No.

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE REPUBLIC OF THE PHILIPPINES

Japan International Cooperation Agency

PROVINCIAL GOVERNMENT OF CAVITE

THE STUDY ON COMPREHENSIVE FLOOD MITIGATION FOR CAVITE LOWLAND AREA IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

Volume 1: Master Plan Study

February 2009

CTI ENGINEERING INTERNATIONAL CO., LTD.
in association with
NIPPON KOEI CO., LTD

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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a development study on Comprehensive Flood Mitigation for Cavite Lowland Area and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Makihiko Otogawa of CTI Engineering International Co., Ltd. in association with Nippon Koei Co., Ltd, between March 2007 and January 2009. In addition, JICA set up an Advisory Committee which examined the Study from specialist and technical point of view.

The Study Team held discussions with the officials concerned of the Government of the Philippines, and conducted field surveys at the study area. Upon returning to Japan, the Study Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and promotion in the Philippines, and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Philippines for their close cooperation extended to the Study Team.

February, 2009
Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

The Study on Comprehensive Flood Mitigation for Cavite Lowland Area in the Republic of the Philippines

February 2009

MR. ARIYUKI MATSUMOTO
Vice-President
Japan International Cooperation Agency
Tokyo, Japan

Ref.: **The Study on Comprehensive Flood Mitigation for Cavite Lowland Area in the Republic of the Philippines**

Subj.: **Final Report - Letter of Transmittal**

Dear Sir:

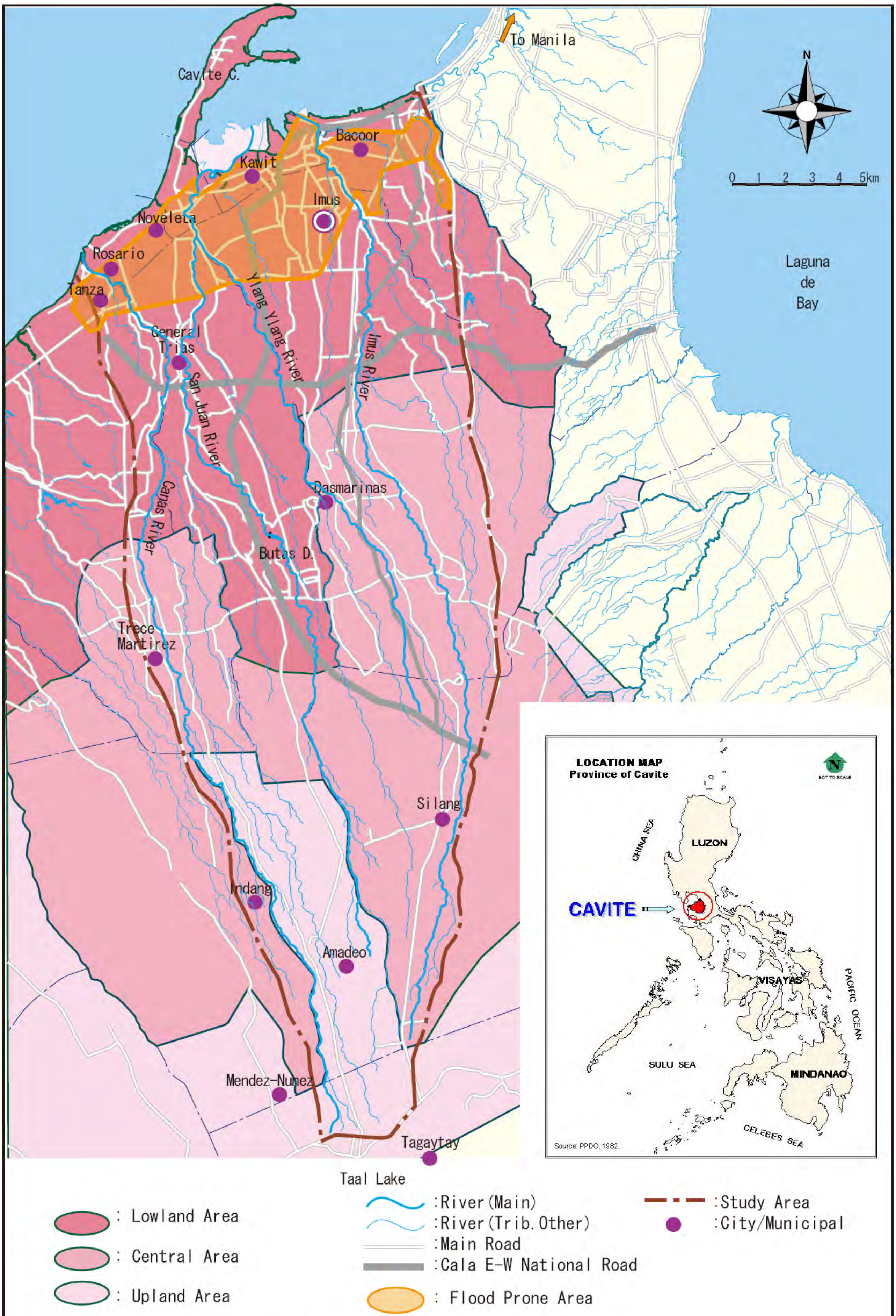
We are pleased to submit herewith the Final Report on "The Study on Comprehensive Flood Mitigation for Cavite Lowland Area" for your kind consideration. This report compiles the results of the Study in accordance with the contract between CTI Engineering International Co., Ltd. in association with Nippon Koei Co., Ltd. and the Japan International Cooperation Agency (JICA) during the period of March 2007 to February 2009.

During the Study, the Study Team formulated the master plan and conducted the feasibility study on comprehensive flood mitigation composed of applicable structural and non-structural measures for the Cavite Lowland Area based on the analysis of existing/future conditions and problems in the area. The report consists of Volume I: Master Plan Study, Volume II: Feasibility Study, Volume III: Adaptation to Climate Changes, and Volume IV: Appendix. The summaries of the master plan and feasibility studies are included in Volume I and Volume II respectively.

On this occasion the Study Team would like to express its sincere appreciation to JICA, the Ministry fo Foreign Affairs, and also to the officials concerned of the Government of the Republic of the Philippines, the Provincial Government of Cavite, and the Local Government Units (LGUs) concerned for the cooperation extended to the Team during the Study. We sincerely hope that the results of the Study will contribute to the solution and/or mitigation of flooding problems in the Cavite Lowland Area and that the amicable relationship between both our countries will further continue in the future.

Very truly yours,

MAKIHIKO OTOGAWA
Team Leader
The Study on Comprehensive Flood
Mitigation for Cavite Lowland Area



LOCATION MAP

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Volume 1 : Master Plan Study

Volume 2 : Feasibility Study

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EXECUTIVE SUMMARY

1. Background of the Study

The Study Area of 407.4 km^2 is situated in the eastern part of Cavite Province close to the boundary of Metro Manila. The lower reaches of the Study Area are especially vulnerable to floods because of the extremely low ground elevation and the insufficient flow capacity of the river/drainage channels. The vulnerability is further accelerated by the current excessive urbanization in the middle and upper reaches, which decreases the basins' flood detention capacity and increases the peak runoff discharge. Flood overflow from the Imus and San Juan rivers in the Study Area had caused casualties and damage to many houses in the recent typhoons in 2000, 2002 and 2006. Some hundred thousand residents in the lowland area of the river basins also suffer from chronic inundation by storm rainfall and/or high tide every year.

2. Objective of the Study

The objective of the Study is to mitigate flood damage in the lowland area through the formulation of a master plan of flood mitigation, execution of a feasibility study for the priority project components, and development of flood management capacity for counterpart organizations.

3. Outline of Proposed Plan

To cope with the complex factors of vulnerability to floods in the Study Area, a comprehensive flood mitigation plan is proposed, including a variety of structural and non-structural project components.

3.1 Structural Flood Mitigation Plan

The structural flood mitigation plan aims at mitigating damages caused by river overflow and inland floods. The design scales for the proposed flood mitigation measures were determined taking the affordability of project cost, the possible extent of land acquisition, and other relevant factors into account. As a result, the measures to mitigate river overflow flood are designed to cope with a flood of 10-year return period for the mainstreams of Imus and San Juan rivers, and 2 to 5-year return period for the tributaries of Imus River. As for inland drainage improvement, the proposed structures are designed to cope with a flood of 2-year return period.

The plan includes the identification of short-term and long-term projects. The short-term projects are defined as the priority projects, and the target completion year is set at 2013. Other components are classified as the long-term projects, and their target completion year is set at 2020.

On the premise of the above design scales and target completion years, the following structural measures are proposed:

(1) **Off-Site Flood Retarding Basin:** The downstream stretches of the Imus and San Juan rivers have extremely small flow capacities, which could hardly cope with even the probable flood of 2-year return period. A full-scale river channel improvement is, however, virtually difficult due to the large number of house relocations required. Under these circumstances, off-site flood retarding basins are proposed in the middle reaches to increase the basin flood detention capacities and minimize the extent of river channel improvement. An off-site flood retarding basin with the storage volume of 7.55MCM and the required ROW of about 220ha is proposed at ten (10) sites. Among them, the three off-site flood retarding basins in the Imus River Basin with the storage volume of 2.48MCM and the required ROW of about 81ha are selected as the priority project.

(2) **Partial River Improvement:** The above off-site flood retarding basins alone could hardly protect the estuary river sections against tidal flood, and they could not get rid also of the flood overflow at several bottleneck sections of the rivers. Due to this background, partial river channel improvement is proposed for the estuary section of about 5.4km in total and at bottleneck sections along the middle river stretch of 15.5km in total length along the Bacoor and Julian rivers.

(3) **On-Site Flood Regulation Pond:** The construction of an on-site flood regulation pond at every new subdivision is proposed. The on-site flood regulation pond could be progressively constructed proportionate with the expansion of housing subdivisions to properly offset the increment of peak runoff discharge caused by the expansion of subdivisions. This could be constructed within 3% of the entire premises of each subdivision, and its storage capacity is designed to cope with a flood of 20-year return period.

(4) **Inland Drainage Improvement:** The inland drainage works aim at protecting the lowland area from inundation by storm rainfall and tidal flood. The principal works include: (a) improvement of existing drainage channel (3.8km in length); (b) construction of new drainage channel/interceptor (7.0km in length); (c) tidal gate (12 units); (d) flap gates (18 units); (e) off-site flood detention pond (52ha in extent); and (g) coastal dike (4.1km in length).

3.2 Non-Structural Flood Mitigation Plan

The non-structural project component could bring about the early effect of flood mitigation with less cost of implementation as compared with the structural project component. In this case, the following project components are proposed:

(1) **Control of Excessive Land Development:** Legislation of two regional ordinances is proposed. One is for urban growth management and the other is for adoption of the aforesaid on-site flood regulation pond in each new subdivision. The urban growth management aims at regulating the excessive land development and preserving the farmlands.

(2) **Community-Based Flood Mitigation:** The plan includes two objectives. One is the "information and educational campaign for the cleanup of waterways" and the other is the "promotion of community-based flood warning and evacuation" activities. Pilot projects for both of these objectives were conducted in the Study to initiate the activities relevant to the community-based flood mitigation activities.

(3) **Management of River Area:** The plan contains the definition on the extent of river area, the necessary activities for the control of encroachment to the river area, and the database to be used for the river area management.

4. Project Cost

The initial investment cost and operation and maintenance cost for the structural project components are summarized below:

Project Cost for Structural Component

Phased Program	Initial Investment Cost (million pesos)	Annual O&M Cost (million pesos/year)
Priority Project	1,848	4.7
Overall Project	6,868	34.7

Note: All project costs exclude price contingency.

In addition to the above project cost for the structural components, the annual operation cost for the non-structural components, which include (a) meetings, workshops and public consultations; and (b) preparation of materials such as training manual and leaflets, is estimated at about 0.76 million pesos/year.

5. Project Evaluation

5.1 Economic Evaluation

The structural project components are evaluated to be viable based on the economic internal rate of return shown in the table below. As for the non-structural project components, however, the intangible benefits are limited, and their economic evaluation was not included in the Study.

Economic Evaluation for Structural Component

Phased Program	Number of Households benefited by Flood Mitigation Project	EIRR
Priority Project	12,800 households	26.0%
Overall Project	24,700 households	22.2%

5.2 Social and Environmental Consideration and Assessment

The main negative impacts caused by the project are to be addressed by providing house relocation and land acquisition. The number of house relocations required is estimated to be 470 houses for the overall project and 12 houses for the priority project. The Provincial Government of Cavite currently plans to develop the resettlement site of 122ha in and around the Study Area. This new resettlement site would possibly accommodate the potential resettlers. In addition to the preparation of a resettlement site, the LGUs are required to formulate and execute a comprehensive resettlement program, which involves social/income restoration for the project-affected-persons (PAPs).

As for the land acquisition, the overall project would require the acquisition of about 109ha of farmland and 167ha of fish ponds in total, while the priority project would require the acquisition of about of 29.9ha of farmland. These land acquisitions may deprive the tenant farmers and fishpond operators of their jobs. The LGUs are, therefore, required to give special consideration on the provision of vocational training courses and support in the creation/introduction of jobs for the tenant farmers and fishpond operators to be affected by the project.

In addition to the above problems, the overall project would require the clearing of about 4.1ha of mangrove forests. To mitigate this impact, the Project shall make it a rule to adopt the transplantation of whole mangroves affected by the implementation of the project. Moreover, the LGUs are requested to conduct studies for the conservation of mangroves at the beginning of project implementation.

6. Conclusions and Recommendations

The structural project components are found to be viable, and it is urgently required to implement them for flood mitigation. The non-structural project components are also important to bring about the early effect of flood mitigation with less cost of implementation. Of the proposed project components, the implementation of the following three components, in particular, is important to achieve the target safety level against flood: (a) partial river improvement; (b) construction of flood retarding basins; and (c) introduction of the urban development plan. The recommendations on the proposed project components are as described below:

(1) Urgent Project Implementation of Off-Site Flood Retarding Basin

The off-site flood retarding basins are the key structures to minimize the number of house relocation and achieve the early effect of flood mitigation. However, the rapid expansion of built-up area at present may encroach into the eligible sites for off-site flood retarding basin unless the sites are secured at the earliest time. Accordingly, project execution for the off-site flood retarding basins shall be urgently implemented.

(2) Legislation of Ordinances for the Control of Excessive Land Development

The proposed ordinances on “Urban Growth Management” and “On-Site Flood regulation Pond” shall be legislated and enforced as soon as possible to regulate the excessive land development and the increment of basin flood runoff discharge.

(3) Enhancement of Sustainable Activities for Community-Based Flood Mitigation

The LGUs shall enhance the sustainable activities for community-based flood mitigation based on the lessons learned from the pilot projects.

(4) Activation of Flood Mitigation Committee (FMC)

The LGUs shall review the existing organizational setup of the FMC and facilitate the issuance of an Execution Order, together with the budgetary arrangements, so that the could start taking the initiative on the community-based flood mitigation and other activities.

(5) Environmental and Social Considerations

The overall flood mitigation plan proposed in the Master Plan Study requires the formulation and implementation of the relocation action plan (RAP) without unnecessary delay in accordance with the "Land Acquisition, Resettlement and Indigenous Peoples Policy of the Department of Public Works and Highways." The overall flood mitigation plan also requires the clearing of about 4.1 hectares of mangrove forests. To mitigate the impact to the mangrove forests, it is required to formulate and implement a plan to transplant and/or regenerate the mangrove forests.

Of the project components in the overall flood mitigation plan, construction of the three off-site flood retarding basins is selected as the priority project component with target completion year in 2013. The number of families to be relocated by the project is limited to twelve (12) families. The LGUs in collaboration with the NGOs shall properly formulate and implement the RAP even for such a small number of families to be relocated.

(6) Project Execution Body

The DPWH is recommended as the project execution body for the proposed structural project components other than the on-site flood regulation pond, judging from the affordability of project cost. The LGUs shall take the supportive works for land acquisition, including consensus building of the PAPS in the relocation, preparation of relocation site, and support of social rehabilitation/income rehabilitation for the PAPS. The LGUs are also requested to undertake the non-structural flood mitigation works.

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ABBREVIATIONS AND ACRONYMS

A&B	Alienable and Disposable
AAB	Authorized Agent Bank
AAGR	Average Annual Growth Rate
ADB	Asian Development Bank
AFMA	Agricultural and Fisheries Modernization Act
AKPF	Abot-Kamay Pabahay Fund
AO	Administrative Order
B/C	Benefit / Cost Ratio
BIR	Bureau of Internal Revenue
BDCC	Barangay Disaster Coordinating Council
BOD	Biological Oxygen Demand
BOT	Build – Operate – Transfer
BRS	Bureau Research and Standards
BSWM	Bureau of Soils and Water Management
BP	Batas Pambansa
C/T	Census Survey and Tagging
CALA EW	CALA East – West Highway (Project)
CALA	Cavite – Laguna
CALABARZON	Cavite. Laguna, Batangas, Rizal and Quezon
CARP	Comprehensive Agrarian Reform Program
CDCC	City Disaster Coordinating Council
CENRO	City Environmental and Natural Resources Office
CITES	Convention on International Trade of Endangered Species of Wild Fauna and Flora
CLUP	Comprehensive Land Use Plan
CMP	Community Mortgage Program
CO	Carbon Monoxide
DA	Department of Agriculture
DAO	Department Administrative Order
DAR	Department of Agrarian Reform
DBB	Dasmariñas Bagong Bayan
DBP	Development Bank of the Philippines
DECS	Department of Education, Culture and Sports
DENR	Department of Environment and Natural Resources
DENR-EMB	DENR – Environmental and Management Board
DENR-LMB	DENR – Land Management Bureau

DILG	Department of Interior and Local Government
DND	Department of National Defense
DO	Dissolved Oxygen
DOF	Department of Finance
DOH	Department of Health
DOJ	Department of Justice
DOST	Department of Science and Technology
DOTC	Department of Transportation and Communications
DPWH	Department of Public Works and Highways
DPWH – MTIDP	DPWH Medium – Term Infrastructure Development Program
DTI	Department of Trade and Industry
ECC	Environmental Compliance Certificate
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EMB	Environmental Management Bureau
EMMP	Environmental Management and Monitoring Plan
EO	Executive Order
EOHO-DOH	Environmental and Occupational Health Office
ESC	Environmental and Social Consideration
ESSO	Environmental and Social Service Office (in DPWH)
FCIE	First Cavite Industrial Estate
FMB	Forest Management Bureau
FMC	Flood Mitigation Committee
F/S	Feasibility Study
GDP	Gross Domestic Product
GEA	General Emilio Aguinaldo
GINI	Gini Coefficient
GIS	Geographic Information Systems
GMA	General Mariano Alvarez
GOCC	Government Owned and Controlled Corporation
GOP	Government of the Philippines
GSIS	Government Service Insurance System
ha(s)	Hectare (s)
HDMF	Home Development Mutual Fund
HGC	Home Guarantee Corporation
HLURB	Housing and Land Use Regulatory Board

Hr/hr	Hour
HUDCC	Housing and Urban Coordinating Council
I/A(I/P)	Implementing Arrangement (Implementing Program)
ICET	International Center for Environmental Technological Transfer, Japan
IEC	Information Education Campaign
IEE	Initial Environmental Examination
ILO	International Labor Organization
IRA	Internal Revenue Allotment
IRTAF	Inter-agency Resettlement Task Force
IUCN	International Union for the Conservation of Nature and Natural Resources
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KIIs	Key Informant Interview
Km	Kilometer
LAPRAP	Land Acquisition Policy and Resettlement Action Plan
LARC	Land Acquisition Resettlement Cost
LARR	Land Acquisition Resettlement and Rehabilitation
LBP	Land Bank of the Philippines
LGUs	Local Government Units
LRT	Light Rail Transit
LTFRB	Land Transportation Franchising and Regulatory Board
MCM	Million Cubic Meter
MDCC	Municipal Disaster Coordinating Council
MDG15	Mellenium Development Goal 2015
MFC	Municipal Financial Corporation
MGB	Mines and Geosciences Bureau
MFCP	Major Flood Control Project
MM	Metro Manila
MMDA	Metro Manila Development Authority
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPDC / MPDO	Municipal Planning and Development Coordinator / Municipal Planning and Development Office
MPN	Most Probable Number
MRF	Material Recovery Facility
MTPDP	Medium Term Philippine Development Plan
MTPIP of DPWH	Medium Term Public Investment
MWSS	Metropolitan Waterworks and Sewerage System

m^2	Square Meter
m^3	Cubic Meter
NAMRIA	National Mapping and Resources Information and Authority
NAPC	National Anti-Poverty Commission
NAPOCOR	National Power Corporation
NCR	National Capital Region
NDCC	National Disaster Coordinating Council
NEDA	National Economic Development Authority
NEDA – ICC	National Economic Development Authority – Investment and Coordination Committee
NFPP	National Framework for Physical Planning
NG	National Government
NGOs	Non – Government Organizations
NHA	National Housing Authority
NHMFC	National Home Mortgage Finance Corporation
NHRC-UPERDFI	National Hydraulic Research Center
NIA	National Irrigation Authority
NIPAS	National Integrated Protected Areas System
NOx	Nitrogen Oxide
NPCC	National Pollution Control Commission
NPV	Net Present Value
NSCB	National Statistical Coordination Board
NSO	National Statistic Office
NWRB - DENR	National Water Resources Board
O&M	Operation and Maintenance
OCD	Office of Civil Defense
ODA	Office Development Assistance
PAF / PAPs	Project Affected Families / People(s)
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PAG – IBIG	Pagtutulungan sa Kinabukasan: Ikaw, Bangko, Industriya at Gobyerno
PAWB	Protected Area and Wildlife Bureau
PCFC	People’s Credit and Finance Corporation
PCM	Public Consultation Meeting
PCUP	Presidential Commission for the Urban Poor
PD	Presidential Decree
PDCC	Provincial Disaster Coordinating Council
PDTF	People’s Development Trust Fund

PEA	Public Estate Authority
PEQR	Philippine Environmental and Quality Report
PEZA	Philippine Economic Zone Authority
PHDMO	Provincial Housing Development and Management Office
PHILSSA	Partnership of Philippine Support Service Agencies Inc
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PIF	Philippine Infrastructure Fund
PMO – FS	Project Management Office – Feasibility Studies
PNCC	Philippine National Construction Corporation
PNP	Philippine National Police
PO	People's Organization
PPDO	Provincial Planning and Development Office
PPFP	Provincial Physical Framework Plan
PPP	Public-Private Partnerships
PRA	Participatory Rapid Appraisal
PSP	Private Sector Participation
PTFAPSSS	Provincial Task Force Against Professional Squatters and Squatting Syndicates
R1	Radial Road (Number)
RA	Republic Act
RAP	Resettlement Action Plan
RBCO	River Basin Control Office
RDCC	Regional Disaster Coordinating Council
RIC	RAP Implementation Committees
RIS	Resident Interview Survey
RDC	Regional Development Council
ROW	Right of Way
RTAF	Resettlement Task Force
SAFP's	Strategic Agricultural & Fisheries Planning Zones
SCC	Sagip Ilog Cavite Council Inc.
SES	Socio – Economic Survey
SHF	Special Housing Fund
SHFC	Social Housing Finance Corporation
SIRP	Save Imus River Rehabilitation Project
SOx	Sulfur (Di) oxide Concentration
SRA	Social Reform Agenda
SSS	Social Security System
STM	Stakeholder Meeting

TESDA	Technical Education and Skills Development Authority
TMC	Trece Martirez City
TOR	Terms of Reference
TSP	Total Suspended Particulates
TWG	Technical Working Group
UDHA	Urban Development and Housing Act
μg	Microgram
UNESCO	United Nation Educational, Scientific and Cultural Organization
UPAO	Urban Poor Affairs Office
UPERDFI	UP Engineering Research and Development Foundation, Inc.
W/R	The ratio of employment at workplace / at residence
WB	World Bank

SUMMARY OF THE MASTER PLAN STUDY

1. Objective of the Study and Location of the Study Area

1.1 Objective of the Study

The objective of the Study on Comprehensive Flood Mitigation for the Cavite Lowland Area is to mitigate flood damage through the following:

(1) Formulation of the master plan for flood mitigation of three river basins; namely, the Imus, San Juan and Canas rivers;

(2) Feasibility study on the priority components of the above master plan; and

(3) Development of the flood management capacity of the Philippine counterpart organizations.

1.2 Location of the Study Area

The Study Area covers three river basins; namely, the Imus, San Juan and Canas river basins, which extend over a total area of 407.4 km^2. These three river basins are situated in the eastern part of Cavite Province, close to the border of Metro Manila (refer to the General Map). The Study Area is administratively composed of three congressional districts with two cities and eleven towns, which further consist of 411 barangays.

1.3 Study Organization

The Study was undertaken by the JICA Study Team in close coordination with the Department of Public Works and Highways (DPWH) and the Provincial Government of Cavite, which have been designated as the counterpart agencies, with support from the JICA Philippine Office and the Embassy of Japan in Manila. A Steering Committee and a Technical Working Group were set up in the Philippines, and the Advisory Committee was organized to provide guidance on the smooth implementation of the Study. During the study period, five steering committee meetings were held, and three of these meetings were carried out during the Master Plan Study Stage. (Refer to Sections 1.3 to 1.5 of Chapter 1 in Volume I, and Section 6.2 of Chapter 6 in Volume II of this report.)

