayan River and Marilao River, and the area from Manila bay to the existing coastal dike in Municipality of Obando.

Another one is overflow from Meycauayan River and Marilao River. The area along the reach downstream from North Luzon Highway is potentially risk area against the overflow. Because the watershed area has been already highly urbanized, runoff-volume has been increased, which resulted in the increase of risk against the overflow.

(4) Previous Related Study

For the VOM area, there is a project for ”Feasibility Study on Valenzuela-Obando-Meycauayan (VOM) Area Drainage System Improvement Project” in 2001. The stage of the projects is F/S level. After completion of the KAMANAVA project, it is expected that the VOM project will be implemented. The purpose of the project is to reduce damage by inland flood in the VOM area. Safety level has been set as follows:

- Overflow from Meycauayan River: 1/30
- Inland flood in the VOM area: 1/10

The proposed components are shown in the following table:

Table 5.48 Major Work Items of the VOM F/S

	Components	Work item
1	Meycauayan River Improvement	Masonry wall, Riprap and Embankment
2	Polder Dike Construction	Earth dike
3	New Open Channel Construction	Naked channel excavation & R.C. box culvert
4	Regulation Pond Construction	Excavation and Embankment
5	Raising of Existing Road	Concrete pavement with retaining wall
6	Installation of Gate Structure	Steel roller gate
7	Installation of Pumping Station	Submergible motor pump

5.4.2 Hydrologic Analysis

The design discharge is set with reference to the previous related study. Distribution of the design discharge for 30-year return period is shown in Figure 5.20.

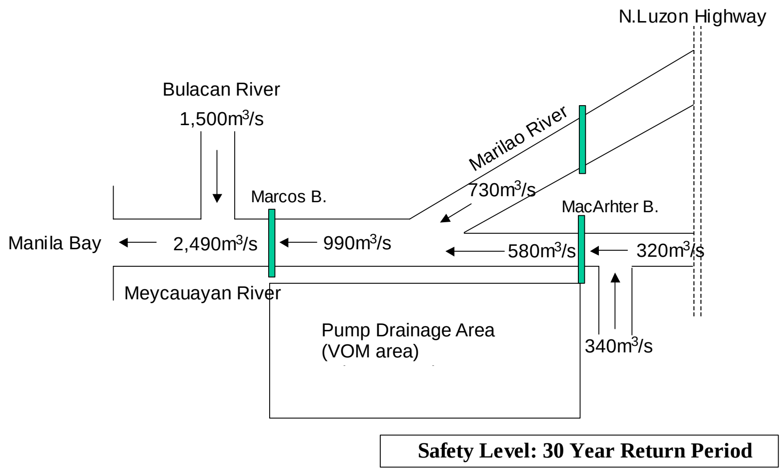


Figure 5.20 Design Discharge Distribution in the Meycauayan River Basin

5.4.3 Flood Inundation Analysis

(1) Flow Capacity

The flow capacity of the existing river channel is analyzed with HEC-RAS using the river cross sections newly obtained in the survey. The flow capacities of Meycauayan River are estimated as shown below.

Table 5.49 Flow Capacity of Existing River Channel in the Meycauayan River Basin

Location of Calculation	Flow Capacity (m^3/sec)
Meycauayan River (Downstream of Confluence)	400
Meycauayan River (Upstream of Confluence)	140
Meycauayan River (Bridge at 31.4 km)	330
Marilao River (Upstream of Confluence)	240

(2) Flood Inundation Area

Flood inundation area is analyzed with HEC-RAS and HEC-GeoRAS using the river cross sections newly obtained. In the analysis, the altitude data of SRTM is adjusted by comparison with the river cross sectional survey data.

Valenzuela, Obando, Meycauayan and Malabon are generally located at very low elevation so that the area is always under the menace of flood inundation. Particularly, the flood inundation area is remarkable in the downstream portion from the North Luzon Highway. The total inundation area is estimated at 5,222 ha with 30-year return period flood, as others are tabulated below. Figure 5.21 shows the flood inundation area.

Table 5.50 Area of Flood Inundation of the Meycauayan River Basin

(Unit: ha)

Land Use	Flood Scale (Return Period): 30-year			
	VOM	Improvement Area	Other	Total
Built-up Area	804.2	352.8	157.8	1,314.8
Fishpond	741.5	92.0	2,830.7	3,664.2
Cultivated, Annual Crop	56.9	25.2	24.0	106.1
Other	0.0	93.7	42.8	136.5
Total	1,602.6	563.7	3,055.3	5,221.6

5.4.4 Basic Layout of Main Structural Measures

(1) Applicable Structural Measures

The flood type of the Meycauayan River Basin is F+O/O/F (Group 3). Comparing with the flood type of this basin, the following structural measures are considered as the applicable ones:

Table 5.51 Basic Applicable Structural Measures for Flood Type in the Meycauayan River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir and/or Sabo dam	Retarding Basin	Diversion Channel	Drainage Facilities
Flash Flood (F)	O	O			
Over Flow (O)	O	O	O	O	O

Note) Flash flood is not a major flood type based on the field survey.

