PART I
General and Present Condition

CHAPTER 1 INTRODUCTION

1.1 Background and Objectives

1.1.1 Study Background

The study area is located in the western river basins of Mount Pinatubo in the mid-western part of Luzon Island, as shown on the attached location map. Luzon Island is situated in the active volcanic and earthquake zone between the East Luzon Trench to the east, and the Manila Trench to the west.

In June 1991, Mount Pinatubo erupted and approximately 6.7 billion m^3 of pyroclastic material was deposited around the mountain slopes. Of the deposited materials, it is estimated that about 4.7 billion m^3 was deposited in the study area. A report issued by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) shows that the amount of pyroclastic material deposited in the respective basins of the Bucao, Sto. Tomas and Maloma Rivers was 2.8 billion m^3, 0.6 billion m^3 and less than 0.1 billion m^3. Deposited materials were then transported down the mountain in the form of mudflow during the rainy season.

Since the eruption of Mount Pinatubo, twelve years have passed and the volcanic activity has subsided. However, the lahar materials deposited on the mountain slopes continue to be remobilized with the occurrence of concentrated rainwater resulting in secondary disasters including mudflows, riverbed rising and flood/mudflow inundation. Livelihood in both of lowland and mountainous areas, which has been damaged due to deposition of volcanic ash and pyroclastic flow material and resulted influence to infrastructures, has not been recovered yet in the western river basin.

The Government of the Philippines (GOP) made a large effort to implement a rescue mission immediately after the eruption of Mount Pinatubo, and organized the “Mount Pinatubo Commission (MPC)” to rescue approximately 600,000 affected inhabitants. Since then, this Commission has promoted employment searches for the affected people and has constructed approximately 34,000 houses. Meanwhile, the Department of Public Works and Highways (DPWH) has implemented mudflow disaster prevention facilities including levee construction.

The Government of Japan (GOJ) has provided assistance in the establishment of a mudflow forecasting and warning system, supply of construction equipment and construction of sabo dams.

As it was anticipated that a huge volume of the deposited material has been transported down the mountain and has induced secondary disasters, the GOP requested assistance from the donor countries for the preparation of a flood and mudflow control plan. In response to this request from the GOP, the United States of America (USA) prepared a long-term flood and mudflow control plan for eight major rivers around Mount Pinatubo and the final report was issued in March 1994. This control plan has not been implemented in the western river basins of Mount Pinatubo except for levee construction due to the occurrence of a large-scale mudflow, and also because rehabilitation of the western side has a relatively low priority compared with the eastern side.

In view of recovery of the livelihood and equitable regional development as well as the anticipated disasters due to flood and mudflow, the GOP requested a technical assistance to the GOJ to conduct a master plan formulation and feasibility study (the study) for sabo and flood control in the western river basins on the basis of the present basin conditions. In response to the request, the GOJ decided to conduct the study and the implementing arrangement (IA) was signed on December 6, 2001 between JICA and DPWH. In accordance with the IA, the study team was organized by JICA and dispatched to the Philippines to commence the study in April 2002 after some preparatory works in Japan in March

2002.

1.1.2 Study Objectives

The objectives of the study are as follows:

(i) To formulate a master plan for sabo and flood control in the major three rivers (Bucao, Maloma and Sto.Tomas Rivers), and to carry out a feasibility study for main priority projects, however, excluding a study on internal drainage issues,

(ii) To transfer technology that is used for the formulation of plans for sabo and flood control to the counterpart personnel during the study, and

(iii) To assist with disaster rehabilitation and economic development in the study area, as well as other river basins in the Philippines, by transferring planning technology which would reduce regional economic disparity and poverty levels and therefore improve and enhance the welfare of the regional inhabitants.

1.1.3 Study Area

The study area is confined to the western river basins of Mount Pinatubo as shown in the location map. The subject rivers of the study are the Bucao, Maloma and Sto.Tomas Rivers. The municipalities concerned are Iba, Botolan, Cabangan, San Felipe, San Narciso, San Marcelino, San Antonio and Castillejos, all of which are located in Zambales Province.

1.1.4 Scope of the Study

The study is divided into the following two phases:

(a) Phase 1: Basic study and formulation of master plan for sabo and flood control. The high priority projects are selected as the subjects for a feasibility study to be performed in the subsequent phase.

(b) Phase 2: Feasibility study for the high priority projects. A supplementary investigation is carried out for the priority project and a feasibility study on sabo and flood control works is performed.

1.2 Study Schedule and Activities

1.2.1 Study Schedule

The study is to be carried out over 18 months between the middle of March 2002 and the beginning of September 2003. Figure 1.2.1 shows the overall work schedule for the study. The study is comprised of two phases, namely, Phase 1: Formulation of the master plan between March 2002 and October 2002, and Phase 2: Feasibility study for the high priority project between November 2002 and September 2003.

1.2.2 Activities

Figure 1.2.2 shows the progress of the phase 1 and 2 studies. The details are as follows:

(1) Explanation and Discussion about Inception Report

Upon submission of the inception report to the DPWH on April 1, 2002, the contents of the report were explained by the study team to the counterpart staff of the DPWH and the Technical Working

Group on April 2 and 3, 2002, respectively. The Steering Committee meeting was held on April 4, 2002, and the study approaches and methods proposed in the inception report were accepted in principle by the committee.

(2) Collection and Analysis of Data/Information and Field Reconnaissance

Data/information relevant to the study were collected in the National Government Agencies in Manila, in their Regional Office No. 3 in San Fernando, and in Local Government Units (LGUs) in the study area. Field reconnaissance was also conducted in the study area to acquire the necessary information about the natural and social conditions in the basin.

(3) Field Investigations

Field investigations conducted for the master plan formulation included: a) installation of hydrological gauges and observation, b) topographic survey and mapping, c) geological investigation, d) a traffic volume survey, e) a water quality survey, f) a riverbed material survey, g) a river structures inventory survey, and h) a flood damage survey. All the field investigations were completed during the phase 1 study period, although some delays were experienced in the topographic survey due to severe floods that occurred in July 2002.

Four rainfall gauges were installed in the study area and in San Fernando. In addition, three sets of staff gauges were installed on the Bucao, Maloma, and Maculcol Bridges to record the river water level. The recording commenced in the middle of June 2002 at all the stations and still continues.

Aerial photogrammetric maps were prepared covering a part of the study area for 793 km^2 including 300 km^2 of the Mount Pinatubo western slope, 180 km^2 of the Bucao River basin, 30 km^2 of the Maloma River basin and 283 km^2 of the Sto. Tomas River basin.

The geological investigation planned at the Maraunot Notch using core drilling was not undertaken by the DPWH in the phase 1 stage because of a contractual problem with the local contractor. The geology of the notch was assessed by the study team at the master plan level using the existing data as well as the results of a visual inspection at the notch.

(4) Formulation of a Master Plan for Sabo and Flood Control

A master plan for sabo and flood control was formulated for the Bucao, Maloma and Sto. Tomas River basins based on the collected data/information and results of the field investigations as well as discussions with the DPWH counterparts and the other agencies' officials. The three main components of: structural measures, non-structural measures and community based disaster prevention plans were combined in the master plan. In planning the structural measures, future sediment yield was estimated, and sediment balance and mudflow simulation analysis were conducted. The planning scale was set at a 20-year probable flood as being the most economical within reason.

The proposed structural measures in the master plan include: 1) dike heightening, a consolidation dam and sand pockets in the Bucao River, 2) channel improvement in the Maloma River, 3) dike heightening/strengthening, channel training works and sand pockets with a consolidation dam in the Sto. Tomas River, 4) the Maraunot Notch improvement by gabion mattress, and 5) reconstruction of the Bucao, Maloma and Maculcol Bridges.

The proposed non-structural measures in the master plan are: 1) a flood/mudflow forecasting and warning system, 2) improvement of evacuation centers, 3) extension of community-based forest management, and 4) basin management of the Mapanuepe Lake.

The proposed community-based disaster prevention plans include: 1) agricultural development on the lahar area, 2) disaster information and education, 3) livelihood programs for the GOP resettlement centers, and 4) community infrastructure development for the NGO resettlement centers.

Priority projects were selected from the projects proposed in the master plan in order to conduct a feasibility study in the next phase (Phase 2). The selected priority projects were: 1) Bucao River dike heightening including reconstruction of the Bucao Bridge, 2) Sto. Tomas River dike heightening/strengthening and channel training/sand pockets, 3) the Maraunot Notch improvement, 4) a Provincial/Municipal level flood/mudflow forecasting, warning and evacuation system, 5) community infrastructure development in the Tektek resettlement center, 6) extension of community-based forest management, and 7) a pilot project for agricultural development on the lahar area.

The above mentioned master plan and priority projects were reviewed and modified in the subsequent stage.

(5) Initial Environmental Examination (IEE)

The initial environmental examination (IEE) was carried out in order to identify potential impacts of the proposed structural measures in the master plan on the physio-chemical, biological and socio-economic environmental conditions. The IEE also included a study on mitigation measures and the preparation of an environmental management plan. A consultation meeting was held in Iba to explain the results of the IEE to the LGUs concerned.

(6) Workshops for Master Plan Formulation

Workshops were held in Iba on September 19, 2002 and in Manila on September 24, 2002 to explain the results of the master plan formulation, including the selected priority projects, to the DPWH counterparts and other staff, staff of the National Government Agencies including their regional offices, LGUs, NGOs, etc. After explanation and discussions, the participants agreed in principle on the proposed master plan and the priority projects selected for the feasibility study.

(7) Preparation of Interim Report

The interim report was prepared in the middle of October 2002 as originally scheduled. It presented all the results of the investigation and study conducted during the phase 1 stage.

(8) Transfer of Technology for Master Plan Formulation

Transfer of technology to the DPWH counterparts was carried out through on-the-job training, workshops, Technical Working Group meetings, and joint meetings.

(9) Explanation and Discussion about the Interim Report

Thirty copies of the interim report for the study were sent to the DPWH in Manila from Tokyo in the middle of November 2002. After receiving the report, the DPWH distributed it to the Steering Committee members, the Technical Working Group (TWG), and other related agencies.

An explanation of the interim report was made by the study team followed by discussions in the TWG meeting on December 10, 2002 and the Steering Committee meeting on December 11, 2002, both in Manila. After the explanation and discussions, the master plan and selection of the priority projects, which are presented in the interim report, were accepted in principle by TWG and the Steering Committee.

(10) Technology Transfer Seminars for Master Plan Formulation

Technology transfer seminars took place in Iba of Zambales Province on December 16, 2002 and in Manila on December 17, 2002, as scheduled in Figure 1.2.2, to explain the technologies applied in formulating the master plan for sabo and flood control. There were about 60 participants in Iba and about 40 in Manila. The main topics of the seminar presented by the study team were: 1) the formulated master plan, 2) the flood runoff model through the HEC-HMS, 3) a two-dimensional mudflow simulation, 4) sabo structures, 5) the GIS database, and 6) economic evaluation. A presentation was also made by a DPWH counterpart about the introduction of sabo works in Japan.

(11) Supplementary Survey

The study team collected additional data and carried out supplementary field reconnaissance in phase 2 for the feasibility study. In addition, supplementary field investigations were carried out and completed, which included: 1) a topographic survey, 2) a geological survey, 3) a water and bed material quality survey, 4) agricultural development research on the lahar area, 5) hydrological observation, 6) an environmental impact survey, 7) a cell phone network survey, and 8) an electric resistivity survey at the Maraunot Notch.

As a kind of needs survey for reviewing the community-based disaster prevention plans, PCM workshops were conducted in January and February 2003 to hear from local people, who are living in the resettlement centers and midstream/upstream of the Bucao and Sto. Tomas Rivers, about the present situation and their needs.

(12) Feasibility Design

The feasibility design commenced for the priority projects selected in the phase 1 study. The design includes: structural measures for the Bucao and Sto. Tomas Rivers and at the Maraunot Notch, non-structural measures, and community-based disaster prevention plans, as well as an environmental impact assessment. Among the above, structural measures for the Maraunot Notch improvement were discarded because of present stable geological condition, and only monitoring was proposed. The first scoping meeting for EIA was conducted on January 31, 2003 in San Fernando.

(13) Preparation of Progress Report

A progress report was prepared and submitted in March 2003, at the end of the second works in the Philippines, summarizing interim results from the feasibility study for sabo and flood control carried out in the second works stage.

(14) Transfer of Technology for Feasibility Studies

On-the-job training, the technology transfer seminars, the Technical Working Group meetings and the joint meeting were the main activities undertaken in the second works phase in the Philippines.

(15) Construction of Website for the Study

A website has been prepared by the study team and the DPWH counterparts for disseminating the outline and progress of the study. The DPWH and JICA approved the contents of the website before uploading.

(16) Technical Guidance related to Urgent Small Scale Projects

The DPWH counterparts decided to conduct a feasibility study for the Maloma River Flood Control receiving the technical guidance provided by the study team. The Maloma scheme was initially assessed by the study team and it was not selected as a priority project. However, flood damage occurs every year in the lower stretch of the river and the counterpart agency decided to conduct a study for urgent flood control works with a design reference of a 5- to 10-year probable flood. The study was commenced at the end of April 2003, and a cross sectional survey and hydraulic analysis of the river were carried out in May and June 2003. The study team provided the technical guidance, particularly for the cross sectional survey, flood inundation investigation, and hydraulic analysis of the river.

(17) Environmental Impact Assessment for Priority Projects (EIA)

An EIA for the structural measures of the priority projects was carried out. The second scoping meeting for the EIA was conducted on 21 May 2003, and successfully completed with a minimum of comments. The EIA as well as a resettlement plan were prepared by the study team.

(18) Construction Plan and Operation and Maintenance Plan

Construction plans and operation and maintenance plans were formulated for the structural priority projects. The construction period is scheduled for 35 months for the Bucao flood/mudflow control work, and 35 months for the Sto. Tomas River. A 30-year regular maintenance plan was formulated for sustainable use of the proposed structures. The required budget, staff and equipment to undertake the maintenance works have also been proposed.

(19) Estimate of Project Cost

Project costs for all the priority projects were estimated. For the structural measures, the unit rates for similar projects under international bidding for nearby project sites were investigated. These were the basis of the structural cost estimates. Local price based on unit prices was applied for the cost estimates for non-structural and Community Based Disaster Prevention measures. The total project cost for the priority projects is estimated at P4,019 million, of which the structural measures are estimated at P3,638 million and non-structural and CDPP measures at P381 million.

(20) Preparation of Implementation Program

An implementation schedule and proposed institutional arrangements were formulated and discussed with counterpart agencies as well as the steering committee. The implementation schedule is for 20 years, which comprises the short-term (0-10 years), the mid-term (5-15 years) and the long-term (10-20 years). For institutional arrangements, two PMOs as executing agencies are recommended. PMO-MPE, the existing office under the DPWH, should be responsible for implementation of the structural measures, and PMO-Zambales under the Provincial Government should be responsible for implementation of the non-structural and CDPP measures. A Project Coordination Committee and a Working Group are also proposed to integrate the benefit of the structural, non-structural and CDPP programs.

(21) Project Evaluation and Recommendation

A project evaluation for the respective priority projects as well as the overall project was conducted. An integrated approach for the recovery and further disaster mitigation activities is strongly recommended in this study. This would solve the complexity of the problems caused by the disaster damage, the poverty situation and the environmental degradation, and would provide security against the further disasters. The overall Economic Internal Rate of Return (EIRR) is estimated at 20.0%.

(22) Workshop for River, Sabo and Disaster Prevention

The second set of workshops for sabo and disaster prevention were held in June 2003 in Iba and Manila. The study team carried out the public dissemination of the results of the feasibility studies and held discussions with the participants. The comments raised in the workshops were taken into account when finalizing the feasibility studies.

(23) Preparation of Draft Final Report

To contain all the aspects mentioned in items (1) through (22) above, a draft final report was prepared in July 2003.

(24) Explanation and Discussion about Draft Final Report

Thirty copies of the draft final report were submitted to DPWH on July 31, 2003. The contents of report were explained by the study team to the Technical Working Group (TWG) on August 6, 2003 and the Steering Committee on August 11, 2003 in Manila. Through discussions, the Steering Committee and TWG accepted in principle the contents of the draft final report.

(25) Technology Transfer Seminars for Feasibility Study

Technology transfer seminars took place in Iba, Zambales on August 5, 2003 and in Manila on August 8, 2003 to present technologies, especially procedures for feasibility studies of sabo and flood control. The topics were: formulation of overall plan, structural measures, non-structural measures, community disaster prevention systems, and environmental assessment.

Beside the above, a workshop was held in Iba on August 7, 2003 for technologies of agricultural development on lahar area.

(26) Preparation of Final Report

The final report was prepared incorporating the comments of the GOP into the draft final report.

1.3 Transfer of Technology

The transfer of technology is one of the most important objectives of the study. A total of four workshops and four seminars are scheduled for the transfer of technology to the counterpart personnel. A practical schedule, including participating staff, the period and content of the workshops and seminars, is shown in Figure 1.3.1.

In addition to the workshops, meetings with the Technical Working Group, joint meetings, and On the Job Training (OJT) have been carried out during the phase 1 and phase 2 study for the purpose of technology transfer as shown in Table 1.3.1.

(1) Workshops for Master Plan Formulation

The staff who participated in workshops were from a number of national government agencies and regional offices, a science related agency, local government units and NGOs for the purpose of formulation of the master plan and the feasibility study. The number of participants in the workshops in Manila and Iba was approximately 40 and 100, respectively.

The main theme of the workshops on 19 and 24 September 2002 was to explain and discuss the master plan and the priority projects for the feasibility study. The participants generally agreed on the proposed master plan and priority projects for the feasibility study.

(2) Technology Transfer Seminars

The first technology transfer seminars were held in the Training Center of Ramon Magsaysay Technological University, Iba, Zambales on December 16, 2002 and in the Multipurpose Hall of the DPWH central office, Manila on December 17, 2002. There were 60 participants in Iba including the LGU officials, students, NGO members and DPWH counterparts, while the number was about 40 in Manila with staff from the National Government Agencies and DPWH officials.

The subjects of the seminar in Iba were 1) master plan formulation, 2) the flood runoff model through the HEC-HMS, 3) two dimensional mudflow inundation simulation, and 4) sabo structures. The subjects in Manila were 1) master plan formulation, 2) the flood runoff model through HEC-HMS, 3) the GIS database, 4) two dimensional mudflow inundation simulation, 5) sabo structures, 6) sabo works in Japan, and 7) economic evaluation. Almost all the above subjects were presented by the study team except for "sabo works in Japan", which was introduced by a counterpart official.

There was rather active discussion in the seminar in Manila on topics including the condition of mudflow simulation, the necessity for a public information drive, application of the HEC model, etc. Some questions were raised in the seminar in Iba, such as the purpose of the sabo dam and the meaning of lahar and sabo.

The second technology transfer seminars took place in Provincial Capitol, Iba, Zambales in August 5, 2003 and in the Multipurpose Hall of the DPWH central office, Manila on August 8 to explain mainly procedures of the feasibility study for sabo and flood control.

(3) GIS Seminar

Subsequent to the introductory explanation on GIS given in the technology transfer seminar held on December 17, 2002 in the DPWH central office in Manila, the GIS seminar took place on February 20 to 22, 2003 at the study team's office in Iba. The seminar was designed for the DPWH counterparts and LGU officials to practice operating the GIS computer software, ArcView 8.1, through direct operation of the computers.

The GIS seminar consisted of such subjects as 1) basic information on the ArcView 8.1 software, 2) editing of a layer and coordinate system, and 3) outline of a digital database. The participants were the DPWH counterparts, Provincial Engineer of the Zambales Province, and staff of the DPWH Iba District Engineering office. All the participants were interested in GIS and actively participated in the seminar.

GIS is a supporting tool to find and analyze problems and/or issues on relevant subjects, and to develop and assess countermeasures. It may be said that, once the trainee is familiar with GIS operation, on-the-job training is more effective than seminars to train staff on how to use GIS for finding, analyzing, developing and assessing.

(4) Workshops for Feasibility Study

The second set of workshops was held in Iba on June 11, 2003 and Manila on June 16, 2003. There were 60 participants in Iba including the LGUs officials, NGO members and DPWH counterparts, while the number was approximately 40 in Manila with staff from the National Government Agencies and DPWH officials.