2. Natural Condition of the Study Area

2.1 Topographic Condition

The Study Area is topographically divided into four areas; the extreme lowland area, the lowland area, the central hilly area, and the upland mountainous area. The approximate extent and topographic characteristics of each area are listed below.

Table 1 Topographic Division of the Study Area

Division	Extent	Ground Slope	Ground Elevation
Extremely Low Land Area	4.0 km^2	Almost Flat	EL. 0 to 2m
Lowland Area	97.5 km^2	Less than 0.5%	EL. 2 to 30m
Central Hilly Area	236.7 km^2	0.5% to 2%	EL. 30 to 400m
Upland Mountainous Area	69.2 km^2	More 2%	EL. 400 to 650m

2.2 Meteorology and Hydrology

The Study Area has two pronounced seasons: the dry season from November to April and the wet season during the rest of the year. Annual mean rainfall in and around the Study Area is approximately 2,000mm, while total rainfall in the wet season accounts for more than 80% of the annual rainfall. Tropical cyclones usually occur during June to October, and about 20 typhoons enter the Philippine Area of Responsibility with about 16% passing through the middle part of Luzon Island.

The average monthly highest tide level is 1.3 m above Mean Lower Low Water (MLLW), and the historical extreme tide level at Manila South Harbor reached 1.89m above MLLW on 13 July 2006. The results of the simulation on global warming by the IPCC suggests that global warming may cause the increment of short-term rainfall intensity, more frequent occurrences of tropical cyclones, and rise of sea level. Therefore, flood mitigation structures need to be designed with particular attention on the effects of climate change.

2.3 River Condition

The Imus, San Juan and Canas rivers originate from the Tagaytay Ridge, which has a peak elevation of 650m above Mean Sea Level (MSL), run northward in parallel and finally flow into the Manila Bay/Bacoor Bay. The salient features of these rivers are as listed below.

Table 2 Salient Features of Principal Rivers in the Study Area

Description	Imus River	San Juan River	Canas River	Residual*[1]
Catchment Area (km^2)	115.5	146.8	112.3	21.9
Length (km)	45.0	43.4	42.0	42.0
Average Slope	1/80	1/79	1/66	-

Note *1: Residual catchment areas are not inside the boundary of main river basins like Imus, San Juan and Canas. Small rivers and drainage channels in this area flow directly into the sea.

The flow capacity of the downstream sections of Imus and San Juan rivers, as well as the drainage channels in the coastal area, have been evaluated to cope with the probable flood of less than those of a 2-year return period. On the other hand, the upstream sections of Imus and San Juan rivers from the NIA Irrigation Canal have a substantial flow capacity coping with the flood of 5-year return period and 20-year return period, respectively. Moreover, the whole section of Canas River could cope with the flood runoff discharge of more than 20-year return period.

2.4 Flood Condition

Floods in the Study Area are classified into "river overflow flood" and "inland flood." The former is caused by floods that overflow the river channel, and the latter by the stagnation of storm rainfall and/or overflow from the local drainage channels. Four major typhoons in the 2000's had caused severe river overflow floods accompanied by severe damage in the Study Area, as listed below. Of the recent typhoons, Typhoon Milenyo is assumed to be the severest causing the flood inundation area of 53.6 km^2 which corresponds to a 100-year return period flood.

Table 3 Recent River Overflow Flood Damages in the Study Area

Date	Name of Typhoon	Damages
Oct. 2000	Reming	Death: 10; Affected population: 380,616
Jul. 2002	Gloria	Affected population: 173,075
Jul. 2002	Inday	Death: 1; Affected population: 168,025
Sep. 2006	Milenyo	Death: 28; Missing: 18*[1]; Injured: 61; Evacuated: 28,322; Affected: 196,904

Note : *1 : Residents at the riverbank watching the overflow on the dam crest died due to the riverbank collapse.

2.5 Ecology

There exist neither rare species of fauna to be conserved nor endangered species of flora within the Study Area. It was however noted that the mangrove area has been largely converted to fishponds, salt-beds and built-up/settlement areas, and the area of mangrove presently remaining in the Study Area is 18.6 ha area-wise and 24.0 km strip-wise.

2.6 Oceanography

The Cavite Spit sticks out of the southeastern shore of Manila Bay forming the Bacoor Bay. The western shore of Bacoor Bay is closed by the Cavite Spit, while the eastern one is open and connected to the Manila Bay where the wind-driven currents prevail with seasonal variations in direction and velocity. Due to the wind-driven currents in the Manila Bay, the sediments in the Bacoor Bay are hardly transported to the outside. On the other hand, serious erosion is in progress along the eastern shoreline of the Cavite Spit and/or around the river mouth of Canas due to the Northeast winds.

2.7 Sediment Runoff

The principal source of sediment runoff in the Study Area is assumed to be the surface soil erosion but not from the severely eroded area, and the annual sediment runoff volume is roughly estimated at 214,000 m^3/year. Among the sources, the on-going land development may be greatly contributing to the sediment runoff from the entire river basin, since the on-going land development area corresponding to only 1.4% of the whole study area makes up 41% of the total annual sediment runoff volume.

2.8 Geology

The Study Area is broadly covered with Quaternary volcanic products of Taal Volcano; namely, the Taal Tuff and the sedimentary rocks of Guadalupe Formation. These formations are further divided into two members (upper and lower) based on their lithological facies and engineering characteristics. Alluvium forms small deltas at the coastal area.

3. Socio-Economic Condition in the Study Area

3.1 Population

The population of Cavite Province has steadily increased in over nine decades. The increment of population was accelerated after the 1990's in particular due to the introduction of intensive industrialization in the province. As a result, the population in the Study Area has increased from 850 thousand in 1990 to 1,114 thousand in 2000, as shown below.

Table 4 Population in the Study Area

City/ Municipality	Basic Census*1		Estimated for the Study Area						
	Population in Entire Jurisdiction (Thousand)		Area Overlapping the Study Area		Population (Thousand)*2		Population Density (person/km^2)		Population Growth
	1995	2000	Built-up Area	Whole Area (ha)	1995	2000	1995	2000	(1995-2000*3)
Study Area	1,212	1,589	9%	40,743	850	1,114	2,086	2,734	5.93%
Cavite Province	1,610	2,063	70%	142,605	1,610	2,063	1,129	1,447	5.45%

Note*1: 2005 Socio Economic Profile, Provincial Government of Cavite
*2: Population in the Study Area is estimated by the total population of city/municipality multiplied with the rate of built-up area overlapping the Study Area
*3: Estimated on the premise of time interval of 56 months between the populations in 1995 and 2000.

3.2 GDP and Industry

Cavite Province has rapidly promoted the industries as the core of the Cavite, Laguna, Batangas, Rizal and Quezon (CALABARZON) Economic Development Zone, which is placed as one of the highest priority economic development areas in the Philippines. Cavite Province recorded the Gross Domestic Product (GDP) of about 29,160 million pesos in 2000, corresponding to 3.0% of the National GDP and 20.6% of the GDP in CALABARZON.
The total number of employment in Cavite Province has increased from 445,800 in 1995 to 585,136 in 2003. These numbers both in 1995 and 2003 correspond to about 28% of the whole provincial population. Of the sectors, the manufacturing sector takes the highest share of 45.3% of the employments followed by 20.7% for the service sector, and 15.1% for the construction sector as of 2003. The manufacturing sector also shows the second highest growth rate of 172% after 224% in the electricity, gas & water sector in terms of growth rate of number of employment from 1995 to 2003. On the other hand, the agricultural & forestry sector and the mining & quarrying sector tend to dwindle.

3.3 Land Use

3.3.1 Present Land Use

The built-up area in the Study Area had expanded to cope with the rapid urbanization since the large-scale infrastructure development in the CALABARZON started in the 1990's. The built-up area currently covers 24.6% of the Study Area as shown in the table below. The non-built-up area is divided into five categories and takes the share of 75.4%, while there is no sizable forest area except the narrow strips along the rivers.

Table 5 Existing Land Use in the Study Area

Category	Classification	Area (ha)	Share (%)
Built-up Area	Residential	8,420	20.7%
	Industrial	914	2.2%
	Institutional	208	0.5%
	Commercial	422	1.0%
	Built-up/Mix Use	57	0.1%
	Sub-Total	**10,021**	**24.6%**
Non-Built-up Area	Agricultural	19,037	46.7%
	Grassland/Open Area	6,278	15.4%
	Tree Plantation	4,484	11.0%
	Water Bodies	903	2.2%
	Unclassified	21	0.1%
	Sub-Total	**30,722**	**75.4%**
Total		**40,743**	**100.0%**

3.4 Future Land Use

Each city/municipality had prepared a Comprehensive Land Use Plan (hereinafter referred to as the CLUP) for its territory where the built-up area in the Study Area is projected to increase from 24.6% as of 2003 to 65.2% by around 2010. Such dynamic increment of the built-up area is based on the assumption of extremely high population growth and the extensive conversion from farmland to urban area.

The cities/municipalities had assumed in their CLUPs that the past population growth rate of 5%/year recorded in 1995 to 2000 would continue by the year 2010. However, the future population growth is deemed to decline judging from the policy of Cavite Province on the control of new industrial estates/subdivisions, decrease of national population growth, and delay of major infrastructure development in the Province. From these points of view, the Study estimated the future population growth in the Study Area in a range of 80 to 90% of the said past population growth.

Moreover, the Housing and Land Use Regulatory Board (HLURB) imposed a certain restriction on the conversion of farmlands through the Regulation of Land Conversion, MC No. 54 (1993) under which, the extent of farmlands to be converted to built-up areas is estimated at 9,212 ha, while the cities/municipalities predict to expand the built-up area by 16,540 ha.

Based on the above evaluation, the CLUP was revised in the Study and the built-up area was limited to 17,413 ha (42.7% of the Study Area), as shown in Table 6 and Fig. 1. It was further noted that the CLUP projected a large share of mixed land use, but such mixed land use is not applied in the plan proposed in the Study to avoid several potential problems in the mixed land use such as (1) decline of public investment; (2) fragmentation of farmlands; (3) marring of the natural landscape; and (4) serious traffic congestion.

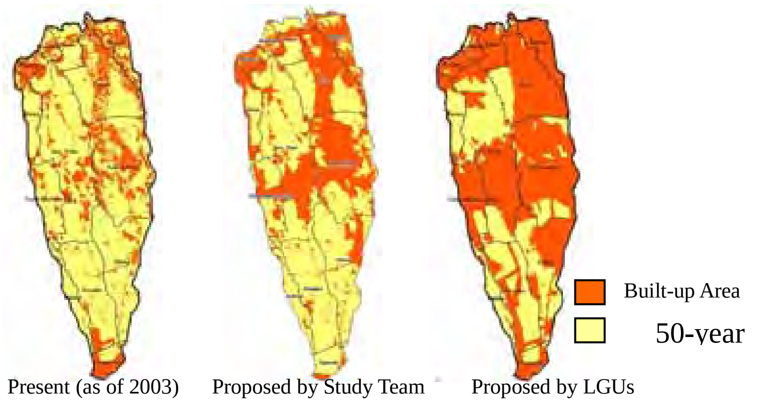


Fig. 1 Present and Projected Built-up Area in the Study Area

Table 6 Land Use Plans Proposed in the Study and CLUP

Land Use	Land Use Projected in the Study		Land Use Projected in the CLUP	
	Area (ha)	Share	Area (ha)	Share
Built-up Area	17,413	42.7%	26,561	65.2%
Non Built up Area	23,330	57.3%	14,182	34.8%
Total	40,743	100.0%	40,743	100.00%

4. Hydrological Analysis

4.1 Rainfall Analysis

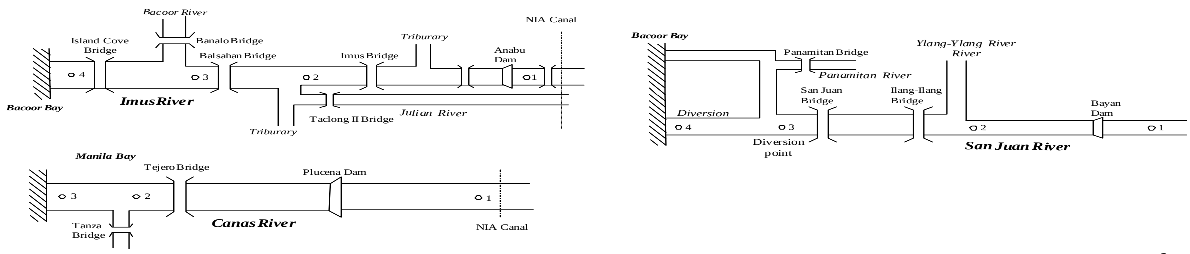
The probable basin mean 2-day rainfall has been estimated through a combination of the "Thiessen Polygon Method" and "Log Pearson-III Method." For developing the design storm hyetograph, the rainfall intensity curves (Kimijima Type) were further developed with the annual maximum rainfall records of 5-minute to 2-day duration at the Manila Port Area Station. Then the center concentrated type of long design storm (model hyetograph) was developed based on the rainfall intensity curves. Both probable basin mean 2-day rainfall and probable rainfall intensity are listed below.

Table 7 Estimated Probable Basin Mean 2-day Rainfall

Return Period (year)	Basin Mean 2-day Rainfall (mm)	Peak Rainfall Intensity (mm/5-min)	Total Rainfall (mm/120 min)
2	191	12.3	72.5
5	258	15.5	97.2
10	295	17.8	112.3
20	326	19.8	128.5
50	360	22.6	148.2
100	383	24.7	162.1

4.2 Flood Runoff Analysis

The "Quasi-Linear Storage Type Model" was employed for the basin runoff model, and MIKE-11 was used for the river channel routing. The flood runoff model configuration was classified into the Imus, San Juan and Canas river basins and their drainage areas, and further divided into several sub-basins. The probable flood discharges of 2 to 100-year periods were then simulated through the said flood runoff models assuming the two different land use conditions in 2007 and 2020. The results of flood runoff simulation of a 10-year return period flood for the three river basins are shown in Fig. 2, where the flood runoff discharges in the future land use condition considerably increased compared to those in the present land use condition.



(Unit m^3/s)

Point No.	Imus River		San Juan River		Canas River	
	Present Land Use in 2007	Future Land Use in 2020	Present Land Use in 2007	Future Land Use in 2020	Present Land Use in 2007	Future Land Use in 2020
1	415	495	330	345	670	710
2	560	670	440	460	700	750
3	740	960	800	850	750	800
4	910	1,200	640	680	-	-

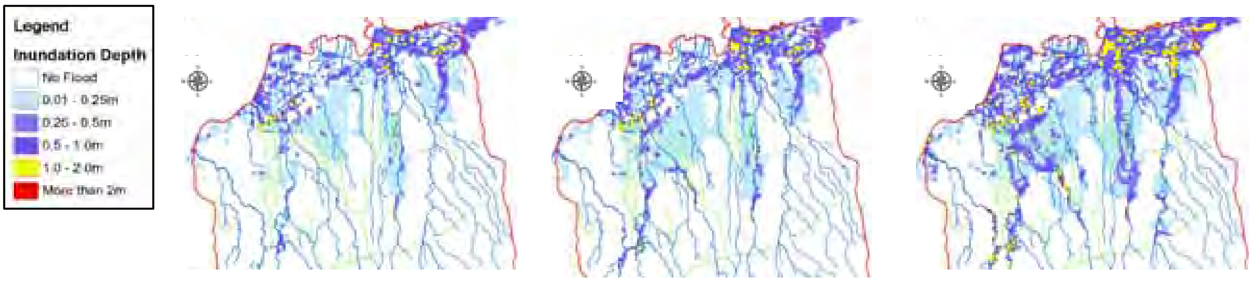
Fig. 2 Distribution of Probable Flood Runoff Discharge of 10-year Return Period in Imus, San Juan and Canas Rivers

4.3 Flood Inundation Analysis

The extent of probable flood inundation area for 2 to 100-year return periods was simulated through the MIKE FLOOD Model, assuming the land use status in 2003 (present) and 2020 (future). Even under the present land use condition, there are some areas where inundation depth may exceed 2m with a 20-year return period flood. The results of simulation are summarized in Table 8 and Fig. 3, and circumstantially described in Chapter 5 in the main texts together with the calibration and comparative analysis with actual inundation depths experienced during Typhoon Milenyo.

Table 8 Inundation Areas caused by River Overflow Flood

Land Use Status	River Basin	Extent of Inundation Area (km^2)						
		2-yr	5-yr	10-yr	20-yr	30-yr	50-yr	100-yr
Present Land Use	Imus River	8.39	11.75	13.78	15.59	16.43	17.46	19.64
	San Juan River	0.93	4.77	8.67	13.43	14.88	16.36	17.93
	Total	9.32	16.54	22.56	29.53	31.97	34.66	38.57
2020 Land Use	Imus River	11.50	14.67	16.57	18.05	18.46	19.98	20.93
	San Juan River	2.11	5.95	9.44	14.67	15.50	17.03	18.90
	Total	13.62	20.66	26.13	33.19	34.62	37.66	40.86



10-year Flood 20-year Flood 50-year Flood

Fig. 3 Estimated Flood Inundation Area

5. Planning Condition

5.1 Comprehensive Flood Mitigation Plan

The comprehensive flood mitigation plan consists of the structural and non-structural components. The structural component, particularly on the design scale, was formulated with keen consideration of the social impacts such as house relocation and the affordable budget for its implementation. The non-structural flood mitigation measures are proposed and combined with the structural measures, since they would play an important and effective role in flood mitigation as good as the structural measures.

5.2 Planning Framework

The planning frameworks include (1) Target project completion year; (2) Socio-economic framework (land use condition); and (3) Design scale of the project, as described below.

5.2.1 Target Project Completion Year

The objective flood mitigation project composed of the structural and non-structural measures is classified into the short-term project and the long-term project. The target year for the priority non-structural flood mitigation plan is proposed to be the year 2010, while that for the structural plan is the year 2013. Target year for the long-term project is assumed as the year 2020.

5.2.2 Land Use Condition

The flood mitigation plan was formulated on the premise of land use condition in the target year 2020.

5.2.3 Design Scale of the Project

The alternative design scales of 2 to 20-year return periods were assumed and, among them, the optimum design scale is to be determined based on the evaluation of financial affordability of the project proponent for the project cost, the allowable extent of land acquisition and the other restrictions on project implementation.

5.3 Institutional Framework for Implementation

5.3.1 Organizational Setup for Flood Mitigation

The existing organizations could be broadly classified into groups: (1) Nationwide policy-making/coordination bodies such as NEDA, NWRB-DENR and NDCC; (2) National government agencies, which could be the implementing agencies in the water resources sector, such as DPWH, NIA, PAGASA and OCD; and (3) Local government units (LGUs), which are divided into three types, the Provincial Government, the City/Municipality and the Barangay.

Among the above organizations, the DPWH and NIA take the role of developing the major and/or large-scale infrastructures for flood mitigation, and PAGASA and OCD contribute to the non-structural flood mitigation measures such as flood forecasting, warning and evacuation. On the other hand, the roles and authorities of the LGUs on flood mitigation are limited to the construction, maintenance and rehabilitation of local drainage systems and/or the non-structural measures such as the cleaning of waterways and the small-scale watershed management.

5.3.2 Flood Mitigation Committee (FMC)

Most of the non-structural flood measures proposed in the Study, in particular, would be implemented through full collaboration among the national government agencies, LGUs concerned, NGOs and residents in the area, while the LGUs shall take the leadership, among others. For the effective monitoring of the implementation of measures as well as coordination among the implementing offices, the Flood Mitigation Committee (FMC) is proposed to be organized. The proposed members of the FMC are listed below.

Table 9 Proposed Members of Flood Mitigation Committee

Designation	Personnel and Organization
Chairperson	Provincial Planning and Development Coordinator (PPDC)
Secretariat	Provincial Planning and Development Office (PPDO)
Vice-Chairperson	District Engineer of DPWH in Trece Martires City
Member	Provincial Director of Philippine National Police (PNP)
Member	Head of PG-Environmental and natural Resources Office (PG-ENRO)
Member	Head of Provincial Housing and Urban Development Office
Member	Head of Provincial Engineering Office (POE)
Member	Representative from District Office of DENR in Trece Martires City
Member	Representative from District Office of NIA in Naic, Cavite
Member	Provincial Action Officer of the Government Service Office

5.3.3 Financial Condition for Project Implementation

(1) National Government

The share of investment for flood mitigation of the whole sector in the DPWH Medium Term Public Investment Program (DPWH-MTPIP) has slightly decreased from 13% for 1999-2004 to 12% for 2005-2010, while the investment cost for flood mitigation projects has increased from 5.1 billion pesos for 1999-2004 to 8.2 billion pesos for 2005-2010. In the DPWH-MTPIP, the implementation of 33 foreign financial assistance projects (9 on-going projects and 24 new projects) is included in the sector of flood mitigation. The average investment cost per project is estimated at about 2.8 billion pesos (4.3 billion pesos for the on-going projects and 2.3 billion pesos for the proposed projects), as listed below.

Table 10 Investment Cost for On-going and Proposed Flood Mitigation Projects
(Foreign Financial Assistance Projects)

Project Status	Number of Projects	Investment Cost (million pesos)				Ave. Invest. Cost/Project (million pesos)
		Prior Years	2005 to 2010	After 2005	Total	
On-going	9	17,414	21,173	0	38,587	4,287
Proposed	24	0	23,050	31,785	54,835	2,285
Total	33	17,414	44,223	31,785	93,422	2,831

Source: DPWH-MTPIP 2005-2010

In addition to the above foreign financial assistance projects, it is projected that the investment cost of 4.9 billion pesos in total is allocated for the locally funded projects in 2005-2010 in the sector for flood mitigation. This cost is likely to be oriented to the maintenance of flood mitigation facilities such as drainage along national roads, protection works along national roads/seawalls, and maintenance for river channels.

DPWH has taken efforts, through its Cavite District Office, to mitigate flood damage in Cavite Province such as bank protection, dredging works on riverbed and drainage improvement works, including maintenance and cleaning works of drainage channels along the national roads. The annual investment cost of DPWH for flood mitigation works in Cavite Province is in the range of 16.7 to 53.8 million pesos.

(2) Local Government

The annual income of the Provincial Government of Cavite is a little over 1 billion pesos, of which about 70% is covered by the Internal Revenue Allotment (IRA), the share from the national budget. More than 90% of the annual expense is allocated to office operating cost, mostly for personnel expenses. Judging from the revenue and expenditures, the Provincial Government could hardly afford the budget for flood mitigation works. Under such circumstances, the congressional allocation as the Priority Development Assistance Fund is widely used for small projects funded by the local government. This fund should be considered proactively as the financial source for small components of the proposed projects.

6. Proposed Structural Flood Mitigation Measure

The optimum plans for river overflow flood mitigation and inland drainage improvement were selected from among several alternatives in due consideration of (1) affordability of project cost; (2) economic viability; (3) efficiency of flood mitigation; and (4) negative environmental and social impacts. The following measures and design scales are proposed as the optimum plan.

6.1 Mitigation against River Overflow Flood

Among the three objective rivers, Canas River is evaluated to presently possess the adequate channel flow capacity which could cope with the flood runoff discharge of 20-year return period, while the present channel flow capacity of the Imus and San Juan rivers could hardly cope with even the flood of 2-year return period. Based on the evaluation of these present channel flow capacities, the structural flood mitigation plan is formulated for the Imus and San Juan rivers.

The optimum plan for the said two rivers is composed of the off-site flood retarding basin, partial river improvement and on-site flood regulation pond. The design scale for mainstreams of the rivers is set at 10-year return period, while those for tributaries of the Imus; namely, Bacoor and Julian rivers, are set at 2 and 5-year return periods, respectively. The details of these components of the structural flood mitigation plan are described below.

6.1.1 Construction of Off-Site Flood Retarding Basin and Partial River Improvement

The river channel improvement and construction of flood diversion channel are conventionally adopted as the principal measures against flood overflow from the rivers in the Philippines. However, the area along the downstream river stretches in the Study Area is densely packed with houses, and it is virtually difficult to adopt such conventional measures due to the extremely large number of house evacuations required. Under the circumstances, adopted is the off-site flood retarding basin, together with minimum partial river channel improvement (refer to Fig. 4).

The off-site flood retarding basin could be constructed in the less populated agricultural land/grassland in the middle reaches to serve as the principal flood mitigation measure. The flood peak discharge could be reduced by temporarily retarding the flood runoff discharge in the off-site flood retarding basin. The number of proposed flood retarding basins is 10, covering an area of about 220ha (refer to Table 11 and Fig. 4).

Partial river channel improvement is further proposed as a supporting measure to enhance the extremely small channel flow capacity at the bottlenecks of the river channels in the lower reaches of the off-site flood retarding basin. The partial river improvement would be made within the downstream stretch of 20.8km in total (refer to Table 11 and Fig. 4).