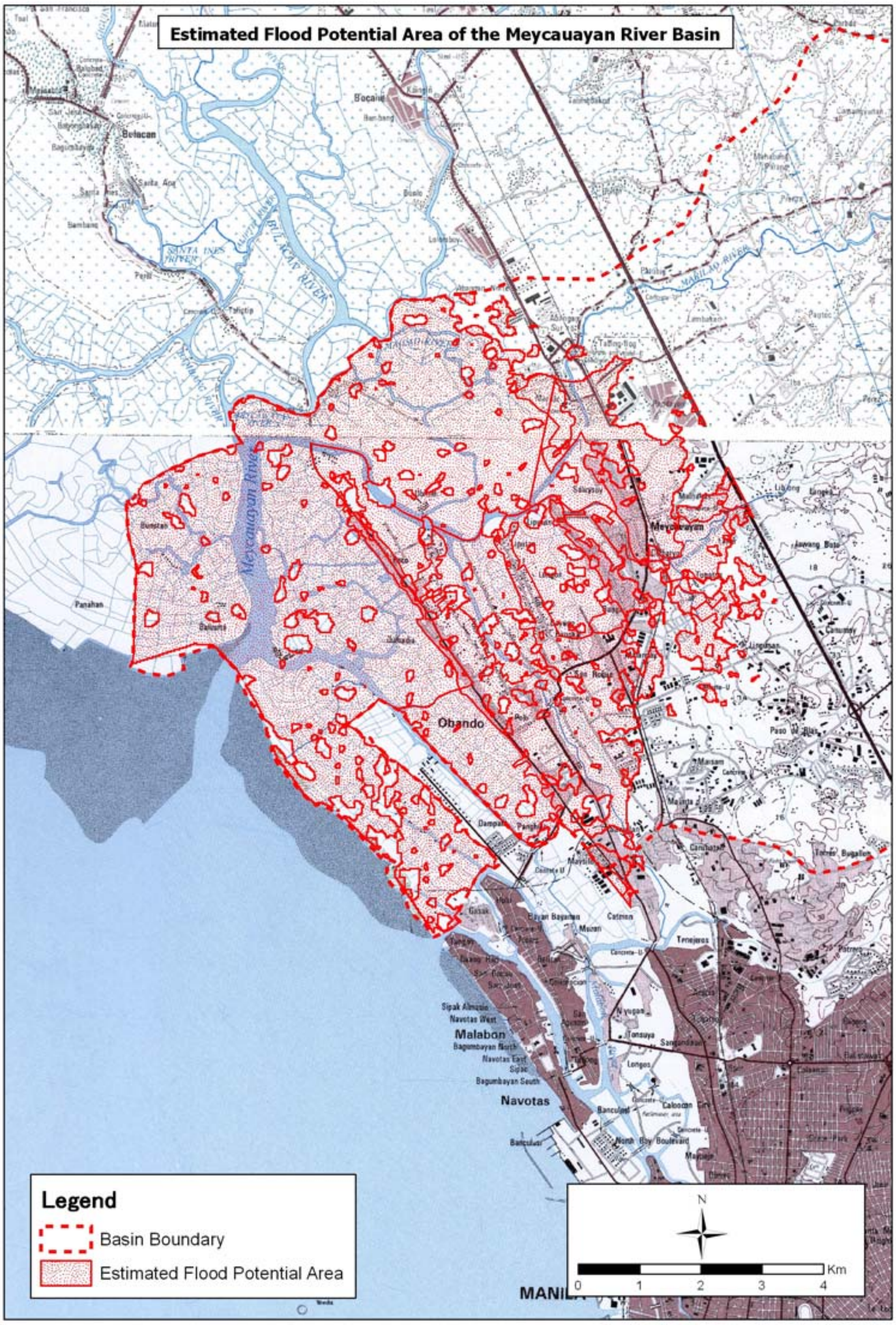


Figure 5.21 Flood Inundation Area of the Meycauayan River Basin

Judging from the river basin conditions, among these applicable measures, the dam, retarding basin, diversion channel are not applicable to the basin considering the topographic and land use conditions. In addition to this, in the VOM area, drainage facility to reduce inland flooding is necessary. Hence, applicable measures are the river channel improvement and drainage facilities as described below.

Table 5.52 Applicable Structural Measures for the Meycauayan River Basin

Flood Type	Applicable Measures				
	River Channel Improvement	Dam and Reservoir and/or Sabo Dam	Retarding Basin	Diversion Channel	Drainage Facilities
F+O/O/F O+I (the VOM area)	O				O

(2) Basic Idea of Structural Measures

1) Target Area of Flood Mitigation

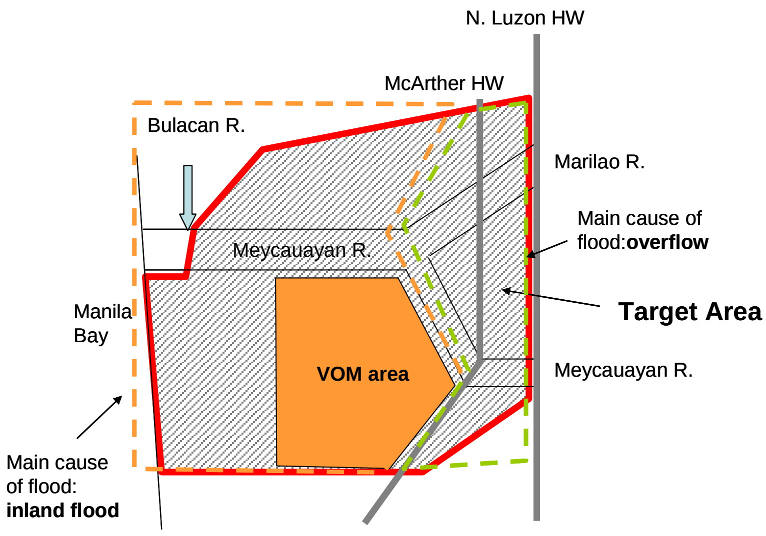
Target area of flood mitigation by structural measures is selected from a potential flood area along the downstream reach of Meycauayan River and Marilao River. Based on the ocular observation during the filed survey and the result of workshop, the potential target reach is set at downstream of North Luzon Highway.