The objective of the second workshop was to disseminate the results of the feasibility study to the relevant government agencies, people in the study area and the related NGOs and others. The subjects of the seminar were 1) outline of the study, 2) sediment balance analysis, 3) structural design, 4) the GIS database and hazard mapping, 5) non-structural and the CDPP plan formulation, 6) EIA and resettlement plans, and 7) project evaluation and institutional planning.

An open forum was conducted after the presentation to discuss the output from the study team. The comments raised in the open forum have been assessed / considered in finalizing the feasibility study.

(5) Meetings with Technical Working Group

Nine Technical Working Group (TWG) meetings have been conducted during the field investigation works between April 2002 and August 2003. The TWG is composed of the Director, Assistant Directors and Managers of the related divisions in the DPWH, National Water Resources Board (NWRB), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), PHIVOLCS, and Department of Environment and Natural Resources (DENR).

In the TWG meetings, progress of the study was presented by the study team and counterparts for discussion. The counterpart staff largely conducted the presentation on the progress and output of the respective sector, which is one way of transferring technology from the study team to the counterpart team. This was quite effective to encourage the participation in the study and to understand the various technical aspects.

Throughout the presentation in the TWG meetings, the counterpart staff gained a good understanding of the details of the study and investigations as well as improving their presentation skills.

(6) Joint Meeting

There were four joint meetings for the purpose of transferring technology from the study team to the counterpart staff. The participants in the joint meetings were generally all members of the study team and counterpart staff working in Iba. The meetings were usually held prior to the TWG meetings, and the experts of the study team presented the progress and outputs of the study in respective parts. Various comments and questions were raised by the counterparts and detailed discussions were generally conducted for the entire day.

(7) On the Job Training (OJT)

On-the-job training has been provided to each counterpart through day-to-day work with the study team member. The training includes explanation by the study team member and discussion with the counterpart on the purpose and procedures of the investigations and studies for each field. It also involves conduct of investigations and studies together with the study team member and an exchange of opinions on the future application of the procedures in the training and the results of the studies.

The previous experience of the on-the-job training conducted during the phase 1 study, however, suggested that this type of training was less effective compared with joint meetings, workshops and technical working group meetings. Improvement of on-the-job training was required for effective technology transfer.

As a trial, a target setting and post evaluation system was introduced for the on-the-job training for the phase 2 study. Each counterpart set his/her own target for the training before starting and achievement was evaluated by him/herself on its completion together with getting comments from the study team member. The prepared target setting and post evaluation sheets are attached for each counterpart in appendix XV. Results of the training show that the target setting and post evaluation system functions well for guiding their daily work and assessing progress. It was confirmed that on-the-job training through the target setting and post evaluation system was quite effective for monitoring the progress and output of the training for both the experts and the counterpart personnel.

CHAPTER 2 MOUNT PINATUBO ERUPTION

2.1 Mount Pinatubo Eruption

2.1.1 Volcanic Activities

Mount Pinatubo is surrounded by a highly dissected depositional apron of older pyroclastic flow, lahar, and associated stream deposits. According to a geological survey by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the US Geological Survey (USGS), older eruptive periods have been identified by ^{14}C dates on charcoal in pyroclastic flow deposits at approximately 2,500 to 3,000, 5,000 to 6,000 and 35,000 years ago. The last eruption has been dated at 460±30 years ago.

On July 16, 1990, an M7.8 earthquake occurred along the Philippine Fault, about 100 km northeast of Mount Pinatubo. The seismic records measured by PHIVOLCS show that an M4.8 earthquake occurred about 10 km southeast of Mount Pinatubo a few hours after the main shock. It was thought that the renewal of the Mount Pinatubo activity may have been caused by an earthquake along the Digdig Fault, a segment of the Philippine Fault Zone, creating a landslide along the northwest side of the volcano.

The initial eruptive activity was characterized by minor steam and ash explosions 1.5 km northwest of the summit. Only a very thin layer of ash was deposited over the area and the surrounding forests near the explosion vents were devastated. However, no lahars were observed. It was only after some major eruptive sequences on July 12 that the pyroclastic-fall and pyroclastic-flow deposits appeared on the flanks of the edifice.

On June 15, 1991, after 400-500 years of dormancy, Mount Pinatubo awoke with a climatic Plinian eruption. Mount Pinatubo's summit was lowered from 1,745 m to 1,449 m as shown in Figure 2.1.1. The caldera floor was partially filled with water to form a lake. The early filling may have been attributed partly to groundwater seepage while the rest could be due to rainfall and leakages of brine from the pre-volcanic basement.

The Government of the Philippines had planned for the overall development in Luzon Island before the eruption of Mount Pinatubo. In order to restore the development condition on the targeted region, top priority was to be given to the restoration of the areas that had suffered from flooding and mudflow, and prevention of probable disaster. The National Economic and Development Authority's (NEDA) plan had proposed that a triangular zone, connecting Manila, Subic and Clark, was to be the most important area for regional development. In order to realize the middle Luzon development plan, following on from the restoration work in the economically active eastern region, implementation of restoration works was required in the western region of Mount Pinatubo.

The key framework for the restoration of the western region was the enhancement of security of the Olongapo-Iba road, which is the main artery in the region. Securing this road network is the basis for sound development in the region. Along the coast of the Zambales district, this road runs across the mouth of the Sto. Tomas, Maloma and Bucao Rivers. It is important to study the development framework of the whole region when considering measures for enhancement of the security of this road network.

Another key framework is the improvement of land use. The economy of the region depends entirely on agriculture. However, due to repetitive disasters caused by flooding and mudflow, the land use potential has been degraded. The establishment of measures to promote agricultural land use in the inundated areas is a key point in the regional development, together with enhancement of the security of the road network.

In order to facilitate the restoration of the above two sectors, it will be prerequisite to stabilize the three rivers, which have a huge amount of erupted lahar deposits in their upstream reaches and braided channels, having raised riverbeds due to mudflow in their downstream stretches. In other words, restoration works for the above two sectors is possible through the establishment of a plan to stabilize the three river channels and prevent riverbed rising.

2.1.2 Pyroclastic Fall and Flow Deposits

Areas within the 10-40 km radius danger zone of Mount Pinatubo bore the brunt of heavy ashfall blown all over the archipelago. The volume of the pyroclastic flow deposited on the slopes of Mount Pinatubo was estimated to be approximately 5 to 7 billion m^3. These hot deposits, up to 220 m thick in places, covered approximately 120 km^2. They completely filled the upper catchment of the rivers and formed broad deposition surfaces that extended as far as 16 km downstream from the vent. The pyroclastic flow deposit, lahar deposit (as of 1991) and isopack line of ash fall are shown in Figure 2.1.2.

The total accumulation of pyroclastic flow deposits was the greatest to the west and northwest in the Bucao River, but substantial deposition also occurred to the southwest in the Marella River, to the east in the Sacobia-Bamban River, and to the north in the O'Donnell River. Figure 2.1.3 shows the deposition and erosion of pyroclastic material at the Marella River from 1991 to 2002.

2.1.3 Lahar

(1) Lahar Characteristics

"Lahar" is an Indonesian term, defined as "… a rapidly flowing mixture of volcanic rock debris and water from a volcano". Lahars from Mount Pinatubo, triggered by heavy monsoon or typhoon rainfalls on erodible erupted materials, have been flowing into densely populated areas of Luzon since the major eruption of June 1991. Although the toll of lives was small, enormous property loss and social disruption was caused. For the following four years (1991 – 1994), the most devastating lahars were generated during prolonged southwesterly monsoonal rains that were induced by the passage of tropical typhoons in the vicinity of Luzon.

Lahars were classified into the following two types depending on the flow characteristics:

1) Debris flows typically had peak discharges of several hundred to a thousand m^3/s and contained about 60-65% (rarely, 70%) sediment by volume.

2) Hyper concentrated flows typically had peak discharges of several hundred m^3/s and contained about 50% sediment by volume. Hyper concentrated flows are numerically more common, but the large debris flows carry a large part of the sediment that is deposited downstream.

(2) Grain Size Distribution

The grain sizes and specific gravity have a great influence on sediment transportation. Regardless of whether it originates as a primary hyper concentrated flow or as the runout of a debris flow, flows with hyper concentrations of sediments volumetrically dominated the flow system and depositional records in the downstream reach.

Hyper concentrated flow deposits in the drainage of Mount Pinatubo are dominated by sand-size phenocrysts from the pyroclastic flow deposits with an admixture of mineral grains from older deposits. Pumice clasts are present but are volumetrically minor; most are preserved in coarse deposits near the surface.

2.2 Extent of Damage

2.2.1 Damage Immediately after Eruption

The massive damage caused by the Mount Pinatubo eruptions and the lahar flows that followed was valued at 10.6 billion pesos at the end of 1991[*1]. The heaviest toll was on public infrastructure, including power, telecommunications, water supply systems and school and health facilities, estimated at 3.8 billion pesos as given in Table 2.2.1. Losses to agriculture were estimated at 1.8 billion pesos, to commerce and industry, 851 million pesos, and natural resources, 120 million pesos.

The total cost for relief operations, evacuation and resettlement, rehabilitation and reconstruction was estimated at 30 billion pesos (US $1.034 billion). The cost of reconstruction and rehabilitation of vital infrastructure like roads, bridges and other facilities was placed at 9.5 billion pesos.

Approximately 489 km of major national roads and 163 km of municipal roads in Pampanga, Zambales, Bataan and Tarlac were covered under 20-40 cm of ash and sand. Six major bridges, namely Abacan, Pandan (Sapang Maraqui), Mancatian and Pabanlag in Pampanga, and Santa Fe and Umaya in Zambales collapsed immediately after the eruption. Later, lahar flows destroyed the Bamban Bridge in Tarlac, and a portion of Capaya Bridge along the north expressway in Angeles City. Two bridges along the Botolan-Capas road in Botolan, Zambales were inundated while the approaches of several bridges were also damaged. In all, 13 major bridges were destroyed or damaged.

Spans of four railway bridges in Angeles, Dau and between Mabalacat and Bamban were washed away by cascading lahars. Ten telegraph stations in Zambales, 13 in Pampanga, and three in Tarlac had either collapsed buildings, damaged telecommunications and office equipment or telephone lines.

2.2.2 Amount of Damage to Zambales up to year 2000

The damage due to ashfall, pyroclastic flow and lahar flow were tremendous in Zambales. According to PDCC in Zambales, 19 barangays were completely buried due to the pyroclastic flow and the lahar flow after the eruption. The affected families in Zambales were estimated at approximately 66% of the total in Zambales. One-third of the houses in Zambales were totally damaged, and another one-third of houses were partially damaged due to the disasters caused by the eruption of Mount Pinatubo in 1991.

It was reported that 215 persons were dead and 157 persons were injured in Zambales in the course of the Mount Pinatubo disasters as of 2000.

During the height of the Mount Pinatubo calamity period, there were 70 evacuation centers in Zambales. Total evacuees were estimated at 260,000, which was approximately 60% of the provincial population of Zambales. Among them, 55,000 were evacuated into evacuation centers, and the rest were evacuated to other places. The additional expense due to the evacuation was estimated at P7.00/day/person.

[*1] The Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River Draining from Mt. Pinatubo, May 1996, JICA

The damage to the infrastructures was also quite serious. The estimated amount of damage to the infrastructure was 206 million pesos in 1991. 75% of the irrigation facilities were not functioning, and the production in the irrigation area was reduced by 64%. Farm land was reduced by 57%, which was buried by the deposition of pyroclastic materials.

The Mount Pinatubo Commission in the area of Zambales immediately planned the rehabilitation / reconstruction of the area, with the following budget schedule:

Proposed Budged for Rehabilitation Program in Zambales

No.	Item	Amount (Million Pesos)
1	Infrastructures	
	a) Roads	268.7
	b) Bridges	31.5
	c) School Buildings	512.2
	d) Health Facilities	28.5
	e) Public Buildings	69.8
	f) Irrigation	110.0
	g) Water Supply	36.1
	h) Flood Control	423.0
	i) Others	91.6
	Sub-Total	1,573.4
2	Livelihood	
	a) Livestock/Poultry	3.7
	b) Crop Production	5.9
	c) Agro-Forestry	13.2
	d) Others	5.3
	Sub-Total	28.0
3	TOTAL	1,601.4

Source: MPC

However, the above budget was not released in a timely manner and no major rehabilitation activities have commenced yet due mainly to financial constraints.

2.3 Immediate Efforts by the Government and Others

2.3.1 Efforts Immediately before Eruption

Research activities were conducted by PHIVOLCS with technical assistance by USGS before the eruption of Mount Pinatubo. Detailed observation and monitoring of volcanic activities was carried out, including investigations of the mechanism of eruption and changes in topography due to volcanic activities. The research results were compiled into a hazard map and disseminated to the Local Government Units (LGUs) and local people within the possible hazard area.

Immediately before the eruption of Mount Pinatubo in 1991, evacuation of people residing in and around Mount Pinatubo was performed smoothly because the warning for evacuation was issued as specified in the hazard map prepared by PHIVOLCS. The issuance of a warning with some time tolerance made it possible to decrease the number of fatalities that would have been caused by volcanic cinders and/or pyroclastic flow.

2.3.2 Emergency Activities and Organizations

The Presidential Task Force Pinatubo was established on June 26, 1991 to put in place a concrete structure to guide the rehabilitation efforts of the government after the eruption of Mount Pinatubo. The task force was replaced by the Mount Pinatubo Commission (MPC) in October 1992. MPC carried out various activities including relief activities, urgent support, development of resettlement areas, livelihood programs for the affected people and damage investigations with assistance from various foreign donors. Through their own funding, MPC constructed approximately 34,000 houses (with a total capacity of approximately 160,000 people) within the resettlement areas.

In 1992, MPC prepared an "Integrated Plan for the Mount Pinatubo Affected Areas" to deal with the most urgent activities. For the major river basins, the plan aimed at providing appropriate and feasible engineering solutions to mitigate the damage in areas identified to be prone to the continuing threat of lahar, flooding and other related hazards. Their policies and strategies are described in the integrated plan as follows:

1) Engineering intervention measures shall be provided only to the extent where they can reasonably, or in a feasible manner, save or protect communities and areas from further damage. The protective measures should be conclusively shown to be reasonable or feasible in technical, economical, social and environmental terms.
2) Given the nature and magnitude of the problem; i.e., the potential damage from lahar, floods and other hazards, it is necessary that all promising alternative schemes, both engineering and non-engineering, be explored and evaluated, taking into account the degree of risk to each affected area.
3) In technical terms, the engineering intervention means to be adopted must be structurally sound in the sense that they can safely and adequately contain or discharge the designed volume of lahar and flooding, and withstand their destructive forces, based on accepted engineering design and construction standards.
4) In economic terms, the engineering measures must be feasible, generating benefits to the economy that exceed project costs. Where several alternative measures are considered, the one with the greatest economic benefit to cost ratio will be adopted. Quantifiable economic benefits resulting from the engineering measures include, (i) damage or loss reduction to crops, industrial/business operations, infrastructure, properties and lives, (ii) avoided costs when engineering measures are implemented such as relocation, livelihood, health and welfare expenses.
5) In social terms, the engineering measures must result in minimum dislocation of households and in maximum protection of communities against lahar, flooding and other hazards. Moreover, the measures must be acceptable to the majority of the people affected.
6) In environmental terms, the engineering measures must result in minimum displacement of sensitive habitats and minimum health/sanitation hazards from lahar, flooding, and other threats.

For each of the major rivers, a discussion on the risks that may occur within their impact areas should precede the presentation of the corresponding engineering intervention measures needed to mitigate any adverse effects. The structural measures should also be classified based on their implementation duration such as short-term, medium-term and long-term plans.

2.3.3 Structural Measures and Responsible Organizations

The DPWH was appointed as the organization responsible for urgent rehabilitation and protection measures against lahar and flood damage. The DPWH prepared an infrastructure rehabilitation plan for the period of 1992-1997 for the Mount Pinatubo affected areas, focusing on the following priorities:

1) Keeping transport systems, particularly major roads and river crossings, open in order to provide uninterrupted movement of people, goods, and services to enhance speedy recovery and rehabilitation.
2) Protection of life, communities, agricultural and fishpond areas and infrastructure from further

destruction, and mitigation of the effects of potential damage, especially from lahar and flood waters.
3) Reconstruction and rehabilitation of schools and other public buildings to areas outside of those affected by mudflows to restore the educational program and essential administrative services.
4) Support to rehabilitation activities of other agencies by providing assistance to relief and social services, and infrastructure support to resettlement and livelihood programs.

Based on the above policy, the DPWH formulated two Project Management Offices (PMO) to execute the rehabilitation / lahar and flood control works. One is PMO-Mount Pinatubo Rehabilitation (PMO-MPR), which is in the DPWH-Region III office. PMO-MPR is the executing body for the projects funded by the Government of the Philippines.

The other PMO is PMO-Mount Pinatubo Emergency (PMO-MPE) in the DPWH-Central Office. PMO-MPE is the executing body for the foreign assisted projects. To date, the activities of PMO-MPE have been limited to only the eastern part of Mount Pinatubo, such as the Sacobia-Bamban River, the Pasig-Potrero River and the Porac-Gumain River.

In addition to the two PMOs, the District Engineering Office of Zambales, in the DPWH-Region III, is also working on various activities in the western part of Mount Pinatubo.

2.3.4 Structural Rehabilitation Plan

The structural rehabilitation plan was initially prepared by MPC in 1992 as part of the "Integrated Plan for the Mount Pinatubo Affected Areas". In this plan, the basic concept of rehabilitation activities was prepared by the various government agencies of the Philippines.

For mudflow and flood control activities, the "Recovery Action Plans for Eight River Basins of Mount Pinatubo Area" was prepared by the USACE in March 1994. This was the basis of the existing and on-going structural rehabilitation, particularly for the river training and improvement works to prevent further damage.

For the eastern part of Mount Pinatubo, "The Master Plan and Feasibility Study on Flood and Mudflow Control for the Sacobia-Bamban and Abacan Rivers draining from Mount Pinatubo" was carried out by JICA, completed in May 1996. The proposed permanent rehabilitation plan for the Sacobia-Bamban River was realized by the DPWH in the year 2001 with financial assistance from the Japan Bank for International Corporation (JBIC). The DPWH also conducted the study for permanent rehabilitation of the Pasig-Potrero River and the Porac-Gumain River with financial assistance from JBIC. Construction works for the Pasig-Potrero River are currently on-going, and are scheduled for completion in the year 2004.

For the western part of Mount Pinatubo, embankment dike construction, revetment works for dikes, and temporary channel excavations continue to be based on the structural rehabilitation plans mentioned above. No permanent rehabilitation measures have yet been carried out for the Bucao, Maloma and Sto.Tomas River basins in the western part of Mount Pinatubo.

2.3.5 Support of Donors

Immediately after the eruption of Mount Pinatubo, the Government of the Philippines took action in the form of damage investigations, relief activities, and urgent recovery of the damage to basic infrastructure through a task force under the Office of the President. The task force was formulated just 10 days after the eruption.

International agencies and foreign donors also contributed with various types of urgent support and technical assistance.

Assistance from the USA was conducted before the eruption of Mount Pinatubo, through the investigation and forecasting of volcanic activities. USGS was the main-body for the assistance involving the activities of PHIVOLCS. They published a study report in June 1992 describing the protection against mudflow damage. In addition, USAID and USACE conducted an overall study in 1992. Aerial photographs were taken for the entire Mount Pinatubo basin area, and a study on the natural conditions and engineering measures was carried out.

The Swiss Government dispatched a mission to conduct a hazard assessment using a topographic approach.

The Japanese Government executed urgent assistance in the provision of heavy equipment for structural rehabilitation, deep wells/drainage pumps for community rehabilitation and warning systems for efficient evacuation activities. In addition, various technical experts were sent by the Japanese Government to provide technical advice to the Philippines.

In 1992, the Government of the Philippines made a request to donor countries for technical and financial assistance for the rehabilitation of the eight major rivers affected by the eruption of Mount Pinatubo. The following task allocations were proposed; however, they were not all implemented, particularly for the western rivers.

1) Sacobia-Bamban (East):	Japan
2) Abacan (East):	Japan
3) Pasig-Potrero (East):	U.S.A.
4) O'donnell (East):	Switzerland
5) Porac-Gumain (East):	Netherlands
6) Bucao (West):	German
7) Maloma (West):	Denmark
8) Sto.Tomas (West):	E.C.