Table 11 Proposed Off-Site Flood Retarding Basin and Partial River Improvement

Description	Quantity
Design Scale	10-year return period for mainstream for Imus and San Juan River 5-year return period for Julian River 2-year return period for Bacoor River
Off-Site Flood Retarding Basin	7 retarding basins of 139 ha in Imus river basin 3 retarding basins of 80ha in San Juan river basin
Partial River Improvement	Improvement length of 3.4km for Imus Main Stream Improvement length of 6.4km for Bacoor River Improvement length of 9.0km for Julian River Improvement length of 2.0km for San Juan River

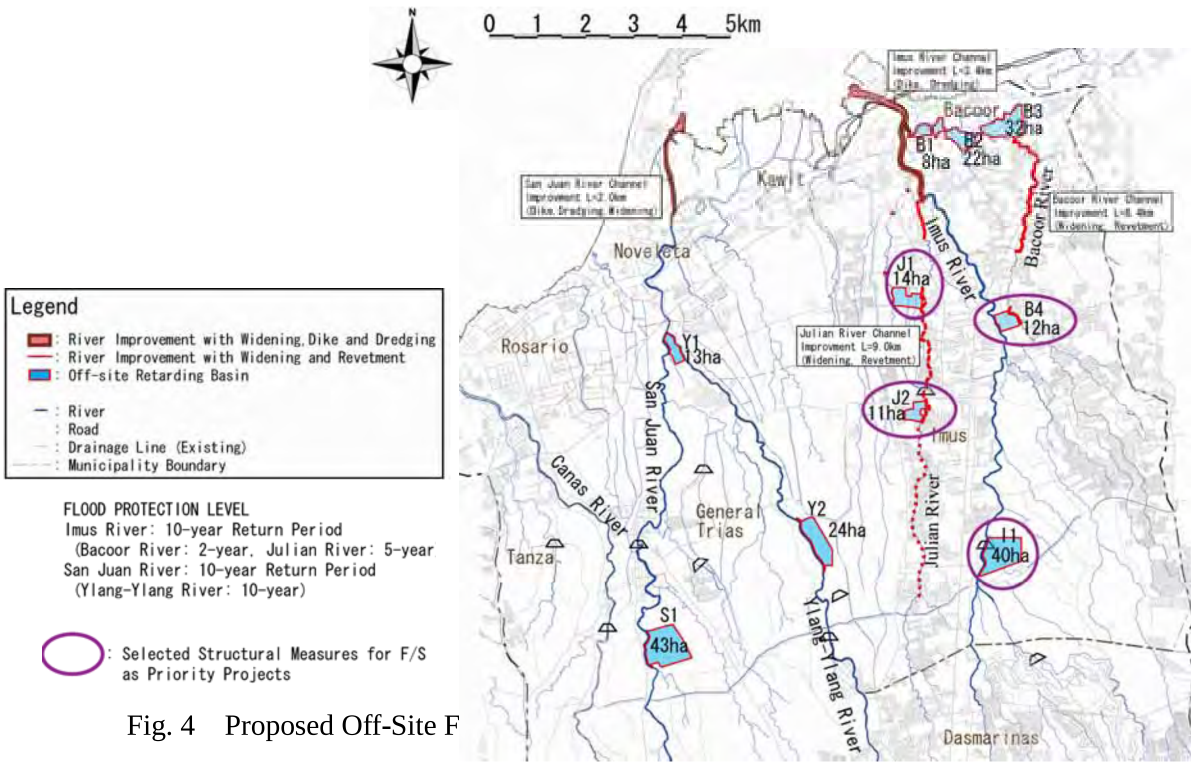
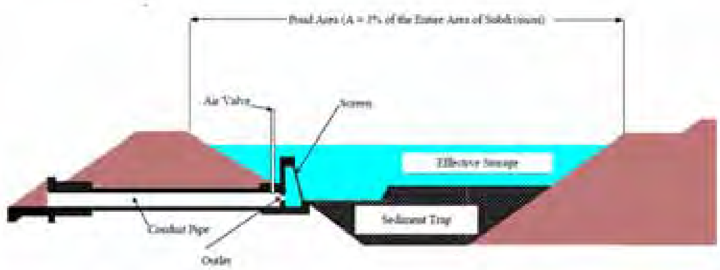


Fig. 4 Proposed Off-Site F

6.1.2 Construction of On-Site Flood Regulation Pond within the Compound of New Subdivisions

The intensive land development for residential estates is currently in progress in the middle and upper reaches of the Study Area. As the Study Area is covered with the road pavement, houses/buildings and other impermeable structures by the land development, storm rainfall would more hardly penetrate into the ground, which leads to increment of the basin peak flood runoff discharge. To offset such increment of the flood runoff discharge, the creation and enforcement of an ordinance is proposed to obligate the land developers to construct an on-site flood regulation pond at every new subdivision of five hectares or larger. The on-site flood regulation pond is designed to occupy 3% of the entire extent of the subdivision and offset the increment of the peak flood runoff discharge of 20-year return period or shorter caused by the development of the subdivision. The conceptual drawing of the on-site flood regulation pond is shown in Fig. 5. During floods, the on-site flood regulation pond would function as an impounding pond, while it could be used as an amenity space such as sports ground during the non-flood time.



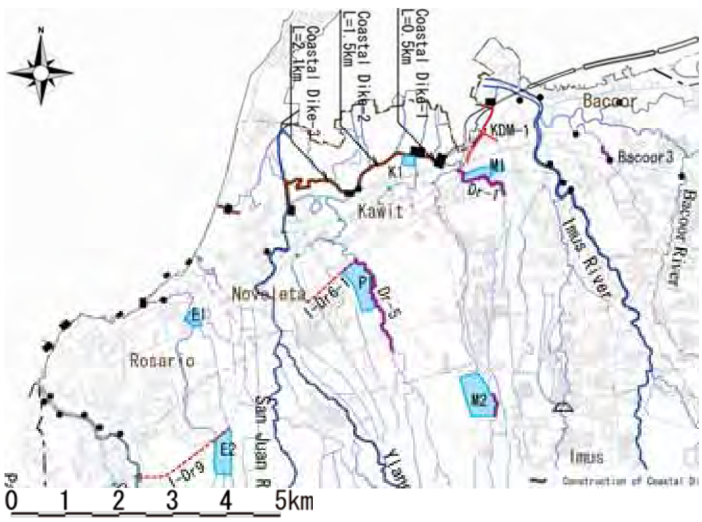
awing of Proposed Onsite Flood Regulation Pond

6.2 Inland Drainage Improvement and Protection against Tidal Flood

The drainage channel improvement works and the construction of coastal dike, together with tidal/flap gates, are proposed to mitigate the inundation by storm rainfall and tidal flood (refer to Fig. 6). The proposed drainage channel improvement work includes the improvement of existing drainage channels of 3.8km in length, construction of new drainage channel of 2.6km in total, construction of interceptors of 4.4km, off-site flood detention ponds of 52ha in total, and 18 flap gates.

The off-site flood detention pond would function to collect and temporarily store the storm rainfall so as to reduce the burden of the downstream drainage channel, while the flap gates are constructed at the outlet point of the drainage channel to prevent seawater and/or river water from reversely flowing into the drainage channel.

The coastal dike of 4.1km in length is also proposed along the shoreline to protect the coastal lowland area against the tidal flood. Tidal gates are further constructed at twelve sites, where the coastal dike crosses the rivers/the creeks, to facilitate drainage of the inland storm water to the sea during low tide and the present navigation between the sea and the rivers. The crown level of the tidal dike is set at EL. 2.41m, which is one meter higher than the recorded highest sea level (refer to Fig. 7).



Description	Quantity
Design Level of Drainage Improvement	2-year return period
Length for Improvement of Existing Drainage Channel	3.8 km
Length for Construction of New Drainage Channel	2.6 km
Length for Construction of New Interceptor	4.4km
Number of Tidal Gate	12 units
Number of Flap Gates	18 units
Area of Offsite Flood Detention Pond	52 ha in total
Length of Coastal Dike	4.1 km

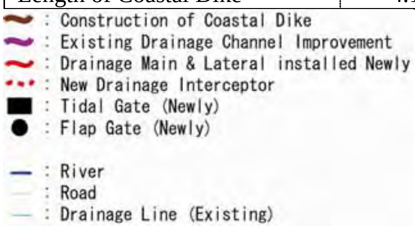


Fig. 6 Proposed Inland Drainage Improvement and Protection Works against Tidal Flood

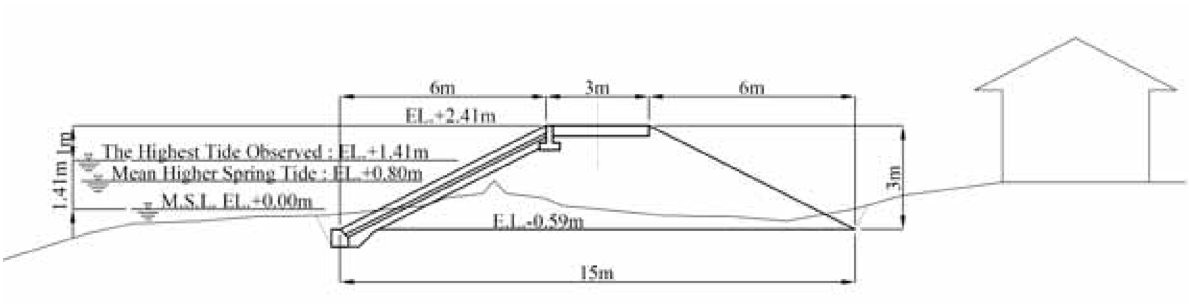


Fig.7 Typical Cross-Section of Proposed Coastal Dike

6.3 Project Cost and Project Economic Evaluation

The project scale, cost, EIRR and number of house relocation of the optimum structural flood mitigation plans are given below.

Table 12 Optimum Structural Flood Mitigation Plan

Classification of Plan	Objective Area	Design Scale (Return Period)	Project Cost (million pesos) *3		EIRR	No. of Houses to be Relocated
			Shouldered by P.P.*2	Shared by Developer		
River Overflow Flood Mitigation	Imus River Basin	10-year*1	2,855	2,404	32.4%	275
	San Juan River Basin	10-year	1,445	1,282	20.7%	74
Inland Flood Mitigation	Entire Drainage Area	2-year	2,560	321	8.1%	121
Total			6,860	4,007	22.2%	470
Annual O&M Cost			35	36	-	-

Note *1: The design scale of the two tributaries of Imus; namely; Bacoor River and Julian River, are limited to 2-year return period and 5-year return period, respectively.
*2: P.P. = Project Proponent
*3: The above costs are exclusive of Price Contingency.

7. Non-Structural Flood Mitigation Measure

The non-structural measures are broadly classified into three in accordance with the functions required.

Table 13 Eligible Non-Structural Flood Mitigation Measures

Classification	Measures
(I) Measures for Securing Flow of Waterways (To maintain the flow capacity of river/drainage channel and safely convey the flood discharge to the sea.)	(1) Clean-up of Waterway. (2) Prevention of encroachment in the river area.
(II) Measures for Retaining Basin Run-off (To maintain the retention capacity of the river basin and control the increment of basin peak flood runoff discharge.)	(3) Control of excessive land development. (4) Legal arrangement for introduction of on-site detention facility and control of excessive urban area development.
(III) Measures for Flood Evacuation (To mitigate flood damage through capacity building on dealing with floods.)	(5) Establishment of flood warning/evacuation system and flood hazard map.

The above non-structural measures could be attained only when the local communities as well as other stakeholders will initiate and participate in the plan formulation, implementation and monitoring/evaluation. From these standpoints, various approaches to the local communities were taken during the Study such as public consultation meetings/workshops, questionnaire surveys to the communities, and implementation of the pilot project. The details of the approaches for each of the non-structural measures are further described below.

7.1 Cleanup of Waterways

There exist 14 critical bottleneck bridge sections and 6 drainage channels that habitually cause flood overflow due to the clogging with garbage, other drift materials and sediment deposits. To maintain the flow capacity at the bottlenecks, the following activities for the cleanup operation are proposed:

7.1.1 Regular Maintenance of Critical Bottlenecks

The FMC together with DPWH-DEO and the cities/municipalities would undertake the following tasks:

(1) FMC is to coordinate and supervise the entire cleanup programs prepared and the actual field works undertaken by the DPWH-DEO and/or the cities/municipalities, and to further coordinate and arrange the necessary annual budget for work execution;

(2) DPWH-DEO-Trece Martires, as the core member of FMC, is to undertake the cleanup operation at the critical bridge sections of national roads, including the preparation of cleanup programs, monitoring and execution of removal of garbage and driftwood and de-clogging of drainage channels; and

(3) Cities/municipalities and barangays are to undertake the cleanup operation at the bottleneck sections and/or drainage sections in their own jurisdiction area other than those undertaken by DPWH-DEO, including the preparation of cleanup programs, monitoring and execution of removal of garbage, driftwood and sediment deposits at the bottleneck sections and/or drainage channels.

7.1.2 Information and Education Campaign on Cleanup of Waterways

The FMC would coordinate with the Executive Committee of "Oplan Linis Cavite" to contemplate the annual programs of the Information and Educational Campaign (IEC) addressed to a particular issue on the cleanup of waterway. Based on the annual programs, the City/Municipal Technical Working Group for Oplan Linis Cavite, in collaboration with FMC, would undertake the following tasks:

(1) To conduct seminars and/or workshops;

(2) To prepare and distribute periodical publications;

(3) To install signboards along the riverbank; and

(4) To conduct regular field practices for cleaning the waterways and/or greening or planting along the riverbanks (involvement of academe, rotary clubs and other private organizations).

7.1.3 Capacity Development

In order to educate the leaders and spread basic knowledge on the cleanup of waterways to the residents, the FMC, in collaboration with the Executive Committee of Oplan Linis Cavite, would undertake the following tasks with support from the academe/research centers and/or external technical assistance:

(1) To organize seminars/workshops and disseminate knowledge on the cleanup of waterways;

(2) To prepare and distribute manuals for the cleanup of waterways, which shall contain procedures methodologies, demarcation of relevant stakeholders for the cleanup of waterways; and

(3) To conduct pilot projects and initiate capacity development on the advanced technology of segregation and recycling of household wastes.

7.1.4 Implementation of Pilot Project

To materialize the above IEC and the other activities relevant to the cleanup of waterways, pilot projects for the two municipalities of Imus and Kawit were implemented during the Master Plan Study Stage. The expansion program for the pilot project in five municipalities was further taken up during the Feasibility Study Stage. The principal activities undertaken through the pilot projects in the Master Plan Study Stage are enumerated below:

(1) Development of module materials on the river cleaning activities for future trainers;

(2) Development of training materials for the residents;

(3) Indoor and field trainings on river cleaning; and

(4) Seminars/workshops on river cleaning with the attendance of both the formal and informal dwellers.

7.2 Prevention of Encroachment to the River Area

The number of existing houses located in the river areas of Imus, San Juan, Canas and their major tributaries is estimated at about 500. The following tasks for the management of river area, especially, the prevention of encroachment in the river area, are proposed, including definite roles and demarcations of the national and local government units concerned:

(1) The clear extent of the river area shall be declared for the prevention of encroachment as well as the effective management of the river area, and from this point of view, the river area was preliminarily proposed to cover the following water body and river corridor (area of river banks) with reference to Presidential Decree No. 1067:

- Water Body: the riverine area confined by the river dike/bank, if they exist, should be defined as the water body. In case of difficulties in recognizing the clear river dike/bank, the water body should be assumed as the potential waterway of floods with the recurrence probability of 2-year return period.
- River Corridor: the river corridor should have the widths of 3m in an urban area, 20m in an agricultural area and 40m in a forest area from the outward bound of the above water body synonymous with the banks of rivers defined in Article 51 of PD No. 1067.

(2) The database of the river area should be developed as the base of maintenance and management of river area. The prototype database would be developed in the Feasibility Study Stage.

(3) The annual program for the relocation of houses in the river area shall be executed by the Provincial Housing & Urban Development Office and the Provincial Legal Service Office.

(4) The land zoning in the river area should be made in order to establish the proper land readjustment of the river area, which could promote public interest on the environment of the river area, ensuring the safe flow of river floods and preventing the re-occupancy of the river area after the relocation of houses. The land uses applicable as the objectives of the zoning plan shall define the river parks, sports ground, river walk lanes, and the biotope providing a living place for specific groups of vegetation and animals. To achieve such land readjustment, the City/Municipal Planning and Development Office (CPDO/MPDO) shall Integrate and appraise all land zoning plans prepared by the cities/municipalities for the river area cleanup; and coordinate and arrange the necessary annual budget for implementation of the land-zoning plan for the river area.

7.3 Control of Excessive Land Development

As described above, the excessive land development would induce the remarkable increment of peak runoff discharge. To cope with this issue, the zoning plan for the urbanized area in the Study Area is proposed as described in the foregoing Section 3.4 (refer to Fig. 1). The Study further proposes the following items to materialize in the zoning plan.

7.3.1 Control of Expansion of Built-Up Area

The expansion of the built-up area should be properly controlled to be within the built-up ratio of 42.7%, assuming the following conditions:

(1) Establishment of the province-wide strategic land use plan taking more detailed and realistic approach to the population projection, and well-balanced distribution of the built-up area among cities/municipalities;

(2) Conservation of farmlands at the allowable level guided by the Housing and Land Use Regulatory Board, and conversion of farmland currently abandoned and remaining as vacant land into a built-up area;

(3) Control of increment of built-up area/mixed land use by zoning to separate urban growth centers and e residential areas;

(4) Development of the organizational setup, human resources and tools for processing the land use plan following the results of the relevant initial training undertaken in the Study; and

(5) Exclusion of the following environmentally critical areas from the projected land use: (i) steep slope area with the ground inclination of more than 15%; (ii) the farmland/fishpond specified as the Strategic Agricultural and Fishery Development Zone (SAFDZ); (iii) the protected farmland specified in the Comprehensive Agrarian Reform Program (CARP); (iv) the NIA irrigated area; and (v) the habitual flood inundation area, which is provisionally assumed, in the Study, as the probable flood inundation area of 2 year return period with the inundation depth of more than 25cm.

7.3.2 Legal Arrangement for Introduction of On-Site Flood Regulation Pond

A draft ordinance titled "Onsite Flood Regulation Pond Requirement in a New Subdivision Project" is provisionally proposed to make installation of the on-site flood regulation pond mandatory in new subdivision development projects in Cavite. With the ordinance, the construction of an on-site flood regulation pond at the downstream end of each new subdivision of 5ha or more could be a requirement for land developers when applying for a license or permit.

7.4 Establishment of Flood Warning and Evacuation System (FWES)

7.4.1 Flood Risk Area

The flood risk area is defined as the inundation area with the depth of more than 50cm by a probable flood of 100-year return period, of which the water depth hampers social activities and harm human lives. This definition is based on the original concept of the Study such that the depth of 50 cm is adopted as the critical level to do the injury to a person and the probable flood of 100-year return period is also adopted as the recoded maximum flood in the Study Area (recoded in the Typhoon Milenyo in 2006). The total flood risk area is estimated at 1,283ha, where the biggest area of 305ha is located in the Municipality of Bacoor.

7.4.2 Stepwise Flood Warning and Evacuation Procedure

In order to release information together with the hydro-meteorological conditions to initiate each stage of the flood warning and evacuation activities earlier, a stepwise flood warning and evacuation procedure is proposed.

7.4.3 Disaster Operation Center and Evacuation Center

The disaster operation centers for the PDCC, CDCC/MDCC and BDCC shall be established, primarily, to initiate coordination among the members of each council and operate the FWES. Further, the rainfall gauging equipment and communication tools are indispensable for disaster operation. Each of the municipalities and barangays shall establish a definite evacuation center and make it known to the residents through distribution of the flood risk map. The Provincial Government of Cavite had provisionally identified eight existing public places in and around the Study Area as evacuation centers, and further considering public elementary/secondary schools as potential evacuation centers.

7.4.4 Communication Network for Execution of Flood Warning and Evacuation

The eligible communication route among the government and non-government organizations relevant to flood warning and evacuation, as well as the residents, is proposed as shown in the following figure.

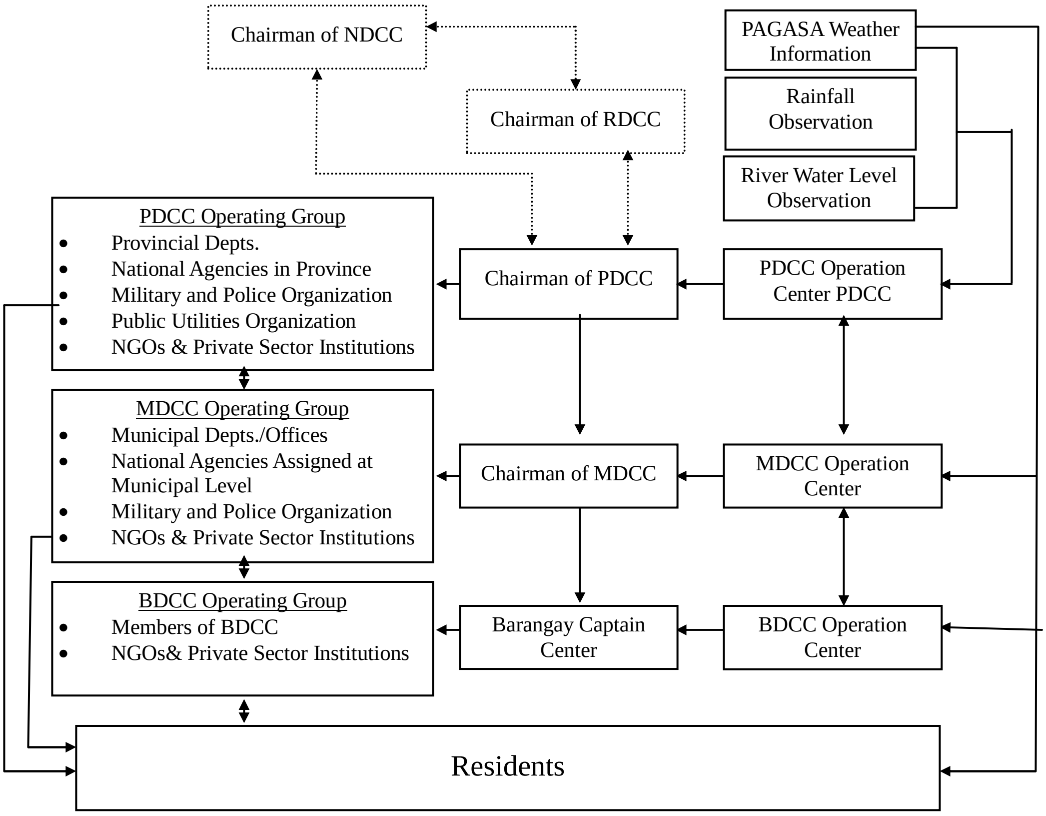


Fig. 8 Communication Flow for Operation of Flood Warning and Evacuation

8. Priority Project and Implementation Program

The priority project is selected from among the components of the optimum flood mitigation plan contemplated, as described in the preceding Chapters 6 and 7. The priority project is expected to produce immediate and significant flood mitigation effects in the short period of time. The target project completion year of the priority structural measures is 2013, while it is 2010 for the priority non-structural measures.

8.1 Priority Project for Structural Measures

The proposed Optimum Plan is broadly divided into three components; namely, (1) the plan against river overflow of the Imus River; (2) the plan against river overflow of the San Juan River; and (3) the plan for the mitigation of inland floods. Each of these three plan components could independently effect flood mitigation. Of these three components, however, the plan against the river overflow of Imus River could relieve the largest number of houses and area, as listed in Table 14. Moreover, the plan could generate the largest EIRR, as shown in Table 12. Judging from these flood mitigation effects and the economic viability, the plan against the overflow of Imus River shall take priority over all the other components of the Optimum Plan.

Table 14 Number of Houses and Area to be relieved by the Optimum Flood Mitigation Plan

Classification of Plan	Objective Area	Number of Houses to be relieved by the Optimum Plan			Area to be Relieved by the Optimum Plan (ha)		
		2-year Return Flood	5-year Return Flood	10-year Return Flood	2-year Return Flood	5-year Return Flood	10-year Return Flood
Plan against River Overflow Flood	Imus River Basin	6,911	10,356	10,500	839	1,000	1,056
	San Juan River Basin	99	3,146	4,963	93	477	867
Plan against Inland Flood	Drainage Area	1,926	-	-	291	-	-

The plan against the river overflow of Imus River is further divided into three components; namely, (1) four upstream off-site flood retarding basins along Imus River, Julian River and Bacoor River; (2) three downstream off-site flood retarding basins along Bacoor River; (3) partial river improvement works; and (4) the construction of on-site flood regulation pond (refer to Fig. 4). Of these components, the upstream off-site flood retarding basins could regulate the peak flood discharge flowing into the downstream damageable river stretches and, therefore, they are preferable for the flood mitigation of Imus River. Moreover, the proposed sites of the upstream off-site flood-retarding basins are vacant lands at present and would require less number of houses to be relocated. However, these sites may soon be occupied by houses and/or other structures unless some actions are taken to preserve as the right-of-way for construction of the off-site flood-retarding basins. Under the circumstances, the construction of the upstream off-site retarding basins is urgently necessary. Moreover, because of the small number of house relocations, the implementation period for construction could be made shorter, leading to the immediate effect of flood mitigation.

Judging from the above flood mitigation efficiency, the urgent necessity of project implementation and the immediate effect of flood mitigation, construction of the upstream off-site flood-retarding basins shall be the priority project, and further detailed study for this project should be made in the Feasibility Study Stage.

8.2 Priority Project for Non-Structural Measures

The non-structural flood mitigation plans described in Chapter 7 could take the important role of flood mitigation in the different fields and could bring out the immediate effect of flood mitigation. Accordingly, all components of the non-structural flood mitigation plan are proposed to comprise the priority project for non-structural measures, and the following issues are to be clarified in the Feasibility Study Stage:

(1) **Cleanup of Waterway:** The expansion program for the pilot projects in five municipalities in the lowland area of Cavite is to be taken up in the Feasibility Study Stage in order to materialize the Information and Educational Campaign (IEC) on the cleanup of waterways.