There are following two cases for setting target area in the potential target area as shown in Figure 5.22.

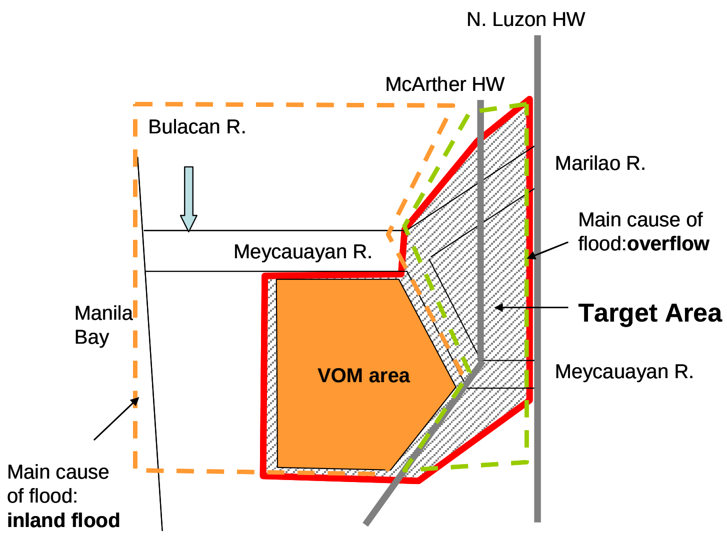
- Case-1: All area downstream from North Luzon Highway
- Case-2: The VOM area and the area upstream from the confluence of Meycauayan River and Marilao River

In the present Study, Case-2 is recommended.

In Case-1, to reduce the damage by flood, both overflow and inland flood should be mitigated. To do so, full scale of river improvement, which consists of excavation and construction dike, construction of coastal dike and installation of drainage facilities, is required for the entire target area. Very rough cost estimation only for river improvement along Meycauayan River (0 to 9km) shows that it may cost at order of 5,000 million pesos. If the cost for the construction of coastal dike and installation of drainage facilities are considered, it would double or triple or more. It is too costly considering the damage by flood in the area without highly urbanized.



Case-1



Case-2

Figure 5.22 Alternatives for Target Area to be Protected

In the territory of Municipality of Obando, except the VOM area, it is not expected that significant urbanization will proceed, based on the future land use plan by Municipality of Obando. Future land use plan for Municipality of Marilao is currently under preparation. However, in the territory of Municipality of Marilao along the right bank of Meycauayan River at downstream from the confluence of Meycauayan River and Marilao River, there is no clear indication for future significant urbanization. Therefore, Case-1 is not recommendable in the present Study, considering the current situation. Case-1 should be considered in future if significant development plan for the area is proposed, although there might be still several difficulties such as economical feasibility.

2) Safety Level

Considering the F/S for the VOM area safety level is set, as follows:

- Overflow from Meycauayan River: 1/30
- Inland flood in the VOM area: 1/10

3) Relationship between the Present Study and the F/S for the VOM Area

The F/S level study has been completed for the drainage improvement of VOM area. In the present Study, it is reviewed briefly and basically same work items are proposed, unless they are not suitable for the additional works for the outside of the VOM area proposed in the present Study.

4) River Channel Improvement

To reduce risk for flood caused by overflow from Meycauayan River and Marilao River in the target area, it is necessary to keep enough flow capacity of both rivers along the target area. To keep enough flow capacity, excavation and construction of dike for the following reach is proposed:

- Meycauayan River:
  - ➢ From confluence with Marilao River to North Luzon Highway
- Marilao River:
  - ➢ From confluence with Meycauayan River to North Luzon Highway

For conservative estimation, the water level at the confluence is set at the same level as the design high water level set in the previous F/S, which is slightly higher than the past maximum high tide level.

5) Drainage Improvement in the VOM Area

To reduce the risk for inland flooding in the VOM area, basically same work items proposed in the pervious F/S are proposed. The proposed works comprise, as follows:

- Polder Dike Construction;
- New Open Channel Construction;
- Regulation Pond Construction;
- Raising of Existing Road;
- Installation of Gate Structure; and
- Installation of Pumping Station.

(3) Recommended Structural Measures

1) Recommended Structural Measures

Based on the basic idea above mentioned, the recommended structural measures are the above river channel improvement and drainage improvement for the target area. The major work items proposed by this Study and the previous F/S are shown in Table 5.53 and Table 5.54. The location of these structural measures is shown in Figure 5.23.

Table 5.53 Major Work Items Recommended in the Study

	Components	Work Item	Description	Quantity
1	Meycauayan River Improvement	Concrete Revetment Excavation	Height: 0.5～3.5m	9,500 m
2	Marilao River Improvement	Concrete Revetment Excavation	Height: 0.5～3.5m	4,500 m
3	Polder Dike Construction	Earth dike	Embankment: 3m high	5,200 m
4	New Open Channel Construction	Naked channel excavation and R.C. box culvert	Channel: 5-10m wide, and 1.5-2.0m deep	2,540 m
5	Regulation Pond Construction	Excavation and Embankment	Excavation: 0.5m Embankment: 1.0m	27ha at 2 sites
6	Raising of Existing Road	Concrete pavement with retaining wall	Width: 12 m Height: 1 m	3,900 m
7	Installation of Gate Structure	Steel roller gate	Leaf area: 416 m^2 in total	11 sites
8	Installation of Pumping Station	Submergible motor pump	Pump capacity: 22.1 m^3/s in total	4 stations
9	Re-Construction of Bridge	Concrete bridge	Length: 40m Width: 12m	5 sites