2.3.6 Support by Non-Government Organizations (NGO)

Various international NGOs participated in the relief and recovery activities immediately after the eruption of Mount Pinatubo. Their activities were primarily in the form of direct support of the affected people, such as the conducting of livelihood programs, improvement of resettlement areas, recovery of agricultural activities, rehabilitation of school buildings and social welfare facilities, provision of scholarships and special assistance for the Aeta people.

Table 2.3.1 shows the list of major NGOs that participated in activities in the study area to support the communities affected by the eruption of Mount Pinatubo.

CHAPTER 3 CHANGES IN THE NATURAL AND SOCIAL BASIN CONDITIONS AFTER THE ERUPTION

3.1 Geographical Location

The study area covers the western river basins of Mount Pinatubo, including basins of the Bucao River, Maloma River and Sto.Tomas River. The area is a part of Zambales Province, which is located on the western coast in the Central Luzon Region with the coordinates of 15 degrees latitude and 120 degrees longitude. The western part of the study area faces the South China Sea, and Mount Pinatubo is located on the eastern side.

The area includes eight municipalities within Zambales. They are, from north to south, Iba, Botolan, Cabangan, San Felipe, San Narciso, San Antonio, San Marcelino and Castillejos. The total study area is 1,444 km^2, which is approximately 40% of the area of Zambales, as shown in the location map.

3.2 Socio-economy

3.2.1 Administrative Structure

The administrative structure of the Philippines comprises 16 Regions which are: National Capital Region (NCR), Cordillera Administrative Region (CAR), Autonomous Region in Muslim Mindanao (ARMM), and Regions 1 to 13. Regions are subdivided into provinces, provinces into cities and municipalities, and cities and municipalities into barangays. The barangay is the smallest administrative unit in the country.

Approximately 95% of the study area is in the Zambales Province in Region 3 (Central Luzon) and is mainly composed of the eight municipalities mentioned above. The eight municipalities concerned are listed (sourced from Figure 3.2.1) in the table below, together with their official administrative areas and the estimated area of the study area in each:

Municipalities in the Study Area

Municipality	Land Area (km^2)	
	Administrative Area (as stated by the Land Management Bureau)	Study Area (% of Administrative Area)
Botolan	614	645 (<100%)
Cabangan	239	175 (100%)
Castillejos	87	20 (<100%)
Iba	153	14 (<100%)
San Antonio	205	17 (<100%)
San Felipe	104	119 (100%)
San Marcelino	441	294 (<100%)
San Narciso	72	75 (100%)
Total	1,914	1,359
Total for Zambales Province	3,611	1,366
Overall Total		1,444

Notes: 1. Due to rounding, totals may not equal the sum of the component figures.
2. Land area of the study area was computed by the JICA study team and does not agree exactly with official figures.
3. (<100%) in column 3 indicates that the study area does not cover the entire area of the municipality.

3.2.2 Population and Employment

(1) Population

From the 2000 Census of Population and Households, the Philippines have a population of 76.5 million. This is an increase of 15.8 million or 26% from the 1990 census total of 60.7 million, equivalent to an annual growth rate of 2.34%. This is consistent with the annual growth rate of 2.35% recorded between the 1980 and 1990 census readings, when the population increased by 48.0 million.

For the eight municipalities[1] that largely cover the study area, the 2000 census population was estimated at 228,148 or only 0.3% of the national population. The average annual population growth rate in the 1990s (i.e. from the 1990 to the 2000 censuses, and mostly since the eruption) was 1.13%, and in the 1980s, 2.39%, a much higher rate, and higher also than the national average (2.34%) but lower than the average for Region 3 (2.62%). In the 1990s, the highest annual average growth rate was achieved by Botolan at 2.78%, while the lowest was –3.57% in San Marcelino.

Of the eight municipalities, Botolan is the largest in terms of land area (613.7 km^2) and population (46,602), while San Felipe is the smallest in population (17,702) and San Narciso in land area (71.6 km^2). Castillejos has the highest population density at 383 people/km^2, compared with San Marcelino which has the lowest at 58 people/km^2. The average for the whole basin is (according to the 2000 census) 119 people/km^2.

Further detail is available in Table 3.2.1 which also shows similar demographic statistics for nine municipalities in the East Pinatubo Study Area[2] in 1995 and 1990.

(2) Labor Force

In 2000, the population aged 15 years and over in Region 3 (national figures are given in brackets after each regional figure) was estimated at 4.965 million (48.076 million), amounting to 62% (62%) of the total population of 8.031 million (76.503 million) as shown in Table 3.2.2. Of this adult population, 61% (64%) were economically active in the labor force, and of this labor force, 90% (90%) was employed, leaving 10% unemployed. Only 8% (20%) of the employed workforce were reported to be under-employed, surely an under-estimate.

In Region 3 in 2000, agriculture absorbed only 25% of the total employed labor force, while services (including trading and community, social and personal services) employed 52%, and industry 23%. National figures show a different employment pattern as follows: agriculture employed 37% of the total employed labor force, services employed 47%, and industry employed 16%.

Table 3.2.3 sets out the labor force nationally and in Region 3 for both males and females in the 2000 census year. Men and women have very similar levels of unemployment, approximately 10% of the total labor force, which is the same nationally and in Region 3. However, of those not in the labor force, 73% are women.

3.2.3 National and Regional Economy

The smallest administrative unit for which regional accounts are available is the ‘region’. For the study area this is Region 3. However, the study area has a population of only 228,000 or 3% of the Region 3 population. Moreover, its estimated total land area of 1,444 km^2 is only 8% of that of Region

[1] Botolan, Cabangan, Castillejos, Iba, San Antonio, San Felipe, San Marcelino and San Narciso
[2] Sourced from The Study of Flood and Mudflow Control for Sacobia-Bamban/Abacan River Draining from Mount Pinatubo, May 1996, funded by JICA.

3. Despite this, the economic performance of Region 3 is outlined here as the best available indicator of economic performance in the study area.

Ranked by per capita gross regional domestic product (GRDP), for many years Region 3 has ranked around the median of the provinces with a slight decrease (7^{th} in 1990, 8^{th} in 1995 and 9^{th} in 2000). In 2000 this indicator was estimated to be 30,800 pesos per capita or 73% of the national average. Details of the GRDP for all provinces in these three years are shown in Table 3.2.4.

Gross domestic product (GDP) in the Philippines was 3,303 billion Pesos in 2000. This is analyzed into gross value added (GVA) of the main economic sectors in Tables 3.2.5 and 3.2.6. The share by sector can be summarized as 15.9% for the agricultural sector, 31.1% for the industrial sector, and 52.9% in the services sector. Similar national statistics for 1995 were 21.6% for agriculture, 32.1% for industry, and 46.3% for services. As Table 3.2.7 shows, per capita GDP was, in 2000, 42,117 Pesos (27,124 Pesos in 1995), equivalent to approximately US$940 (US$1,050 in 1995). The fall in the US$ figure for GDP between 1995 and 2000 reflects the 42% decline in the exchange rate of the Pesos against the US$. During the five years from 1995 to 2000, a significant decline in the relative importance of agriculture can be seen, approximately matched by an increase in services' share of GDP.

Again from Tables 3.2.5 and 3.2.6, the Gross Regional Domestic Product (GRDP) of Region 3 in 2000 was 245 billion Pesos representing 7.4% of GDP in the Philippines. Gross value added for the main economic sectors were: 18.8% for agriculture, 32.9% for industry and 48.3% for services. In 1995 the figures were: 160 billion for Region 3 GRDP representing 8.4% of GDP, and agricultural, industrial and services GVA components of Region 3 GRDP were 24.1%, 37.1% and 38.8% respectively. Between 1995 and 2000, as for national figures, there was a marked shift from agriculture to services accompanied by a relative fall in industrial output.

Table 3.2.8 shows national GDP and Region 3 GRDP at 1985 constant prices by economic sector for 1990, 1995 and 2000. From this table the real annual growth rates in GDP and Region 3 GRDP by economic sector was computed in Table 3.2.9. The real growth of per capita GDP and Region 3 GRDP were obtained in Table 3.2.10.

These three tables show that GDP increased in real terms from 721 billion Pesos in 1990 to 955 billion Pesos in 2000, an average growth rate of 2.85% per annum. The five years from 1995 to 2000 showed the faster annual growth of 3.55% compared with only 2.17% for the five years up to 1995. All three of the main economic sectors performed better in the second half of the decade with services showing the fastest real growth of 4.38% per annum. GRDP in Region 3 performed more erratically than national GDP. Agriculture grew at the slowest rate in both 5-year periods, although growth remained positive throughout. Only the services sector grew consistently and improved from the first period (2.09%) to the second (3.61%)..

As was noted earlier, the net result was a reduction of Region 3's share of both GDP and per capita GDP during the 1990s.

3.2.4 Sectoral Economic Profile

As proposed in the previous section, in terms of GRDP, Region 3 best represents the economic characteristics of the study area. Therefore the sectoral economic profiles of the three west Pinatubo river basins can be deduced from those of Region 3 in this section. Additional information is provided at province and study area level also.

(1) Agriculture

In Region 3, the agricultural sector output is slightly more important than in the nation overall but is declining as a proportion of total GRDP, as is agricultural GVA at a national level. For example, Table 3.2.6 shows that agricultural GVA in Region 3, as a proportion of GRDP, declined from 24.3% in 1990 to 18.8% in 2000 while nationally the equivalent figures are 21.9% and 15.9%. Considering the labor force, Table 3.2.2 shows that in 2000 approximately 25% of employed persons were in the agricultural sector, a higher proportion than the sector's share of GRDP.

Production of the major crops in the Philippines and the region is set out in Table 3.2.11. From this table the most important crops in the country in order of their value in 2000, are paddy (rice), corn, coconut, banana, sugar cane, mango, pineapple, cassava and tobacco. This order has not changed much since 1990. Production of paddy, the staple crop, has increased from 9.3 million tons in 1990 to 12.4 million tons in 2000, equivalent to an average growth of approximately 2.9% per annum. Despite this increase, imports of rice have also risen to a peak of 2.2 million tons in 1998, but have reduced since then to approximately 20% of this amount in 2000.

In Region 3, the major crops were, in order of production value[3] in 2000, paddy, mango, sugar cane, corn, banana, coconut and pineapple. Paddy had by far the largest share at 83% (producing 1.89 million tons) followed by mango (9% share) and sugar cane (5% share). The order has changed since 1990 when paddy was again the dominant crop at 83% (producing 1.91 million tons), but sugar cane ranked second (12% share) followed by mango with a 4% share. No doubt due to the Mount Pinatubo eruption, paddy production in 1995 fell slightly to 1.76 million tons although, curiously, the area of paddy cultivation reported by BAS[4] increased from 521,000 ha in 1990 to 548,000 ha in 1995.

The Mount Pinatubo effect is demonstrated more clearly in Table 3.2.12, which displays paddy production, harvested area and yield in Zambales Province in 1990, 1995 and 2000. Total annual production of paddy decreased from 75,200 tons to 56,500 tons in 1995 (a 25% fall) due to a 28% reduction in the area harvested. By the year 2000, production had recovered to 78,000 tons, partly due to an increase in yield to 3.1 tons per hectare. Similar statistics for white and yellow corn are given for 1995 and 2000 in Table 3.2.13. Figures for 1990 were not available.

Production of mango, now the second most important crop in the region, increased rapidly during the 1990s from 44,000 tons (equivalent to a value of 420 million pesos) in 1990 to 88,000 tons (equivalent to a value of 1.66 billion Pesos) in 2000. Sugar cane production, however, fell from 2.18 million tons in 1990 to 1.30 million tons (equivalent value 914 million pesos) in 2000. It may be significant that the mango price per ton doubled over the decade while the sugar cane price only increased by 15%, in current terms.

Annual averages of current farm-gate prices of paddy and two types of corn in the region given in Table 3.2.14 show a virtually flat trend: between 1996 and 2000, annual growth in all cases averaged less than 1% per annum.

Table 3.2.15 shows that neither Zambales Province nor the study area have nationally significant areas of freshwater fishponds. The entire province has less than 100 hectares compared with 25,500 hectares in the region overall, of which 13,900 hectares or more than half are for commercial scale fishponds. In the province there are no commercial scale fishponds and only Castillejos municipality has more than 20 hectares of fishponds. Table 3.2.16 confirms this by showing that only tilapia production is measured in tons, the annual production ranging between 43 and 59 tons (in 2001).

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[3] Due to Region 3 price information not being available, national values computed from Table 3.2.18 have been used to generate approximate production values for Region 3 crops.

[4] Bureau of Agricultural Statistics in Manila

The livestock and poultry industry is said to be more economically important than inland fishery in the region. Table 3.2.17 shows an inventory of some items of livestock and poultry in Zambales Province from 1996 to 2000. In 2000 there were 32,300 head of cattle, 27,800 carabao, 107,000 swine, 43,300 goats, 829,400 ducks and chicken in the province. As noted elsewhere, agriculture is the least important of the three main economic sectors and is on a reducing trend. This is demonstrated by comparing the above statistics for Zambales with a province where agriculture is the leading sector. In 1998, Isabela Province in Region 2 had an inventory of 75,200 head of cattle, 145,300 carabao, 191,800 swine, 23,800 goat, 570,200 duck and 5,120,200 chickens. Table 3.2.17 also gives farm-gate prices of some livestock and poultry where these are available. These indicate fairly low rates of price inflation between 1996 and 2000 of around 4.2% to 5.4%.

(2) Industry

Tables 3.2.18 and 3.2.19 enumerate, respectively, the industrial establishments registered to DTI in Zambales and the study area from 1997 to 2002, and the assets of the manufacturing industry in 1997 nationally and in Region 3. Region 3 had 1,400 manufacturing firms employing 10 or more people registered in 1997, approximately 10% of the national total at that time, responsible for 151.2 billion Pesos of output and employing a total of 102,700 staff.

(3) Services

In Region 3, services accounted for 48.3% of GRDP and trade accounted for a smaller percentage which could not be determined due to lack of data. According to Table 3.2.18, 4,300 wholesale and retail trading firms and 3,700 establishments providing other services[5] were registered to DTI for business licenses in Zambales Province between 1997 and 2002; the same statistics for the eight municipalities within the study area are 856 trading firms and 466 services firms.

(4) Family Income and Expenditure

Living conditions may be deduced from family income and expenditure statistics. With respect to average family income, Table 3.2.20 shows that the national average of 144,000 Pesos at current prices in 2000 was below similar figures for Region 3 (151,400 Pesos) but higher than those for Zambales Province (123,700 Pesos). After deducting average annual family expenditure, average annual savings in Region 3 (31,400 Pesos) and, surprisingly, Zambales Province (28,600 Pesos) were well ahead of the national average of 26,000 Pesos. This is in marked contrast to the GDP per capita relationship where that of Region 3 is only 73% of the national figure (see 3.2.3).

Examining the Engel coefficient (ratio of food expenditure to total income) in the above three cases gives some apparently conflicting conclusions. For example, the lower income families normally show the higher ratio; in fact the Engel coefficient is a recognized indicator of (relative) poverty. Here, both Region 3 and Zambales Province families save the most and Region 3 has the highest income, but also spend the most on food as a proportion of income: 37.2% and 39.0% respectively, compared with 35.7% for the nation. However, the differences are not large, and Zambales does have the lowest family income.

Similarly, differences in expenditure on housing are relatively small and tend to compensate for the differences in food expenditure. Thus Region 3 and Zambales families that spend more on food than the nation as a whole, spend less on housing items, and considerably less in the case of the family in Zambales Province.

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[5] For example, transport, communications, storage, finance, private and government services.

(5) Price Indices and Exchange Rate

Price indices are vital information for the adjustment of past benefits and costs. In the Philippines, indices of consumer prices (CPI) and wholesale prices (WPI) are published monthly. Tables 3.2.21 and 3.2.22 show both indices from 1985 to mid-2001, together with the most recent figures available for 2002.

The table below summarizes both CPI (for nation and Region 3) and WPI (for Metro Manila: General Index and Construction Materials) for 1985, 1990, 1995, and particular months in 2000, 2001 and 2002.

CPI in the Philippines and Region 3 and WPI in Metro Manila

Year	CPI (1994=100)		WPI (1985=100) in Metro Manila	
	Philippines	Region 3	General Index	Construction Materials
1985	46.1	n.a.	100.0	n.a.
1990	67.1	67.8	141.8	157.5
1995	108.0	107.1	197.1	208.2
2000, December	157.8	157.4	265.5	238.0
2001, June	161.6	159.5	264.3	243.7
2002, January	165.0	161.5	266.7	243.2
2002, August	167.6	163.6	n.a.	n.a.
Ratio (2002/1990)	2.50	2.41	1.88	1.54
Average annual inflation rate (IR)	8.3%	8.0%	5.9%	4.0%

Note: Average annual inflation rate applies to the years 1990 to mid-2002.
Source: 2001 Philippine Statistical Yearbook, NSCB

The above table shows that the average consumer price inflation from 1990 to mid-2002 for Region 3 (8.0%) was very similar to the national figure of 8.3%. However, Table 3.2.21 indicates that the CP index has decreased significantly from the 1980s and early 1990s to the rest of the 1990s and 2002: for the first six months of 2001, national rates were between 6.5% and 6.9% annually. The same trends can be observed for Region 3, but at a lower level: for the first six months of 2001, the CP index was between 5.0 and 6.4. The CPI decreased further from mid-2001 to mid-2002 for both Region 3 (2.6%) and the nation (3.7%).

Wholesale price inflation in Metro Manila generally and for construction materials is lower than the CP inflation, as the above table shows. Details are given in Table 3.2.22.

Table 3.2.23 gives the foreign exchange rate of Pesos per US$ from 1987 to 2001 at the end of each period and the annual average. During the 15-year period, the Pesos fell in value from 20.48 Pesos per US$ to 51.40 Pesos per US$, a decline of 60%. The rate of decline was the highest between 1996 and 2001, but has stabilized somewhat since then, partly due to US dollar weakness.

3.2.5 Infrastructure

(1) Education

For the 2001-2002 school year, the following educational facilities were in use:

Educational Facilities for the 2001-2002 School Year

Level	Philippines	Region 3	Zambales Province
Pre-school	11,643	1,573	87
Elementary	40,284	3,214	220
Secondary	7,509	688	41
Tertiary	1,603	153	7

Note: Both government and private facilities are included at each level
Source: 2001 Philippine Statistical Yearbook, NSCB,
DECS (Department of Education Culture and Sports), Provincial Division & Region 3

Table 3.2.24 shows a detailed distribution of these facilities. The proportion of government to private institutions varied greatly from level to level.

Considering the ratio of elementary schools to population, nationally the figure is 5.27 schools per 10,000 population (40,284 schools per 76.5 million population) compared with ratios of 4.02 (3,214 schools per 8.0 million population) for Region 3 and 5.07 (220 schools per 433,500 population) for the Zambales Province. So both regional and provincial ratios for elementary schools are below the national average, especially the regional ratio.

In the case of secondary schools, the national ratio is 0.98 (7,509 per 76.5 million population) compared with ratios of 0.86 (688 per 8.0 million population) for Region 3 and 0.95 (41 per 433,500 population) for Zambales Province. Here, differences are smaller but neither regional nor provincial ratios exceed the national ratio.

Finally, for tertiary education, the ratios are 0.21 nationally, 0.19 for Region 3, and 0.16 for Zambales Province; again both regional and provincial figures are significantly lower than the national ratio.

Table 3.2.24 also details the number of enrolled students and these can also be reviewed in terms of national, regional and provincial population.

For elementary schools, the ratios of enrolled students to 100 population at national, regional and provincial levels were 16.7, 16.5 and 16.2 respectively. For secondary schools, the three ratios were 7.0, 7.1 and 8.4 respectively. For tertiary education, the ratios were 2.7, 2.0 and 1.8 respectively. Thus in secondary education, Region 3 and Zambales Province perform marginally better compared to the nation, but in only one case, Zambales Province, is the ratio significantly better than the national average.

(2) Medical

Table 3.2.25 shows the distribution of medical facilities such as hospitals, barangay health stations and rural health units, mainly in 2000, in the Philippines, Region 3 and Zambales Province. Facilities are summarized below.

Medical Facilities in the Philippines, Region 3 and Zambales Province

Facility	Philippines		Region 3		Zambales Province	
Hospital	1,712	(81,016)	155	(n.a.)	13	(549)
Barangay Health Station	14,416*		1,464*		80	
Rural Health Unit	2,405#		252#		35	

Notes: Number of beds appears in brackets. * 1999 data. # 1997 data.
Source: 2001 Statistical Yearbook, NSCB, Statistical Yearbook, 2001, NEDA Region 3, Department of Health (DOH), Regional Division

Although hospitals are managed by both government and private bodies, other facilities such as barangay health stations and rural health units are under the general jurisdiction of LGUs.