(2) **Prevention of Encroachment to River Area:** The prototype of the database for the river area is to be developed as the basis for the management of the river area.

(3) **Control of Excessive Land Development:** The ordinances on the zoning of the urban area and the construction of off-site flood regulation ponds to strengthen the basin flood detention capacity are prepared. Their ordinances are to be created and legislated including the preparation of legal arrangements for their implementation.

(5) **Establishment of Flood Warning/Evacuation System and Flood Hazard Map:** A pilot project is to be conducted to develop a prototype of the flood hazard map and transfer the knowledge to the relevant stakeholders.

9. Implementation Program

The structural project is divided into three construction packages; namely, (1) Package 1 for the project against the river overflow of Imus River; (2) Package 2 for the project against the river overflow of San Juan River; and (3) Package 3 for the drainage improvement project. The detailed implementation schedule is shown below.

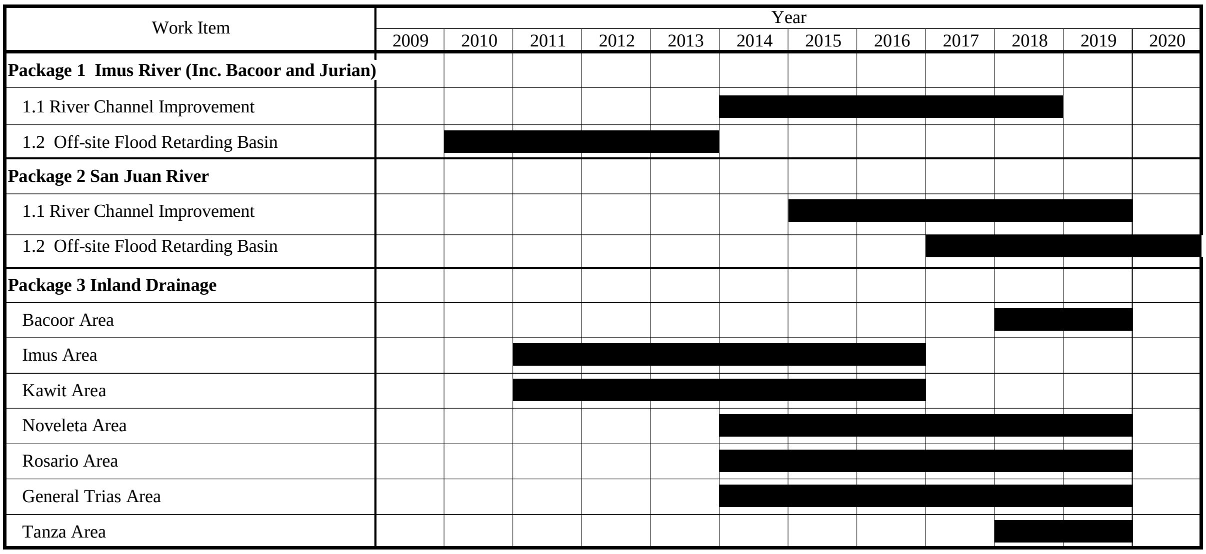


Fig. 9 Implementation Schedule of the Structural Flood Mitigation Project

In connection with the above schedule presented in the Draft Final Report, one of the officials of DPWH commented that the schedule is not doable and suggested that the year for commencement of the project should move to 2011 instead of 2010, the year proposed in the Study. It is, however, urgently required to secure the ROW for the proposed project site taking the present rapid expansion of the built-up area into account, and the LGUs are ready to start consultation meetings with PAPs for the sake of consensus building on land acquisition and/or house relocation. Moreover, there is a fair chance to secure the necessary budget for the engineering services taking the possibility of the external financial assistance into account. From these points of view, the commencement of the project is still set at 2010.

The non-structural project is also divided into four components; namely, (1) Cleanup of waterways; (2) Prevention of encroachment to the river area; (3) Enforcement of ordinance regarding the on-site flood regulation pond; and (4) Setup and execution of flood warning and evacuation system. Setting up of all of these non-structural components are proposed to commence even within the study period and completed before the year 2010. The detailed implementation schedule of the non-structural project is shown below.

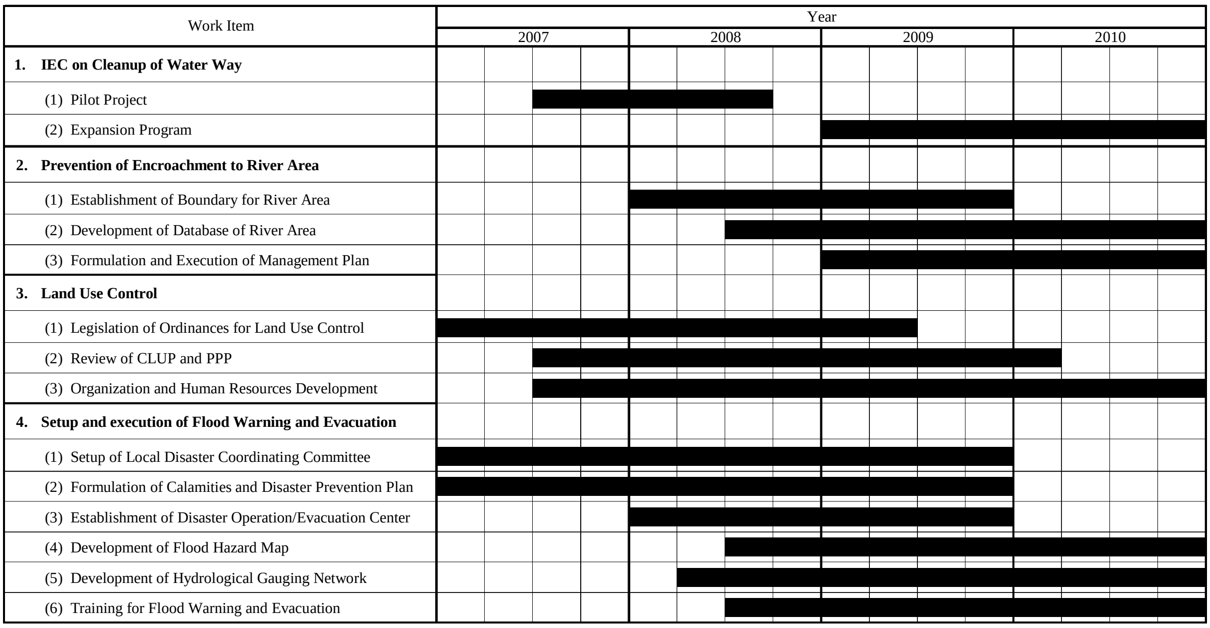


Fig. 10 Implementation Schedule of the Non-Structural Flood Mitigation Project

10. Environmental and Social Considerations on the Alternative Flood Mitigation Plan

10.1 Objectives of the IEE

The initial environmental evaluation (IEE) for the Project proposed in the Master Plan was made in accordance with the guidelines of the GOP as well as JICA. The objectives of the IEE include: (1) the identification environmental elements based on scoping; (2) the assessment of impacts on the environmental elements; (3) the identification of possible mitigation measures against the impacts; and (4) the identification of the necessary monitoring items in the future. The impacts caused by the prevention of river overflow flood are to be assessed for all of the following eight proposed alternative projects together with the "without-project" situation.*

Table 15 Alternative Flood Mitigation Plans against River Overflow

Objective River Basin	Alt. No.	Component of Flood Mitigation Measures				
		Full Scale River Improvement	Partial River Improvement	Off-site Flood Retarding Basin	Flood Diversion Channel	On-site Flood Regulation Pond
Imus	F_I.1	●				
	F_I.2		●	●		
	F_I.3		●	●		●
San Juan	F_S.1	●				
	F_S.2		●	●		
	F_S.3		●	-	●	●
	F_S.4		●	●	●	
	F_S.5		●	●	(●)*	●

Note: F_S.5 is basically assumed to include the flood diversion channel as one of the components. However, the least project cost for the design scale of 10-year return period, which is selected as the optimum design scale, comes out, when the flood diversion channel is excluded by maximizing the scale of the off-site flood retarding basin. Due to this, F_S.5 excludes the flood diversion channel from its component in case of the design scale of 10-year return period.

The two alternatives (Alt. D-1 and Alt. D-2) with the design scale of 2-yaer return period are further proposed for the inland drainage. Both of these alternatives apply the combination of various measures for drainage improvement and prevention against tidal flood. The difference of the two alternatives lies in the fact that Alt. D-1 applies the coastal dike together with tidal gates for the prevention of tidal floods in Kawit Municipality, while Alt. D-2 applies the ring dike.

10.2 Identification of Environmental Elements for Assessment (Scoping)

The environmental elements for assessment were identified through scoping on the alternatives, and the following major adverse impacts of the proposed alternative flood mitigation projects are anticipated:

(1) The alternatives for full-scale river improvement (Alt. F_I.1 and Alt. F_S.4) would cause a large number of house relocation.

(2) The alternatives other than those for full-scale river improvement and drainage improvement will largely decrease the number of house relocation, and they will require a considerable land acquisition of farmlands/fishponds which may affect the job of tenant farmers and/or fishpond operators.

(3) The proposed structures for inland drainage (Alt. D-1 and Alt. D-2) would also require a certain extent of house relocation and land acquisition of farmland/grassland and fishpond.

(4) All of the alternatives would need to clear a certain extent of the existing mangrove in the river mouth and coastal areas.

(5) All of the alternatives would intersect the existing roads and irrigation canals.

* The alternative design scales of 2 to 20-year return periods for the prevention of river overflow were examined as the objectives of the IEE. However, the results of IEE on the design scale of 10-year return period, which was selected as the optimum design scale, are described as the summary of IEE in this section.

(6) Wastewater may be discharged into the proposed off-site flood retarding basin causing emission of foul odor.

10.3 Impact Assessment and Possible Mitigation Measures for Proposed Projects

Adverse impacts as anticipated in the above scoping and the possible mitigation measures for them were assessed as described below.

10.3.1 House Relocation

The alternatives for full-scale river improvement with the design scale of 10-year return period would require the house relocation of 1,940 in total, which include 1,480 for Imus River Basin (Alt. FI_1) and 460 for San Juan River Basin (Alt. FS_2), as shown in Table 16. On the other hand, the number of house relocation for the alternatives with the combination of off-site flood retarding basin, on-site regulation pond and partial river improvement would be remarkably reduced to 349, which include 275 for Imus River Basin (Alt. FI_3) and 74 for San Juan River Basin (Alt. FS_5).
As for the inland drainage with the design scale of 2-year return period, the D-1 alternative (assuming the coastal dike/tidal gate against tidal flood) requires 121 house relocations, while D-2 (assuming the ring dike against the tidal flood) requires 341 house relocations.

Table 16 Number of House Relocations of Proposed Alternatives

Objective Scheme	Objective Area	Alt. No.	Number of House Relocations
River-Overflow Flood Prevention	Imus River Basin	FI-1	1,480
		FI-2	275
		FI-3	275
	San Juan River Basin	FS-1	460
		FS-2	74
		FS-3	285
		FS-4	204
		FS-5	74
Inland Drainage	Whole Drainage Area	D-1	121
		D-2	341

Note: The above figures are subject to the design scales of 10-year return period for River-Overflow Flood Prevention and 2-year return period for inland drainage

The JICA Study Team conducted a sample interview survey among the 199 residents along the river and/or the possible sites of the flood-retarding basin as part of the Initial Environmental Examination (IEE) Study. As a result of the survey, the socio-economic conditions of the potential project-affected-persons (PAPs) are described as follows:

(1) Of the respondents, about 32% (63 families) are headed by a female.

(2) The number of family members is 5.69 persons/family on the average. Among them, 1.90 persons/family (33%) are employed. The largest number of persons are employed in business/sales (24%) followed by the factory workers (16%), drivers (8%), office employees (8%) and fishermen/farmers (8%).

(3) The income of 51% of the total families and/or 56% of the female-headed families is considered to be below the poverty line (Php 1,700/person/momth).

(4) Among 199 families, 31 families (16%) own their lots and 127 families (64%) have their own houses. However, those who own both a lot and a house account for only 30 families (15%). About 35 households (18%) informally occupy government land.

(5) The houses of the respondents are made of scrap material (25%), semi-concrete (42%) and concrete (28%).

(6) Among 199 families, 13% opposed any relocation even when they are required under the Project.

The provincial government is planning to develop resettlement sites of 122 hectares in total which may possibly accommodate the potential re-settlers (refer to Section 11.2). The resettlement problems mentioned above would possibly be solved through the development of resettlement sites and the formulation/execution of a comprehensive resettlement program, which involves a variety of activities such as identification of the PAPs, appraisal of the necessary compensation/entitlement for the PAPs, and social/income restoration for the PAPs during the post-relocation stage. Details of the activities and arrangements required for the resettlement plan are as described in Sections 11.3 and 11.4.

10.3.2 Unemployment due to Acquisition of Farmland and Fishpond

The land to be acquired for execution of the Project is classified into: (1) house lot; and (2) farmland/fishpond. The impacts of land acquisition could be examined as an issue under the aforesaid house relocation. As for the acquisition of farmlands and fishponds, however, unemployment of the tenant farmers and fishpond operators is anticipated as the particular impact. From this point of view, the extent of farmlands and fishponds to be acquired for the Project and the number of tenant farmers/fishpond operators have been estimated as shown below.

Table 17 Extent of Acquisition of Farmlands and Fishponds

Objective Scheme	Objective Area	Alt. No.	Extent of Acquisition of Farmlands and Fishponds (ha)			Number of Tenant Farmers and Fishpond Operators Affected		
			Farmland	Fishpond	Total	Farmer	Fishpond Operator	Total
River Overflow Flood Prevention	Imus River Basin	FI-1	0	0	0	0	0	0
		FI-2	36	40	76	30	44	74
		FI-3	31	40	71	26	44	70
	San Juan River Basin	FS-1	0	0	0	0	0	0
		FS-2	62	0	62	52	0	52
		FS-3	0	0	0	0	0	0
		FS-4	34	0	34	29	0	29
		FS-5	58	0	58	49	0	49
Inland Drainage	Whole Drainage Area	D-1	20	9	29	17	10	27
		D-2	20	10	30	17	11	29

Note: The above figures are subject to the design scales of 10-year return period for River Overflow Flood Prevention and 2-year return period for inland drainage improvement.

As shown above, the alternatives involving the off-site flood retarding basins and/or the inland drainage facilities (i.e., the alternatives except Alts. FI_2, FS_1 and Fs_3) require a considerable area of farmland and fishpond, which would possibly deprive the jobs of the tenant farmers and fishpond operators.

Based on the sampling interview survey with 34 households, the following principal socio-economic profiles of the tenant farmers and tenant fishpond operators were estimated:

(1) Income by farming and fishpond operation takes the following percentages of the total family income: 42% for the tenant farmers and 16% of the tenant fishpond operators on the average. Thus, most of the tenant farmers and fishpond operators are deemed to take side businesses.

(2) The incomes of 64% of the tenant farmers and 33% of the tenant fishpond operators are below the poverty line (Php 1,700/person/momth).

(3) The tenant farmers and tenant fishpond operators have a relatively low educational attainment; about 60% of the tenant farmers and 80% of the tenant fishpond operators have not taken the secondary or high school education. Such low educational attainment would be a handicap in seeking employment.

(4) All of the tenant farmers and tenant fishpond operators reside close to the urban area where employment opportunities are deemed to be high.

To mitigate the unemployment problem, the government shall take the following activities, taking the income restoration program as described in Subsection 11.3.3.

(1) Give special consideration on people who may lose their jobs in the allocation of resettlement sites so that they can resettle within the same municipality or in a nearby area.

(2) Provide various vocational training courses to people who want to change their jobs.

(3) Assist in creation/introduction of jobs, which are applicable to the personnel with low-level education.

10.3.3 Disruption of Infrastructure, Water Use and Fishery

The major parts of the existing infrastructure, which would be disrupted by the Project, are as enumerated below.

(1) Road and Bridge

Several bridges, road sections and irrigation canals are disrupted by the Project during the construction period as listed below. These disruptions could be solved by the reconstruction of existing structures. Traffic disturbance during the construction period could be also mitigated to an allowable level by detouring vehicles to neighboring roads or by constructing temporary detour roads.

Table 18 Number of Disrupted Roads and Bridges during Improvement Works

Alternative	Bridge on Arterial Road	Bridge on Secondary Road	Road	Irrigation Canal
FI-1	5	8	-	-
FI-2, FI-3	2	8	3	2
FS-1	4	-	-	-
FS-2, FS-4	1	-	-	-
FS-3, FS-5	1	-	-	-

(2) Anchorage of Fishing Boat

The coastal dike and the ring dike proposed in Alt. D-1 and D-2 would hamper the anchoring of small fishing boats at the exiting harbors in Kawit Municipality. This adverse impact can be solved or mitigated by constructing simple locks on the dikes, which allow the fishing boats to go in and out through the locks even at high tide.

10.3.4 Clearing of Mangrove

Clearing of a certain extent of the existing mangrove would be required for the Project, as shown below.

Table 19 Mangroves Cleared for the Proposed Structural Projects

Alternative	Extent of Mangrove to be Cleared		Remarks
	Forest (ha)	Strip (km)	
FI-2, 3	-	5.2	
FS-1	2.0	-	
FS-2, 3, 4, 5	2.1	0.2	
D-1, 2	-	1.7	Width: about 10 m

To mitigate the negative impacts to the existing mangrove, the Project shall make it a rule to adopt transplantation of the whole mangrove to be affected by implementation of the Project. Moreover, the government shall conduct the following additional studies for conservation of the mangrove at the beginning of project implementation:

(1) To reconfirm the updated habitat of mangroves to be affected by project implementation.

(2) To clarify the ecological system of the affected mangroves and judge whether the affected mangroves could be transplanted to the project site such as the area along the river channel improvement section and the area around the flood retarding basin.

(3) To specify and secure the area where mangrove could be regenerated when the transplantation of mangrove is judged to be difficult.

(4) To formulate the implementation plan for transplantation and/or regeneration of mangroves.

10.3.5 Solid Waste Disposal

The residents might dump garbage into the proposed project facilities such as the river channel improvement works, retarding basins, and drainage structures. To mitigate these adverse effects, maintenance of the project facilities is indispensable. Moreover, another important mitigation measure has to be addressed to the information and educational campaign for the cleanup of waterways as currently undertaken by the local government in collaboration with the residents under the project "OPLAN LINIS."

10.3.6 Impact Assessment without Project

The Project Area is affected by frequent floods, which cause serious damage on lives and properties. Flood damage will increase in the future based on the population growth in the flood prone areas. On the other hand, land development in the central and upper areas will increase the flood peaks in the downstream reaches of rivers, resulting in further increments of flood damage in the lowland areas. Flood damages vary depending on the scale of flood. The future flood damage without project has been estimated as shown below.

Table 20 Flood Damage without Project

Food Type/Scale	Existing Conditions		Future Conditions in 2020	
	Flooding Area (ha)	Damaged House (No.)	Flooding Area (ha)	Damaged Houses (No.)
River-Overflow Flood				
2-year	930	7,000	1,360	20,700
5-year	1,650	14,600	2,070	34,500
10-year	2,260	19,500	2,610	41,100
20-year	2,950	23,200	3,320	48,000
Inland Flood				
2-year	710	4,900	890	9,200

Further, the road networks including the national roads are frequently inundated at many places at present. The frequent inundation causes not only traffic disturbance but also damage on the economic activities of the project area. These damages on the economic activities will become more intensive in the future.

10.4 Identification of Necessary Monitoring Items

The monitoring of environmental assessment aims at (1) checking the reality of the predicted adverse impacts; (2) checking the effects of the proposed mitigation measures against the adverse impacts; and (3) revising the proposed management plan of adverse impacts as required. The necessary monitoring items to fulfill the objectives have been identified, as listed below.

Table 21 Necessary Monitoring Items of Environmental Assessment

Environmental Item	Monitoring Item	Aim of Monitoring
(1) Resettlement	(a) Resettlement Site	To find out whether the resettlement sites are provided with necessary public facilities as planned.
	(b) Employment	To find out whether the resettled people are employed.
	(c) Vocational Training	To find out whether necessary vocational trainings are provided for people who want to change jobs.
(2) Natural Environment	(a) Mangrove	To find out whether the necessary replanting of cleared mangrove is implemented as planned.
(3) Public Hazard during Construction Period	(a) Traffic Disturbance	To find out whether traffic disturbance is due to the reconstruction of road/bridge.
	(b) River Water Turbidity	To find out whether river water turbidity is due to the river channel excavation.
	(c) Noise	To find out whether the noise is due to the operation of construction equipment.
(4) Public Hazard in Operation Phase	(a) Garbage Dumping	To prevent illegal garbage dumping on the improved river channel, diversion channel, off-site retarding basin, off-site retention pond and on-site regulation pond.
	(b) Wastewater Discharge	To prevent illegal wastewater discharge into the off-site retarding basin and the off-site retention pond.

11. Provisionary Plan for Resettlement

11.1 Potential Project-Affected Persons (PAPs)

It is estimated that the implementation of the optimum flood mitigation plan proposed in the Master Plan will likely require the relocation of 470 families and further acquisition of agricultural farmlands and/or fishponds, which would affect the livelihood of 92 tenant farmers and 54 tenant fishpond operators. The number of PAPs in each project component is shown below.

Table 22 Number of PAPs in Each Project Component

Item	Number of PAPs to be Affected by the Project			
	Imus River Overflow Prevention	San Juan River Overflow Prevention	Inland Drainage Improvement	**Total**
House Relocation	275	74	121	**470**
Faming Activities to be Affected	26	49	17	**92**
Fishpond Operation to be Affected	44	0	10	**54**
Total	345	123	148	**616**

At the average household size of 5.69 (the average of households in a sampling survey by the JICA Study Team), the total figure would readily translate to a significant number of more than 2,600 potential project-affected-persons (PAPs). It will be noted, however, that from 2003 to 2005 the province also posted a positive average annual population growth rate of 2.63 percent. This could mean that the actual number of potential PAPs who will be requested to house relocate may be more than 3,700 by the target completion year 2020 of the Master Plan.

As described above, the Study Team conducted a sample interview survey among 199 river residents and 34 farm/fishpond occupants as part of the Initial Environmental Examination (IEE) study. As a result of the survey, the socio-economic conditions of the PAPs are outlined as described in Subsections 10.3.1 and 10.3.2.

11.2 Potential Resettlement Sites

The Provincial Housing Development and Management Office (PHDMO) is the executive arm tasked with the implementation of the housing and resettlement program of Cavite. Consistent with its mandate, the PHDMO prepared the draft blueprint of the Province's comprehensive shelter program. The blueprint includes plans to develop present and potential resettlement sites to address the province's housing backlog.

The potential resettlement sites are placed at several locations within the Study Area, and among them, sites with an area of 122 hectares in total could possibly accommodate the influx of potential resettlers due to the implementation of the proposed flood mitigation plan, if acquired and developed before the Master Plan is implemented.

In addition to the above resettlement sites, the province foresees a need to purchase a property located in the coastal area to accommodate the fisher folks who will be affected by the ongoing demolition drive. The possible area being eyed is in Bgy. Halang, Municipality of Naic. The municipality lies outside of the Study Area. Nevertheless, if the province's plan is materialized, this resettlement site could possibly include as potential beneficiaries the fishing communities from Kawit, Noveleta and Rosario who will likely be displaced by the proposed coastal structures.

11.3 Procedures, Strategies and Measures for Resettlement

Consistent with the JICA's and other bilateral agencies' policy on involuntary resettlement, a full-scale Resettlement Action Plan (RAP) tailor-suited to the needs of resettling families and the affected communities should be crafted. To ensure effective implementation, emphasis is placed on involving the PAFs and their local leaders as early as possible in the RAP formulation process.

The RAP contains three stages: the pre-relocation stage, the actual relocation stage and the post-relocation stage (refer to Fig. 18). The pre-relocation stage aims at adequately preparing the PAPs physically, materially and psychologically for the impending relocation. During the relocation stage, the objective is to physically remove the PAPs from the project's right-of-way to preclude impediments to project implementation. Transport and movement of PAFs should be done in a stepwise manner, preferably in parallel with project time frames. During the post-relocation stage, the PAPs are assisted so that they can re-establish their social and economic base at the soonest time possible, thereby ensuring that their conditions would not be worse after resettlement.

To achieve the stated objectives, the RAP will identify the specific activities and corresponding strategies, measures and mechanisms, which should be undertaken step by step until full-scale re-establishment of PAPs in the new location is achieved. A detailed discussion of the activities and strategies/measures involved in each stage is shown below.

11.3.1 Pre-Relocation Stage

Before commencement of relocation, required are the consensus buildings of the PAPs on the resettlement plan, identification of objects to be compensated, and development of the resettlement site. The principal activities to be made during this stage are enumerated as follows:

(1) Social Preparation: An inter-agency resettlement task force, which will take care of the entire resettlement program, would be firstly organized involving concerned government agencies as well as the affected communities. The task force would undertake consensus building of the PAPs on the plan of resettlement and establish the grievance redress to guarantee the PAFs' right.