Table 5.54 Major Work Items Proposed in the VOM F/S

	Components	Work Item	Description	Quantity
1	Meycauayan River Improvement	Masonry wall, Riprap & Embankment	Raising of existing dike: 1m high	7,240 m
2	Polder Dike Construction	Earth dike	Embankment: 3m high	5,200 m
3	New Open Channel Construction	Naked channel excavation & R.C. box culvert	Channel: 5-10m wide, 1.5-2.0m deep	2,540 m
4	Regulation Pond Construction	Excavation and Embankment	Excavation: 0.5m Embankment: 1.0m	27ha at 2 sites
5	Raising of Existing Road	Concrete pavement with retaining wall	Width: 12 m Height: 1 m	3,900 m
6	Installation of Gate Structure	Steel roller gate	Leaf area: 416 m^2 (333 ton) in total	8 sites
7	Installation of Pumping Station	Submergible motor pump	Pump capacity: 22.1 m^3/s in total	4 stations

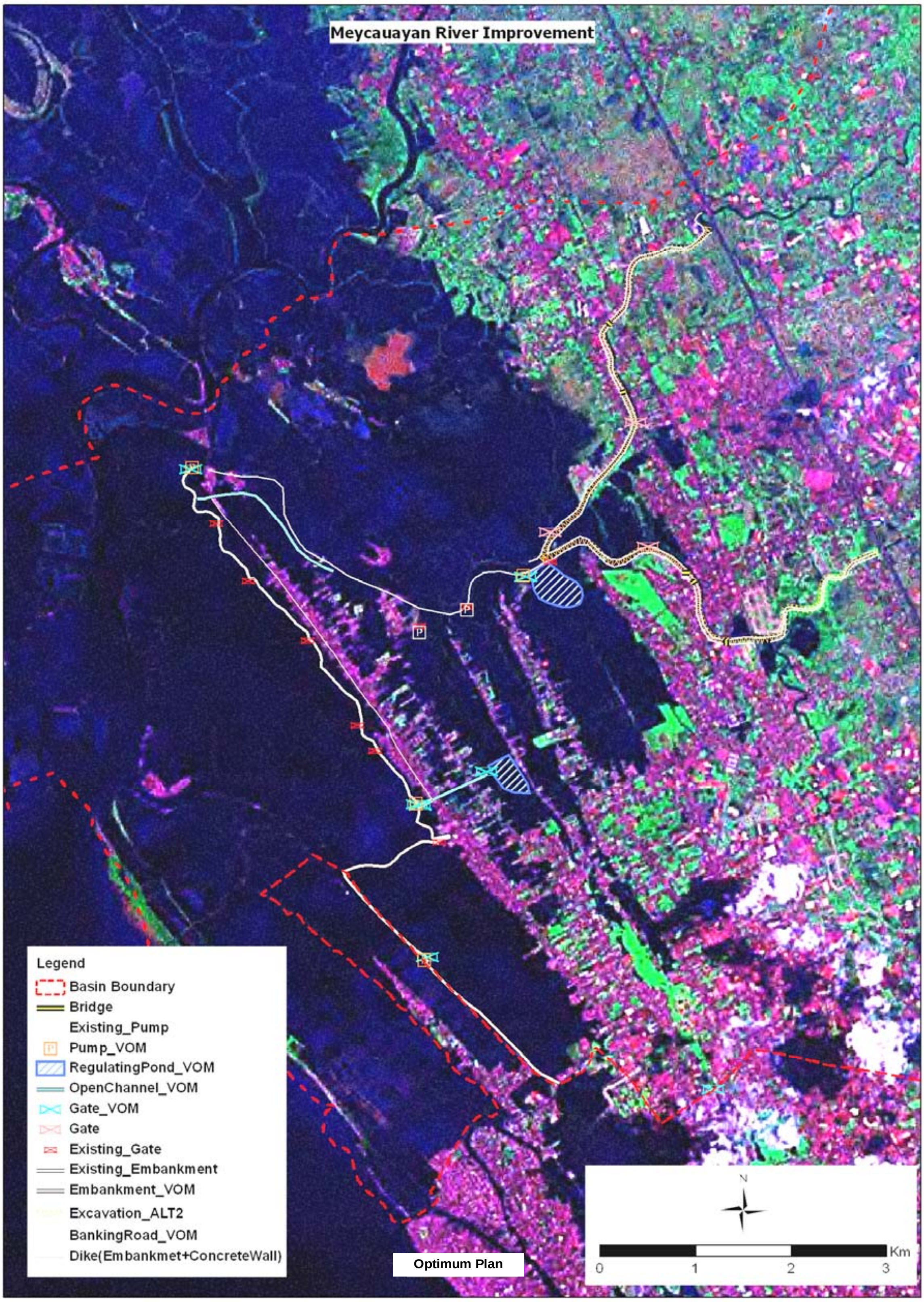


Figure 5.23 Recommended Structural Measures in the Meycauayan River Basin

With the recommended structural measures, the design discharge of 30-year return period will be distributed as shown below.