In the region, there are 43 government hospitals and 112 private hospitals. Nationally, 623 government hospitals and 1,089 private hospitals providing a total of 81,000 beds which amount to 10.6 beds per 10,000 population as shown in Table 3.2.25. This compares with the Zambales figure of 12.6 beds per 10,000 persons. No data was available on the number of beds in Region 3.

A comparison of numbers of barangay health stations per 10,000 population gives the ratios 1.9, 1.8 and 1.8 respectively. Again, the regional and provincial coverage is no better than average.

(3) Roads and Bridges

In 2001, according to aggregated regional and district data dated December 2001, there were 201,765 km of roads in all classes nationally, 14,530 km in Region 3, and 4,480 km in Zambales Province. Table 3.2.26 gives this summarized information in terms of road classes and surface type. The table also shows an analysis of these totals by class and surface type, nationally and for Region 3 and Zambales.

The national road density overall was 673 m/km^2 including 99 and 407 m/km^2 of national and barangay roads respectively. Road density in Region 3 was considerably higher at 835 m/km^2 which included 95 and 740 m/km^2 of national and local roads respectively. Finally, the road density in Zambales Province overall is 533 m/km^2 including 51 m/km^2 of national road and 482 m/km^2 of local roads.

Concrete roads are the most resistant to flood damage. In Region 3 the total length of this road surface was 3,908 km or a high 25.7% of the total length (the national ratio is only 14.9%). In Zambales, there was only 204 km of concrete road or 10.3% of total provincial road length. This low proportion suggests that roads in Zambales are more susceptible to flood damage than in the rest of Region 3.

Table 3.2.26 also shows the total length of permanent and temporary bridges in the Philippines (286.8 km), Region 3 (24.1 km) and Zambales Province (3.9 km).

(4) Water Supply

Water supply systems are classified into three groups: Level 1, which indicates service from point sources such as wells, developed springs, rivers, ponds, undeveloped springs and rain collectors; Level 2, which describes a communal faucet system; and Level 3, a piped system connected to individual consumers.

According to Table 3.2.27, the proportion of households served by potable water systems in the Philippines (ranging from point sources and untreated water through to treated piped water to individual households) was 36% in 1990 (there appears to be no more up to date data), but only 5.6% were served by a piped system connected to individual houses. Unfortunately, Region 3 and Zambales information was incomplete even for 1990, but the study team were able to determine from the basic data that coverage by individual connections (Level 3) was approximately 2.4% for Region 3 and 3.2% for Zambales Province, both figures lower than the national average.

(5) Electricity Supply

Electricity supply is divided into two main groups: (a) generation and primary power transmission and (b) power distribution and connection to consumers. Services in (a) are provided by the National Power Corporation (NAPOCOR) and in (b) by the individual retailers. In the Zambales Province the electricity retailing is shared between the retailers ZAMECO I and ZAMECO II.

Table 3.2.28 shows the coverage, number and proportion of total population in December 2000 at three levels: municipality, barangay and individual connections. Every municipality, in Region 3 and the country overall, is supplied with electricity. At barangay level the national average electricity coverage is 77%, significantly less than the Region 3 barangay coverage of 96%. Individual connections showed the same trend: 96% of the Region 3 population was connected while only 68% of the national population was covered. Rural areas of the country tend to be connected later than the urban because of the cost of serving a dispersed population and also the higher risk of flooding and similar problems.

(6) Telecommunications

Telephone service penetration was much smaller than that of electricity as can be seen from Table 3.2.29. This table shows that in Region 3 there were only 2.8 subscribers and 6.4 lines per 100 persons, while nationally there were 4.0 subscribers and 9.1 lines per 100 persons. These figures, as expected, compare unfavorably with those of the NCR where there were 14.5 subscribers per 100 persons.

The lack of penetration is partially due to the success of the cellular phone companies. The table below gives only the national figures for December 2000.

Telephone Service Penetration in the Philippines, Region 3 and Zambales Province

Cellular Phone Company	Number of Subscribers		
	Philippines	Region 3	Zambales
Smart	2,858,479	n.a.	n.a.
Globe Telecom	2,563,000	n.a.	n.a.
Piltel	656,814	n.a.	n.a.
Extelcom	194,452	n.a.	n.a.
Islacom	181,614	n.a.	n.a.
TOTAL	6,454,319	n.a.	n.a.

Source: 2000 Census of National, Regional and Provincial Population

3.2.6 Poverty Incidence

An explanation of the terms used in this section is as follows. “Poverty incidence” is the number of poor families expressed as a percentage of the total number of families in the population, and will be termed “incidence of poor families”. “Poor families” are those families who receive an annual per capita income below the annual per capita poverty threshold, and third, the “annual per capita poverty threshold” is the minimum annual per capita income needed to satisfy basic nutritional requirements and other basic needs. These definitions can also be expressed in population terms resulting in poverty indicators that are generally higher, as can be seen in the table below. “Subsistence incidence” means the proportion (percentage) of families (as shown in the table below) which fall below the annual per capita food threshold: this is the minimum annual per capita income needed to satisfy basic nutritional needs only.

In Region 3, the annual per capita poverty threshold was estimated at 14,653 Pesos in 2000; 281,707 families (equivalent to a population of 1,781,782) had an income below this threshold[6]. The incidence of poor families was 18.6% in Region 3. The table below gives the incidence of poor families with supporting information on a national and regional basis. The table shows that Region 3 has the second lowest incidence of poor families in the country.

[6] According to the 2001 Philippine Statistical Yearbook.

Poverty and Subsistence Incidence: 2000

Area	Annual per capita poverty threshold (Pesos)	Magnitude of poor families	Incidence of poor families (%)	Order of incidence of poor families	Subsistence incidence of poor families (%)	
Philippines	13,916	5,215,421	34.2 (40.0)	-	16.7	-
NCR	18,001	211,559	9.7 (12.7)	1	1.5	[1]
CAR	15,706	101,562	36.9 (48.9)	5	18.0	[6]
Region 1	14,800	300,258	37.2 (43.5)	6	15.9	[5]
Region 2	12,488	173,649	30.6 (36.3)	4	12.4	[4]
Region 3	14,653	281,707	18.6 (22.9)	2	4.6	[2]
Region 4	15,307	590,693	26.0 (31.7)	3	10.1	[3]
Region 5	13,010	617,267	56.3 (62.8)	14	34.0	[14]
Region 6	12,646	526,072	43.4 (51.2)	10	22.1	[8]
Region 7	11,089	429,928	38.9 (43.9)	7	22.5	[9]
Region 8	10,868	316,780	43.0 (50.5)	9	24.8	[10]
Region 9	11,046	280,823	46.5 (53.0)	12	26.7	[12]
Region 10	12,131	386,745	45.7 (52.2)	11	26.3	[11]
Region 11	12,546	465,128	41.2 (46.3)	8	20.0	[7]
Region 12	12,247	261,850	50.9 (57.9)	13	28.0	[13]
ARMM	14,017	271,399	68.8 (73.9)	15	35.5	[15]

Source: 2001 Philippine Statistical Yearbook, October 2001

Note: Figures in round brackets show poverty incidence by population. Figures in square brackets show the ranking by region of subsistence incidence in poor families.

The subsistence incidence of poor families is shown in the last column of the above table. Region 3 is shown to have the second lowest incidence at 4.6%[7], just above the NCR at 1.5%, and far below the national average of 16.7%. In Region 3 this ratio has been steadily improving from a high of 11.6% recorded in 1985. The highest subsistence incidence (35.5%) is to be found in the ARMM Region, where more than one family in three cannot afford the basic food requirement. It was not possible to obtain recent poverty information for the Zambales Province or the eight municipalities of the study area.

3.3 Topography, Geology and Soil Condition

3.3.1 Topography

Figure 3.3.1 shows a topographic map of the study area. Mount Pinatubo is situated at an approximate latitude of 15°08'20" North and longitude of 120°21'35" East. Before June 1991, the elevation of Mount Pinatubo was 1,745 m above sea level. The surrounding mountains are older volcanic centers and relics of ancestral Mount Pinatubo. The gently-sloping apron consists of thick pyroclastic-flow and lahar (volcanic mudflow) deposits. The volcano was located at the boundary of the provinces of Zambales, Pampanga and Tarlac.

Mount Pinatubo is densely and deeply dissected by eight major river systems, each characterized by radial drainage and ending in broad, gently sloping aprons of laterally coalescing alluvial fans which extend beyond the flanks of the mountain. These major river systems are (clockwise, from the North) the O'Donnell, Sacobia-Bamban, Abacan, Pasig-Potrero, Gumain, Sto. Tomas, Maloma and Bucao Rivers. Three rivers, namely the Sto. Tomas, Maloma and Bucao Rivers, flow down the mountainous slopes of west Pinatubo, and out into the South China Sea.

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[7] This means that 4.6% of all families in Region 3 cannot afford the food needed to maintain basic minimum health.

The difference between east and west Pinatubo topography is the existence of non-volcanic mountains at the foot of western Mount Pinatubo, such as Mount Iba, Mount Lunitan, Mount Maquineng and Mount Mabolinoc. These mountains restrict the direction of the three river systems of west Pinatubo.

The Bucao River system flows north-west through the northernmost part of the west Pinatubo area, then travels west along the southern part of the Mount Iba range before joining the Balin Baquero River. After this confluence, it flows south of Botolan city to the South China Sea. The Balin Baquero River joins the Maraunot River, Lubao River and other tributaries at the east basin of the Mount Lunitan mountain range.

The Maloma River flows towards the south-east of the Mount Pinatubo mountain range and then flows down between the mountain ranges of Mount Lunitan and Mount Maquineng to the South China Sea.

The Sto. Tomas River flows down the mountain range of Mount Pinatubo towards the south (Marella River). At the junction of the Mapanuepe River, at the foot of Mount Mabolinoc, the Sto. Tomas River changes direction to the west before flowing through the northern part of San Marcelino to the South China Sea.

Aerial photography, mapping and cross section surveys were conducted in the study. The detail is presented in appendix II of the supporting report.

3.3.2 Geology

Figure 3.3.2 shows a geological map of the study area. Mount Pinatubo is flanked on the west (and partly underlain) by the Zambales Ophiolite Complex, an easterly-dipping slab of Eocene ocean crust uplifted during the late Ologocene. North, east and southeast of Pinatubo, Late Miocene to Pliocene marine, non-marine, and volcaniclastic sediments, namely the Tarlac Formation, is believed to unconformably overlie the Zambales Ophiolite Complex.

The Zambales Ophiolite Complex, west and northwest of Mount Pinatubo is dominantly peridotite and gabbro; that north of Pinatubo is dominantly basalt. The ophiolite, topographically high west and northwest of Mount Pinatubo, is apparently downdropped to the east across a north-south fault along the Balin Baquero River

The lower part of the Tarlac Formation is dominated by fossiliferous sandstone and siltstone, overlying the Zambales Ophiolite Complex. The upper part of the Tarlac Formation is dominated by a conglomerate, with sandstone lenses cut by andesite dikes.

Mount Pinatubo is composed largely of holnblende andesite and dacite plus lesser amount of pyroxene andesite and basalt emplaced as lava flows, pyroclastics, dilkes, sills and domes. The eruptive history of the volcano has been divided into two major periods termed ancestral and modern Mount Pinatubo.

Ancestral Pinatubo was a Plistocene andesite and dacite stratovolcano whose center was in roughly the same location as the modern Pinatubo. Activity of the ancestral volcano ended several tens of thousands years (or more) before the caldera-forming eruption and initial growth of the modern Pinatubo.

Modern Mount Pinatubo is a dacite-andesite dome complex surrounded by sheets of dacitic pyroclastic flows and related lahars. ^{14}C dating reveals at least six distinct eruption periods. The largest eruption in the history of modern Pinatubo occurred 35,000 years B.P., called the Inararo eruptive period, and deposited up to 100 m or more of pumiceous pyroclastic-flow material on all sides of Mount Pinatubo. These pyroclastic-flow deposits contained pumice blocks of biotite-hornblende-quartz dacite with approximately 67% SiO_2.

After this eruption, the Sacobia eruptive period (17,000 years B.P.), Pasbul eruptive period (9,000 years B.P.), Crow Valley eruptive period (6,000-5,000 years B.P.), Maraunot eruptive period (3,900-2300 years B.P.), and the Buag Eruptive period (500 years B.P.) occurred prior to the 1991 eruption. The latest pre-1991 eruptive period placed pyroclastic-flow deposits in all major watersheds of Mount Pinatubo, except those of the Gumain and Porac Rivers.

3.3.3 Soil Condition

The general soil classification for each river basin is as follows:

General Soil Classification for Each River Basin

River Basin	Soil Types
Bucao	Angeles Sand
Maloma	Antipolo Clay and Cabangan Sandy Loam
Sto. Tomas	Angeles Sand

Soil Types

(a) Angeles Sand

Angeles sand is formed on recent level and near level alluvial fans, flood plains, or other alluvial deposits subject to river flooding over unconsolidated materials. These soils have medium to coarse textures and are moderately well, well, or particularly well drained. The relief is generally level to near level.

(b) Antipolo Clay

In upland areas, Antipolo clay has developed from hard igneous bed rock materials. These soils are formed from the underlying igneous rock and rolling to steep topography. The Antipolo series is a good example of soils formed from basaltic rocks.

(c) Cabangan Sandy Loam

Cabangan sandy loams are formed on older alluvial fans, alluvial plains, or terraces above the river flooding level. Shallow flooding from tributary creeks and impeded local runoff may occur. They have moderately developed profiles (moderately dense subsoil) over unconsolidated materials. These are generally deep soils and are not covering claypans or hardpans, although the subsoils are dense to moderately dense.

Soil and Sediment Sampling and Analysis

Two sampling stations (downstream and upstream) were selected for each river basin, about 3 to 5 m away from the riverbanks. In the Sto. Tomas River basin, only one sampling site was selected since the Dizon Mining Dam is located in the upstream area where the soil conditions are considered as toxic and hazardous. The sampling depth was approximately 0.5 m and was dug using a shovel instead of a hand auger due to the very coarse soil conditions. The soil samples were analyzed for pH, organic matter content, nitrogen, phosphorus, potassium and metals (chromium – hexavalent, copper, cadmium, lead, zinc, and mercury). The location of the soil sampling points is shown in Figure 3.3.3.

Sampling locations for riverbed materials are also shown in Figure 3.3.3.

Laboratory Results

The laboratory results for the soil samples are presented in Table 3.3.1. and Table 3.3.2. Since there are no existing Philippine soil standards, the Dutch Intervention Values (DIV) have been used for comparison. For comparison purposes, the environmental soil standards of Japan are also listed in the table.

The results of the soil and sediment analysis show higher values of Hg than the environmental limit of Japan (about 200 times as the limit in the upstream reaches of the Bucao River). In the case of Cu, the concentration at the exit of Mapanuepe Lake is higher than at other locations, especially along the Sto. Tomas River. This may be caused by the deposits from the mine facility.

Generally, it can be said that the soil and sediment is still in good chemical condition, except for the mercury and copper concentrations. Monitoring of mercury and copper would be desirable for predicting the potential impact of the mines near Lake Mapanuepe.

From the agricultural point of view, the following soil conditions are noted:

1) The pH levels ranged from 6.0 to 8.0 (moderately acidic to moderately basic). This range of pH levels is suitable for planting rice, corn, bananas, sugarcane and coconut.
2) In the case of nutrient elements (N, P, K), the nitrogen level ranges from 0.03% to 0.15%, which is relatively adequate for the crops cited. The phosphorous content ranges from 1 ppm to 21 ppm, which barely satisfies the critical level required for crops. In the case of potassium, it is also below the critical value required for crops.
3) The analysis results for organic matters (OM) as a whole showed the range to be from 0.26% to 3.76%, whereas crops need at least 3% to 5%.

In general, the above results show that the soil in the study area is not fertile enough for crops.

3.4 Meteorology and Hydrology

3.4.1 Meteorology

Tropical cyclones, categorized as tropical depressions, tropical storms or typhoons depending on their wind speed, all follow a similar route in the Philippines. The eye of the storm initially heads westward towards Luzon Island, followed by a swerving to the northeast, away from the Philippines. The swerve is caused by the southwest monsoon winds that are typically encountered in western Luzon Island.

The climate in the study area (Zambales Province) is classified as Type I in the Philippines. It is characterized by a pronounced wet season between May and October, and a distinct dry season from November to April. Figure 3.4.1 presents the monthly mean rainfall, temperature and relative humidity at the Iba Station. Regional data from synoptic stations at Baguio to the north, Cabanatuan to the east and Manila Port to the southeast are shown for reference. All figures are based on 30-year data, recorded between 1971 and 2000.

(1) Rainfall

Heavy rain occurs between June and September, commonly induced by the southwest monsoon winds. Rainfall is minimal during the dry season from December to April due to the reversal of the monsoon wind direction. It is noted that with the exception of Baguio, the annual rainfall is significantly less than that of Iba. The monthly mean rainfall in Iba ranges from 3 mm in January to 1,020 mm in August with mean annual rainfall of 3,600 mm.

The western slopes of Mount Pinatubo, where the study area is located, have experienced more rainfall than the eastern slopes. An isohyetal map was prepared from the 1995 annual rainfall data, as shown in Figure 3.4.2. Assuming this map is indicative of rainfall in the region, then three major points can be made. First, the western slopes of Mount Pinatubo have a far greater amount of rainfall than the eastern slopes. Second, rainfall in the western coastal area is lower than the rainfall in the western mountain area. Third, a higher amount of rainfall occurs towards the south-western side, compared to the north-western side.

(2) Temperature

Air temperature ranges between a minimum of 25.6℃ in January and a maximum of 28.1℃ in April and May with an annual mean of 26.8℃ at Iba, Zambales as shown in Figure 3.4.1. The highest temperature occurs at the end of the dry season, typically in April, while the lowest is generally between December and February. However, there is no significant change in temperature between the dry and rainy seasons. The temperature in Manila and Cabanatuan in Central Luzon has a similar trend to that given for Iba, however Baguio has lower temperatures due to its high elevation.

(3) Relative Humidity

At 79%, the average annual relative humidity recorded at Iba is significantly high. Humidity becomes the highest (at 86%) during the wet season while the lowest monthly mean humidity is 73% during the dry season as shown in Figure 3.4.1.

3.4.2 Hydrology

During the wet season, the combination of steep upper slopes and typhoon-induced rainstorms in the study area results in rapid runoff and frequent fluctuations in the level of the riverbed. This phenomenon is thought to be aggravated by the additional deposits and lahar flows.

The annual runoff characteristics in the three river basins are similar to those of the other basins draining from Mount Pinatubo. Historical data indicates that the coefficient of annual runoff is between 54% and 58% for the three basins, while the Sacobia River basin, one of the other basins of Mount Pinatubo has reported 62%.

3.4.3 Water Quality

(1) Surface River Water Quality

Water samples were collected from a total of six sampling stations at the three rivers and two lakes: two in the Bucao River (S-1 and S-2) and one each in the Maloma River (S-3), the Marella River (S-4), Lake Mapanuepe (S-5) and Pinatubo Crater Lake (S-6). The Marella River is an upstream tributary of the Sto. Tomas River. Lake Mapanuepe is also located in the upstream section of the Sto. Tomas River. Sampling was undertaken twice, once during the rainy season and once during the dry season. The location of the water sampling stations is shown in Figure 3.4.3.

Water samples were analyzed for pH, color, conductivity, temperature, dissolved oxygen, BOD, COD and 20 other inorganic substances. These parameters were chosen to determine the possible contributions from the volcanic deposits and the mine tailings dam (of the abandoned mining operation upstream of the Sto. Tomas River) to the water quality of the rivers draining from the flank of Mount Pinatubo.

Water flow through the three main rivers draining the western flank of Mount Pinatubo is largely a function of the amount of rainfall. That is, during the dry season when there is no precipitation, water flow is limited to a small, shallow stream. The river channel changes dramatically during the rainy season, with the large volume of flowing lahar filling the whole river bed. These seasonal changes in river flow affect the water quality.