(2) ROW Acquisition: The Appraisal Committee would be newly organized to inventory the whole properties affected and appraise the fair market value for the compensation and entitlement of the PAPs. Payment for compensation should be made through negotiation between the Appraisal Committee and the owners of the properties to be compensated. If the negotiation fails, expropriation proceedings would be initiated. The entitlements besides the compensation would be further made for the PAPs other than the legitimate landowners. The entitlements include the financial assistance to tenants and settlers, the disturbance compensation to the agricultural lessees, the mediation for resettlement lot, the allowance for inconvenience, and the assistance for relocation and rehabilitation.

(3) Census Survey and Tagging: The census survey and tagging (C/T) aims at establishing identify of the whole formal and informal PAPs and thus prevent fraudulent claims by opportunists who may move into the project area after the C/T activities. The socio-economic survey is further made to identify particularly vulnerable groups who will require special rehabilitation assistance; and craft appropriate plans for resettlement and socio-economic rehabilitation for them.

(4) Resettlement Site Development: The government would select the location of the resettlement sites acceptable to the PAPs and develop the sites with basic infrastructure and amenities in accordance with appropriate standards and criteria. The LGUs usually prescribe the manner and criteria by which beneficiaries of housing programs are selected and prioritized for distribution or assignment of lots

11.3.2 Resettlement Stage

The actual resettlement should be made through the following activities:

(1) Eviction: Eviction and/or physical movement for the legitimate resettlers will be done in a humane manner, in accordance with the guidelines and procedures prescribed by UDHA. Summary eviction proceedings may be, however, initiated against "professional squatters" or members of "squatting syndicates" without benefit of any resettlement assistance. Upon completion of demolition, the RAP should incorporate measures to preclude future encroachment and re-occupation of cleared areas.

(2) Physical Relocation: Detailed relocation plan should be prepared ahead including schedules, logistics, identification and transportation of people and belongings, and arrangements for temporary services (food, water, emergency medical care, waste management, and other provisions) en route to, upon arrival and during transition period at the new site. A contingency plan should be also prepared in anticipation of possible resistance to demolition and relocation

by certain PAPs and nuisance groups. The plan should be closely coordinated with social workers, the local police force, and medical teams.

11.3.3 Post-Relocation Stage

The activities made in the post-relocation strategies and measures aims at allowing PAFs to share in project benefits through income/livelihood restoration and social re-integration programs. In anticipation of eventual project decommissioning, the responsibility for post-relocation restoration is often delegated to LGUs in coordination with relevant government agencies, NGOs and community organizations. These are discussed in more detail below.

(1) Social Rehabilitation: The LGU should facilitate integration of the PAPs into the social fabric of the new community. At the same time, the receiving LGUs/communities should be ready to provide the social environment and support system that will hasten the integration of the newcomers in the life of the community. An NGO-initiated social housing program more popularly known as "*Gawad-Kalinga*" provides a model of holistic community shelter development work.

(2) Income Restoration: The income restoration would be made through the following activities:

- Livelihood development: a menu of livelihood options should be developed based on the results of the socio-economic survey and environmental scanning, giving particular consideration to: (1) resources available in the resettlement area; (2) relevant programs and projects of the different government and private institutions; (3) current occupation and skills of the PAPs; (4) population carrying capacity; and (5) proximity to urban centers and places of work.
- Cooperative Development: Organization of cooperatives and livelihood associations would be useful to provide PAPs the legal identity that would allow them better access to livelihood enhancement programs and financial assistance that are otherwise not available to individuals.
- Access to Micro-Finance: The LGU should assist the PAPs to apply the Community Mortgage Program (CMP) as a low-income home financing for capital generation and build-up of the new business.
- Skills Development: The skills development program should be prepared and implemented based on the inventory of the PAPs' skills in order to enhance the capability of PAFs and find employment and income-earning opportunities for them.

(3) Estate Management: The LGU should tap all possible sources of funds for low-cost housing assistance to ease the financial burden that house construction entails. The RAP should also outline the manner and procedure by which the LGU will dispose or award the lots and/or housing structures to qualified beneficiaries. The LGUs responsibility will include securing the tenurial status of PAFs by way of delivery of titles and legal documents to prove ownership. The RAP should also define the schemes and mechanisms by which the LGU could recover cost of investments for resettlement land and/or housing development. Moreover, the RAP should clarify agency responsibility for conservancy and maintenance of physical at the resettlement site.

11.4 RAP Implementation Arrangements

Resettlement may be undertaken through existing institutional arrangements under the leadership of the LGU and in coordination with government housing agencies, civil society groups and the private sector. However, there is also a need to further involve the communities and the PAPs themselves in the planning as well as implementation process. Hence, the creation of an inter-agency resettlement task force or RAP implementation committee is put forward.

The RAP should include an estimate of the costs that will be entailed to undertake resettlement activities from pre-relocation to relocation to post-relocation stages. The schedule for undertaking the resettlement activities through the various stages of resettlement implementation vis-à-vis project time frames and targets would also be clarified in the RAP.

The RAP should also include monitoring and evaluation on the progress of activities throughout the various stages of resettlement operations and the use of these information to facilitate management decision. Monitoring will take place against the activities, entitlements, time frames, budget and target benefits. The RAP should identify the specific monitoring indicators to be able to track the progress of resettlement implementation and assess the achievement of stated resettlement objectives as set out in the RAP.

Chapter 1. Introduction

1.1 Objective of the Study and Justification of the Project Proposed in the Study

1.1.1 Objective of the Study

The Study on Comprehensive Flood Mitigation for Cavite Lowland Area in the Republic of the Philippines (hereinafter referred to as "The Study") has the following objectives:

(1) To formulate the flood mitigation Master Plan for three river basins; namely, Imus, San Juan and Canas;

(2) To conduct the Feasibility Study for the priority components of the Project selected in the above Master Plan; and

(3) To develop the flood management capacity of Philippine counterpart organizations concerned.

1.1.2 Location of the Study Area

The Study Area covers three river basins; namely, Imus, San Juan and Canas, which encompass a total area of about 407.4km^2. These three river basins are situated at the eastern part of Cavite Province, close to the border with Metro Manila (refer to Figs. 1.1 and 1.2 attached). The Study Area is administratively composed of three congressional districts with two cities and eleven municipalities, which are further subdivided into 411 barangays, the smallest administrative unit of government in the Philippines.

1.1.3 Justification of the Project Proposed in the Study

The Study Area lies very close to major sea and air transportation routes in Metro Manila such as the Manila International Container Port Terminal in South Harbor, City of Manila, and the Ninoy Aquino International Airport in Parañaque City. Due to this accessibility, the Study Area has been undergoing intensive industrialization since the 1990's. Investors have established businesses in the industrial estates in Cavite Province, which opened job opportunities and attracted people to migrate to the Study Area. As the result, the Study Area is expected to undergo a dynamic change in land use and population, as follows:

(1) Built-up areas (commercial, industrial, residential) are projected to cover about 65% of the entire Study Area in 2010, which is far larger than the coverage of about 27% as of 2003.

(2) Annual population growth in the Study Area from 1995 to 2000 is estimated to be 5.43%, which is far higher than the national average of 2.32%. Thus, the population of the Study Area is projected to increase to about 2.6 million in 2010, which is 1.7 times higher than the population in 2000.

The three major river basins, Imus, San Juan and Canas, are particularly vulnerable to flooding because of the extremely low ground elevation along the coastal area in the lower reaches and the insufficient flow capacity of the river/drainage channels. In spite of their vulnerability, intensive industrialization is continuously being introduced without adequate consideration about floods. The recently recorded flood damages in the river basins have exceeded the tolerable level due to the following causes:

(1) Natural flood retarding basins have been reclaimed, and considerable parts of the ground surface were covered with pavement, which decreased the flood retention capacity of the river basins and increased the flood peak runoff discharge.

(2) Residential areas have spilt over the habitual inundation areas due to the rapid population growth, which lead to the significant increment of flood damage potential.

(3) Areas along and around the river/drainage channels have been densely populated with houses overhanging the drainage channels and dumping a large volume of solid wastes that seriously reduced the channel flow capacity and deteriorated the river environment.

Flood overflow from the rivers in the Study Area caused the serious damages including death of people four times after 2000. Some hundred thousand residents in lowland areas of these river basins also suffer from prolonged inundation by storm rainfall and/or high tide every year. Such chronic inundations affect not only the living condition of residents but also the economic and social development in the province.

The project proposed in the Study includes structural measures for the physical increment of flood mitigation capacity, non-structural measures to control the excessive land development in the river basins and other necessary approaches for sustainable flood management. These comprehensive flood mitigation approaches are indispensable to cope with the complex features of river-overflow flood and inland flood.

1.1.4 Technical Cooperation Program by JICA

In response to the request of the Government of the Republic of the Philippines (hereinafter referred to as “GOP”), the Government of Japan (hereinafter referred to as “GOJ”) decided to conduct the Study and exchanged the Note Verbal with GOP concerning the implementation of the Study.

Japan International Cooperation Agency (hereinafter referred to as “JICA), the official agency responsible for implementation of the technical cooperation programs of the Government of Japan, dispatched the Preparatory Study Team to Philippines in November 2006 to discuss the scope of works and other study requirements. The implementation arrangement of the Study together with the Scope of the Works was agreed on November 24, 2006 between the GOP and the Preparatory Study Team.

In accordance with the agreement on the implementation arrangement of the Study, JICA dispatched the Study Team in March 2007. Since then, the Study Team conducted investigations and studies in Philippines until December 2008, and further finalized the study outputs in Japan/Philippines towards February 2009.

1.2 Study Schedule

The Study has been carried out for 24-month period from March 2007 until February 2009 as shown in Fig. R 1.1 below.

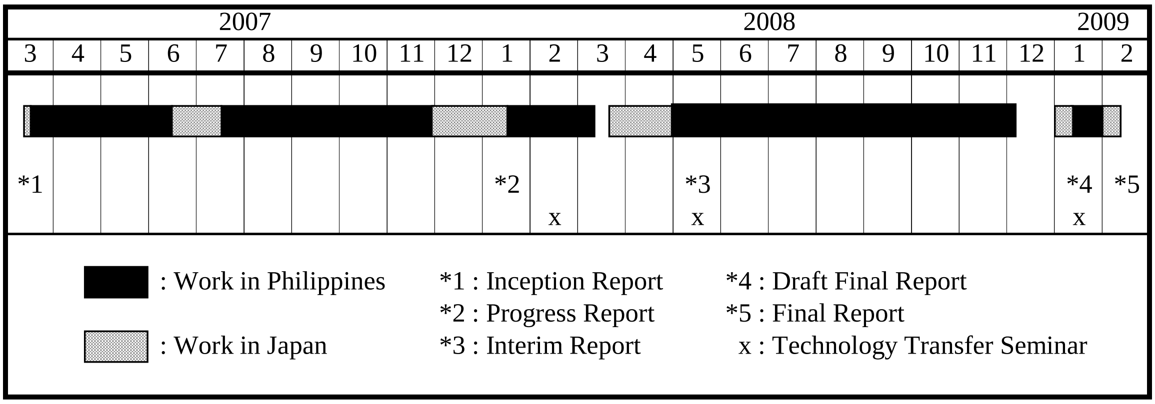


Fig. R 1.1 Study Schedule

The entire study is divided into two phases, namely, the first phase for the Master Plan Study and the second phase for the Feasibility Study. The Master Plan Study was made from March 2007 until January 2008, and at the end of the Study, the Study Team submitted the Progress Report, which complies the results of the Master Plan Study. Then, the Feasibility Study was made for 12-month period from January to December 2008. The Draft Final Report is to be submitted in January 2009 compiling all of the study out puts and the submission of the Final Report is scheduled on February 2009, after reflecting the comments on the contents of the Draft Final Report.

1.3 Counterpart Agency

On the part of GOP, the Department Public Works and Highway (DPWH) and the Provincial Government of Cavite have acted as the counterpart agencies for the Study facilitating the smooth implementation of the Study. At the same time, the agencies assigned the following counterpart personnel, who worked with the Study Team.

Table R 1.1 Counterpart Personnel for the Study

Expatriate	Agency
Project Manager	PMO-FCSEC, DPWH
Development Planning Specialist	DPD, PS, DPWH
Hydrologist/GIS Specialist	Research and Development Division, PMO-FCSEC, DPWH
Environmental and Social Development Specialist	ESSO, DPWH Environment and Natural Resources Offices, Provincial Government
Public Works Engineer	District Engineering Office, DPWH
Flood Control Engineer	District Engineering Office, DPWH
Development Planning Specialist	Provincial Planning & Development Office, Provincial. Gov.
Flood Control Engineer	Provincial Planning & Development Office, Provincial. Gov.
Land Use Planning Specialist	Provincial Planning & Development Office, Provincial. Gov.
Community Participation Specialist	Environment and Natural Resources Offices, Provincial Government

1.4 Steering Committee

The Steering Committee was set up to guide the smooth implementation of the Study and to coordinate the relevant government and non-government organizations under the initiative of DPWH and the Provincial Government of Cavite. All of the reports for the Study have been presented to and discussed by the Steering Committee at each stage of the Study. The following government agencies acted as the permanent members, and other agencies also occasionally joined to the Committee according to the particular issues of the Study.

(1) DPWH

(2) Provincial Government of Cavite

(3) DENR

(3) PAGASA

(4) NIA

(5) OCD

(6) NEDA

1.5 Technical Working Group

The Technical Working Group (TWG) was set up to provide the technical support services to the above Steering Committee. The TWG has held the coordination meetings with the Study Team to discuss and monitor the progress of the Study. The following government agencies acted as the permanent members, and other agencies also occasionally joined to the TWG according to the particular issues of the Study.

(1) DPWH

(2) Provincial Government of Cavite

(3) DENR

(3) PAGASA

(4) NIA

(5) OCD

(6) NEDA

1.6 Composition of the Final Report

The Final Report is to be submitted as the final product of the Study containing (i) the proposed optimum flood mitigation measures proposed in the Master Plan, (ii) the proposed priority project examined in the Feasibility Study and (iii) the results of the capacity buildings undertaken throughout the study period.

The Final Report consists of the following four volumes:

Table R 1.2 Composition of the Final Report

Volume No.	Title	Contents
Volume 1	Master Plan Study (This Report)	The executive summary on the results of the entire study and the results of the Master Plan Study
Volume 2	Feasibility Study	The results of the Feasibility Study as well as the capacity development for the counterpart personnel as well as other stakeholders undertaken throughout the entire study period.
Volume 3	Adaptation to Climate Changes in the Study Area	The results on the study on the future possible climate changes in the Study Area and the eligible structural and non-structural flood measures to be adapted to them.
Volume 4	Appendix	The inventories of existing infrastructures, the guidelines/manuals, the basic data sheets related to the Study and the Capacity Development.

Chapter 2. Natural Condition of the Study Area

2.1 Topographic Condition

The Study Area is topographically divided into four divisions; namely, the extremely low land area, the lowland area, the central hilly area and the upland mountainous area. The approximate extent of each topographic division is as shown in Table R 2.1 and the features are further described in items (1) to (4) below. (Refer to Fig. 2.1 attached)

Table R 2.1 Topographic Divisions of the Study Area

Division	Extent (km^2)	Ground Slope (%)	Ground Elevation (EL. m)	Covered City/Municipality
Extremely Low Land Area	4.0	Almost Flat	EL. 0 to 2m	Bacoor, Kawit, Noveleta, Rosario
Lowland Area	97.5	Less than 0.5%	EL. 2 to 30m	Bacoor, Kawit, Noveleta, Rosario, General Trias, Imus, Tanza
Central Hilly Area	236.7	0.5% to 2%	EL. 30 to 400m	Trece Martires City, Dasmariñas, Indang, Silang
Upland Mountainous Area	69.2	More 2%	EL. 400 to 650m	Amadeo, Tagaytay
Total Area	407.4			

(1) Lowest Lowland Area

The coastal plain in particular, which stretches in municipalities of Bacoor, Kawit, Noveleta and Rosario, has an extremely low ground level of EL. 0m to EL. 2m compared to the high tide level of about EL. 0.8m from the Mean Sea Level (MSL). As a result, tidal foods often occur in a substantial part of the coastal plain even without storm rainfall. Such tidal flood is aggravated by the progress of land subsidence.

(2) Lowland Area

The lowland area consists of the coastal and alluvial plains, which have the flat ground slope of less than 0.5% and low ground elevation of EL. 2m to EL. 30m, as shown in the table above. The alluvial plain has been developed by lateral erosion or sediment deposits from the rivers and has a flat and/or gentle ground slope. The alluvial plain extends over Imus Municipality and the southern part of General Trias, forming the transition area between the coastal plain and the central hilly area.

(3) Central Hilly Area

The central hilly area exists on the mountain foot slope forming the undulating tuffaceous plateau, which includes steep hills, ridges and elevated inland valley. The plateau is characterized with ground elevation ranging from 30m to nearly 400m, and the ground slope of 0.5 to 2%.

(4) Upland Mountainous Area

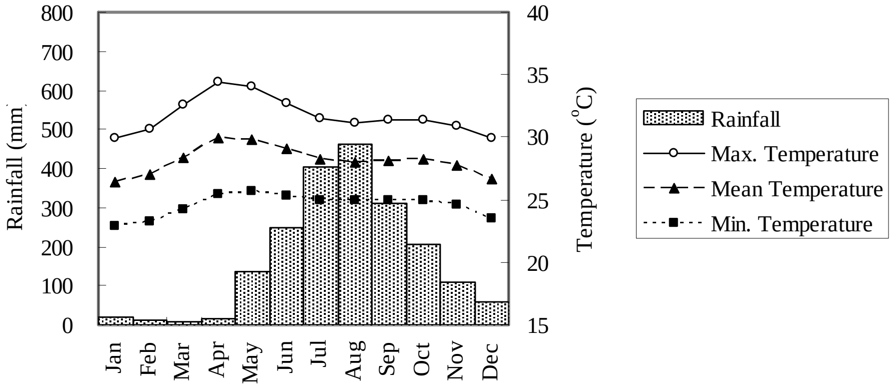
The upland mountainous area is situated at a very high elevation above EL. 400m with slopes of more than 2%. This area includes Tagaytay Ridge, which has the peak elevation of 650m.

2.2 Meteorology and Hydrology

2.2.1 Climate

The Study Area has two pronounced seasons; namely, the dry season from November to April and the wet season during the rest of the year. Seasonal dominant monsoons, trade winds, tropical cyclones, and their combinations mainly govern the meteorological characteristics over the Study Area. Annual rainfall in and around the Study Area ranges from about 1,500mm to about 2,000mm. In the past, the annual rainfall of more than 3,000mm was observed at the Sangley Point and Port Area stations, both of which are located near the Manila Bay. On the other hand, annual maximum recorded rainfalls are about 2,500mm to 2,600mm near the Tagaytay Ridge; i.e., at the Tagaytay and Ambulong stations.

The monthly rainfall at Sangley Point Station is compared with temperature in the following figure. Total rainfall of the months accounts for more than 80% of the annual rainfall, because of the influence of wet monsoon and occasional typhoons. Monthly mean temperature ranges from 26.4°C in January to 29.9°C in April. The maximum peak of monthly mean relative humidity takes place in August with about 82% in the middle of the rainy season, and the minimum in April with about 71% during the dry season.



Source: Prepared by JICA Study Team based on data from PAGASA

Fig. R 2.1 Monthly Mean Rainfall and Temperature at Sangley Point Station (Average of 1974 to 2006)

Tropical cyclone usually occurs during June to October, and about 20 typhoons enter the territory of the Philippines. Of the typhoons, about 16 percent pass through the middle part of the Luzon Island where the Study Area is located. Those tropical cyclones cause strong wind and storm rainfall, resulting in severe damages to life and property. There were four major typhoons in the year 2000 that caused severe flood damages in the Study Area; namely, Typhoon Reming in October 2000, Typhoon Gloria in July 2002, Typhoon Inday in July 2002 and Typhoon Milenyo in September 2006. The inundation damage by Typhoon Milenyo that passed through the Study Area in 2006 is assumed to be the most severe among them.

2.2.2 Tide

The Manila South Harbor Station (Pier 9) is the primary tidal station nearest to the Study Area and it has been operated by NAMRIA for many years. Monthly tide level records at Manila South Harbor were collected from NAMRIA in this Study. The average of monthly highest tide level is about 1.3m above Mean Lower Low Water (MLLW) and the historical extreme tide level at Manila South Harbor reached 1.89m above MLLW on 13 July 2006.

2.2.3 Impacts of Climate Change by Global Warming

The Intergovernmental Panel on Climate Change (IPCC) has warned climate changes associated with global warming. The climatic changes include the rise in temperature, rainfall and sea level, which could aggravate the flooding condition of the low-lying plain along the coastal area in particular. From this point of view, the impacts of climate change in the Study Area were preliminarily examined based on the results of assessment by IPCC as well as the long-term hydrological data observed in the Study Area. The results of the Study are as described in Vol.3 Adaptation to Climate Changes.

2.3 River Conditions

2.3.1 River System

Of the objective three rivers (Imus, San Juan and Canas), San Juan River has the major tributary, Ylang-Ylang River, which meets the mainstream at about 4.8km upstream from the river mouth. Imus River has also the major tributary, Bacoor River, which meets the mainstream at about 1.5km upstream from the river mouth. All of these rivers originate in the Tagaytay ridge, which has a peak elevation of EL+650m, run in parallel northward and finally flow into the Manila Bay/Bacoor Bay. In addition to the main streams and tributaries, the flows merge into the main flow or drain into the bay directly of many tributaries. The name and catchment area of all tributaries as well as the main flow are listed in Table R 2.2 below and illustrated in Fig. 2.2 attached.

Table R 2.2 Catchment Area of Main River sand their Tributaries in the Study Area

Name of Main Stream	Sub-basin Divisions		Catchment Area (km^2)
Imus River	Bacoor River Basin		19.62
	Pasong Buaya River Basin		10.74
	Julian River Basin		19.78
	Buluctot River Basin		19.74
	Imus River Main Stream Basin		45.62
	Total		**115.50**
San Juan River	San Juan River Basin	Panamitan Drainage	12.42
		Pason Cama Chile River Basin	10.22
		San Juan Main Stream Basin	65.56
		Sub-Total	88.20
	Ylang Ylang River Basin	Dasmarinas River Basin	15.09
		Ylang-Ylang River Main Stream Basin	43.47
		Sub-Total	58.56
	Total		**146.76**
Canas River	Tanza River Basin		5.97
	Panay Sayan River Basin		31.77
	Patda River Basin		6.57
	Pulonan River Basin		24.64
	Canas Main Stream Basin		43.37
	Total		**112.32**
Residual (Residual catchment areas are not in main river basins such as Imus, San Juan and Canas. Small rivers and drainage channels in this area directly flow into the sea.)	Bacoor Shoreline		0.98
	Kawit Shoreline-1		1.03
	Malamok Drainage		12.74
	Tirona Drainage Basin		2.54
	Panamitan Outlet		0.27
	Kawit Shorelone-2		1.66
	Noveleta Shoreline		1.66
	Rosario-1		3.15
	Rosario-2 (EPZA)		6.59
	Rosario-3		2.24
	Total		**32.84**
Grand Total			**407.43**

2.3.2 River Features

The rivers in the "Central Hilly Area" and "Upland Mountainous Area" stipulated in Section 2.1 shape the deep gorge with a steep riverbed slope on the very hard tuff consisting of the Quaternary Alluvium and Taal Tuff, while those in the "Low Land Area" tend to have U-shaped channel sections with rather gentle river slope (refer to Fig. 2.3 attached). Salient features of principal rivers in the Study Area are listed below:

Table R 2.3 Salient Features of Principal Rivers in the Study Area

Description	Topographic Division	Imus River	San Juan River	Canas River	Residual
Catchment Area (km^2)	Ex. Low Land	3.6	4.3	0.0	10.9
	Low Land	25.6	19.6	15.6	21.9
	Central	79.5	103.4	53.8	0.0
	Upland	6.8	19.5	42.9	0.0
	Whole	115.5	146.8	112.3	21.9
River Length (km)	Ex. Low Land	1.6	2.0	0.0	-
	Low Land	5.1	11.8	9.7	9.7
	Central	31.6	18.2	16.8	16.8
	Upland	6.7	11.4	15.5	15.5
	Whole	45.0	43.4	42.0	42.0
River Bank Slope	Ex. Low Land	Flat	Flat	Flat	Flat
	Low Land	1/522	1/474	1/313	Approx. 1/500
	Central	1/74	1/79	1/77	-
	Upland	1/39	1/42	1/40	-
	Whole (Ave.)	1/80	1/79	1/66	-

There exist a rather large number of irrigation dams and head works on the above three rivers and their tributaries and, further, the channel revetments along the downstream stretches of the rivers (refer to Fig, 2.4 attached). Some of these river facilities are, however, heavily damaged and certain extents of rehabilitation works are required.

Floodwaters in each river channel of the upland and central areas are carried to the lowland and extremely low land areas directly and rapidly. Therefore, floodwaters overtopped the banks and inundated the floodplain in lowland areas. In this connection, it is essential for the mitigation of damage due to river overflow to manage the stretches in the Lowland Area (from river mouth to NIA CALA Canal). The features of each river in the lowland area are as described below.

(1) Imus River and Bacoor/Julian River in Lowland Area

As described above, the river system of Imus River in the lowland area consists of one main stream and two major tributaries, namely Bacoor and Julian River, and other small canals. The mainstream of Imus River has spacious channel cross-sections from the river mouth to Sta. 2+000 (nearly passing under the national Coastal Road) and gentle riverbed slope (less than 1/1000) including the stretch from Sta. 2+000 to Sta. 6+000 (nearly passing under Aguinaldo Highway). Most channel banks are protected with concrete masonry.