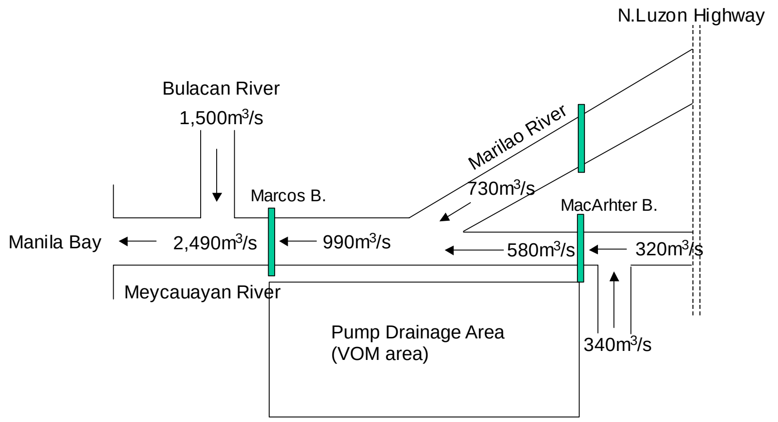


Figure 5.24 Design Discharge Distribution with Proposed Structural Measures in the Meycauayan River Basin

2) Preliminary Design of Main Structural Measures

The preliminary design of the river channel improvement and the drainage improvement of the VOM area is presented below.

a) River Channel Improvement

The improvement works will be required the following rivers in order to attain the flood mitigation against the project scale of 30-year return period. The length and section for the improvement are tabulated below. On the other hand, longitudinal profile and typical cross sections of the improvement are shown in Fig.5-3 and Fig.5-4.

Table 5.55 Improvement Plan of Meycauayan River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)	Remarks
	From	To				
1	5.0	9.5	580	4.5	-	Embankment Type
2	9.5	11.2	580	1.7	90	Embankment Type
3	11.2	12.2	580	1.0	40	Vertical Wall Type
4	12.2	13.6	320	1.4	50	Embankment Type
5	13.6	14.5	320	0.9	30	Vertical Wall Type
Total				9.5		

Table 5.56 Improvement Plan of Marilao River

Stretch	Station Number		Design Discharge (m^3/s)	Length (km)	Width (m)	Remarks
	From	To				
1	0.0	0.5	730	0.5	66	Embankment Type
2	0.5	1.0	730	0.5	30	Vertical Wall Type
3	1.0	2.0	730	1.0	50	Vertical Wall Type
4	2.0	3.5	730	1.5	45	Vertical Wall Type
5	3.5	4.5	730	1.0	30	Vertical Wall Type
Total				4.5		

b) Drainage Improvement for the VOM Area

As mentioned before, the same work items proposed in the pervious F/S are adopted for this flood mitigation plan. The salient features of the proposed drainage improvement works are shown in Table 5.54. Proposed works for the basin is shown in Figure 5.25.