Tables 3.4.1 and 3.4.2 show the analysis results of surface water quality in the dry and wet seasons respectively. Based on the results, and in consideration of the DENR water quality criteria in the DENR AO 34-90, the following points are noted:

1) Arsenic, cadmium, chromium (VI) and mercury are all below the DENR standards for Class D (agriculture/irrigation), whereas the copper concentration at the exit from the Lake Mapanuepe is somewhat higher than the standard.
2) In the rainy season, BOD_5 is lower than its limit (10). However, BOD_5 in the dry season ranges from 14 to 35, which implies that domestic waste and other organic waste from livestock breeding has contributed to the high values.

(2) Ground Water Quality

Laboratory analysis of the groundwater in the western part of Mount Pinatubo was conducted during the study. The result is compiled in Table 3.4.3. To understand the contents of sulfate in the groundwater, the concentration of sulfate was compared between the surface and ground water as follows:

Comparison of SO_4 Concentration of River/Ground Water in West Pinatubo

River	River Surface Water		Groundwater	
	Mid-stream SO_4(ppm)	Downstream SO_4(ppm)	Mid-stream SO_4(ppm)	Downstream SO_4(ppm)
Bucao	131	262	No sample	33
Sto Tomas	246	No sample	428	34

Notes: Water sampling of river surface water: May 2002 / Water sampling of groundwater: March 2003.

Source: JICA Study Team

High concentration of sulfate in the river surface water is seen as observed in east Pinatubo. For the ground water, however, the high concentration of sulfate is observed only adjacent to the river. The samples located in the downstream plain a few kilometers away from the river channel showed low concentration of sulfate. Though the samples are quite limited and it is still too early to reach conclusions, the affect on soil acidity of a high concentration of sulfate might be less in the downstream plain of West Pinatubo than in the eastern part, apart from the lahar affected rivers.

However, it is observed that the electrical conductivity of the groundwater in the western part is rather high compared with the NIA standard for irrigation water. The measured EC is between 210 uS/cm and 1,120 uS/cm but the NIA standard is 350 uS/cm. Generally, the EC value is applied for measuring the chloride concentration for irrigation but the sample values were much less than the standard. This means that some other minerals such as Magnesium and Manganese, which are recorded as high concentration in the laboratory test, would increase the EC value. Therefore, a detailed analysis would be required to assess the availability of groundwater for irrigation purposes in the study area.

3.5 River Conditions

3.5.1 River System

Figure 3.5.1 shows the boundary map of the three river basins, the Bucao, Maloma and Sto.Tomas River basins, which was developed based on the aerial photographs taken in May 2002.

The three river systems consist mainly of the following sub-basins:

Bucao River System

River System	Sub-system	Tributary	Catchment Area (km^2)	Lahar Source
Bucao	Upper Bucao	Upper Bucao	142	Yes
		Balintawak	154	No
	Balin Baquero	Balin Baquero	153	Yes
		Lubao	51	Yes
		Maraunot	12	Yes
	Lower Bucao	Baquilan	61	No
	-	Others	82	No
	TOTAL		655	

There are six major tributaries in the Bucao River system. Four of these tributaries are still identified as lahar sources. These are the Upper Bucao, Balin Baquero, Lubao and Maraunot Rivers. The total catchment area of these four tributaries is 358 km^2, which equates to 55% of the Bucao River system.

Maloma River System

River System	Sub-system	Tributary	Catchment Area (km^2)	Lahar Source
Maloma	Maloma	Maloma	99	No(*)
		Gorongoro	42	No
		Others	11	No
	TOTAL		152	

Notes: (*) previously identified as lahar source but no more unstable material is remaining.

Immediately after the eruption of Mount Pinatubo, the upper portion of the Maloma tributary was affected by the pyroclastic deposits. Lahar flows were observed for several years, and a remarkable amount of lahar deposits occurred along the river. Lahar flows are no longer observed at present, although riverbed fluctuations caused by floods are still observed in the downstream portion of the river.

Sto. Tomas River System

River System	Sub-system	Tributary	Catchment Area (km^2)	Lahar Source
Sto. Tomas	Marella	Marella	91	Yes
	Mapanuepe	Mapanuepe	88	No
	Sto. Tomas	Santa Fe	42	No (*)
		Others	41	No
	TOTAL		262	

Notes: (*) previously identified as lahar source but no more unstable material is remaining.

The Marella River is identified as a lahar source river with a catchment area of 91 km^2 (35% of the whole catchment area of the Sto. Tomas River basin). A lake was created in 1991 by the formation of a natural dam at the confluence of the Marella and Mapanuepe Rivers due to lahar deposition from the Marella River. The Mapanuepe Lake has a surface area of 6.8 km^2 with approximately 30 million m^3 of storage capacity. The Santa Fe River was also a lahar source for several years after the eruption; however it is no longer identified as a lahar source tributary.

A comparison between a topographic map produced in 1977 and the recent aerial photographs taken in May 2002 was undertaken to examine the changes in catchment area of the three river basins. The following table shows the changes in catchment area before and after the eruption of Mount Pinatubo:

Changes in catchment area before and after the eruption of Mount Pinatubo

River Basin	Catchment area before the eruption of Mount Pinatubo (1977)	Catchment area after the eruption of Mount Pinatubo (2002)	Change in catchment area
Bucao River	646 km^2	655 km^2	(+) 9km^2
Maloma River	151 km^2	152 km^2	(+) 1 km^2
Sto. Tomas River	262 km^2	262 km^2	-

A significant change is observed in the Bucao River catchment area due to the creation of the Mount Pinatubo Crater Lake as shown in Figure 3.5.2. Discharge from the Mount Pinatubo Crater Lake commenced in September 2001 at the Maraunot Notch in the Bucao River basin. The entire Crater Lake catchment area discharges to the Bucao River basin.

In addition to the creation of the Crater Lake of Mount Pinatubo, many other natural lakes have formed in the Bucao and Sto. Tomas River basins due to dams created at the confluence of the lahar deposition channel and its tributaries. There are 24 dammed lakes, mostly located in the Bucao River basin. Figure 3.5.3 shows the location of the dammed lakes.

3.5.2 River Channel

Channel conditions in the three rivers changed dramatically after the eruption of Mount Pinatubo due to the remarkable volume of lahar deposition along the river channels, particularly in the Bucao and Sto. Tomas Rivers.

Table 3.5.1 summarizes the major changes in the channels of the three rivers.

The volume of lahar deposition within the Bucao and Sto. Tomas River areas is estimated at 843 and 818 million m^3 respectively, as shown in Figure 3.5.4. The deposition depth is only a few meters in the lower stretches. However, the thickness increases to approximately 30 m in the upstream reaches. The huge volume of lahar deposition in the channel has significantly affected the surface run-off conditions. A considerable volume of the surface flow infiltrates into the lahar deposition area and the surface run-off ratio is dramatically decreased particularly during flooding periods.

The area converted from riverside farm land into un-used areas due to the spread of the lahar flow along the river is estimated at 9,461 ha, of which 5,534 ha is along the Bucao River and 3,797 ha is along the Sto. Tomas River stretches. The areas are currently confined by dike embankments or surrounded by mountains, and no land recovery actions have been taken.

In the lower reaches the river gradient became steeper after the eruption of Mount Pinatubo. The changes in the gradient of the lower reaches were as follows:

River Gradient in the Lower Reaches (before and after eruption)

River	Stretch	River Length (m)		Gradient	
Bucao	Mouth ~ Malomboy	14,100	13,300	1/400	1/270
Maloma	Mouth ~ Gorongoro	7,400	7,000	1/1200	1/800
Sto. Tomas	Mouth ~ Vega Hill	13,400	13,700	1/450	1/300
	Vega Hill ~ Mt.Bagang	13,300	12,300	1/150	1/140

3.6 Flood and Mudflow Damage

3.6.1 Bucao River Basin

(1) Changes after Mount Pinatubo Eruption

After the eruption of Mount Pinatubo in 1991, lahars (mudflow with high concentration of sediment) continued to flow until 1995, burying riparian villages along the Upper Bucao River and the Balin Baquero River, namely, Malomboy, Poonbato, Maguisguis, Nacolcol, Moraza and other barangays. No lahars have been reported since 1996, and diluted muddy water in the water course is observed at present. Figure 3.6.1 shows the lahar deposit area in the Bucao River system.

In order to protect a wide lowland area, a dike of 5.8 km in length was constructed just after the eruption of Mount Pinatubo on the right bank of the downstream reaches (from the Bucao Bridge to 5.8 km upstream). The dike was heightened by 3 m in 1997. This dike prevented any overflows from the Bucao River to the residential areas. The maximum difference between the riverbed level and the ground level along the right bank of the Bucao River is 2.8 m and the average is 1.2 m, as measured in May 2002. The clearance of the Bucao Bridge is decreasing every year due to siltation, and at present is approximately 2 m. However, the change has been very slow over the last 5 years.

After the eruption, the intake facilities from the Bucao River for irrigation were buried by lahar deposits and became un-operational. However, many springs and ponds with abundant volumes of water were naturally formed on the inland side due to seepage from the elevated riverbed of the Bucao River, and this water is now being utilized for irrigation as well as water from the rehabilitated intake.

(2) Flood Damage at Present

No dike has been constructed downstream from the Bucao Bridge, and flood water from the Bucao River overflows every year submerging part of a farmland (15 ha) and a few houses along the right bank between the river-mouth and the Bucao Bridge. The area of habitual inundation is shown in Figure 3.6.2.

3.6.2 Maloma River Basin

(1) Changes after Mount Pinatubo Eruption

The pyroclastic flow deposit area in the Maloma River basin is negligible. However, just after the eruption the riverbed of the Maloma River was filled with a sediment deposit consisting of volcanic ash.

At present, the sediment deposit in the river courses and flood plain seems to be stable, because no deposit terraces have formed, and a considerable part of the surface has already been covered with weeds. However, flood inundation is a very severe problem at Barangay Maloma in San Felipe due to the very low capacity of the river channel caused by the raised riverbed.

Concrete faced revetments were constructed in four short sections along the Maloma River between 1998 and 2000.

(2) Flood Damage at Present

Along the Maloma River, flood inundation occurs during the rainy season every year, and the actual damage caused by the inundation is larger than that of the Bucao or Sto.Tomas Rivers.

In the flood of August 2001, extensive inundation damage occurred in and around Barangay Maloma in the vicinity of the Maloma Bridge. The flood inundation lasted 4 hours with a water depth of 1.0 m. A portion of the national highway on the right abutment of the Maloma Bridge was partially damaged due to flooding, and was then restored and raised by 1 m. The number of the affected houses amounted to 360 (1,790 people) with 26 ha of damaged agricultural land. One high school and one elementary school with an enrollment of 709 and 410 respectively were also affected. The total inundation area amounted to 350 ha. The inundation area mentioned above is illustrated in Figure 3.6.3.

In July 2002, another flood caused extensive inundation damage along the Maloma River. On this occasion, severe inundation took place only in the upstream portion of Barangay Maloma and submerged a wide rice field. The residential area of the barangay suffered again, although the inundation depth (0.5 m) was shallower compared with that of 2001 because of the attenuation effect of the peak flood discharge caused by the upstream inundation. Ninety houses (460 persons) were affected and 120 ha of agricultural land was damaged. The inundation area from this flood in 2002 is illustrated in Figure 3.6.4.

3.6.3 Sto. Tomas River Basin

(1) Changes after Mount Pinatubo Eruption

After the eruption in 1991, the Marella Valley and the Sto.Tomas River were buried by lahars, forming the Mapanuepe Lake in the largest left tributary. The lahars also ruined riparian villages along the Sto. Tomas River, namely, San Rafael, Umaya, Maculcol and other barangays. Villages along the Mapanuepe River were also ruined. No lahars were reported after 1996, and flooding is now the main problem. Figure 3.6.5 shows the lahar deposition area in the Sto.Tomas River system.

The construction of a dike along the Sto.Tomas River commenced in 1992. In 1993, the dike on the left bank in the upstream reaches partially breached, causing mudflow inundation on the farmland in and around San Marcelino. Subsequently, the dike was restored and heightened several times, and the dike reached a maximum height of 13 m. The length of the left bank dike is 19.1 km, and right bank dike is 7.6 km.

In 1992, a channel was excavated through a small hill that is located on the southern side of the original confluence of the Marella and Mapanuepe Rivers, to facilitate drainage from the Mapanuepe Lake. The lake now serves as a natural reservoir for flood control, and this function is very helpful for reducing the peak flood discharge in the Sto.Tomas River.

The riverbed of the Sto.Tomas River is higher than the ground level by 6.7 m (maximum) or 1.9 m (average) on the left bank side. On the right bank side, the riverbed was higher than the ground level by 2.4 m (maximum) or 0.5 m (average) as in May 2002.

Riverbed excavation works have been performed every year on the short section immediately upstream and downstream of the Maculcol Bridge to secure the required clearance under the bridge girder to enable the flood discharge to pass. The volume of sand excavated in 2000 was recorded as 750,000 m^3.

The municipality of San Marcelino, which is located at the left bank of the Sto.Tomas River, had a wide rice field and profited from a triple crop before the eruption. At present, a single crop during the rainy season is all that is available due to the lack of irrigation water resources. The population of the municipality drastically decreased from 40,000 to 22,000 after the eruption.

(2) Flood Damage at Present

Since 1993, dike breaches have occurred in 2000, 2002 and 2003. In 2000, a dike breach of 400 m in length occurred in the left bank, 6 km upstream from the river-mouth, causing flood inundation in and around San Narciso and finally reaching the seashore at Barangay Lapaz. The inundation lasted for one week with a shallow water depth of 0.2 m. The breached section of the dike was restored in the following year using mountain soil and gabions.

After two typhoons in July of 2002, another dike breach took place on the left bank near the river-mouth. A total of 25 houses and 2.5 ha of agricultural land in and around Barangay Alusiis in San Narciso were submerged and buried with sand. In 2003, dike breach occurred at the same portion as in 2002.

The areas inundated in 2000 and 2002 are shown in Figure 3.6.6

3.7 Existing Flood and Mudflow Control Plans/Projects and Facilities

3.7.1 Existing Flood and Mudflow Control Plans/Projects (Structural Measures)

Immediately after the eruption of Mount Pinatubo, the Government of the Philippines formed the Mount Pinatubo Commission (MPC) task force team, directed by the Office of the President. Under their own initiatives, various activities were carried out including relief activities, urgent support for the affected people and damage investigations with assistance from various foreign donors.

The procurement of heavy equipment for channel excavation and dike embankment activities during 1991 and 1992 was initially carried out by the Government of Japan and the United States. The Government of the Philippines implemented urgent channel excavation and dike construction for the various rivers affected by the eruption of Mount Pinatubo. Currently, intensive river maintenance works continue at the Sto. Tomas River using the procured equipment.

In 1994, the Government of the Philippines requested technical assistance from the U.S.A. for the formulation of action plans for flood and mudflow control measures for the eight rivers around Mount Pinatubo. The United States Army Corps of Engineers (USACE) finalized the “Recovery Action Plan for Eight River Basins” in March 1994 and the Government of the Philippines implemented some of the proposed recovery action plans for the respective rivers through their own funding efforts. Figure 3.7.1 is a compilation of the proposed recovery action plans for the three western rivers.

For the Bucao River, the alternatives that were studied by the USACE were the construction of a levee on the right bank or the construction of sediment retention structures at Malomboy. USACE recommended the levee alternative based on an economic evaluation. The GOP followed the USACE proposal and the dike construction was implemented using the GOP funding.

For the Maloma River, three alternatives, dike construction, channel excavation and sediment retention structures were studied. Of these, dike construction was finally proposed by USACE based on an economic evaluation. The Government of the Philippines basically followed the USACE proposal although the existing dike is still not fully covered as had been proposed.

For the Sto. Tomas River, the study recommended construction of levees on both banks (rather than channel excavation and sediment retention structures) based on the results of the economic evaluation. The Government of the Philippines followed the proposed dike alternative and implemented the works through their own funding.

After 1994, the Government of the Philippines continued their best efforts for flood and mudflow control in accordance with the recovery action plans formulated by USACE. However, they were not considered as long-term solutions. Permanent solutions, taking into consideration sustainable regional development, are still required, and are expected under this JICA study.

3.7.2 Existing Disaster Prevention System (Non-Structural Measures)

The agencies taking action to prevent and mitigate the flood and mudflow disasters by non-structural measures are government agencies and NGOs. The followings are brief descriptions of the actions undertaken by these organizations.

(1) Flood and Mudflow Forecasting and Warning System

If a warning bulletin or information is issued relating to an impending disaster or emergency by any of the warning agencies such as PAGASA for typhoons, floods, tsunamis and other meteorological hazards; PHIVOLCS for volcanic eruptions, earthquakes and other geological hazards, and Armed Forces of the Philippines (AFP) and Philippine National Police (PNP) for civil unrest, the said bulletin or information is relayed by these agencies simultaneously to their respective regional/field offices concerned and is broadcast to the general public to ensure the widest dissemination.

The RDCC-3 (branch office of the Office of Civil Defense (OCD)) is the office responsible for flood and mudflow forecasting and warning in the Mount Pinatubo affected area.

After receipt of the monitoring information on mudflow and heavy rainfall, the RDCC-3 disseminates the flood and mudflow warning information to government agencies in Region 3, Provincial Disaster Coordinating Council (PDCC), Municipal Disaster Coordinating Council (MDCC) and Barangay Disaster Coordinating Council (BDCC).

The flood and mudflow monitoring systems existing in the RDCC-3 area are as follows:

1) AFP/PNP watch point,
2) PHIVOLCS/USGS monitoring system,
3) PAGASA weather information, and,
4) OCD/JICA monitoring system

However, of the above four systems, the real time flood and mudflow monitoring systems (items 2 and 4 above) are malfunctioning at present, and the PAGASA system (item 3) is not located in the study area. There are no real-time information systems there except the AFP/PNP lahar watch point, and that seems rather uncertain.

(2) Evacuation System

Due to this situation, it seems that any evacuation actions immediately before the onset of flooding or mudflow would be impossible. Present evacuations from flooding or mudflow are being carried out on the basis of probable disaster information and the evacuee’s own judgment through their past experience.

(3) Relocation System

Within the study area there are ten relocation/resettlement sites. MPC has established seven relocation sites and another three were established by the NGOs after the eruption of Mount Pinatubo. Relocation sites provided by the government agencies have an electricity supply, deep well(s), a school, medical center, church, community center and some have several hundred hectares of agricultural land for the evacuees. The relocation sites provided by NGOs are suffering from a lack of such facilities and prompt enhancement of this basic infrastructure is important.

Some of the officially organized relocation sites still have open spaces that are able to accommodate further evacuees, although new basic facilities shall be installed.

(4) Watershed Management

A reforestation program (Community-Based Forest Management) is ongoing under DENR in limited areas of the targeted river basins.

(5) Campaign against the Hazards

As the end units of the administration system, the barangay are the core recipients for the campaign activities of "How to avoid becoming a victim of a mudflow". As for the case previously initiated by RDCC-3, each barangay shall make the effort to educate the residents on the evacuation route and location of the evacuation centers, by effective utilization of the hazard map that will be prepared through this study.

(6) Activities of the NGOs

A total of 92 organizations are listed as officially accredited NGOs and an additional 38 organizations have applied for accreditation. They shall assist in the fields in which the official activities tend to be difficult. If, through discussion, the organizations can be appointed to their appropriate fields, this will utilize them most efficiently and outstanding evacuation and resettlement initiatives may be expected.

3.7.3 Existing Flood and Mudflow Control Facilities

After the Mount Pinatubo eruption in 1991, in order to protect the area against flooding and mudflow, dikes along the Bucao River and Sto. Tomas River were constructed and rehabilitated by the DPWH-IBA District Engineering Office (IBA-DEO) and the Mount Pinatubo Rehabilitation Office- Region 3 (MPR). The IBA-DEO also provided riverbank protection for the Maloma River.

Figure 3.7.2 shows the construction record for the existing flood and mudflow control works undertaken by the agencies concerned.

(1) Bucao River Basin

(a) Features of the Existing Dike and Revetment

The IBA- DEO constructed the dike along the right side of the river in 1992, with a length of 6.0 km, with grouted riprap 0.3 m thick and a loose boulder apron on the embankment material hauled from the mountain.

After the construction, a large lahar traveled down from the upstream reaches of the Balin – Baquero River, Maraunot River and Lubao River and the riverbed was raised due to the lahar deposits, nearly to the crest of the constructed dike.

As the countermeasure for the above-mentioned situation, the dike was raised by additional embankment of 3.0 m in height using mountain soil and an armoring of grouted riprap on the riverside slope from Sta. 2.4 km to Sta. 6.0 km. These dike improvement works were undertaken by the IBA – DEO in 1997.