On the other hand, the upper stretch in the lowland area from Sta. 2+000 to Sta. 13+000 (passing under NIA CALA Canal) has a comparatively narrow channel cross-section. In this section, the stretch from Sta. 6+000 to Sta. 13+000 in particular has less meandering alignment and steep riverbed gradient. The Anabu Dam, one of the irrigation facilities of NIA, is located at Sta. 12+100 in the upper reach.

The upper stretch of Imus River has a large channel flow capacity because of the steep riverbed gradient. On the other hand, the lower stretch is influenced by the backwater effect of the tidal level of Manila Bay. This backwater effect and the gentle river slope occasionally causes a serious flood overflow (flush flood) and the extensive flood inundation along the lower stretches of tributaries. In the 2006 flood, the water level of the Imus mainstream rose rapidly and exceeded the bank level, which led to the extensive flood inundation along the lower reaches.

Bacoor River, the major tributary of Imus River, has a catchment area of about 20km^2, most of which is situated in the lowland area. The lower reaches of the Bacoor River have small channel cross sections with meandering alignment and their channel flows are influenced by the backwater effect of the Imus River and Manila Bay. Due to these conditions, the Bacoor River has formed a wide-expanse of swampy area and fishponds along the lower stretch. These swamps/fishponds play the role of retardation and retention of floodwater to mitigate damages in the residential area. According to the land use plan of 2010 prepared by the Municipality of Bacoor, however, these swamps/fishponds will be reclaimed into new residential and commercial areas resulting in the extinction or decrease of the retarding and retention effect on floodwater.

In addition to Bacoor River, Julian River, whose catchment area is about 20km^2 that almost cover the whole lowland area, is also one of major tributaries of Imus River. The Julian River is a typical urban river passing through the densely built-up area of the Municipality of Imus like the Bacoor River, which passes through the areas densely packed with houses in the Municipality of Bacoor. The Julian River has comparatively broader channel than the Bacoor River, and an irrigation system including the Bucandala and Julian dams runs in parallel as a tributary of the Julian River.

(2) San Juan and Ylang-Ylang River in Lowland Area

Below NIA CALA Canal, San Juan River (Rio Grande) passes through the center of the administrative area of Gen. Trias and merges with Ylang-Ylang River at the administrative boundary between the municipalities of Imus and Noveleta at about 4.8km from the river mouth. After merging with Ylang-Ylang River, the main river course passes through the extremely low land area and finally flows into the Manila Bay through an artificial channel at the boundary of Noveleta and Kawit.

The extremely low land area and the mangrove area of Kawit Municipality spreads out and forms several branch channels and small tidal delta along the right bank of the river in the lower reaches. This lowland tidal delta is currently utilized as fishpond using saline water from the sea. Most of the banks of the channel with a gentle riverbed slope (less than 1/1000) in the area are protected with concrete masonry. The river section from Sta. 4+800 to Sta. 14+200, which runs between the above lowland mangrove area and NIA CALA Canal, has a rather narrow channel cross-sections with meandering alignment and steep riverbed gradient.

Ylang-Ylang River meets with San Juan River after passing through the jurisdiction boundary of Gen. Trias and Imus. The section of Ylang-Ylang River above the junction with San Juan River has rather narrow channel cross-sections but with a less meandering alignment and steep riverbed gradient.

(3) Canas River in Lowland Area

The downstream of Canas River forms the administrative boundary of the municipalities of Tanza (left side), Gen. Trias (right side) and Rosario (right side). The downstream of the river of about 9.4km from the river mouth to NIA CALA irrigation canal has spacious cross sections and steep riverbed slope as compared with the Imus and San Juan rivers. The Plucena Dam, one of major irrigation facilities of NIA, is located at Sta. 7+600.

2.3.3 Present Flow Capacity of Rivers and Drainage Channels

The probable water level of major rivers and drainage channels in the Study Area were firstly estimated by the non-uniform calculation method using the mean higher high water level (EL+0.8m) at the Manila Bay as the boundary condition at the downstream end. Then, channel flow capacities were estimated through comparison of the probable water level of the channels and the existing bank levels. The results of the estimation are listed in Tables 2.1 to 2.2 attached and illustrated in Fig. 2.5 attached.

As indicated in Tables 2.1 to 2.2, most sections of the Imus and San Juan rivers in the lower reaches from the existing alignment of NIA Irrigation Canal could hardly cope with the probable flood discharge of even a 2-year return period. Most of the drainage channels in the coastal area also have extremely small channel flow capacities that could hardly cope with the probable storm rainfall of even a 2-year return period.

On the other hand, the sections in the upper reaches of Imus and San Juan from the NIA CALA Irrigation Canal have a substantial flow capacity. That is, the upper sections of the Imus River could cope with floods of a 5-year return period and those of San Juan, a 20-year return period. As for Canas River, all sections could cope with the flood runoff discharge of more than 20-year return period.

There are some bottlenecks and low dike stretches/sections along each river. The bottlenecks swell the water head and bring about the abrupt rise of flood water level just upstream of each bottleneck, and the backwater effect extends up to the upstream sections. The backwater effect causes unfavorable conditions in the upper reaches along with the drop of channel flow capacity of the upper sections.

The reversal of channel flow capacities from the upper to the lower sections due to longitudinal riverbed gradient brings the risk of flood overflow, so that it should be unconditionally stopped. To offset the reversal of channel flow, it is indispensable to improve the bottlenecks, or retard floodwaters to the downstream or divert them to other areas. As for the method of river channel improvement, the necessary channel improvement could be made through the enlargement of channel cross-sections.

2.4 Flood Conditions

2.4.1 General

A flood damage survey was conducted in the First Field Survey (from April to June, 2007) to collect data/information related to the flooding situation and flood damages in the Study Area. As the result, it was clarified that floods in the Study Area are classified into the “river-overflow flood” and the “inland flood.” The river-overflow flood is, herein defined as the flood caused by overflow from the riverbanks usually associated with typhoons that cause intensive rainfall over a large extent of the catchment area and the river flow discharge in excess of the river channel flow capacity.

On the other hand, the “inland flood” is defined as the inundation caused by stagnant storm rainfall and/or overflow from the local drainage channels that have a limited catchment area, and/or the intrusion of seawater due to high tide. Inland floods chronically occur in coastal low-lying areas in particular, while river-overflow flood occurs less frequently but affects a wider area than the inland flood. Details of the flood damage survey on river-overflow floods and inland floods are as described in the following subsections.

2.4.2 River-Overflow Flood

The three rivers of Imus, San Juan and Canas as well as their major tributaries have inadequate flow capacities that cause the frequent flood overflow. The floods tend to occur at low dike sections, the narrow/bottleneck sections, and the bridge sections, which are frequently clogged with debris. Moreover, the flood peak discharges in the recent years tended to increase due to the intensive land development for industrial and housing uses in the middle and upper reaches of the river basins. Four major river overflows have occurred during the period from 2000 to 2006, affecting some hundreds of people and causing casualties in the area, as shown in the table below.

Table R 2.4 Recent Representative Flood Damage in the Study Area

Date	Name of Typhoon	Affected Area	Remarks
Oct. 2000	Reming	Lowland Area (Bacoor, Noveleta, Rosario, Imus, Kawit, etc.)	Death: 10 Affected population: 380,616
Jul. 2002	Gloria	Lowland Area (Bacoor, Noveleta, Rosario, Imus, Kawit, etc.)	Affected population: 173,075
Jul. 2002	Inday	Lowland Area (Bacoor, Noveleta, Rosario, Imus, Kawit, etc.)	Death: 1 Affected population: 168,025
Sep. 2006	Milenyo	Lowland Area (Bacoor, Noveleta, Rosario, Imus, Kawit, etc.) and General Trias	Death: 28, Missing:18, Injured: 61, Evacuated: 28,322, Affected: 196,904

Of the above floods, almost all of the respondents to the flood damage survey declared that Typhoon Milenyo in September 2006 caused the worst river flood. The overflow of river discharge occurred along a substantial length of the Imus and San Juan rivers, and the overflow discharge extended over an extensive area at middle and lower reaches including the municipalities of Kawit, Noveleta, Rosario, Imus and General Trias.

Typhoon Milenyo also caused the overflow above the crest of Butas Dam managed by NIA in San Juan River, Barangay Buena Vista in General Trias. The upstream river water level of the dam reached the critical level and the riprap along the riverbanks on both sides of the dam cracked, widening the river channel to twice its width. Then, the dam body finally collapsed and as a result, 46 onlookers on the clipped riverbank were drawn into the river and drowned or became missing.

Some of the respondents also declared that the flood brought by Typhoon Reming in October 2000 was the second worst, next to Typhoon Milenyo. During the typhoon, 10 residents died and the flood affected 380,616 people.

2.4.3 Inland Flood

The coastal areas in the municipalities of Kawit, Noveleta, Rosario and Tanza in particular have always suffered from chronic inland floods due to complex factors such as: (1) the low-elevated ground below the tidal level; (2) the inadequate capacity of the existing drainage facilities; (3) the clogging of drainage channels due to dumping of solid wastes; (4) the illegal encroachment of structures on the drainage channels; and (5) the reclamation of existing natural retarding basins and drainage channels. In contrast to the coastal areas, most of the residents in the upland municipalities such as Indang, Amadeo and Silang declared that inland floods occur at only very limited places and their locations are not flood prone areas, although river-overflow floods occasionally affect the informal settlers along the river channels.

Inland floods occur even during the time of no-rainfall due to high tide. Moreover, the land development decreased the basin retarding capacity for inland floodwater, resulting in the increase of flood damage. It is also reported that one land developer narrowed the cross-section of a waterway that caused water to overflow during heavy rains. Another land developer also filled up a waterway because his land development area has to cross the waterway. As the result, the water in the waterway flows to the adjacent low-lying areas causing flood during heavy rains.

2.4.4 Extent of Flood Inundation Area

The extent of the flood inundation area caused by the Typhoon Milenyo was estimated, based on the interview survey, at about 60 km^2, which spreads over a substantial part of the low land area in the Study Area. As described in Chapter 5, an attempt was made to reproduce this extent of the inundation by Typhoon Milenyo through trial hydrological simulation. The results of the simulation clarified that the extent of flood inundation as experienced during the typhoon could be explained, only when the following assumptions are made:

(1) The entire extent of the Study Area is assumed to have received the rainfall equivalent to the above recorded maximum point rainfall at Tagaytay gauging station.

(2) According to the interview survey, the Imus and San Juan rivers caused extensive channel overflow over an area of more than 20km^2 during Typhoon Milenyo, while the area affected by the flood from Canas River was limited to less than 4km^2 located just along the riverbank. According to the non-uniform calculation, Canas River is evaluated to have a large channel flow capacity, which could cope with even the peak flood runoff discharge during Typhoon Milenyo. In spite of such large channel flow capacity, the section at Tejero Bridge was blocked was blocked by driftwood entangled around the bridge piers. The flood from Canas River could be explained on the assumption that the entangled driftwood lifted the river water level.

The results of simulation of the Typhoon Milenyo was verified based on the above assumptions, and the probable flood inundation areas under various return periods were estimated using the same simulation model, as listed in the table below.

Table R 2.5 Estimated Extent of Probable Flood Inundation Area by Typhoon Milenyo

(Unit: km^2

Basin	Extent of Probable Inundation Area under Various Probable Flood Scale (Return Period)								Typhoon Milenyo, 2006
	2-yr	3-yr	5-yr	10-yr	20-yr	30-yr	50-yr	100-yr	
Imus	9.62	11.62	13.31	15.59	18.05	19.02	20.36	22.25	23.71
San Juan	9.03	11.52	14.63	18.60	22.51	23.20	24.32	25.66	26.51
Canas	0.62	1.00	1.34	1.59	2.30	2.47	2.71	2.84	3.38
Total	19.27	24.14	29.28	35.78	42.85	44.68	47.38	50.75	53.60

2.5 Ecology

The typical features of ecology in the Study Area were clarified based on the results of baseline surveys, which include field reconnaissance, interview survey and review on the relevant previous studies. Of the baseline surveys, the interview survey was made through the public consultation meetings and/or the door-to-door canvass during the first and second field survey from March to November 2007. The key informants for the interview survey include the officials of the relevant government agencies, academes and the residents (the interview was made to about 300 residents in the residents). The results of previous study such as the “the Feasibility Study on CALA East-West National Road, by JICA” was also reviewed and referred to the Study. The information given from the results of the interview survey and the review survey were further confirmed though the field reconnaissance, which was made throughout the said first and second field survey period. The results of clarification on the ecology in the Study Area are as described hereinafter:

(1) Fauna

The Department of Environment and Natural Resources (DENR) designated 125 species of birds, 27 species of mammals and 11 species of reptiles for conservation in Philippines (refer to DENR Administrative Order, DAO 48). DENR further prepared a national red list of Philippine wildlife for the above species describing name, conservation status, known occurrence/distribution and habitat. According to the red list, only one species of mammals is listed for Cavite Province. The name and habitat of this species are as described in the table below.

Table R 2.6 Mammals for Conservation in Cavite Province as Listed in DENR's Red List

Common Name	Philippine Nectar Bat/Philippine Dawn Bat
Scientific Name	*Eonycteris robusta*
Habitat	Until the 1960's, this bat has been commonly taken in caves adjacent to forests and commonly netted adjacent to primary forest from sea level to 1,100m, often in areas with mixed forest and clearings but never in primarily agricultural area.

Source: DENR Protected Areas and Wildlife Bureau; 2002 statistics on Philippine Protected Areas and Wildlife Resources

There remain only small forestlands in the Study Area. Forests as the habitat of the above Philippine Nectar Bat/Philippine Dawn Bat was not identified in the Study Area, therefore, it is evaluated that there exists no rare species to be conserved in the Study Area. The results of the relevant previous study also concluded that the above species was not identified within the Study Area (refer to EIA on the Feasibility Study and Implementation Support on the CALA East-West National Road by JICA, hereunder referred to as "JICA CALA East-West Road Project").

(2) Flora

The International Union for Conservation of Nature and Natural Resources (IUCN) designated 213 species of flora as endangered species, of which 13 species are imposed with severe restrictions on trade under the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). According to the results of the previous relevant study and interview survey, however, there is no endangered species within the Study Area (refer to the JICA CALA East-West Road Project).

(3) Protected Area

The National Integrated Protected Areas System Act (NIPAS Act) prescribes the following eight categories of protected areas: (a) strict nature reserve, (b) natural park, (c) natural monument, (d) wildlife sanctuary, (e) protected landscapes and sea views, (f) resource reserve, (g) natural biotic areas; and (h) other categories established by law, conventions or international agreements which the Philippine Government is a signatory. According to the results of interview survey with the relevant agencies, there is no protected area in the Study Area. Moreover, the Study Area has no wetland designated under the Ramsar Convention, the World Heritage-listed area and Man; and the Biosphere Reserve designated by UNESCO.

(4) River Ecology

The most common vegetation within the rivers in the Study Area is the common kangkong. There is no rare species of fish in the rivers of the Study Area. The common fishes found in the rivers are bia or biya (*Glossogobius*), tilapia (*Tilapia*), dalag (*Ophicephalus spp.*), hito (*Clarias*) and eel (*Anguilla*).

(5) Mangrove Area

The mangrove areas of the Project Area have been largely converted to fishponds, salt-beds and built-up/settlement areas. However, some mangroves remain in the coastal low-lying area, forming area-wise and strip-wise ones. The JICA study team estimated the quantities of existing mangroves in each municipality in the Project Area by interpreting the aero-photos with field check, as listed below.

Table R 2.7 Existing Mangroves in the Project Area

Municipality	Area-wise	Strip-wise	Location
Bacoor	3.3 ha	8.6 km	Imus River mouth, bank of fishponds and bank of drainage canals
Kawit	10.1 ha	11.9 km	Fishpond front area, bank of fishponds and bank of drainage canals
Noveleta	2.5 ha	3.4 km	San Juan river mouth, bank of drainage canals, and mouth of drainage canal
Rosario	2.7 ha	-	Mouth of drainage canal
Total	18.6 ha	24.0 km	

2.6 Oceanography

The Cavite Spit juts out in the southeastern part of Manila Bay forming the Bacoor Bay. The Cavite Spit closes the west side of Bacoor Bay, while the eastside of the Bay is open and connected to the Manila Bay.

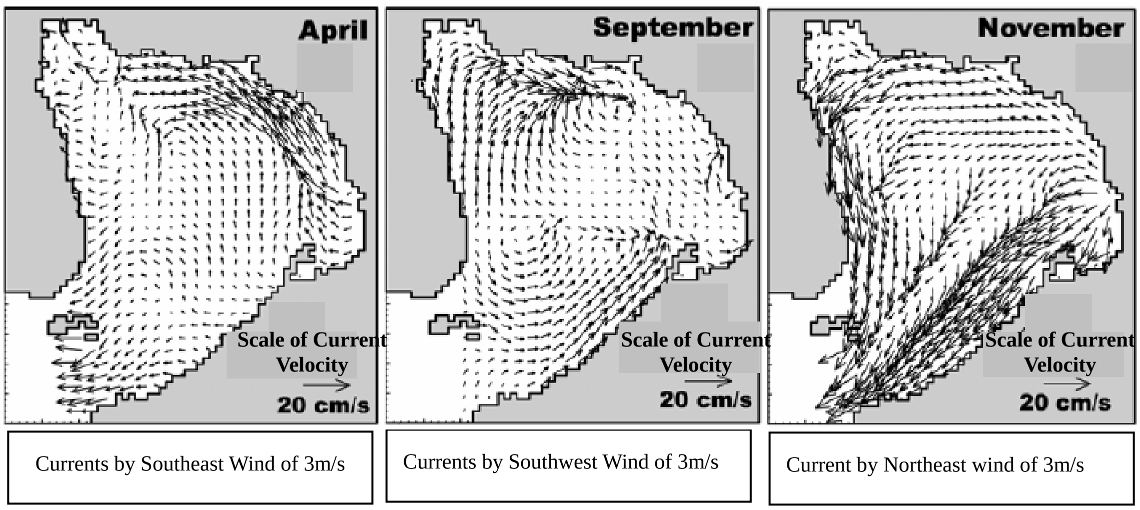
Of the three principal rivers in the Study Area, Imus and San Juan flow into the inside sea of Bacoor Bay. On the other hand, Canas River flows directly into the Manila Bay west of the Cavite Spit. The morphologies of Bacoor Bay and Manila Bay around the river mouths of Imus, San Juan and Canas in particular are as described below.

(1) Wind-Driven Current in Manila Bay

Manila Bay is isolated from the open sea, and the ocean current hardly influences tidal movement of the Bay. Instead, wind-driven currents prevail in the Bay. The direction and velocity of the wind-driven current is dominated by the wind and the undulations of seabed.

The wind in the Manila Bay has three seasonal variations in its direction: (a) the southeast from February to May; (b) the southwest from June to September; and (c) the northeast from November to January (refer to PAGASA; "The Average Wind Direction and Speed from 1961 to 1995 at Manila").

On the premise of the above seasonal wind variations and the seabed undulations, a simulation was made to clarify the variations in the directions and velocities of the wind-driven currents obtained in the previous study (refer to "Tide, Tidal Current and Sediment Transport in Manila Bay 2002," Wataru Fuji-ie, Tetsuo Yanagi, Fernando P. Siringan). As the result of simulation, the following typical movements of wind-driven currents were confirmed:



(Note: the directions and velocities of wind-current 1m below Mean Sea Level)
(Source: Tide, Tidal Current and Sediment Transport in Manila Bay, 2002)

Fig. R 2.2 Simulated Seasonal Variation in Direction and Velocities of Wind-Driven Current

(2) Sediment Deposits around the River Mouths of Imus and San Juan in Bacoor Bay

As shown in the above simulation result, the wind-driven currents caused by the South-East and/or South-West winds in Manila Bay are far weaker than those by the North-East wind. Moreover, the Cavite Spit shields the flow of these wind-driven currents into the Bacoor Bay. As the result, the Bacoor Bay has little tidal current during the time of the South-East and/or South-West winds from February to September.

On the other hand, the wind-driven currents by the North-East winds have the rather strong velocity of more than 20cm/s, and directly flow into the Bacoor Bay. Due to this prevailing wind-current by North-East wind, the sediment in the Bacoor Bay is hardly transported to the outside of the Bay.

Bacoor Bay has the shallow seabed level of approximately 1.0m below Mean Lower Low Water and its seabed slope is in a range of 1/1000 to 1/2000. The major cause of such shallow and flat seabed level could be attributed to the said little transportation of sediments from Bacoor Bay to the open sea.

The littoral drift from the Manila Bay may be considered as one of the possible sources of sediment deposits in Bacoor Bay. It is, however, reported that the modal diameter of seabed sand in Manila Bay is 0.38mm, which is hardly transported by the afore-said wind-driven current (refer to "Coastal Marine Science 30(1): 54-61, 2006, Wataru Fuji-ie, Tetsuo Yanagi, Accor"). Accordingly, the major source of sediment deposits in Bacoor Bay could be assumed as sediment runoff from the inland river basins, so that one of the important issues on the maintenance of river mouths in the Bacoor Bay would be addressed to the sediment runoff from the inland river basins. The conditions of sediment runoff from the river basins are as described in the following subsection.

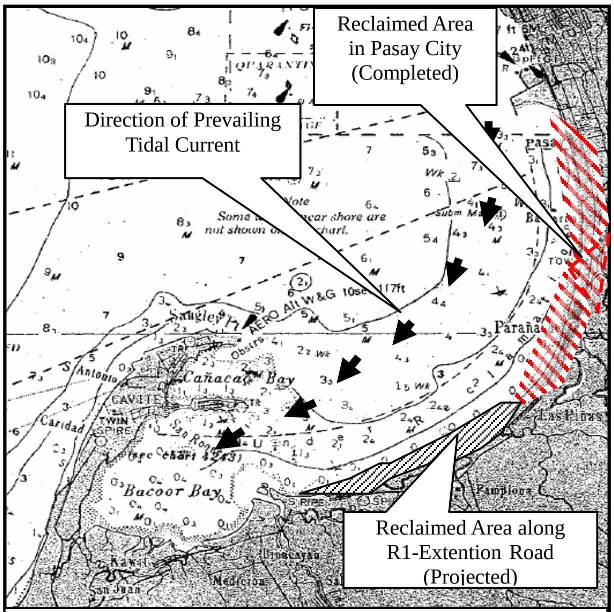


Fig. R 2.3 Reclamation along Shoreline of Manila Bay

The shoreline of about 600ha along Pasay City, which is located northeast of the Bacoor Bay, had been reclaimed. Reclamation is further project along the projected R-1 Extension Road, which starts from the southern edge of the existing reclaimed area until the left bank of the Imus River as shown in Fig. R 2.3. This projected reclamation, which has the seaward width of about 1,500m, may change the direction of near-shore currents that cause local accretion/erosion and, further, may influence the cause of wind-driven current. Nevertheless, the reclamation would not create new tidal currents to transport the sediment deposits in the Bacoor Bay and, therefore, would not dynamically change the present tendency of sediment deposits in the Bay.

(3) Outside of Bacoor Bay around River Mouth of Canas

Serious erosion of the east shoreline of Cavite Pit around the river mouth of Canas was confirmed through the field reconnaissance and the interview survey with the residents in the Study. The principal cause of erosion could be attributed to the wind-driven currents by the North-East wind in particular with less transportation of seabed sand from the Manila Bay. Under this progress of retreat of shoreline, one of the major concerns would be the measure to prevent such retreat of the shoreline.

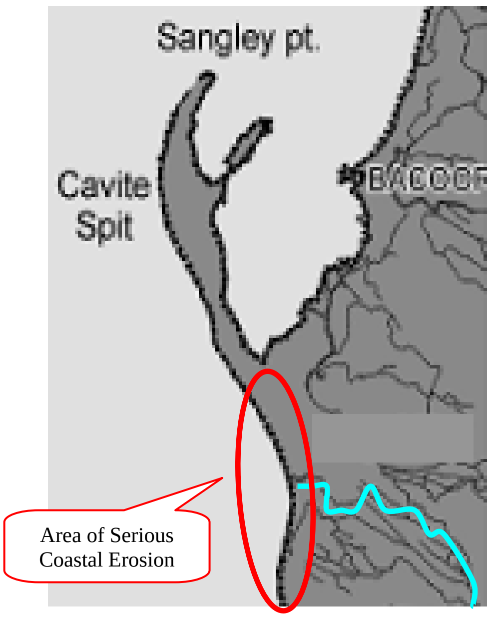


Fig. R 2.4 Erosion along West Shoreline of Cavite Spit

2.7 Sedimentation Runoff

DPWH has always undertaken maintenance dredging along the estuary of Imus and San Juan River once in every two to four years. The recent dredging volumes were 54,000m^3 for Imus River in 2006 and 39,120m^3 for San Juan River in 2006 and 2005. Should these dredging volumes be conservatively assumed as the basin sediment runoff volume for four years, the specific basin sediment runoff volume is estimated at about 117m^3/km^2/year for the Imus river basin (115.49km^2) and 67m^3/km^2/year for the San Juan river basin (146.69km^2). However, the actual runoff volume would be several times these estimated volumes taking the limited dredging capacity of DPWH and sediment trap by the existing NIA irrigation dams/weirs into account.