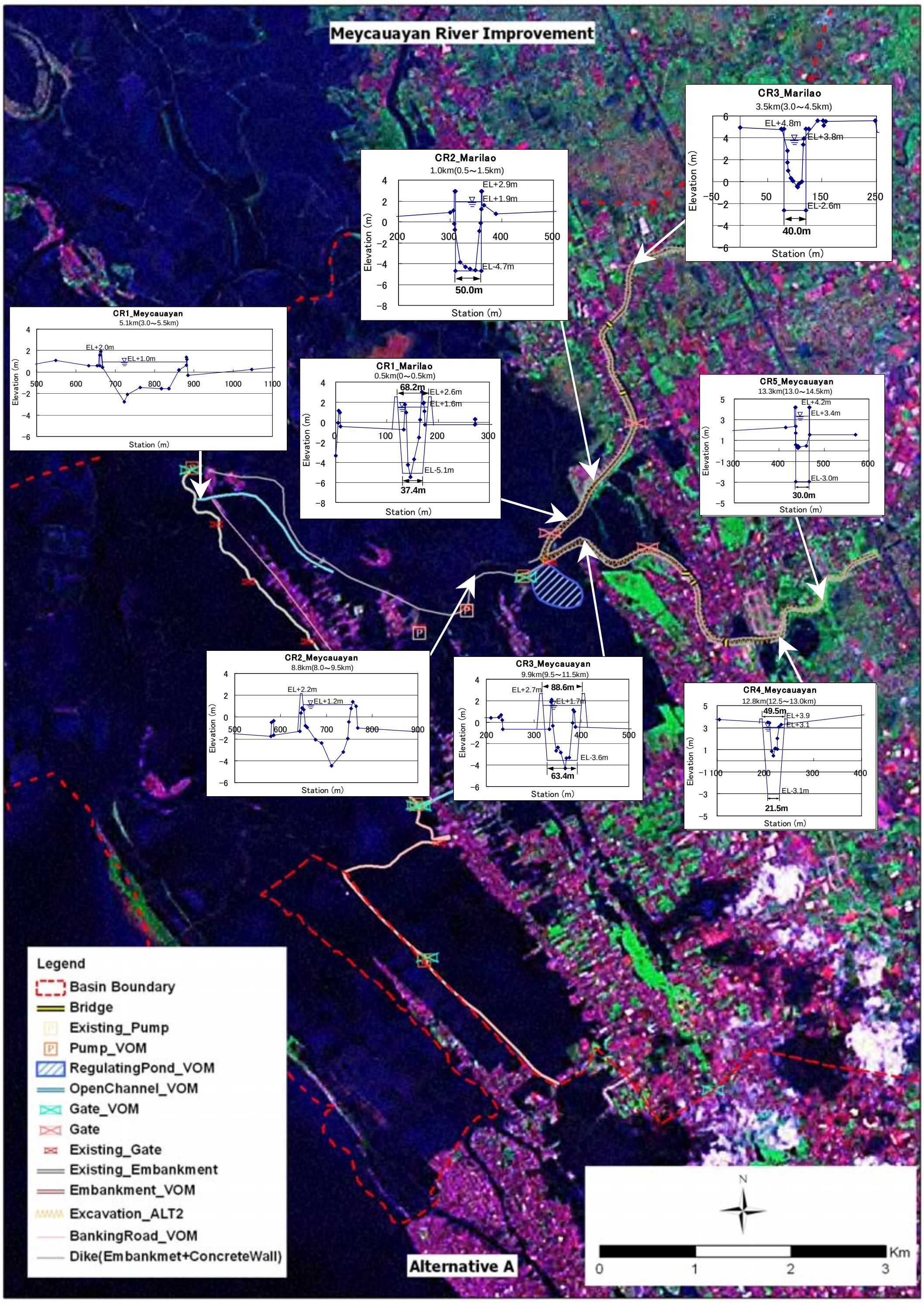


Figure 5.25 Proposed Works of the Meycauayan River Basin

(4) Estimation of Cost for Structural Measures

1) Construction Cost of Structural Measures

The construction cost of the recommended structural measures is estimated at 3,937.6 million pesos as shown below.

Table 5.57 Main Construction Cost for Structural Measures of the Meycauayan River Basin

Work Item	Unit	Quantity	Unit Cost (Pesos)	Amount (thousand Pesos)
River Improvement	m	14,000	302,896	2,447,769
Meycauayan River	m	9,500	93,043	1,027,163
Marilao River	m	4,500	343,382	1,420,605
Polder Dike Construction	m	5,200	26,027	135,340
Pinagkabalian River & Paliwas River	m	4,700	26,030	122,342
Palasan River	m	500	25,996	12,998
New Open Channel Construction	m	2,541	8,701	22,110
Polo-Palasan Diversion Channel	m	850	10,562	8,978
Small Channel	m	1,650	3,086	5,092
Box Culvert	m	41	196,098	8,040
Regulation Pond Construction	ha	27	2,193,630	59,228
Raising of Existing Road	m	3,900	22,574	88,038
Installation of Tidal Gate (11 sites)	m^2	416	985,803	410,094
Installation of Pumping Stations(4 sites)	m^3/s	22	35,070,407	775,056
Total				3,937,635

2) Project Cost

The project cost is estimated at 6,828.1 million pesos as shown below.

Table 5.58 Project Cost for Structural Measures of the Meycauayan River Basin

No.	Description	Amount (thousand Pesos)
1	Construction Cost	4,528,280
(1)	Preparatory Works	590,645
(2)	Main Construction Cost	3,937,635
2	Administration Cost	135,848
3	Engineering Services	724,525
4	Compensation Cost	818,681
5	Physical Contingency	620,733
	Total	6,828,068

3) Economic Cost

The economic project cost is estimated as shown below.

Table 5.59 Financial and Economic Costs of the Project of the Meycauayan River Basin

	Financial (mil. Pesos)	Economic (mil. Pesos)
Project Cost	6,828.1	4,984.5

(5) Estimation of Benefit of Structural Measures

1) Estimation of Flood Damage for Over Flows

Inundation areas under the project scale are calculated in the flood inundation analysis, and are applied to estimate the flood damage. The flood damage is estimated considering with and without project conditions. Because, in the VOM area, inland flooding can occurs even after the river improvement work will be implemented, only outside of the VOM area is considered for the reduction of damage for floods by overflow, as shown below.

Table 5.60 Flood Damage in the Meycauayan River Basin (Excluding the VOM Area)

Item		Area Inundated (ha)	Assets Inundated (mil. Pesos)	Flood Damage (mil. Pesos)
I.	Direct Damage			1,255.7
	Built-up Area	352.8	3,210.5	963.2
	Annual Crop	25.2	0.3	0.2
	Fishponds	92.0	2.8	2.5
	Infrastructure			289.8
II.	Indirect Damage			251.1
III.	Total			1,506.8

2) Annual Average Benefit for Over Flows

Based on the estimated flood damage above mentioned, the annual average benefit under present condition is computed at 527.4 million pesos.

3) Annual Average Benefit for Drainage Improvement

Even though there is no overflow form Meycauayan River, the VOM area is subject to inundation due to high tide and insufficient drainage when heavy rainfall occurs. Therefore, flood damage in the VOM area is estimated using the results of the F/S. Based on the results of the F/S, annual average benefit was calculated at 273.6 million pesos (economic term in 2001). This annual average benefit is converted from 2001 to 2006 with the annual growth rate of 3.35%. Finally, the annual average benefit is estimated at 322.6 million pesos.

4) Annual Average Benefit for the Entire Structural Measures

The benefit of the recommended structural measures accrues from the flood inundation area (by river channel improvement) and the VOM area (by drainage improvement). As the results, the present benefit is estimated at 850.0 million pesos. The future benefit is shown in Tab.5-5.

5.4.5 Non-Structural Measures

(1) General

Non-structural measures are examined on the basis of filed survey and preliminary studies on flood warning system and soil loss related to reforestation. The methodology and detailed results of the study are described in Supporting Report H. It should be reminded that the Study is preliminary level because of limited time frame and resources. The Study concentrated to discuss general direction of flood mitigation using currently available information. Further detailed study toward implementation of flood mitigation measures is recommended at the next stage such as feasibility study. The recommended non-structural measures at this stage are summarized below.