The present right dike has two riverbank protection types:

1. From Bucao Bridge to Sta. 2.4 km and from Sta. 5.8 km to Sta. 6.0 km, riverbank protection consists of a single slope facing, with a gradient of 2.0 (H) : 1 (V) to 0.5 : 1,

armored by grouted riprap.

2. From Sta. 2.4 km to Sta. 5.8 km, riverbank protection consists of a double slope facing, with a gradient of 1.0 (H) : 1 (V) to 0.5 : 1, armored by grouted riprap.

In addition to the above, there is a spur dike armored by concrete facing (L = 300 m) at Sta. 5.8 km. The spur dike was constructed, expecting 1) to fix the watercourse from flooding and/or mudflow, and 2) to augment embedding of the revetment against scouring caused by flooding and/or mudflow.

The following observations were made regarding the effectiveness of this structure.

- Almost 1.0 km downstream from this structure, extra sedimentation of riverbed material was found. It is judged that this sediment would reinforce the existing dike against flooding and mudflow.
- The watercourse downstream from the spur dike follows a desirable course compared to the direction without this structure.

The location of the existing riverbank protection is tabulated as follows.

Location of existing Riverbank Protection in Bucao River

Location (Right Bank)	Protection Type	Stretch
Sta. 0.0 km to 2.4 km	Grouted riprap (single section)	L = 2.4 km
Sta. 2.4 km to 5.8 km	Grouted riprap (double section)	L = 3.4 km
Sta. 5.8 km to 6.0 km	Grouted riprap (single section)	L = 0.2 km
	Total	6.0 km
Sta. 5.8 km (Spur Dike)	Concrete facing (single section)	L = 0.3 km

Note: Sta. 0.0 km indicates location of the Bucao Bridge.

The location of the riverbank protection and typical cross sections are shown in Figures 3.7.3 and 3.7.4.

(b) Other Structures

(i) Irrigation Facilities

Other structures along the Bucao River include intake gate and irrigation channels which are part of the irrigation facilities constructed by the National Irrigation Administration (NIA) at the confluence of the Baquilan River in the 1980's. The irrigation system was constructed to provide irrigation water (design discharge of 3.75 m^3/s) to 3,000 ha of farmland in the northern part of the Bucao River basin.

The intake gate consists of two steel slide gates (H x B = 1.2 m x 1.2 m) with manually operated hoisting systems, and the irrigation channel consists of an open channel section and a concrete box culvert section along the river. The box culvert section has sectional dimensions of H x B = 1.8 m x 1.6 m and a length of 1.7 km.

A typical cross section of the box culvert section of the irrigation channel is shown in Figure 3.7.5.

(ii) Drainage Outlet

A drainage outlet, constructed by the IBA- DEO, is situated at Sta. 2.2 km on the right bank. The outlet has five circular barrels, with a diameter of approximately 1.5 m, and a steel flap gate.

The San Juan Creek drains through the structure. However, the structure is not sufficiently sized to operate during the annual rainy season, as the structure's outlet section is buried by sediment that has been transported down from the upstream reaches of the Bucao River.

(2) Maloma River Basin

(a) Features of the Existing Dike and Revetment

After the Mount Pinatubo eruption, the IBA- DEO constructed a 3.2 km long dike, from Sta. 1.5 km to Sta. 4.7 km, along the left side of the river. The dike was constructed using embankment material hauled from the mountain.

After the dike construction, the IBA- DEO constructed riverbank protection along four sections of the river (total stretch = 1.34 km) between the river mouth and Sta. 4.7 km from 1998 to 2000. The riverbank protection was provided in the portions where the river changes direction, in order to protect the river banks from scouring caused by flooding and mudflow.

At present, there are two types of riverbank protection constructed along each bank:

1. From Sta. –1.11 km to Sta.–0.7 km (right bank) and from Sta. 3.6 km to Sta. 3.77 km (left bank), the riverbank protection consists of a concrete facing approximately 0.15 m thick, with a gradient of 2.0 (H) : 1 (V) to 1.0 : 1. To ensure stability of the concrete facing, a gabion mattress 0.3 m thick was provided on the riverbed.
2. From Sta. –0.15 km to Sta. 0.0 km (left bank) and from Sta. 0.0 km to Sta. 0.61 km (right bank), the riverbank protection consists of grouted riprap approximately 0.3 m thick, with a gradient of 1.5 (H) : 1 (V) to 1.0 : 1.

The location of the riverbank protection is tabulated as follows.

Location of Riverbank Protection in the Maloma River

Location	Protection Type	Stretch
(Right Bank)		
Sta. 0.0 km to 0.61 km	Grouted Riprap (single section)	L = 0.61 km
Sta.-1.11 km to –0.7 km	Concrete Facing (single section)	L = 0.41 km
	Total	L = 1.02 km
(Left Bank)		
Sta. 3.6 km to 3.77 km	Concrete Facing (single section)	L = 0.17 km
Sta. –0.15 km to 0.0 km	Grouted Riprap (single section)	L = 0.15 km
	Total	L = 0.32 km

Note: Sta. 0.0 km indicates the location of the Maloma Bridge.

The location of the riverbank protection and typical cross sections are shown in Figures 3.7.6 and 3.7.7.

(b) Other Structures

There are no other structures along the Maloma River.

(3) Sto. Tomas River Basin

(a) Features of the Existing Dike and Revetment

After the Mount Pinatubo eruption in 1991, the IBA- DEO commenced construction of the left and right dikes (L = 19.1 km and L = 7.6 km, respectively) made of sediment deposits, with a concrete facing 0.15 m thick and riverbed protection consisting of a gabion mattress 0.3 m thick.

After the construction, many lahars flowed down from the Marella River and deposited sediment in the middle stream. A major portion of the constructed dike (left bank from Sta. 11.0 km (Vega Hill) to Sta. 18.9 km (Lawin)) was raised with an additional height of 3.0 m to 6.0 m and protected in the same manner as the constructed dike. These works were undertaken by MPR between 1995 and 1997.

On the right bank, between the Maculcol Bridge and Sta. 2.8 km, MPR improved the constructed dike through the construction of a gabion mattress in 2001.

1) Right Bank

At present, there are two types of dike protection along the right bank of the river:

- From the Maculcol Bridge to Sta. 2.8 km and from Sta. 6.5 km to Sta. 6.6 km, the riverbank protection consists of a gabion mattress 0.3 m thick, with a gradient of around 2.0 (H) : 1 (V).
- From Sta. 2.8 km to Sta. 6.5 km and from Sta. 6.6 km to Sta. 7.4 km, the riverbank protection consists of a concrete facing 0.15 m thick and a gabion mattress 0.3 m thick, which has a gradient of 2.0 (H) : 1 (V) to 1.0 : 1.

The location of the existing riverbank protection is tabulated as follows.

Location of Existing Riverbank Protection in Sto. Tomas River (Right Bank)

Location (Right Bank)	Protection Type	Stretch
Sta. –0.2 km to 0.0 km	Concrete Facing (single section)	L = 0.2 km
Sta. 0.0 km to 2.8 km	Gabion Mattress (single section)	L = 2.8 km
Sta. 2.8 km to 6.5 km	Concrete Facing (single section)	L = 3.7 km
Sta. 6.5 km to 6.6 km	Gabion Mattress (single section)	L = 0.1 km
Sta. 6.6 km to 7.4 km	Concrete Facing (single section)	L = 0.8 km
	Total	7.6 km

Note: Sta. 0.0 km indicates the location of the Maculcol Bridge.

2) Left Bank

For the left side of the river, there are four types of riverbank protection:

- From Sta. –0.2 km to Sta. 4.6 km and Sta. 5.0 km to Sta. 7.3 km, the riverbank protection is set by a single section, which has a gradient of 2.0 (H) : 1 (V) to 1.0 : 1 consisting of a concrete facing 0.15 m thick and riverbed protection using a gabion mattress 0.3 m thick. To augment the protection from flooding and mudflow, on an annual basis during the dry season MPR constructed a temporary embankment approximately 3.0 m high.
- From Sta. 4.6 km to Sta. 5.0 km, the riverbank protection is set by a double section, which has a gradient of around 2.0 (H) : 1 (V) with a gabion mattress 0.3 m thick.
- From Sta. 7.3 km to Sta. 16.4 km, the riverbank protection is set by a double section, which has a gradient of 2.0 (H) : 1 (V) to 1.0 : 1, with a concrete facing 0.15 m thick.
- From Sta. 16.4 km to Sta. 18.9 km, the riverbank protection is set by a triple section, which has a gradient of 2.0 (H) : 1 (V) to 1.0 : 1, with a concrete facing 0.15 m thick.

The location of the riverbank protection is tabulated as follows.

Location of existing Riverbank Protection in Sto. Tomas River (Left Bank)

Location (Left Bank)	Protection Type	Stretch
Sta. –0.2 km to 4.6 km	Concrete Facing (single section) + Temporary embankment	L = 4.8 km
Sta. 4.6 km to 5.0 km	Gabion Mattress (double section)	L = 0.4 km
Sta. 5.0 km to 7.3 km	Concrete Facing (single section) + Temporary embankment	L = 2.3 km
Sta. 7.3 km to 16.4 km	Concrete Facing (double section)	L = 9.1 km
Sta. 16.4 km to 18.9 km	Concrete Facing (triple section)	L = 2.5 km
	Total	19.1 km

Note: Sta. 0.0 km indicates the location of the Maculcol Bridge.

The location of the river protection and typical cross sections are shown in Figures 3.7.8 to 3.7.10.

(b) Other Structures

After the Mount Pinatubo eruption in 1991, the confluence of the Sto. Tomas River and the Mapanuepe River was buried by lahar deposits transported down from the Marella River. The lahar deposits blocked the outlet of the Mapanuepe River creating the Mapanuepe Lake.

In 1992, in order to drain the water from the Mapanuepe Lake, the MPR constructed a rectangular shaped diversion channel (approximately 170 m in length and 8.0 m in width) from the Mapanuepe Lake to the Sto. Tomas River.

The location of the diversion channel is shown in Figure 3.7.11.

3.8 Land Use

3.8.1 Land Use Trends

Satellite images were obtained for the study area on four occasions. Figure 3.8.1 shows images taken in 1990, 1992, 1993 and 2001. These maps were used to determine the land use trends over the 12 year span. The land use is categorized into forest area, grass area, bare land area and cultivated area. Table 3.8.1 tabulates the area in square kilometers of these four land types by municipality.

Forest, grass and cultivated areas each had a decreasing trend after the eruption of Mount Pinatubo (1992), followed by a rebound (1993), while bare land area had an increasing one. Cultivated areas continued to make a dramatic increase (2001), and forest area recovered to a lesser extent. However, grass area decreased. Bare land areas also decreased.

3.8.2 Current Land Use

Figure 3.8.2 shows the current land use in the Province of Zambales, which covers 95% of the study area. According to the Provincial Office, the total area of Zambales is 369,658 ha. Of this land area, 69% (255,062 ha) is classified as forest area and the remaining 31% as alienable and disposable land. The current land classification is as follows:

Current Land Classification

Land Classification	Land Use	Area (ha)	Percentage share of Total Area
Forest Area	NIPAS & Non-NIPAS	130,726	35.3%
	Non-Forest	124,336	33.6%
	Sub-Total	255,062	69.0%
Alienable / Disposable Land	Residential / Built-up	41,336	11.2%
	Industrial	1,232	0.3%
	Tourism	7,428	2.0%
	Uncultivated / Open space	29,758	8.1%
	Rivers / Swamps / Marshes, etc.	5,481	1.5%
	Agricultural Area	29,361	7.9%
	Sub-Total	114,596	31.0%
TOTAL		369,658	100%

Notes: NIPAS stands for National Integrated Protected Area System
Source: Province of Zambales

Within the forest area, 33.6% (124,336 ha) of the total provincial area is used for 'non-forest' agriculture (pasture and kaingin) and mines. Alienable and disposable land is being used for paddy fields, fishponds, cultivated annual crops, perennial tree and vine crops, pasture land and other uses such as residential sites, industrial areas, quarries and economic and tourism zones. Approximately 30,000 ha of alienable or disposable areas (8.1% of the total provincial area) remains as uncultivated or open spaces. All of the river-side area covered by lahar deposition has been classified into this category.

3.8.3 Existing Land Use Plan

In 1997, the Provincial Government of Zambales prepared the land use plan for the following 5-year period. This included the planned land use for 2002, as shown in Figure 3.8.3. A comparison between the existing and future land use is summarized as follows:

Comparison of the Existing and Future Land Use

Land Classification	Land Use	Area (ha) at present	Area (ha) in future	Increase/ decrease
Forest Area	NIPAS & Non-NIPAS	130,726	-	-
	Non-Forest	124,336	-	-
	Sub-Total	255,062	-	-
Alienable / Disposable Land	Residential / Built-up	41,336	43,153	+1,817
	Industrial	1,232	3,167	+1,935
	Tourism	7,428	13,786	+6,358
	Uncultivated / Open space	29,758	25,227	(-)4,531
	Rivers / Swamps / Marshes, etc.	5,481	5,481	-
	Agricultural Area	29,361	32,161	+2,800
	Sub-Total	114,596	122,975	+8,379
TOTAL		369,658		100%

Source: Province of Zambales

It was determined that intensive development of the tourism zone is the basic strategy for future land use. The provincial government aims to develop tourism areas, particularly along the western coast. In coastal areas, some activities relating to beach resort development are currently underway. The land use policy for tourism development in Zambales followed the strategy for regional development under NEDA-Region 3, which was based on the proposed regional development plan for Central Luzon by JICA in 1996. Zambales was defined as the "Axis of Tourism Development" of Region 3 in this study.

Another priority for development is the industrial area, for which the land use area is planned to increase by 250% from the existing area. Strategic areas for industrial development are found in Sta.Cruz and Masinloc in the northern part as well as Subic on the southern edge of Zambales.

3.8.4 Existing Agricultural Development Plan

Table 3.8.2 shows the existing agricultural land use condition within the study area. The total area of agricultural land in the eight municipalities is 14,221 ha. The main agricultural land use is for rice fields with a 72% share of the total agricultural land.

The irrigation ratio of paddy fields in the study area is approximately 50%, which is much lower than the irrigation ratio of 71% for the whole Zambales province. In particular, three municipalities in the study area, Cabangan (29%), Castillejos (31%) and San Antonio (31%) attained the lowest irrigation ratios in the year 2000.

There are two major irrigation development plans in Zambales. One is located on the left side of the Sto. Tomas River with a total irrigation area of approximately 2,000 ha. The plan covers four municipalities, Castillejos, San Marcelino, San Narciso and San Antonio. The water source for the irrigation development is Mapanuepe Lake, for which a feasibility study was conducted in 1996 by NIA, and a high economic viability with 26% of EIRR was obtained.

Another irrigation development plan exists in Botolan with a total development area of 800 ha. In this area, an irrigation network of 400 ha has already been rehabilitated by NIA. The existing intake facility is located on the right bank of the Baquilan River, which was destroyed by the lahar and flood after the eruption of Mount Pinatubo, but it was rehabilitated and is currently operational.

The second major agricultural land in Zambales is used for fruit trees. Covering an area of 2,375 ha this segment has a share of approximately 17% of the total agricultural land of Zambales. The majority of the fruit trees in Zambales is mango, which is the second major product in Region 3, next to paddy rice. The cultivation of mangoes had a value of 1,662 million pesos in the year 2000, with an 8.5% share of the total productive value of Region 3.

3.9 Traffic Condition

3.9.1 Present Road Network

The western river basins of Mount Pinatubo are located in the Province of Zambales in Region 3. It is bounded on the west by the South China Sea, east by Tarlac and Pampanga, south by Bataan and north by the Province of Pangasinan which belongs to Region 1.

The Iba South and North Roads are the major highways in the Province of Zambales and run straight from the south to the north along the South China Sea coast.

The Botolan-Capas Road is the only highway that runs from west to east and connects with the other provinces of Central Luzon. However, this road lies at a significantly lower elevation and is not passable at present due to lahar deposits.

Several rivers cross the Iba South Road. Provincial roads along these rivers extend from the river mouth to the middle stream.

The length of the existing road network is shown in Table 3.9.1. The total lengths of national and provincial roads are 91.0 km and 95.0 km, respectively.

National roads serve as the main trunk line especially for transporting goods and services. Provincial roads provide the same function to supplement the national roads.

Current issues relating to the road network in Zambales are summarized as follows:

(1) In the case of a natural disaster occurring, there is no alternative route to the Iba South Road.
(2) There is no access road to residential areas in the upper stream part of Mount Pinatubo.
(3) There is no access road to the crater lake of Mount Pinatubo which is a potential tourist attraction.

3.9.2 Existing Road Development Plan

The existing road development plan is shown in Figure 3.9.1.

The Zambales-Tarlac Road commences in Iba in the Province of Zambales and runs from west to east ending in Tarlac City. This section of road is under construction and approximately 30% of the total length (at the Zambales end) is completed.

The Zambales-Pampanga Road commences in San Marcelino in the Province of Zambales and runs from west to east ending in the Province of Pampanga. Construction has not yet started.

3.9.3 Existing Bridges and Other Facilities

Measurements for the existing bridges are shown in Table 3.9.1.

There are 37 bridges that have been identified along the national roads with a total length of 2,162 lm, and 30 bridges identified along provincial roads with a total length of 943 lm. The average length of bridges along national roads is 60 lm and bridges along provincial roads have an average length of 30 lm.

The Maculcol Bridge, which crosses the Sto. Tomas River, is the longest bridge with a total length of 381 lm, followed by the Bucao Bridge with a length of 300 lm, which is considered the second oldest bridge built in 1939. The Sta. Rosa steel bridge is the oldest bridge built in 1930.

Current issues regarding the bridge conditions are summarized as follows:

(1) The under clearance of the Bucao, Maloma and Maculcol Bridges is very small due to a significant volume of lahar deposits. No alternative or detour bridges are available for use in case of natural disaster.
(2) Bridges with minor to major damages require urgent repair.
(3) The existing bridges should be removed after constructing new ones to avoid negative impact of turbulent flow on the new bridges.

3.10 Baseline Environmental Conditions

3.10.1 Biological Environment

(1) Terrestrial Flora and Fauna

(a) Terrestrial Flora

The three target areas (rivers), namely: Bucao, Maloma and Sto. Tomas, are distinctly bounded by the Savannah ecosystem in all directions and they are followed by the streambank and hilly land ecosystems from Mount Pinatubo crater down to the South China Sea. Noticeable among the three rivers is the presence of the floodplain ecosystem that dominates the flooded areas which have been inundated by lahar. These ecosystems are the home of various kinds of plant communities, namely: grassland, savanna, brushland, woodland (natural and plantation), shrubs and aquatic /riparian groups.

<u>Floral Landscape in and around the Sto. Tomas River</u>

The headwaters of the Sto. Tomas River, particularly at Mt. Balakibok, house 132 species in 53 families which are predominantly from the group of Moraceae and Euphorbiaceae families. The few climax species of the group are dominated by genera Shorea and Dipterocarpus (Dalmacio, 2001). In total, 17 common plant species dominate the entire landscape in nine families. All plant lifeforms are represented in this landscape from trees to vines and forbs (weeds).

<u>Floral Landscape in and around the Maloma River</u>

In total, the floral composition of the Maloma River landscape includes 26 families with 50 species of various plant lifeforms. The forestry farm areas on both sides of the river are planted in fruit trees such as Mango (*Mangifera indica*), Duhat (*Syzygium cuminii*) and Guyabano (*Annona muricata*) interspersed with Coconut (*Cocos nucifera*) and Guava (*Psidium guajava*).

<u>Floral landscape in and around the Bucao River</u>

A total of 61 species in 22 families were identified belonging to all types of plant lifeforms from various ecosystems. The riparian and floodplain ecosystems, in particular, consist of forbs and low-lying plant groups as they are subject to constant flooding and inundation.

The coastal zone is lined with Agoho (*C. equisitifolia*), as the dominant species, in tandem with Pandan dagat (*Pandanus tinctorium)*, Alagao dagat (*Prema odorata*) and Noni (*Morinda citrifolia*) which are all common in sandy and beach soil types.

(b) Terrestrial Fauna

The eruption of Mount Pinatubo has clearly brought havoc to the biological materials surrounding the volcano. The presence of pyroclastic fans immediately adjacent to the volcano and ravaging lahars have inundated the major rivers that drain to the South China Sea. The loss of plants and water volume in rivers that served as habitats and food sources has significantly affected wildlife species, from birds to mammals. Migratory and permanent terrestrial wildlife are important components in the stability and productivity of all the ecosystems in the landscape. Habitat destruction and disturbance commonly constitute the major cause of a dwindling population.