The results of the following past experimental surveys in Japan could serve as reference for the rough estimation of specific sediment runoff volume from the river basin:

(1) The Forestry Agency, Ministry of Agriculture, Forestry and Fisheries of Japan conducted field surveys on sediment runoff volume from devastated land in 1951 and 1952. According to the results of the survey, severely eroded areas such as landslide scars and collapse areas would yield the specific sediment runoff volume of 5,000 to 40,000m^3/km^2/year. In contrast, the grassland/forest would yield the specific sediment runoff volume in the order of only 10m^3/km^2/year, and even the bare ground would yield 1,000m^3/km^2/year.

(2) The specific sediment runoff volume from a land development site is in a range of 7,000 to 24,000m^3/km^2/year in the first year of development. This volume was estimated based on the results of measurement of sediment runoff from a land development site in Japan (refer to "Technical Standard for On-site Flood Regulation Pond"1987, Japan River Association).

In addition to the above standard volumes, the specific sediment runoff from a buildup area, which includes residential, commercial and industrial areas, is deemed extremely small, because the pavement and other covering materials over the buildup area would check sediment runoff.

It was clarified through the field reconnaissance that soil erosion in river channels is moderate and there exists no severely eroded area in the Study Area (such as landslide scar and collapse area). On the other hand, land development for subdivisions is rather intensive in the Study Area, and its area had expanded at the rate of 579.4ha/year during the period from 1990 to 2006.

In due consideration of the above land use in the Study Area, the principal source of sediment runoff in the Study Area could be assumed as surface soil erosion but not from the severely eroded area, and the annual sediment runoff volume in the Study Area is roughly estimated with reference to the aforesaid experimental standards on the specific sediment runoff volume, as shown below.

Table R 2.8 Annual Sediment Yield in the Study Area

Classification of Land Use	Area (km^2)	Assumed Specific Sediment Runoff Vol. (m^3/km^2/year)	Annual Sediment Runoff Vol. (m^3/year)
1. Not Ongoing Land Development Area	**401.63**	-	**126,000**
Grassland/Forest	105.81	10	1,000
Dry Crop Land	123.475	1,000	123,000
Others (Build-up area, water area)	172.34	10	2,000
2. Ongoing Land Development Area	**5.794**	**15,000(*1)**	**87,000**
Total	**407.43**	**500(*2)**	**213,000**

Note: (*1) The standard specific sediment runoff volume from the land development site in the initial year of development work
(*2) Average in the Study Area (= Total of "Annual Sediment Runoff Vol." / Total of "Area")

As estimated above, the ongoing land development area corresponds to only 1.4% of the whole Study Area, but its annual sediment runoff volume makes up 41% of the total runoff volume. Thus, the ongoing land development site is deemed to be greatly contributing to the sediment runoff from the entire river basin. As described in the foregoing subsection, Bacoor Bay is becoming shallower because of the sediment deposits from the river basin, hence the key issue on the reduction of sediment runoff would be addressed to the control of excessive sediment runoff from the ongoing land development site.

2.8 Geology

2.8.1 Outline

Quaternary volcanic products of Taal Volcano, namely the Taal Tuff and the sedimentary rocks of Guadalupe Formation, broadly cover the Study Area. These formations are further divided into two members (upper and lower) respectively based on their lithological facies and engineering characteristics. Alluvium forms small deltas at the coastal area. The geological map of the Study Area is shown in Fig. 2.6 attached, and the stratigraphy is shown in Table R 2.9.

Table R 2.9 Stratigraphic Table for the Study Area

Geologic Age (Ma)	Formation	Lithology	Consistency	Permeability (General Condition)	Thickness (m)
Holocene (0.00-0.01)	Alluvium	Clay, Sand, Gravel	Loose	High	5+
Pleistocene (0.01-1.81)	Taal Tuff	Upper: Scoria tuff, Pumice tuff, Andesite lava	Very soft to soft	High	3~5 (50)
		Lower: Scoria tuff, Pumice tuff, Welded tuff, Pisolite tuff, Andesite lava, Mudflow deposits	Moderately soft to moderately hard	Medium - High	200
	Guadalupe Formation	Upper: Tuffaceous sandstone, Claystone, Conglomerate	Moderately soft to moderately hard	Low - Medium	<50
		Lower: Conglomerate, Claystone, Sandstone, Andesite lava	Moderately soft	Low	>300

Reference: "Cavite (No. 3163 II)", "Silang (No. 3162 I)" and "Mendez-Nunez (No. 3162 II)", MGS, 1982; and "Cavite Water Supply Development Study", JICA, 1995

Note: (1) Geological Age: The geologic age is dated on the basis of International Stratigraphic Chart (2004) endorsed by ICS (International Commission on Stratigraphy); Ma = Million years ago

(2) Consistency: Based on hammer tapping sound. Expected unconfined compressive strength: Moderately hard: 10 MPa; Moderately soft: 5-10 MPa; and Soft: Less than 5 MPa

(3) Permeability: There are some regional variations.

Attached Fig. 2.7 gives a schematic geological profile in South-North direction across the Study Area and schematic river cross sections. The topographical features of the major rivers and the distribution of the base rocks and their engineering characteristics are shown in the table below.

Taal Tuff and Guadulupe Formation gently dip northward. Tuff (upper) is extensively and thinly distributed on almost all of the Study Area. Taal Tuff (lower) would pass laterally into Guadalupe Formation (upper).

Guadalupe Formation (lower) forms a hydrological basement of the Study Area, and Guadalupe Formation (upper) has a high potential for the groundwater resources according to the existing study results (JICA, 1995). The upland mountainous area and the general hilly area play the role of recharge of the groundwater. Many small streams spring out of the slope near the geological boundary between Taal tuff (lower) and Guadalupe Formation (upper) and lithological boundaries.

The distribution and lithology of the geological components of the Study Area are as given in the table below.

Table R 2.10 Distribution and Lithology of Geological Components of the Study Area

Geological Component	Distribution	Lithology
Guadalupe Formation (lower)	Form the basement of Taal Tuff. Crop out only on the south facing slope of Tagaytay Caldera beyond the Study Area	Alternation of tuffaceous sandstone partly including pisolite and tuffaceous siltstone, and conglomerate. Moderately soft.
Guadalupe Formation (upper)	Underlay Taal Tuff; mainly exposed on riverbeds of less than 30m in elevation.	Thin to medium bedded, fine to medium grained tuffaceous sandstone, claystone and conglomerate. Sometimes thin layers of scoria/pumice tuff breccia and pisolitic tuff are intercalated. Moderately soft to moderately hard
Taal Tuff (lower)	Extensively distributed on areas of the Study higher than 30m in elevation where this formation forms a steep V-shaped valleys	Lateral variety in rock facies. Composed mainly of scoria tuff, pumice tuff, welded tuff breccia, andesite lava, mud flow deposits, and partly including some intercalated pisolitic tuff layers shown in photographs as below. Moderately soft to moderately hard.
Taal Tuff (upper)	Relatively thick at Tagaytay, and extensively and thinly distributed on almost all of the Study Area.	Composed mainly of scoria tuff, pumice tuff, and including pisolitic tuff layers. Both members are very soft to soft.
Alluvium	Limited in the major river mouths or coastal area of less than 30m in elevation. Bedrocks are exposed at many places along the river.	Mainly composed of fine to medium grained sand and silt with sub-angular to sub-round gravels.

2.8.2 Geological Structure

There exist the following fault and fold in the Study Area.

(1) Fault

Marikina Fault, a major active fault in the Philippines, lies on the North-South direction ridge to the east of the Study Area, as shown in Fig. 2.6 attached. Although no topographic features indicating faults are distributed in the Study Area, results of the electromagnetic survey suggests a normal blind fault almost parallel to the ridge of Tagaytay Cliff.

(2) Fold

Guadalupe Formation and Taal Tuff form a broad fold with its fold axis in NE-SW or NW-SE direction in the Study Area, as shown in Fig 2.6 attached. These active folds near the Dasmariñas Municipality probably cause the bending of the current river system.

2.8.3 Engineering Geology

The study on engineering geology was made based on the results of the field reconnaissance. The results of the study are as described below.

(1) Irrigation Dam

Eight relatively large-scale old dams; namely, Anabu Dam, Butas Dam, Marcelo Dam, Hassan Dam, Pasong Kastrila Dam, Plucena Dam, Bayan Dam and Matanda Dam; among the many dams constructed at the middle to downstream reaches were surveyed during the Study from the geotechnical point of view. The survey included the inspection of Butas Dam, which was destroyed when a typhoon attacked the Study Area in October 2006. The following findings are based on the results of geological mapping, and detailed dam structures remain unknown since the survey did not include the check on the inner structures.

- Most of the dams are founded on the terraces (natural) to reduce the volume of concrete or construction materials, as shown in Fig. R 2.5
- Dam body is constructed on artificial foundation with plugging blocks (welded tuff quarried near the riverbed) of mortar.
- Dam body is covered with reinforced concrete probably for subsequent maintenance.
- Dam abutment is covered by very soft and erosive Taal Tuff (upper), which could cause collapse and/or damage to the dam body.
- Cover concrete of dam body has deteriorated. However, this might not directly lead to a severe problem on the existing dams, although detailed inner structure checks should be required.

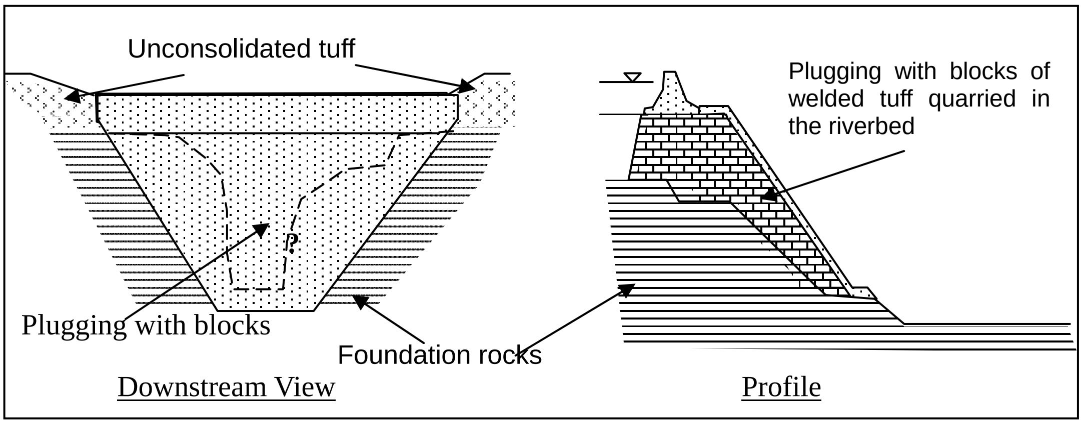
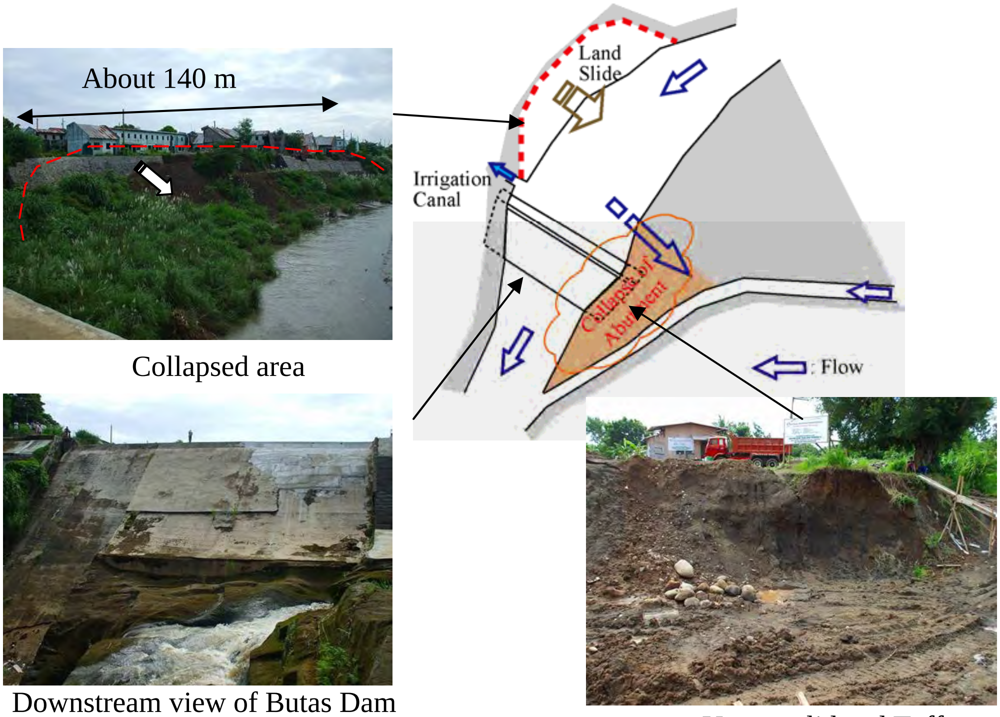


Fig. R 2.5 Image of Dam Site Foundation (Source: JICA Study Team)

Among the existing dams in the Study Area, the Butas Dam on San Juan River broke during Typhoon Milenyo in 2006. In this connection, an attempt was made to clarify the cause of dam collapse through field reconnaissance. The Study Team assumed based on the results of field reconnaissance and interview survey that some on the right bank of the dam reservoir landslides (total length: about 140m, height: 6m-8m) might also have caused further erosion of the left bank abutment, which would lead to dam break, as shown in Fig. R 2.6. The riverbed at the dam site is covered with relatively hard welded tuff rocks, which has enough bearing capacity for dam foundation. However, both abutments of the dam are covered with about five-meter thick loose and erosive tuff. Erosion of the left abutment probably triggered the dam break. Inappropriate water drainage from the residential site close to the dam reservoir might cause landslides.



Collapsed area

Downstream view of Butas Dam

Unconsolidated Tuff

Fig. R. 2.6 Butas Dam Site Condition (Source: JICA Study Team)

(2) Failures of Existing Dike

Some failures of the existing concrete dikes were found at the coastal area (see Fig. R 2.7). Although most concrete dikes are set on bedrocks which are suitable for the foundation of dikes, the dikes did not settle down but slid because of:

- Riverbed degradation,
- Partial unsuitable foundation treatment,
- Less resistance force against sliding force, and
- Increasing pore pressure of the backfilled soil due to unsuitable drainage.

Fig. R 2.7
Dike Failure of San Juan River

(3) Construction Materials

The Study Area is covered with Quaternary volcanic products, which are soft and unsuitable for concrete aggregates. Expected resources of concrete aggregates are the Tertiary sediments and volcanic rocks within 20km from the Study Area, as shown in Fig. 2.8 attached. The materials summarized in Table R 2.11 are expected to be the source of concrete aggregates due to quantity and accessibility, although their quality is required to be confirmed.

Table R 2.11 Sources of Concrete Aggregate

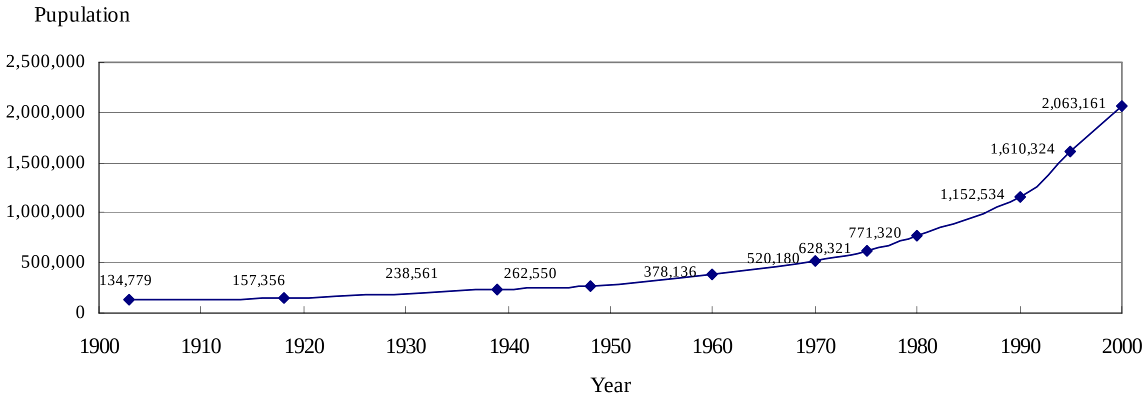
Location	Geology	Expected Volume (m^3)
Labing Ridge, Maragondon	Conglomerate	59,000
Barangay Buhay, Mallaganes	Conglomerate	-
Calugay Peak	Conglomerate	800,00
East of Calugay Peak	Basalt	10,000
Gulod na Malaki / the Golod na Munti Hills	Conglomerate	1,800,000
Pinagsanghan River / Sapang River	River sand	15,000
Kaybian point near Barangay	Basalt	800,000
Caylabne to Baraggay Patungan	Conglomerate	7,000,000

Source: BMG (1980), Quarry Resources of Concrete Aggregates in Cavite Province

Chapter 3. Socio-Economic Condition in the Study Area

3.1 Population

The population of Cavite Province had steadily increased in over nine decades, as shown in the figure below. The increment of population had accelerated after the 1990's in particular due to the intensive industrialization. As a result, the population in 2000 reached up to 1.8 times the population in 1990.



(Source: 2005 Socio-Economic Profile Provincial Planning and Development Office)

Fig. R 3.1 Historical Growth of Population in Cavite Province

The population in the Study Area was estimated at 850,000 in 1995 and 1,114,000 in 2000, corresponding to 53% and 54% of the provincial total, respectively (see the table below). Thus, the Study Area contains a substantial part of the provincial population.

Table R 3.1 Population in the Study Area

City/ Municipality	Basic Census[*1] Population in Entire Jurisdiction (Thousand)		Population Estimated for the Study Area: Area Overlapped with Study Area		Population[*2] (Thousand)		Population Density (persons/km^2)		Population Growth (%)
	1995	2000	Built-up Area (%)	Whole Area (ha)	1995	2000	1995	2000	(1995-2000[*3])
District I	**389**	**475**		**4,619**	**250**	**306**	**5,422**	**6,625**	
Bacoor	251	306	45%	1,809	112	137	6,215	7,573	4.33%
Kawit	57	63	100%	1,548	57	63	3,682	4,070	2.08%
Noveleta	27	32	100%	585	27	32	4,615	5,470	3.43%
Rosario	54	74	100%	677	54	74	7,976	10,931	6.84%
District II	**604**	**836**		**24,497**	**521**	**711**	**2,126**	**2,902**	
Trece Martires City	20	42	58%	2,313	12	24	499	1,038	16.46%
Dasmariñas	262	380	93%	7,012	243	352	3,461	5,020	8.23%
General Trias	67	108	100%	8,482	67	108	790	1,273	10.76%
Imus	177	195	100%	5,160	177	195	3,430	3,779	2.10%
Tanza	78	111		1,530	23	32	1,473	2,092	7.80%
District III	**219**	**278**		**11,628**	**79**	**97**	**678**	**834**	
Amadeo	23	26	29%	4,287	23	26	537	606	2.70%
Indang	43	51	100%	1,204	6	7	465	581	3.97%
Silang	124	156	13%	5,108	48	60	933	1,175	5.05%
Tagaytay	29	45	38%	1,029	3	4	248	389	9.68%
Total	**1,212**	**1,589**	**9%**	40,743	**850**	**1,114**	**2,086**	**2,734**	5.93%
Cavite Province	**1,610**	**2,063**	**70%**	**142,605**	**1,610**	**2,063**	**1,129**	**1,447**	**5.45%**

*1: Abstracted from 2005 Socio Economic Profile, Provincial Government of Cavite
*2: Population in the Study Area is estimated by the total population of city/municipality multiplied with the rate of built-up area overlapping with the Study Area
*3: Estimated on the premise of time interval of 56 months between the populations in 1995 and 2000.

The population density of the whole province was 1,447 person/km^2 in the year 2000. Since the Housing and Land Use Regulatory Board had classified the population density of less than

1,500 person/km^2 as "low density," Cavite Province as a whole is still an area of low population density. However, the Municipality of Dasmariñas in District II (the central area) and the municipalities of Bacoor, Kawit, Noveleta and Rosario in District I (coastal area) have far higher population densities than 1,500 person/km^2. In contrast, the other municipalities in Cavite have a low population density in the year 2000.

The Study Area had the average annual population growth of more than 5% per year in the recent five years from 1995 to 2000, which was far higher than the national average of 2.3%. Trece Martires City, Dasmariñas, General Trias and Tanza in District II in particular recorded a remarkably high annual population growth of more than 7%. The Provincial Government of Cavite attributes this intensive population growth to the rapid migration of farmers from the other provinces looking for jobs and better living conditions in the Study Area.

3.2 Land Use

As early as the late 1800's, the Study Area has been predominantly covered with farmlands managed by the Spanish friars, and grasslands/forests. From the 1980's, farmlands and grasslands/forests began to be converted into agro-industrial, economic and real estate housing development areas. At present, there exist no primary forests in the Study Area.

The existing land use maps were prepared based on the satellite image developed by the JICA CALA East-West Road Project, as summarized in the table below (refer to Table R 3.1 and Fig. 3.1).

Table R 3.2 Existing Land Use in the Study Area

(Unit: ha)

Classification of Land Use		District I (Lower Land)	District II (Central Land)	District III (Highland)	Total
Built-up Area	Residential	1,800	5,781	839	8,420
	Industrial	251	584	79	914
	Institutional	17	153	38	208
	Commercial	69	223	130	422
	Built-up/Mix Use	10	36	11	57
	Sub-Total	2,148 (46.5%)	6,778 (27.7%)	1,096 (9.4%)	10,021 (24.6%)
Non-Built-up Area	Agricultural	994	9,040	9,004	19,037
	Grassland/Open Area	416	5,304	558	6,278
	Tree Plantation	189	3,345	950	4,484
	Water Bodies	873	30	0	903
	Unclassified	0	0	21	21
	Sub-Total	2,471 (53.5%)	17,719 (72.3%)	10,532 (90.6%)	30,722 (75.4%)
Total		4,619	24,496	11,628	40,743

Source: JICA CALA East-West Road Project

Since the start of large-scale infrastructure development in CALABARZON in the 1980's the built-up area had expanded to cope with the rapid urbanization and currently covers about 25% of the Study Area, as shown above. District I, which locates in the lowland area and include the four municipalities of Bacoor, Kawit, Noveleta and Rosario, shows a higher built-up ratio of 46.5%, while District III, which is situated in the highland area, takes a lower built-up ratio of 9.4%. Thus, the built-up ratio in the Study Area decreases as it moves from the lowland to the highland area. The dominant area development scheme of urbanization is made through the development of residential subdivisions, industrial zones, commercial building/commercial zones and others (golf courses, memorial parks, public markets, funeral parlors, sawmill, rice mill, poultry, farm lot).

The non-built-up area is divided into the following areas and takes the share of 75.5% of the entire Study Area. It is worthy to note that there is no sizable forest area in the Study Area, except the narrow strips along the rivers.

- Agricultural land mainly for crop production (rice, corn, vegetables, root crops);
- Grassland/open area mainly for animal husbandry (cattle, carabao or water buffalo, swine, horse,

goat, pigeon);

- Tree plantation; and
- Water body in the lowland area, mainly used for fish and salt ponds.

3.3 Economic Profile

3.3.1 GDP and Industry

Cavite Province, one of the highest priority areas for economic development in the Philippines as well as the core of CALABARZON Economic Development Zone, had rapidly promoted the establishment of industries. The province had the GDP of about 29,160 million pesos in 2000, corresponding to 3.0% of the National GDP and 20.6% of the GDP in the CALABARZON, at constant prices (1985=100).

The total number of employed persons in Cavite Province increased from 445,800 in 1995 to 585,136 in 2003, and he total number of employed in 1995 and 2003 corresponds to about 28% of the whole provincial population. As of 2003, the manufacturing sector took the highest share of 45.3% of the employed, followed by 20.7% for the service sector and 15.1% for the construction sector, as tabulated below. The manufacturing sector also showed the second highest growth rate of 172% after the 224% for electricity, gas & water sector in terms of growth rate of the employed from 1995 to 2003. On the other hand, the agricultural & forestry sector and the mining & quarrying sector tended to dwindle.

Table R 3.3 Number of Employed Persons in Cavite Province

Sector	Number of Employment				Growth Rate 1995 to 2003
	1995		2003		
	Number	Share	Number	Share	
Manufacturing	97,500	21.9%	264,894	45.3%	172%
Services	98,750	22.2%	121,197	20.7%	23%
Construction	56,500	12.7%	88,108	15.1%	56%
Transportation, etc.	54,750	12.3%	82,819	14.2%	51%
Trade Real Estate	58,500	13.1%	75,929	13.0%	30%
Agriculture & Forestry	59,250	13.3%	46,820	8.0%	-21%
Finance, Dwelling & Real Estate	15,250	3.4%	15,610	2.7%	2%
Electricity, Gas & Water	4,300	1.0%	13,926	2.4%	224%
Mining & Quarrying	1,000	0.2%	803	0.1%	-20%
Provincial Total	445,800	100.0%	585,136	100.0%	31%

Source: Provincial Planning and Development Office: The Provincial Physical Framework Plan 2005-2010, Cavite Province; and the Provincial Physical Framework Plan/Comprehensive Provincial Land Use Plan, Province of Cavite, Planning Period 1998 to 2002.