(2) Recommendation on Non-Structural Measures

1) Recommended Flood Warning System

Community Based Flood Early Warning System (CBFEWS), which PAGASA is now introducing, is recommended. It is expected that there is a difficulty of inter-Regional communication between Region 3 and NCR. However, the Meycauayan River Basin is rather compact. Close communication between the municipalities in Region 3 and those in NCR is not impossible. It should be enhanced more through cooperative activities recommended as one of other measures shown below.

After initial introduction of the warning system, it is recommended to refine the system every 3 years using the accumulated data and knowledge. Equipment introduced should also be checked at the same time.

2) Recommendation on Baseline Activities on Watershed Management

Watershed management includes many aspects than flood mitigation. In the present Study, it is recommended that at least minimum necessary activities related to flood mitigation be implemented as baseline activities on watershed management. The following activities are recommended:

- To prepare watershed characterization and watershed management plan
    - ➢ Almost all of land in the Meycauayan River Basin is already alienable and disposal land, which means that DENR can not directly control the landuse condition. There is no watershed characterization and management plan in the Meycauayan River Basin. As a first step of watershed management, watershed characterization and watershed management plan should be prepared.
    - ➢ Because Meycauayan River including Marilao River, one of major tributaries, is deteriorated very much by waste and domestic and industrial discharge. It is said that Marilao River is one of worst rivers in Philippines in terms of water quality. Environmental improvement along the river should be considered as a part of watershed management plan.
    - ➢ The watershed characterization and watershed management plan should be reviewed and revised every 5 years to reflect the watershed situation properly.
- Supporting of River Basin Council
    - ➢ To enhance more communication within a basin, it is recommended to prepare budget to support activities of river basin council.

3) Recommendation on Other Measures

Issues and recommendations for further improvement for disaster management activity for the Meycauayan River Basin based on the result of field survey are summarized.

General recommendations are, as follows:

- Enhancement of disaster management activities at community level;
- Necessity of periodical refinement of disaster management plan; and
- Necessity of preparation and dissemination of hazard map for excess flood after completion of structural measures.

Recommended other measures for the Meycauayan River Basin are, as follows:

- Resettlement of Informal Settlers
  - ➢ Informal settlers are living at dangerous area in river channel. To avoid causality by flush flood, it is recommended for the informal settlers to be resettled properly
- Community-based environmental improvement along channel including solid waste management
  - ➢ To keep living conditions along rivers and to prevent rapid accumulation of garbage in rivers, community-based solid waste management, environmental improvement is recommended.
- Landuse regulation
  - ➢ The Meycauayan River Basin is highly urbanized. There is a plan for future landuse. However, if urbanization precedes more, runoff volume will be increased and as a result the safety level of structural measures will be decreased. It is necessary to prevent further urbanization than that is planed. Landuse regulation is necessary to keep landuse condition as it is planned.
  - ➢ In the middle and upper reach of Meycauayan River and Marilao River, it is highly possible for new residential area to be developed. It is recommended to keep buffer zone along rivers so that residential area will not be located flood risk zone along rivers. It is necessary to identify flood risk zone along the middle and upper reach of those rivers, using detailed river and topographic survey and hydrological and hydraulic simulation. Then identified risk zone should be kept as buffer zone.
- Enhancement of communication between neighboring LGUs
  - ➢ MDCC/CDCC workshop to establish communication and support from neighboring LGUs is recommended. Exchange of know-how of disaster management each other is also recommended. It will also help to overcome the difficulty between inter-Region communication between Region 3 and NCR.

(3) Rough Estimation of Cost and Benefit for Reference

As a reference, rough cost estimation is made for the flood warning system and the baseline activity on watershed management.

Cost for flood warning system is roughly estimated as follows. O&M cost for 26 years includes 1) cost for refinement of the system every 3 years and 2) cost for observer.

Table 5.61 Rough Cost Estimation for Flood Warning System for 26 years in the Meycauayan River Basin (2009 to 2034)

Cost for Initial Setting (mil. pesos)	Total Cost for O&M for 26 years (mil. pesos)	Total Cost for 26 years (mil. pesos)
3.0	6.0	9.0

Cost for recommended baseline activities on watershed management for 26 years (2009 to 2034) is roughly estimated as shown in the following table.

Table 5.62 Rough Cost Estimation for Recommended Baseline Activities on Watershed Management for 26 years in the Meycauayan River Basin (2009 to 2034)

Cost			
Preparation of Watershed Characterization & Watershed Management Plan (mil. pesos)	Reforestation (mil. pesos)	Supporting of River Basin Council (mil. pesos)	Total Cost (mil. pesos)
6.00		5.2	11.20

The breakdown of the estimated costs is shown in Supporting Report H.

Possible benefit by flood forecasting and warning system is preliminary estimated to examine appropriate flood forecasting and warning system in this river basin. Based on it, the above-mentioned flood warning system is recommended. The detail discussion is presented in Supporting Report H.

5.4.6 Initial Environmental Examination

The IEE for these structural measures was carried out based on the information and data collected during this Study and consultation with concerned government and stakeholders.

In the Matrix (refer to Tab.5-6), the major assessment given below is a cross impact matrix, with the major environmental resources as the rows, and the activities for implementation of the proposed plan as the columns. The assessment of impacts was made in terms of magnitude (e.g., significant, moderate, and negligible) of the negative or positive affecting the environmental elements.