The loss of habitat and constant movement of lahars has also affected the invertebrate group. This is due to loss of food supply and plant biomass that serves as thermal cover, for their survival in both seasons. Based on field visits, the group of insects include Order Odonata (dragonfly), Hymenoptera (ant, honeybees), Orthoptera (grasshopper, crickets), Lepidoptera (butterflies, moth), Arachnida (spider), Annelid and Isoptera (termites), among others. Table 3.10.1 shows the common wildlife species found in the Maloma and Sto. Tomas River basins.

(2) Freshwater Flora and Fauna

Several freshwater fish species common to Philippine rivers were present in the three major rivers prior to the eruption of Mount Pinatubo in 1991. Based on interviews conducted, the Maloma River had the most diverse fish community, with four migratory fish species (i.e. eel, milkfish, scat and mullet) compared to the Bucao and Sto. Tomas Rivers which had only migratory eels. The eruption and consequent siltation of the river beds, however, prevented the subsequent entry of migratory fish. At present, no migratory fish species are caught from any of the three rivers.

After the eruption, the Bucao River lost all fish species present in the main trunk river unlike the Maloma and Sto. Tomas Rivers where some fish are still caught. Snake-head, tilapia, and goby can still be caught in both the Maloma and Sto. Tomas Rivers, plus catfish, and carp in the latter. Although fish may still be available, the volume is said to have decreased dramatically especially during the dry season when the river becomes very shallow. Sometimes, fish are also caught in impoundments formed after the eruption such as those in the Bucao River basin.

The presence of benthoic macro-invertebrates was only observed in the marine sediments collected from the two sampling stations fronting each river. The density of the organisms in the mouth of each river was 100 organisms/m^2 (Maloma) and 250 organisms/m^2 (Bucao). The presence of polychaetes shows that marine organisms can colonize lahar given ample time for resettlement. It should be noted that the coast is regularly buried in new lahar deposits during the rainy season.

Edible molluscs such as bivalves and snails were not found in the Bucao and Sto. Tomas Rivers, unlike the Maloma River where there is active collection by locals near the closed mouth. The locals use manual push nets made of either wire screen or bamboo, which they drag along the sediment. Every few minutes, they raise the push nets to collect the bivalves. About one gallon can be collected an hour. The collection is only for home consumption.

Of the insect group, only water striders were observed in the rivers. As the name implies, these insects are associated with the water surface. The non-wetting hairs on their foot-pads do not break the surface film but merely indent it, allowing the water striders to literally walk on water. Apparently, their distribution is unaffected by the lahar deposits below the water.

(3) Marine flora and fauna

The 1991 eruption of Mount Pinatubo resulted in the deposition of lahar materials over large tracts of land and coastal areas. The western coast was buried under several meters of lahar as well as the near-shore biotic communities. Since lahar flows are still being experienced along the Bucao, Maloma, and Sto. Tomas Rivers, the periodic surges of massive sediment loads provide a very unstable environment which cannot support even patches of sea-grass beds or coral reefs. There is an area south of this coast that is a potential source of seeds, larvae, and fry that can repopulate the near-shore area once the sediment becomes stable.

Associated with good coral cover is the presence of a very rich reef fish community. In the northeastern section of Port Silaquin alone, a total of 82 reef fish species were observed. Of the 689 fish observed, the top seven species are: two-spot surgeon fish (20.6%); scaly damsel (10.2%); bicolor chromis (4.6%); six-bar wrasse (4.6%); two-tone tang (4.5%); speckled damsel (4.5%) and parrot fish

(4.5%).

(4) Rare and Threatened Philippine Wildlife

Table 3.10.2 shows the rare and threatened Philippine wildlife identified by the Bureau of Forest Development in 1981 for the whole country. Through a literature survey and interviews with local residents in the study area, it is understood that there are no rare or threatened wildlife, or protected wildlife in the project area.

However, there is a sanctuary called Lake Malimanga Fish and Bird Sanctuary located north of Candelaria, which is about 40 km north of Iba. Another protected area called the Naval Base Perimeter Park & Watershed Forest Reserve is located about 20 km south of Castillejos. Both of them are at least 20 km away from the study area of this project.

From the above, it is understood that there are no protected areas of concern, or endangered or protected wildlife within the study area.

3.10.2 Socio-Economic and Cultural Environment

(1) Historical and Cultural Assets

The province of Zambales has several panoramic areas. The famous Subic Bay town is found in the province. Zambales has numerous beach resorts and spots that are good for swimming, boating, and scuba diving. Aside from its man-made attractions, the province also has natural wonders such as its magnificent and lovely mountain ranges, and the gleaming waterfalls in San Miguel and San Felipe which provide exquisite places for weekend vacations.

Aside from the city of Olongapo and the town of Iba (originally the village of Paynave), another historical mark is Castillejos. The town was originally named Pueblo de Uguic in 1973. It was renamed Castillejos in honor of the Marques de Castillejos (1863) of Spanish Morocco, Africa.

Lake Mapanuepe, formed during the height of the lahar flows from Mount Pinatubo, is also one of the potential tourist spots in the province. Located near the relocated barangay of Buhawen in the municipality of San Marcelino, the lake and the areas around it, is good for sight-seeing and nature watching. Near the center of the lake, the steeple of the town church can still be seen from among the many submerged houses and buildings.

(2) Indigenous people and communities

Table 3.10.3 shows the estimated population of indigenous people and their location as of March 2001. It is clearly seen from the table that the majority of the indigenous people living in the Zambales province are from the Aeta tribe. Botolan registered the highest number of indigenous people (40.6%) in the Zambales Province. In total, the entire province is inhabited by an estimated 52,040 indigenous people, of which almost 97.5% are from the Aeta tribe.

(3) Existing Resettlement Centers

There are ten resettlement centers in the western part of Mount Pinatubo, of which seven centers were established by MPC and the other three were established by NGOs. There have been more than 6,500 families resettled from the affected areas of the Mount Pinatubo eruption.

Under the IEE study, an interview survey was carried out for the seven resettlement centers concerned as listed below.

1. Baquilan Resettlement Center

2. Loob Bunga Resettlement Center
3. Taugtog Resettlement Center
4. Balaybay Resettlement Center
5. Lalek Resettlement Center
6. Tek-tek Resettlement Center
7. Bantay Carmen Resettlement Center

Through the interview survey, it is clear that the following unresolved issues exist for the inhabitants, with regard to their livelihood and social economic conditions:

(1) Implementation of livelihood improvement programs with training, because most of the people in resettlement centers need employment to enable them to survive, sustain and improve their living conditions.
(2) Water supply system improvement to enable access to clean potable drinking water. Several hand pumping machines installed in the past are now all out of order.
(3) Lack of sewerage system.
(4) Further health centers are required, with additional medical personnel and increased availability of medicine.
(5) Improvement of educational facilities and scholarship grants for the poor.
(6) Additional classrooms and teachers.
(7) Asphalt roads/paved roads are needed.
(8) A program for domestic and solid waste collection and disposal is required.
(9) Irrigation facilities for agricultural activities are required.
(10) Better housing to accommodate increasing numbers of family members.
(11) Land ownership issue of the centers.
(12) Recreation facilities.

It is also clear that, without resolution of the above issues, the livelihood of the inhabitants and social economic conditions in the centers will deteriorate.

3.11 Institution

3.11.1 Law and Regulation

The principal legislation concerning the water sector in the Philippines is the Water Code and its related regulations. The subsequent Local Government Code which deals with decentralization and the role of LGUs also has an impact on the management and regulation of rivers and flood control although it does not refer to this directly. Both are reviewed in the following paragraphs.

(1) Water Code

The Water Code is the base law regulating rivers and other water courses in the country. It was promulgated through Presidential Decree No. 1067 (PD 1067) on 31 December 1976. In June 1979, the National Water Resources Council (NWRC), now NWRB, issued “The Implementing Rules and Regulations (IRR)” of the Water Code. The legislation is relatively old and may not be entirely appropriate for present conditions.

The main features of this legislation pertinent to this study are summarized below. Important and relevant issues arising are discussed in section (3) below.

1) Major Rivers

Major rivers are defined as having a drainage area of at least 1,400km^2, of which there are 18 in the Philippines. The Bucao, Maloma and Sto. Tomas river basins have drainage areas of 655, 152 and 262 km^2 respectively, so they do not qualify as major rivers. It is not clear how to determine the responsible agency for managing river basins based on this definition.

2) River Administration

The Code initially states that all management of water resources is “subject to the control and regulation of the Government through the National Water Resources Council” but later says that applies except for “those functions which are specifically conferred on other agencies of the government”. As other studies have pointed out, the many violations of this Code[8] suggest that the present management arrangement is not effective.

3) Ownership of Water

Article 5 of the Code says that rivers are owned by the State and implies that their management should be the responsibility of the National Government. There is apparently no listing of which rivers (if any) are not under National Government control.

4) River Area

The ‘river area’ is defined as public land three meters from the river bank in urban areas, 20 meters in agricultural areas, and 40 meters in forested areas. Furthermore, the ‘river bank’ is defined as the “line reached by the highest flood”. Within this area, nobody is permitted to reside or cultivate land. In practice, however, this provision seems not to be applied, either in physically defining the line of the highest flood, or in preventing settlement and cultivation.

5) Flood Plains and Flood Control Areas

The Code states that the Secretary of DPWTC, now DPWH, may declare flood control areas as required and may construct flood control structures in these areas. It has been reported that DPWH are not aware of any river having such officially designated river areas or flood control areas.

6) Water Permits and Maintenance Flow

The NWRB may give permits to extract up to 90% of available water at the point of extraction, which means that 10% is considered as adequate for maintenance flow under all circumstances. This may not be so in every case.

(2) Local Government Code

The Local Government Code was promulgated by the Republic Act No. 7160 (RA 7160) in October 1991. The aim of RA 7160 is to transfer genuine autonomy to local government[9] and to enhance its capacity to undertake the resulting increased responsibility.

RA 7160’s main provisions include those concerning i) creation/modification of LGUs, ii) basic services and facilities, iii) authorities of LGUs, iv) national and provincial government supervision over (and monitoring of) cities and municipalities, and municipalities’ supervision over barangays, v) LG relations with people’s organizations, NGOs and the private sector, and vi) LG planning, budgeting, funding including taxation and credit financing.

In line with the Local Government Code, it is understood that NEDA has been trying to encourage

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[8] Illegal settlers and therefore cultivation in river areas; illegal water diversion and ground water extraction.

[9] Local Government Units (LGUs) are the governments of provinces, cities, municipalities and barangays

LGUs to implement infrastructure projects such as flood control and other river improvement works. Despite National Government (NG) policy, in general the large scale river improvement projects have been undertaken by NG since LGUs have insufficient management and technical capability or funds to perform this works themselves. This is the case in the Zambales Province where current investment programs do not include flood control or river management projects.

(3) NIPAS Act

The National Integrated Protected Area System (NIPAS) Act was promulgated as Republic Act No. 7586 (RA 7586) on 1 June 1992. Implementing Rules and Regulations (IRR) were issued by DENR Administration Order DAO 25 on 29 June 1992.

With regard to the NIPAS policy, IRR states that management and development of protected areas should ensure conservation of biological diversity. The categories of protected areas include nature reserves, parks, wildlife sanctuaries, protected landscapes and seascapes. The existence of these protected areas in the study area is discussed in Section 3.10 and Chapter 11 of this report.

(4) Related Environmental Legislation

Legislation related to the NIPAS Act includes:

i) Prohibition of cutting trees in designated forests, particularly higher than 1000 meters above sea level;

ii) Prohibition of slash and burn agriculture. This seems to be widely disregarded;

iii) A Network of Protected Areas of Agricultural Development. This is to prevent the conversion of agricultural land to other uses without the permission of the Department of Agriculture and the Sanggunian (LGU parliament).

3.11.2 Organization

(1) Philippine Government

The organization of the Philippine Government is outlined in Figure 3.11.1. The government agencies concerned with the management of water resources and river basin management in particular are:

Department of Public Works and Highways (DPWH)

a) Establishment and maintenance of major flood control and drainage facilities,
b) Management of water resources by the National Water Resources Board (NWRB), attached to DPWH, previously and now transferred to the Office of the President,
c) Raw and treated water supply by the Metropolitan Waterworks and Sewerage System (MWSS) and PMO - Rural Waterworks System (RWS), also attached to the DPWH. PMO - RWS supplies treated water only. LGUs generally supply raw water.

Department of Environment and Natural Resources (DENR)

a) Watershed management,
b) Water quality management,
c) River environment management.

Department of Agriculture (DA)

a) Agricultural development,

b) Establishment of irrigation projects by the National Irrigation Agency (NIA), attached to the DA.

Department of Science and Technology (DOST)

a) Flood forecasting and warning systems by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), attached to the DOST.

Department of National Defense (DND)

a) Disaster prevention and mitigation by the Office of Civil Defense (OCD), attached to the DND,
b) National Disaster Coordinating Council (NDCC) led by OCD.

Department of Agrarian Reform (DAR)

a) Land acquisition and distribution.

Department of Interior and Local Government (DILG)

a) Coordinating and supporting LGUs.

Corporations, NGOs etc.

a) Hydropower by the National Power Corporation (NPC)
b) Emergency services by the Red Cross and other NGOs and private entities.

It is perhaps significant that the words "water" or "river" do not appear in the names of any of the above agencies.

(2) Institutions Concerned with River Basin Management

Many agencies are reported to be concerned with the various aspects of river management. Some of these are listed below under task headings. Where possible, this information was sourced from charts issued by NWRB in 2001 which show functional and organizational relationships (see Figures 3.11.2 and 3.11.3) in water resources management.

1) Watershed Management (river basin conservation)

According to NWRB, the Forest Management Bureau (FMB) is the leading agency with participation from the Bureau of Soils and Water Management (BSWM), NIA, NPC and MWSS. This list does not include DENR, EMB, or DA, all of which would normally be involved in this area. Moreover, FMB may not be the appropriate body to lead this important area if it has any responsibility for commercial forestry.

2) Water Resources Management (development, licensing, allocation, distribution of water resources)

This important area does not appear on the NWRB chart referred to above. However, NEDA and NRWB are said to be the leading agencies with participation from the MWSS, PMO-RWS, Local Water Utilities Association (LWUA), Laguna Lake Development Authority (LLDA), NIA, DPWH, DILG, DA, OCD, PAGASA and LGUs.

3) Flood Control (development of infrastructure, flood forecasting)

From the NWRB chart, DPWH is the leading agency with participation from the two PMOs – for Major Flood Control Projects (MFCPs) and Small Water Impounding Management Projects (SWIMs). DPWH undertakes planning, design and construction of flood control facilities, and defines flood control areas. In addition, other agencies are reported to participate, namely:

a) PAGASA which operates the flood forecasting system and also issues flood warnings to interested agencies and the public,
b) OCD which, as the executive agency of the National Disaster Coordinating Council (NDCC), has to ensure, with other agencies such as DPWH, NIA and NPC, that the nation is prepared for floods, that necessary warnings are issued, and that mitigation measures are implemented, and
c) LGUs.

NWRB is responsible for providing the regulations relating to rivers, including designating river areas; giving permission to water users; and approving construction of all river-related civil works. There may have been some expansion of these responsibilities along with the recent transfer of the NWRB to the Office of the President (see 3.11.3(4) below).

4) River Water Quality Management (water quality monitoring, pollution control)

NWRB states that the Environment Management Bureau (EMB) is the lead agency, with participation from DOH, and the Environmental Health Service (EHS). MWSS, LWUA and LGUs are also reported to be involved.

5) River Environment Management (River Corridor Maintenance, River Environment Land Use Management)

This activity is not shown on the NWRB chart. Participants are reported to include DENR/EMB, NWRB, DOH, NHA, MWSS, LWUA and LGUs.

6) Water Resources Infrastructure Maintenance

This activity is not shown on the NWRB chart, but DPWH would be the leading agency assisted by the relevant units within LGUs to some extent (not clearly defined).

(3) The Organization of DPWH

This section outlines the role and organization of the DPWH Central Office, the DPWH Regional Office in Region 3 and District Offices in relation to river basin management and specifically flood control.

1) DPWH Central Office

a) Mandate of DPWH

The Executive Order No. 124 dated 30 January 1987 established DPWH "as the engineering and construction arm of the Government." As such it was to "develop its technology [to ensure] the safety of all infrastructure facilities and [to secure] the highest efficiency and quality in construction." "DPWH is currently responsible for the planning, design, construction and maintenance of infrastructure, especially national highways, flood control and water resources development systems, and other public works in accordance with national development objectives."

The mandate says nothing about the operation of infrastructure.

b) Organization Structure of the DPWH Central Office

The present structure is shown in Figure 3.11.4. In addition, there are two attached agencies, LWUA and TRB. NWRB was recently transferred from DPWH to the Office of the President.

Master plans and feasibility studies are the responsibility of the planning service, usually with the assistance of consultants. Project implementation is undertaken by the Project Management Offices (PMOs), the heads of which report to an Assistant Secretary or Under Secretary depending on the project's location.

c) Staffing of DPWH

According to DPWH, in June 2002, the total number of staff amounted to some 36,200 (up from 34,800 in 2001), of which the regular staff was about 19,300 or about 53% of the total. The remaining staff were either on contract (944) or casual (14,107) or regular staff charged to the Maintenance Fund (1,829). The total number of qualified engineers cannot be easily obtained as staff are apparently only classified by grade and not by discipline.

d) Staffing of Project Management Offices

Also in June 2002, the total number of staff in all PMOs, PMO Clusters and Field PMOs was about 1,400. Each PMO had an average of 62 staff. There were apparently no regular staff in the field PMOs; all were either contracted or casual. This may not be an ideal arrangement.

e) Annual Investment Program (2001 to 2004)

From the DPWH's Medium Term Public Investment Program (MTPIP), the planned annual investment from 2001 to 2004 is shown in the table below.

Planned Annual Investment from 2001 to 2004 (Unit: Million Pesos)

Year	Highways		Flood Control		Others	Total	Annual Increase
2001	21,878		5,347		7,751	34,976	
2002	27,228	(24.7)	7,079	(32.4)	8,311	42,618	21.8%
2003	37,352	(37.2)	7,849	(10.8)	11,282	56,483	32.5%
2004	43,464	(16.4)	8,546	(8.9)	11,330	63,240	12.0%
Total (01 to 04)	129,922	(98.7)	28,821	(59.8)	38,674	197,417	80.8%
Share	65.8%		14.6%		19.6%	100.0%	

Note: Figures in brackets indicate annual percentage increases

The table indicates substantial annual increases in total investment but smaller increases for investment in flood control. Highways received the largest annual increases both in the amount and as a percentage of the previous total. It is planned that foreign assistance will fund 52.7% of the 197.4 billion Pesos over the four year period.

2) DPWH Region 3 Office

a) Organization

The organizational structure of the Region 3 Office of DPWH is shown in Figure 3.11.5. The office is in San Fernando and has two Assistant Regional Directors (for Areas 1 and 2), six divisions, a Regional PMO, a Regional Equipment Service Office, and three support units reporting to the Regional Director. Zambales Province is in Area 2.

In addition, there are 11 Engineering District Offices, including one in Zambales Province based in Iba, the provincial capital, one Engineering Sub-Office in Olangapo, two Area Equipment Services for Areas 1 and 2, and two PMO-PRCSs[10] for Areas 1 and 2. (The two PRCSs are responsible for the East Pinatubo River basins only and will have no direct relationship with this project.) These field units report to their respective Assistant Regional

[10] Pampanga River Control System

Directors according to their location.

b) Project Authorization

According to the DO 60 in 1998, Region 3 Office was authorized to plan and design projects of up to 50 million pesos and to implement projects of up to 30 million pesos. Also, the DO 61 in 1998 authorized District Engineers (DEs) to implement projects of up to 15 million pesos.