3.3.2 Economic Development

The industrial development in the province as mentioned in Subsection 3.3.1 had induced the implementation of relevant economic and land development projects. These development projects are as described below.

(1) Development of Residential Subdivisions

More than 1,000 residential subdivision projects have been developed in the Study Area since 1988. As of July 2007 these subdivisions occupy the area of 8,466 ha in total that could accommodate 467,805 units of house lots, while the number of existing houses in Cavite Province is at present only about 420,000 units. Moreover, the average annual increase ratio of the area developed for subdivisions is about 18%, while the population increase ratio is about 6% in the Study Area. Thus the supply of residential areas is far over the actual demand and, as the result, many of the developed residential houses and lots remain unoccupied. According to the results of interview survey, about 90% of the lots have been sold, but actual occupancy rate is estimated to be only about 30% of the lots. Judging from this, many of the residential lots/houses may be sold later subject to speculation for more reasonable prices.

(2) Development of Industrial Estates

The first industrial estate in the province, Cavite Economic Zone, was developed in Rosario in 1980 and there are 27 industrial estates in operation at present. Another 14 industrial estates are also in progress, as listed in the table below. In terms of size, the Carmona, Dasmariñas, Gen. Trias and Imus municipalities are the present major centers of industrial estates. In addition, Silang, TMC, Tanza and Cavite City are also expected to become new industrial centers.

Table R 3.4 List of Existing Industrial Estates

City/ Municipality	Existing			In progress			Total		
	Number of Estates	Total Lots	Area (ha)	Number of Estates	Total Lots	Area (ha)	Number of Estates	Total Lots	Area (ha)
Rosario	1	253	288	2	48	173	3	301	461
Carmona	7	129	224	0	0	0	7	129	224
Dasmarinas	3	102	225	1	33	86	4	135	311
Gen. Trias	5	68	324	3	145	382	8	213	706
Silang	6	26	242	1	55	145	7	81	387
Imus	3	16	223	0	0	0	3	16	223
GMA	1	5	10	0	0	0	1	5	10
Tanza	1	3	9	1	44	116	2	47	125
TMC	0	0	0	3	84			84	220
Cavite City	0	0	0	2	72			220	3
Naic	0	0	0	1	6	15	1	190	2
Total	27	602	1,545	14	487	1,327	41	1,089	2,872

Note: Number of lots of parts of industrial estates in progress was estimated by the JICA Study Team.
Source: Philippine Economic Zone Authority (PEZA), Pasay City and MPDO/CPDO

Of the presently existing 27 industrial estates in Cavite Province, 16 industrial estates covering an area of 1,284 ha are located in the Study Area, as listed in the table below.

Table R 3.5 Existing Industrial Estates in Study Area (as of 2007)

Name of Industrial Estate/	Area (ha)	Number of Companies	Location
First Cityland Heavy Industrial Center	32.10	1	Langkaan, Dasmariñas
First Cavite Industrial Estate (FCIE)	155.00	69	Langkaan, Dasmariñas
Dasmariñas TechnoPark	38.00	6	Paliparan. Dasmariñas
New Cavite Industrial City	52.00	24	Manggahan, Gen. Trias
Gateway Business Park	167.92	20	Javalera, Gen. Trias
Manggahan Industrial Estate	10.20	3	Manggahan, Gen. Trias
Golden Gate Business Park	65.16		Buenavista II, Gen. Trias
Golden Gate II Business Park	16.58		Buenavista II, Gen. Trias
Cavite Eco-Industrial Estate	104.95		Pasong Kawayan II, Gen. Trias
Imus Informal Industrial Estate	200.00	13	Imus
Anabu Hills Industrial Estate	10.85	3	Anabu, Imus
EMI Special Economic Zone	12.20	1	Anabu II, Imus
Cavite Economic Zone	278.50	253	Rosario
PNOC Development & Management Corp.	50.32	2	Rosario
Cavite Economic Zone (Annexation)	9.88		Bacao, Gen. Trias
Fil-Estate Industrial Park, Inc.	80.62		Trece Martires City & Tanza
Total	1284.28		

Source: Provincial Planning and Development Office, Cavite Province: Provincial Physical Framework Plan 2005-2010.

According to the Provincial Planning and Development Office (PPDO), the number of industrial establishments, which grew steadily at an average rate of 3.43 per year from 2002 to 2006, had reached up to 760 in 2006 in parallel with the development of the industrial estates. However, an area of about 660 ha in total within the above industrial estates has not been occupied yet. The priority of industrial estate development is put on the occupancy of vacant lots or areas of the already developed industrial estates rather than developing new ones.

(3) Commercial Development

Small-scale commercial shops and facilities have been developed along the major roads, such as Aguinaldo Highway, Governor's Drive, Coastal Road, etc., and the town center areas. Since 1990, large-scale commercial center projects began to be developed along the intersection of major roads, such as:

- SM City in Bacoor (intersection of Tirona Highway and Aguinaldo Highway)
- Robinson Commercial Complex and Makro Warehouse Complex in Imus (along Aguinaldo Highway)
- Walter Mart in Gen. Trias (intersection of Govenor's Drive and Delos Reyes Avenue)
- SM City, Robinson Commercial Complex, Walter Mart, Highway Plaza and New Dasmariñas Public Market Complex in Dasmariñas (intersection of Aguinaldo Highway and Governor's Drive)

(4) Tourism Development

Cavite Province is one of the most attractive tourist areas in the country, having various tourist attractions with its location advantage, proximity to Metro Manila. The number of travelers in the CALABARZON in 2002 is estimated to be more than 3.7 million, of which more than 54% or 2.0 million has visited Cavite. The number of foreign travelers in Cavite is still low (97,897 travelers), as shown in the table below.

Table R 3.6 Number of Travelers in CARABARZON

Province	Domestic Travelers (Persons)	Foreign Travelers (Persons)	Overseas Filipino Travelers (Persons)	Total
Cavite	1,924,168	97,897	n/a	2,022,065
Laguna	43,455	1,157,857	6,695	1,208,007
Batangas	155,877	9,208	4,154	169,240
Rizal	n/a	n/a	n/a	n/a
Quezon	324,729	1,616	570	326,915
Total	2,448,229	1,266,578	11,419	3,726,227

Source: Cavite Provincial Development Plan 2005-2010

The Number of hotels in Cavite Province in 2006 was 77 units. More than 50% of the hotels were concentrated in Tagaytay City, as shown in the table below.

Table R 3.7 Number of Hotels in Cavite Province

Province	No. of Hotels
Kawit	3
Cavite City	9
Carmona	2
Dasmariñas	2
Silang	1
Tanza	4
Tagaytay City	40
Naic	6
Ternate	2
Alfonso	5
Indang	4
Total	77

Source: PPDO

Many types of recreation or tourism spots have developed such as beach resorts, highland resorts, vacation houses, racing tracks, leisure-parks and golf courses, as follows:

- Coastal tourist areas, including the Island Cove and the Aguinaldo Museum in Kawit Municipality.

- Golf courses and resort hotels in the central area which consists of Dasmariñas, Gen. Trias, Trece Martines City, and Silang.
- Tagaytay highland resort areas in Tagaytay City, Silang, Amadeo and Indang.

(5) Agriculture

About 73% (29,798 ha) of the Study Area is currently used as agriculture land, which is composed of farmland (mainly for rice, corn, vegetable and root crop production), grassland/open area (mainly for animal husbandry of cattle, carabao, swine, horse, goat, pigeon), and tree plantation. There is no forest area in the Study Area, except the narrow strips along the rivers. According to the agricultural statistical data, the main products by district are as shown in the table below.

Table R 3.8 Major Agricultural Land Use and Products

District	Major Agricultural Land Use and Product
District I (lowland)	• Only 1.5% of total planted area • Almost all of the area is planted with rice (irrigated) and some vegetables
District II (central)	• Nearly 35% of the total planted area • 80% of rice, 73% of corn, 58% of vegetables
District III (highland)	• Nearly 62% of the total planted area • All coffee, 83% of fruits, 80% of root crops, 94% of coconuts
Whole Study Area	The share of the Study Area in Cavite Province are: • 64% of the total planted area • 64% of the irrigated rice planted area • 73% of the corn planted area • 73% of the coffee planted area

Source: Office of the Provincial Agriculturist in Trece Martires, Province of Cavite: Socio-Economic Profile, 2006

(6) Aquaculture

The Province of Cavite has about 85 km of shoreline stretching along one city and eight municipalities, and those covered by the project area are Bacoor, Kawit, Noveleta, Rosario and Tanza. The sea fishes are caught in the Manila Bay and Cavite Bay. The major species caught in the sea areas are tuna, mackerel (incl. tanigue, hasa-hasa, galunggong), threadfin bream (bisogo), grouper (lapu-lapu), sardinella (tamban) and crab (alimasag).

The sea fishery is divided into two types: commercial fishery and municipal fishery. Commercial fishing is performed by using big boats provided with bag net, trawl or ring seine and operated in only Rosario and Tanza. On the other hand, the municipal fishing is performed by using small boats (banca) with or without engine.

The number of fishermen, number of boats and annual production of sea fishery by municipality in the project area in 2006 are as shown in the table below.

Table R 3.9 Sea Fishery by Municipality in the Project Area

Municipality	Commercial Fishery			Municipal Fishery		
	No. of Fishermen	No. of Boats	Production (ton/year)	No. of Fishermen	No. of Boats	Production (ton/year)
Bacoor	-		-	549	1,166	1,481
Kawit	-	-	-	2,067	645	941
Noveleta	-	-	-	546	62	93
Rosario	1,300	48	2,530	3,606	913	1,621
Tanza	450	45	2,540	1,276	649	1,147
Total	1,750	93	5,070	8,044	3,435	5,283

Source: Socio-economic Profile 2006, Provincial Planning and Development Office, Cavite

There are many fishponds with a total area of 382 ha in the coastal zones (Bacoor, Kawit, Noveleta and Tanza) of the Project Area. Prawn (sugpo), milkfish (bañgus) and tilapia are cultivated in these fishponds. The fishpond area, fish production and number of operators by municipality in 2006 are as listed in Table R 3.9. Further, shellfishes like oyster, and mussel, are cultivated in the Bacoor Bay. The area, production and number of operators for shellfish cultivation by municipality in 2006 are also shown in the table below. There is no river fishery in the project area.

Table R 3.10 Fish and Shellfish Cultivation in the Project Area

Municipality	Fish Cultivation by Fishpond			Shellfish Cultivation		
	Area (ha)	Production (ton/year)	Number of Operator	Area (ha)	Production (ton/year)	Number of Operator
Bacoor	40.0	25.2	28	131.9	4,219.8	124
Kawit	257.0	171.2	107	20.0	810.0	100
Noveleta	72.5	34.0	22	-	-	-
Tanza	11.6	21.3	50	0.1	5.0	2
Total	381.1	251.7	207	152.0	5,034.8	226

Source: Provincial Planning and Development Office, Cavite Province: Socio-Economic Profile, 2006

3.3.3 Family Income

Cavite Province ranks the second highest average family income among all provinces neighboring Metro Manila. The average family income of Cavite Province was 196,401 pesos in 2000 at current prices. GINI coefficient is low compared to those of Metro Manila and the whole Philippines (refer to the table below).

Table R 3.11 Distribution of Family Income

Description		Cavite	Metro Manila	Philippines
Distribution	< 50,000 pesos	4.49%	1.06%	24.39%
	50,000 – 100,000 pesos	21.91%	13.17%	30.62%
	100,000 – 250,000 pesos	56.14%	49.80%	31.52%
	250,000 – 500,000 pesos	13.63%	24.38%	10.01%
	> 500,000 pesos	3.73%	11.59%	3.22%
	Total	100.00%	100.00%	100.00%
GINI coefficient*		0.3554	0.4462	0.4814

Source: Philippine Statistical Yearbook
Note:*: Index of income distribution with limits 0 for perfect equality and 1 for perfect inequality

3.4 Water Use

3.4.1 Surface Freshwater Resources

River water in the Study Area is used only for irrigation. It is not used for any other purposes such as drinking/industrial water, hydropower, fishery and recreation except local uses in the upstream reaches. Local people use the river water for washing, bathing and sometimes cooking in the upstream reaches but water use is limited due to the difficulty of access to the rivers. There are approximately 70 intake dams in the Imus, San Juan and Canas rivers including the tributaries. Among them, about 10 dams are located in the lowland area (downstream river reaches) while the rests are all in the central area (middle river reaches).

3.4.2 Ground Water Resources

In the lowland and central hilly areas covering the municipalities of Bacoor, Imus, Gen. Trias, Dasmariñas and Tanza, hundreds of artesian wells and deep wells provide the water supply for both domestic and irrigation purposes. Due to the presence of numerous wells in the said municipalities, over-extraction takes place resulting to salt intrusion in the aquifers. Most of the ground water is stored in the pyroclastic rock reservoir and little in the volcanic and clastic rock. Potable water is not available near shore due to the presence of alluvium deposits, and the water may be brackish and saline.

Free-flowing wells are found at the 30-meter elevation of Southern Tanza. In Imus, free-flowing well yields come from 36.6 m deep wells drilled to about 15 m.

The source of groundwater is infiltrated rainfall, which serves as the direct source of most near surface aquifers. Inflow from surface water reservoir and irrigation water contributes to the ground water.

3.5 Public Hazard

3.5.1 River Water Pollution

(1) River Water Classification

DENR has defined the classes of river water according to the following applicable usages, based on the concept that the quality of waters in the Philippines shall be maintained in a safe and satisfactory condition according to their best uses. (Refer to DAO 90-34)

Table R 3.12 Classifications of River Water as Defined by DENR

River Water Class	Applicable Water Use
AA	Public Water Supply Class I. This class is intended primarily for waters having watersheds, which are uninhabited and otherwise protected and which require only approved disinfections in order to meet the National Standards for Drinking Water (NSDW) of the Philippines.
A	Public Water Supply Class II. For sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the NSDW.
B	Recreational Water Class I. For primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purpose)
C	(1) Fishery Water for the propagation and growth of fish and other aquatic resources (2) Recreational Water Class II (Boating, etc.) (3) Industrial Water Supply Class I (For manufacturing processes after treatment)

Source: DENR Administrative Order No. 34, Series of 1990

DENR categorizes the water of Imus and Canas rivers as Class C for the whole reaches. On the other hand, the San Juan River is categorized as Class C for the lower and middle reaches and Class B for the upper reaches.

(2) Organic Water Pollution

DENR has been analyzing the water quality of the Imus, San Juan and Canas rivers since 2004. The average water quality at the key stations during the dry season is summarized in the table below.

Table R 3.13 Water Quality of Rivers in the Study Area

(Unit: mg/l)

River Reaches	Station	pH	DO	BOD	TSS
Imus Lower Reaches	Aguinaldo Highway Bridge	7.9	4.1	10.2	21
San Juan Lower Reaches (After Confluence of Ylang-Ylang R.)	Noveleta Bridge/1	8.1	4.7	2.5	16
San Juan Lower Reaches (Before Confluence. of Ylang-Ylang R.)	San Francisco	8.0	3.5	4.5	13
Canas Lower Reaches	Tejero Bridge	8.5	7.5	1.5	13
DENR Criteria for Class C Water		6.5~8.5	>5.0	<7 (10)/2	See /3

Note /1: Tidal area
/2: Figures outside parenthesis are for rainy season and those in parenthesis, for dry season.
/3: Not more than 30mg/l increase

The JICA study team for the Feasibility Study and Implementation Support on the CALA East-West National Road (JICA Study Team for CALA East-West Road Project) had analyzed the total coliform concentration in the Imus and San Juan rivers in March 2005. The results are as shown in the table below.

Table R 3.14 Coliform Concentration in Imus and San Juan Rivers

River	Analyzed Total Coliform (MPN/100ml)			Criteria
	Lower Reaches	Middle Reaches	Upper Reaches	
Imus	20,000	500,000	30,000	< 5,000
San Juan	100,000	700,000	100,000	

As shown in Table R 3.13 and Table R 3.14, the Imus and San Juan rivers are much polluted due to domestic wastewater. However, the water of the Canas River is still clean. For details of the DENR Analysis, refer to the following table.

Table R 3.15 Results of River Water Quality Analysis in the Study Area

(Unit: mg/l)

River	Sampling Location	Sampling Date	pH	DO	BOD	TSS
Imus	Aguinaldo Highway Bridge (in lower reaches)	3rd Quarter 2004	-	4.1	5.0	13
		4th Quarter 2004	7.8	7.3	5.0	23
		Feb. 2005	7.9	0.0	32.0	17
		Jun. 2005	8.1	3.2	21.0	99
		Sep. 2005	7.8	5.8	3.0	122
		Nov. 2005	7.9	4.2	6.0	28
		1st Quarter 2006	8.0	3.7	8.0	10
		2nd Quarter 2006	8.0	2.1	5.0	25
		3rd Quarter 2006	8.4	3.6	4.0	6
		4th Quarter 2006	7.8	7.3	5.0	23
		Average	8.0 (7.9)	4.1 (4.1)	9.4 (10.2)	37 (21)
San Juan	Noveleta Bridge (in tidal area)	4th Quarter 2004	8.4	5.2	3.0	21
		1st Quarter 2005	7.7	4.1	2.0	11
		Average	8.1 (8.1)	4.7 (4.7)	2.5 (2.5)	16 (16)
	San Francisco (downstream of General Trias)	1st Quarter 2006	8.2	3.0	5.0	16
		2nd Quarter 2006	7.7	3.9	4.0	9
		4th Quarter 2006	7.4	5.9	3.0	500
		Average	7.8 (8.0)	4.3 (3.5)	4.0 (4.5)	175 (13)
	Pasong Kawayan (in middle reaches)	1st Quarter 2006	8.4	7.4	1.0	24
		2nd Quarter 2006	8.1	7.3	1.0	22
		4th Quarter 2006	7.6	7.6	1.0	236
		Average	8.0 (8.3)	7.4 (7.4)	1.0 (1.0)	94 (23)
Canas	Tejero Bridge (lower)	2nd Quarter 2004	8.6	7.3	1.0	8
		4th Quarter 2004	8.4	7.6	2.0	18
		Average	8.5 (8.5)	7.5 (7.5)	1.5 (1.5)	13 (13)

Note: Figures in parentheses are average water quality during dry season.
Source: DENR

(3) Heavy Metal Content

The JICA Study Team conducted a sampling analysis for heavy metal contents of the river water and riverbed materials in the downstream of the Imus, San Juan and Canas rivers during September to November 2007 and the results are shown in the table below in reference to the Philippine or Japan standards. For river water quality, the standards of DENR were applied. However, for the quality of riverbed materials, the standards of Japan were applied since there are no standards in Philippines.

Table R 3.16 Heavy Metal Contents of River Water and Riverbed Material

River Water Quality						
Location/Parameter (unit: mg/l)	CN	Hg	As	Cd	Cr	Pb
Imus River: Aguinaldo Highway Bridge	< 0.05	< 0.0001	0.001	< 0.003	< 0.04	< 0.01
River Mouth Area	< 0.05	< 0.0001	0.002	< 0.003	< 0.04	< 0.01
San Juan River: After confluence of Ylang-Ylang R.	< 0.05	< 0.0001	< 0.0005	< 0.003	< 0.04	< 0.01
Noveleta Bridge	< 0.05	< 0.0001	< 0.0005	< 0.003	< 0.04	< 0.01
Canas River: Tejero Bridge	< 0.05	< 0.0001	0.003	< 0.003	< 0.04	< 0.01
Downstream of Tejero Bridge	< 0.05	< 0.0001	0.003	< 0.003	< 0.04	< 0.01
DENR Standards (Freshwater: Class C)	0.05	0.002	0.05	0.01	0.05	0.05
(Coastal/Marine Water: Class SC)	0.05	0.002	0.05	0.01	0.1	0.05
Riverbed Material Quality						
Location/Parameter (unit: mg/kg)	CN	Hg	As	Cd	Cr	Pb
Imus River: River Mouth Area 1	ND	ND	1.8	ND	ND	36
River Mouth Area 2	ND	ND	1.8	ND	ND	41
San Juan River: River Mouth Area 1	1.4	< 0.0002	1.6	< 1.0	< 2.0	< 3.0
River Mouth Area 2	3.9	ND	0.93	ND	ND	7.8
Canas River: River Mouth Area 1	8.0	< 0.0002	1.1	< 1.0	< 2.0	< 3.0
River Mouth Area 2	4.4	< 0.0002	1.1	< 1.0	< 2.0	< 3.0
Standards of Soils in Japan	50	15	150	150	250	150

ND: not detected

As can be seen from the table above, the water and riverbed materials of the Imus, San Juan and Canas rivers are not contaminated by heavy metals.

3.5.2 Solid Waste

Disposal of household wastes, industrial wastes and health care wastes in the Project Area are as described below.

(1) Household Waste and Market Waste

According to information from the Provincial Government of Cavite, the total volumes of household and market wastes as of 2002 generated in the city/municipalities overlapped with the Project Area are estimated at about 1,540 m^3/day and 225 m^3/day, respectively (refer to Table R 3.16 and Table R 3.17).

Table R 3.17 Volume of Household Wastes and the Waste Collection System

Municipality	Total Population	Collection System		
		Volume (m^3/day)	Dump Truck (No.)	Frequency of Collection
District I				
Bacoor	305,699	260	6 mini.	Daily
Kawit	62,751	40	3	Daily
Noveleta	31,939	120	1 and 2 mini.	Daily
Rosario	66,721	15	3	Daily
District II				
Trece Martires	41,653	240	2 and 2 mini.	2 Dump: 5 days a week 2 Mini.: 7 days a week
Dasmariñas	379,512	295	15	Once a week
Gen. Trias	109,845	166	9	Twice a week
Imus	195,482	226	14	Once a week
Tanza	127,147	120	15 mini.	Every other day
District III				
Amadeo	27,737	10 ton	1	3 times a week
Indang	-	-	-	-
Silang	156,628	50	2	3 times a week
Total	1,505,114	1,542		

Source: Provincial Government of Cavite

Table R 3.18 Volume of Market Wastes and the Waste Collection System

Municipality	Size of Market			Collection System		
	Total Area (ha)	Number of Stalls	Frequency of Market Opening	Volume (m^3/day)	Number of Dump Trucks	Frequency of Collection
District I						
Bacoor	Unknown	612	Everyday	72	2	Daily
Kawit	0.7	582	Everyday	12	1	Daily
Noveleta	0.1	177	Everyday	4	1	Daily
Rosario	0.3	468	Everyday	6	3	Daily
District II						
Trece Martires	0.9	202	Everyday	12	1 mini.	Twice a day
Dasmariñas	1	819	Everyday	36	2	Daily
Gen. Trias	1.5	293	Everyday	8	1	Twice a day
Imus	2.5	860	Everyday	61	2	Daily
Tanza	4.0	504	Everyday	Unknown	1 mini.	3-4 times a day
District III						
Amadeo	1.1	191	Twice a week	4	1	Twice a week
Indang	-	-	-	-	-	-
Silang	0.8	820	4 times a week	10	Unknown	Daily
Total				225		

Source: Provincial Government of Cavite

The measure for disposal of the above household and market wastes in the Province could be classified, in general, into open dumping, composting and burning. The local government units (city/municipalities) in the Project Area operate their own designated open dumping site (refer to Table R 3.18 below). In spite of the designated dumping site, a considerable volume of the solid wastes is being dumped into open spaces, bridges, canals and rivers, causing water pollution.

Among the local government units in the Project Area, Imus Municipality had established an eco-center. The eco-center produces and provides the compost free to farmers and to other residents who are interested to use compost as organic fertilizer for their garden plants.

A majority of the city/municipal governments in Cavite Province currently use open dump trucks and/or compactor trucks for the collection of solid wastes. Such vehicles are, however, inadequate and could hardly achieve the appropriate collection level.

Table R 3.19 Disposal Site of Household Waste in the Study Area

Municipality	Type of Disposal	Location (Barangay)	Area (ha)	Lifespan
District I				
Bacoor	Open dumping	Molino IV	5.0	Unknown
Kawit	Open dumping, Burning	Batong Dalig	0.01	5 years
Noveleta	Open dumping	Salcedo II	0.5	None
Rosario	Open dumping, Burning, Composting	Kanluran	3.0	5 years
District II				
Trece Martires	Semi-land fill	De Ocampo	1.9	10 years
Dasmarinas	Open dumping	Lankaan II	1.0	1 year
Gen. Trias	Open dumping	Tapia	1.5	1 year 3 months
Imus	Open dumping	Pasong Buaya	1.0	2 years
Tanza	Open dumping	Sahod Uldan	5.0	Temporary
District III				
Amadeo	Open dumping, Burning	V Poblacion	1.0	5 years
Indang	-	-	-	-
Silang	Open dumping, Burning	Lalaan I	0.5	Temporary

Source: Provincial Government of Cavite

(2) Industrial Waste

According to the "2005 Socio-Economic Profile, Cavite Province," the present total industrial waste generated daily in Cavite Province is estimated at about 1,000 metric tons and

50 percent of it is considered hazardous. Toxic and hazardous wastes generated by industries within the province are currently collected and transported to Manila and Laguna by the particular firms accredited for treatment of toxic and hazardous wastes.

(3) Health Care Waste

Cavite Province had procured an autoclave system through Pan Asia Environment (PAE) Phil., Inc., for the treatment of health care wastes. The autoclave system currently serves all the government hospitals and six private hospitals in the Cavite province.