Table 5.63 Activities for Each Project Phase in the Meycauayan River Basin

Phase	Project Activity
Pre-construction Phase	Resettlement of Project affected Persons/Families
	Land Acquisition
	Project Mobilization
Construction Phase	Construction of Dike and Increasing the Elevation of Existing Road Surface
	Construction of Revetment
	Excavation
	Construction of gate and Drainage Facility
	Reconstruction of Bridge
	Structures in the VOM Flood Control Project/Area
O & M Phase	Dredging and Excavation
	Watershed Management/Conservation
	Installation of Flood Warning/Disaster Management System

Positive impacts are not considered in the cumulative quantification of the environmental impact score for each alternative since they would not lead to any hindrance in decisions of whether or not to proceed with the project. On the other hand, negative environmental impacts remain critical in so far as decisions in the proper selection of project alternatives.

As the result of the assessment, it is evaluated that dredging/excavation, construction of dike together with the proposed increase in road elevation, land acquisition and the completion of the flood control facilities for the VOM area are considered to cause the potential adverse impact for this area. On the other hand, the negligible impacts are mostly due to secondary activities such handling and disposal of dredge/excavated materials, delivery and use of construction based materials, operation of construction equipment, etc. that are contingent of the major flood control civil works. Overall, environmental management and mitigation plan shall be closely exercised during the development phase of these major project components in order to minimize if not totally eradicated the negative environmental impacts. Several potential adverse impacts identified in the evaluation were concluded that the Environmental Impact Assessment (EIA) is required in the succeeding study period (for details, refer to Supporting Report I).

(1) Social Environment

According to the result of IEE, the adverse impacts on the social environment were identified in both construction phase and O&M phase.

Social impacts like the displacement of community (residential households, commercial and industrial business) will likely occur once the construction of the dike starts along the densely populated stretch of Meycauayan and Marilao riverbanks. Also, the areas proposed as regulation ponds will increase the more than 90 PAPs estimated in Meycauayan and the additional 90 PAPs in the section along Marilao River. These number of PAPs are a consortium of residential, commercial and industrial entities situated along the riverbanks. The rate at which the population is increasing in those areas will continue because of urbanization and the poor regulation of local zoning and land use ordinances/laws.

As such, the project should be able to anticipate high financial requirement including opposition from the affected community in pushing for the implementation of the flood control project. In order to reduce the social impact, the IEE shall be substantiated to include social preparation activities like community/stakeholders consultation, preparation of framework for resettlement/compensation and preparation of resettlement action plans (RAP).

The implementation of social mitigation activities will not only encourage community participation but also help the project satisfy the provision of DAO 2003-30 regarding social acceptability and compliance to the compensation requirement of Philippine Republic Act 7279 or the 1992 Urban Development and Housing Act (UDHA).

(2) Natural Environment

As to the ecological impact of the project, there will be a minimum or negligible negative impact on fish habitat in the fishponds. However river overflow might directly affect the operations of fish ponds due to the use of gates and drainage facilities during seasons of heavy rainfall which would increase the volume of the river water. The water quality of the Meycauayan River has high contamination as shown in its BOD and Coliform concentrations. Fish ponds contamination will then be induced by occurrence of river overflow that might result in fish kills or fish contamination. Thus, it may pose issues with regards to fish farming economy and public health. Loss of profit due to “escape” of cultured fish during river overflow is also a consideration. Rarely impact on wildlife is expected since the project area is predominantly urban and nearly devoid of wildlife habitat. Majority of the stretch of Meycauayan River, where the proposed flood control facilities are located is heavily polluted (as shown in the water quality analysis) that fish life is not found to thrive in them.

(3) Pollution

The physico-chemical effects (e.g., increase in air pollution, increase in noise level and ground vibration, accidental spills of cement and oil based products used in the construction, etc.) of these secondary activities on the natural environment can be treated as negligible because it can be addressed by the proposed mitigating and management measures outlined in this IEE report.

5.4.7 Project Evaluation

(1) Technical Feasibility

The Philippines has experienced the construction of river channel improvement and drainage improvement many times. Thus, no difficulty would be encountered in the actual construction work. The recommended non-structural measures have also been experienced in the country. This project is, therefore, evaluated to have a technical feasibility.

(2) Economical Viability

The economic viability is assessed based on the economic cost and benefit stream of the proposed structural measures. As for the assessment of the non-structural measures, this is not carried out based on the situation as discussed before.
Tab. 5-5 shows the economic cost and benefit stream. As the results, the economic viability is figured out as follows:

Table 5.64 Economic Viability of the Proposed Plan in the Meycauayan River Basin

Viability Index	
EIRR (%)	23.3
NPV (mil. Pesos)	1,874.6
B/C	1.67

Based on the above results, EIRR becomes higher than the opportunity cost of capital of 15%. Therefore, the project is evaluated to have an adequate economic viability.

(3) Environmental and Social Acceptance

As the social environmental impacts, the resettlement due to the construction of dike is unavoidable. Therefore, the resettlement framework will be needed to satisfy the achievement of the social acceptability. At this stage, it is understood that social acceptance can be obtainable by providing the satisfactory resettlement framework carefully arranged through further discussion.
As the natural environmental impacts, no significant issue is expected, since the project area is predominantly urbanized and nearly devoid of any wildlife habitat. As the public hazard, the disposal of dredge materials and spoils are expected. This issue can be settled down through preparation of the appropriate disposal site prior to construction work.
Overall, environmental management and mitigation plan shall be closely exercised during the development phase of these major project components in order to minimize if not totally eradicated the negative environmental impacts.
The project plan was explained and discussed with the stakeholders through the stakeholder meetings at each end of the field survey and workshop in the site. Through these experiences and activities, it is concluded that, at this stage, implementation of this project is socially and environmentally accepted by the stakeholders.