These regional and district authority limits are much lower than the cost of either of the projects proposed in this Study (see Section 3.11.5).

c) District Engineer's Offices

The 11 DE offices and one sub-office undertake project implementation and maintenance work on the existing infrastructure. This work is chiefly concerned with national highways and bridges within district authority limits and boundaries. In confirmation, there were 78 infrastructure projects completed in 2001 valued at 189 million pesos, of which only one (valued at 2.7 million pesos, or 1.4% by value) was for flood control. However, seven maintenance projects for flood control were completed at a cost of 12 million pesos from the District's maintenance fund.

d) Regional Equipment Service (RES)

RES maintains and provides the heavy and standard equipment required for new construction and maintenance work. If the Region 3 equipment is typical, it is old and inefficient. As a result, most major road maintenance, for example, is sub-contracted.

e) Staffing

The number of staff in the DPWH Region 3 office at the end of FY 2001 is summarized in the table below:

Number of Staff in the DPWH Region 3 Office

Unit(s)	Positions		
	Authorized	Filled	Vacant
Regional Office	210	209	1
Nueva Ejica & Pampanga	186	185	1
Bataan I, Bulacan I, Tarlac, Zambales	275	274	1
Bataan II	42	42	0
Pampanga II, Bulacan II, Nueva Ejica II	120	120	0
Cities	98	78	20
Regional Equipment Service	134	133	1
Area Equipment Services I & II	209	209	0
TOTALS	1,274*	1,250	24

Note: 1.The Regional Office staffing is analyzed as follows: Regional Director's Office – 18; Planning and Design Divn. – 35; Construction Divn. – 23; Materials Quality Control & Hydrology Divn. – 20; Maintenance Divn. – 41; Controllership & Financial Management Divn. – 23; Administrative Divn. – 52.
2. PMO-PRCS I and II are excluded from this table.
3. *Regular staff. In addition, there are 525 casual employees and 114 charged to Maintenance Fund.

Source: DPWH Region 3

The table indicates a remarkably low level of vacancies, except in the cities. This is consistent with a high unemployment rate. However, this would normally be lower in the cities.

f) Annual Budget for 2002

The annual budget for the DPWH Region 3 office in 2002 is summarized in the table below. Region 3 total includes the regional office, three subdistrict offices and ten district offices, and the regional equipment service.

Annual Budget for the DPWH Region 3 Office in 2002 (Unit: Million Pesos)

Unit	Authorized Appropriations			
	Personnel Service	MOOE	Capital Outlay	Total
Region 3	202.42	277.30	184.37	664.09
Regional Office 3*[1]	45.78	87.89	79.26	212.93
Zambales DEO	11.42	27.24	4.78	43.43
Zambales SDEO	2.98	8.53	-	11.51
Regional Equipment Service	47.20	4.25	-	51.45

Note: 1.*[1] Includes Pampanga, Tarlac and Zambales Subdistrict Engineering Offices.
2. MOOE is an abbreviation of Maintenance Organization and Operation. This cost includes sub-contracted operations and casual personnel.

Source: DPWH Region 3

This table shows that the total cost of the Regional Office and three sub-district offices is about 32% of the overall Region 3 cost, a higher proportion than that for personnel which is only 23%. This difference is due to the higher MOOE cost of district offices. Capital outlay for the Regional Office and sub-districts is the highest of the three types of cost as a proportion of the total Region 3 cost, at 43%. Thus, in terms of both personnel and MOOE cost ratios, the Regional Office is receiving more than its fair share of capital investment. It should be noted also that the sub-district offices are receiving no capital outlay for 2002. This skewed investment pattern suggests that decentralization to districts, explicit in the Local Government Code, is not being properly implemented.

g) Infrastructure Program for 2002

The following table shows the 2002 program for investment in highways, flood control and other types of infrastructure throughout the region. Zambales Province is subdivided into the Iba (District 1) and Olangapo Districts.

2002 Program for Investment in Infrastructure (Unit: Million Pesos)

Province	Highways	Flood Control	Other Infra.	Total
Bataan	40.2	13.8	100.0	154.0
Bulacan	91.5	26.6	200.0	318.1
Nueva Ecija	311.5	2.4	200.0	513.9
Pampanga	101.8	1,079.5	200.0	1,381.3
Tarlac	38.5	208.8	150.0	397.3
Zambales	71.1	14.6	100.0	185.7
- District 1	[13.4]	[13.0]	[50.0]	[76.4]
- District 2	[57.7]	[1.6]	[50.0]	[109.3]
TOTAL	654.6	1,345.7	950.0	2,950.2

Note: Foreign Assistance projected for Highways and Flood Control Projects amounts to P1,743.6 million (about 87% of total investment in these areas or about 59% of total investment).

Source: DPWH Region 3

This program plans to invest about 185.7 million pesos or about 6.3% of the total regional investment in the Zambales Province, and of that amount about 14.6 million pesos in flood control. Zambales receives the second lowest total infrastructure investment. The equivalent figures for District 1 (based in Iba) are 76.4 million pesos of total investment of which 13.0 million pesos would be for flood control.

(4) National Water Resources Board (NWRB)

The functions, duties and powers of NWRB are set out in the NWRC Charter (PD 424 0f 1974), the Water Code (PD 1067 of 1976) and PD 1206 of 1977. Accordingly, the NWRB's main tasks are licensing of water rights and maintaining the necessary database, water allocation and the compilation of hydrological data, although a previous report[11] has criticized the output quality of this last task. In addition, according to the NWRB's own statement of its role within the water sector, it is a coordinator and regulator of the various activities in this sector. NWRB is attached to DPWH administratively but is said to function independently with its own policy-making Board of Directors.

NWRB has very recently been transferred from DPWH to the Office of the President by Executive Order No. 123 signed by the President on 12 September 2002. The order recognizes the need to strengthen NWRB to carry out its mandate of regulating the "utilization, exploitation, development, control, conservation or protection of water resources", and has temporarily transferred this body to the Office of the President and amended the Board membership to exclude those with direct claims on water resources. The Secretary of DENR will chair the new seven member board.

The EO instructed the NWRB to start a review of the Water Code IRR, and to revise the organization of its secretariat, after which, if approved by the President, the NWRB will be transferred to DENR. It is not yet known whether this move has been accompanied by an expansion of its responsibilities and authority.

(5) Provincial Government

The structure of the Zambales provincial government is shown in chart form in Figure 3.11.6. The government has 12 offices delivering various local government services, together with two provincial hospitals, two programs (population and social welfare and development), and the Secretariat to the provincial Sangguniang or parliament.

Among the provincial offices is that of the provincial engineer. This office is staffed by two management level engineers, 10 senior engineers, as well as engineering assistants and draftsmen, other tradesmen, heavy equipment operators and support staff amounting to some 108 employees in all. As an indicator of their activities, in 2001 the province completed 62 projects, which included the improvement and rehabilitation of roads, upgrading and improving public buildings, hospitals and sports facilities. Projects were reportedly funded from the Development Fund (20% allocation of municipal revenue), Trust Fund, General Fund and from the Calamity Fund (5% allocation of municipal revenue), to a total amount of P117.7 million. However, flood control and drainage works were not among the projects reportedly completed.

The total staffing of the provincial office at the beginning of 2002 was 647 which comprised 48 in senior management posts, 306 in technical, supervisory and trade posts, and 293 in support jobs. This breakdown can be compared with a similar analysis of municipal posts in the table under subsection (6) below. The 306 employees in technical, supervisory and trade posts include 17 qualified engineering staff at different levels of seniority.

The provincial annual budget estimate for 2002 comprises a total income of 350.0 million pesos of which 288 million pesos is funded from the Internal Revenue Allotment, and a total expenditure estimated at 349.9 million pesos, leaving a small unappropriated balance of about 100,000 Pesos. The cost of the Provincial Engineering Office is estimated at 40 million pesos, or about 11% of the total

[11] SAPI Study on Institutional Capability Building in [the] River Sector in the Republic of the Philippines, Final Report, August 1999

appropriations.

(6) Municipal Government

As an indicator of the size and viability of the eight municipal LGUs, the following table shows the 2002 annual revenue and expenditure budgets for each municipality.

Annual Revenue and Expenditure in Each Municipality (Unit: Thousand Pesos)

Municipality	Revenue			Expenditure			
	IRA	Local	Total	General	Development	Total	
Botolan	55,500	4,847	60,347	51,414	8,900	60,314	(+33)
Cabangan	20,674	8,803	29,477	28,235	1,242	29,477	(NIL)
Castillejos*	23,534	13,375	36,909	35,903	880	36,783	(+126)
Iba	26,261	19,308	45,569	44,429	1,069	45,498	(+71)
San Antonio	28,452	1,518	29,970	29,114	605	29,719	(+251)
San Felipe*	16,332	2,833	19,164	19,150	0	19,150	(+14)
San Marcelino	28,313	12,843	41,156	41,147	0	41,147	(+9)
San Narciso	19,474	3,416	22,890	22,832	0	22,832	(+58)
TOTAL	218,540	66,943	285,482	272,224	12,696	284,920	(+582)
Non-weighted Average	27,318	8,368	35,685	33,620	1,587	35,615	
% Share	76.6%	23.4%	100.0%	94.4%	4.5%	100.0%	

Notes: Figures in brackets show the budgeted surplus or deficit. *Signifies comprehensive, timely response to the Study Team's request for data. Due to rounding, individual figures may not exactly equal totals.

Source: Municipalities listed above

As can be seen from the above table, most of the income (an average of 77%) is from the Internal Revenue Allotment (IRA) although the proportion varies greatly between municipalities. San Antonio has the highest proportion of IRA at 95% (or the lowest proportion of locally sourced income) while Iba, Castillejos and San Marcelino have the lowest at 58%, 64% and 69% respectively.

A high proportion of income is allocated to general expenses which include the costs of personnel and office operations, and also the 20% allotment for the Economic Development Fund and a 5% levy for the Calamity Fund. Of the average 4.5% to be used for development, only a small proportion is for minor flood and drainage projects.

The table below gives the staffing at the beginning of 2002 for each municipality and the provincial government. As the table shows, except for Botolan, the municipalities only have an engineering department head and no qualified staff.

Staffing at the Beginning of 2002 for Each Municipality and Provincial Government

Municipality	Category of Staff					
	Management*[1]	Engineering	Non-engineering	Support	Total	Regular*[2]
Provincial Government	48	17 + (2 in col 1)	289	293	647	187
Botolan	30	3 + (1 in col 2)	43	37	113	16
Cabangan	13	(1 in col 2)	37	52	102	3
Castillejos	23	(1 in col 2)	40	29	92	15
Iba	26	(1 in col 2)	35	31	92	8
San Antonio	26	(1 in col 2)	33	24	83	8
San Felipe	22	(1 in col 2)	28	51	101	0
San Marcelino	25	(1 in col 2)	51	53	129	25
San Narciso	24	(1 in col 2)	30	31	85	13
Municipal Totals	189	3 + (8 in col 2)	297	308	797	88
Un-weighted Municipalities Average	24	0.4 + (1 in col 2)	37	39	100	11

Note: *[1] Including about 10 members of the Sangguniang Bayan (Municipal Legislature) in brackets where known. *[2] Regular staff are included in municipality totals

Source: Municipalities listed above

3.11.3 Issues

The following is a summary of the main issues identified in this section with some additional material from the SAPI study.

(1) Law and Regulation

The major issues concerning the legislation appear to be:

i) Lack of enforcement, and therefore widespread violation, of the law;
ii) The definition of major rivers (and probably other classes of river also) should be logically linked to decisions on whether they should be managed centrally, provincially or locally;
iii) Rivers managed by the National Government should be specified;
iv) From the Water Code, there is an apparent lack of overall management of the water sector and rivers in particular. The NWRB's role in water resource management should be clarified. This is still needed after the recent issue of EO 123 (see Section 3.11.2(4) above);
v) River areas and flood control areas should be properly defined and the law enforced within the areas defined, or the law should be amended if it is currently inappropriate.

(2) Organizations

The major issues concerning organizations, which have a bearing on the execution of the projects proposed in this study, are summarized in the following paragraphs.

i) It is normal for there to be many agencies involved in the various aspects of river basin management. However, in the Philippines there appears to be no suitably empowered body with clear lines of command and responsibility, and adequate authority, for the management of rivers and the water sector in general at a national or regional level. The same can be said for those major river basins not managed by a river basin development authority. The recent EO 123 transferring the NWRB to the Office of the President en route to the DENR is a move in the right direction, but other changes are also required.
ii) If the NWRB is to continue in its regulatory role and to have additional responsibilities in, for

example, setting and/or approving raw and treated water tariffs and is also to have a greater role in the management of water resources, there is a potential conflict of interest involved. Generally, regulatory functions are separated from line management functions for this reason.

iii) In Section 3.11.2(2), some important agencies are omitted from the areas of river management (refer to Figure 3.11.3). For example, the absence of either DENR or EMB and DA from watershed management, if this is in fact correct, is a significant weakness. Important areas of river management omitted from the same chart include water resources management (NWRB's responsibility) and river environment management.

(3) Project Implementation

It has been noted elsewhere that counterpart funding, for both planning and the delivery of funds, for foreign funded projects is often inadequate and acts as a constraint on progress.

In addition, the SAPI study of 1999 identified some institutional problems and the need for capacity building in the river sector, as follows:

i) Difficulty of land acquisition and compensation, and the apparent lack of standard compensation criteria,
ii) The time consuming procedure for approvals, partly because of an over-centralized approval and decision making system,
iii) Opposition of the community,
iv) Lack of resources and authority for PMO(s),
v) Coordination among the many agencies concerned with river project implementation (already referred to in 3.11.3(2) above),
vi) Weaknesses in the Water Code and its implementation (already summarized in 3.11.3(1) above),
vii) Lack of contractor capabilities, partly due to poor selection procedures.

PART II
Formulation of Master Plan

CHAPTER 4 BASIC CONCEPT OF MASTER PLAN

4.1 Main Issues to be Addressed in the Study Area

The results of the investigations conducted in the study and stated in Chapter 3 revealed the present natural and social conditions and major issues in the study area, mainly in terms of sabo and flood control, which are:

1) Even though 12 years have passed since the eruption of Mount Pinatubo and the volcanic activity has ceased, the estimated annual sediment yields are 25.9 million m^3 (39.5 mm/km^2/year) in the Bucao River basin, 1.4 million m^3 (9.3 mm/km^2/year) in the Maloma River basin and 6.2 million m^3 (23.7 mm/km^2/year) in Sto. Tomas River basin in 2001. Re-mobilization of the sediment deposited in the upper stretches is another major cause of sediment being deposited in the downstream stretches. Sediment control/management is required for further disaster prevention/ mitigation in the downstream residential and agricultural areas.
2) Floods occur in the Bucao, Maloma and Sto. Tomas River basins. One of the major causes of the flooding is high riverbed, elevated by the sediment deposit, which results in a high flood water level. The flood-prone areas include the area downstream of the Bucao Bridge and areas along the Maloma River. Dikes along the Sto. Tomas River have breached several times due to insufficient height and strength and the inundation area has extended toward the municipalities of San Marcelino and San Narciso. Extension, strengthening and/or heightening of the existing dike system is essential to improve the security of the downstream flood/mudflow prone area under abnormal river conditions because the riverbed elevation is much higher than the adjacent residential/agricultural land.
3) The nation-wide road density was 673 meters/km^2 in 2001, while the road density of Zambales Province was 533 meters/km^2. Only one arterial route, national highway No.7, runs along the western coastline and crosses the Bucao, Maloma and Sto. Tomas Rivers. That road is recognized as a lifeline for all the people in Zambales Province which has a population of 434,000. To have sustainable economic growth in Zambales it is essential to improve the reliability and security of national highway No.7. Furthermore, local roads on the outskirts of Mount Pinatubo have been buried by lahars since the eruption. Re-construction of the local roads is desirable to recover the livelihood of people residing in this mountainous area.
4) The area converted from riverside farm land into unusable lahar areas, due to the spread of lahar flow along the river, is estimated at 9,461 ha in the study area, of which 5,534 ha is along the Bucao River and 3,797 ha along the Sto. Tomas River. Use of these lahar areas is desirable for agricultural development, which will induce recovery and improvement of the economy in Zambales Province.
5) The total annual production of paddy rice decreased from 75,200 tons in 1990 to 56,500 tons in 1995 (a 25% fall) from a 28% reduction in the harvest area in Zambales Province. Parts of the existing irrigation systems in Botolan, San Marcelino and other municipalities still remain un-restored after the Mount Pinatubo eruption. The restoration and expansion of the system will lead to an increase in paddy rice production.
6) Annual average family income in the study area dropped seriously from P35,579 in 1990 to P.29,764 in 2002 for the Bucao River basin, and from P79,654 to P44,631 for the Sto. Tomas River basin. The income level in the study area has not yet recovered and is still much lower than the national poverty threshold of P.71,493 as of 2002. Income generation and livelihood development measures need to be incorporated into the master plan as a component of the recovery action after the disasters.

The Government of the Philippines (GOP) and Non-Government Organizations (NGOs), with technical and financial support from donor countries and funding institutions, have taken the following action to address the above issues:

1) For the Bucao River, the GOP followed the structural plan proposed by the USACE in "Mount Pinatubo Recovery Action Plan for Eight River Basins (March 1994)" and a 6km long dike was constructed using the GOP's own finance. For the Maloma River, the GOP basically followed the USACE plan for the construction of a 3.2 km long dike. For the Sto. Tomas River, the GOP implemented the construction of a 26.7 km long dike along both banks, as proposed by USACE.
2) Non-structural measures including forecasting and warning systems (with telemetered rain gauges, acoustic flow monitors and trap-wire type mudflow sensors), and an evacuation system were provided. However, none of these measures are still operational except for the evacuation system.
3) Resettlement area development and livelihood support activities for the affected people were undertaken from 1992 to 2001 by the Mount Pinatubo Commission (MPC), under the Office of the President, together with NGOs. There are 10 resettlement centers in the study area and more than 6,000 families are living in these centers.

However, the issues detailed above remain unsolved.

4.2 Necessity of Master Plan Formulation

One of the major reasons why the issues mentioned above have not been solved in the field of sabo and flood control is the absence of a comprehensive master plan to implement the sabo and flood control projects. The "Recovery Action Plan for Eight River Basins" prepared by USACE in 1994 gives alternatives for recovery action. However, it does not provide the required long-term permanent solutions, priority projects or their implementation schedule.

Therefore, to resolve the issues, a comprehensive master plan for sabo and flood control is required for the Bucao, Maloma and Sto. Tomas Rivers, which should be formulated on the basis of the present river and basin conditions by applying the results of the basin-wide sediment analysis.

It is reiterated that plans, projects, and measures incorporated in the sabo and flood control master plan are not only for sabo and flood control in the study area but also for sustainable regional development including development of agriculture and tourism and traffic improvement.

4.3 Basic Concept of Master Plan

Figure 4.3.1 shows the basic concept of the master plan. Details are explained in the following sections.

4.3.1 Approach to Basin-wide Comprehensive Sediment Control

Effective measures required to attain basin-wide comprehensive sediment control are to be included in the master plan, for which the following estimates and/or analyses are needed:

1) Future sediment yield upstream of the basin,
2) Short-term and long-term sediment transport, in which the design flood is applied for the former and long-term flow hydrograph is applied for the latter,
3) Riverbed movement along the river course midstream and downstream of the basin.

The effective measures for the comprehensive sediment management such as sediment retention, control or release are to be studied on the basis of the sediment transport and riverbed movement analysis mentioned above.

4.3.2 Combination of Improvement Works in Lowlands and Highlands

The master plan covers both areas of lowlands and highlands, and aims not only to mitigate flood/ mudflow damage in lowlands but also to recover people's livelihood in the mountainous area.

Hence, the goal of the master plan, which is the regional economic development and poverty alleviation of the region, can be achieved by efforts in both the lowlands and the highlands.

4.3.3 Combination of Structural and Non-structural Measures

A combination of structural measures to control floods/ mudflows, non-structural measures to reduce vulnerability, and community based disaster prevention plans, is to be incorporated into the master plan.

(1) Structural Measures and Non-structural Measures

A hazard is a risk of natural disaster and may be reduced by structural measures. Vulnerability is a social weakness for coping with hazards. If there are no people in the hazardous area and no property therein, no damage will occur. The vulnerability may be reduced by means of relocation of affected people and/or evacuation when there is risk of an emergency. Evacuation with warning and resettlement are called non-structural measures.

(2) Community-based Disaster Prevention Plans

Community based disaster prevention plans are to be formulated to improve the living standard of damaged communities as one of the activities to alleviate poverty, by contributing to future disaster prevention and/or mitigation.

The key factors to promote successful community based disaster prevention work are:

1) that the local people understand the objective of the community based disaster prevention plans, and,
2) that the local people are willing to overcome disasters due to flooding and mudflow.

4.3.4 Regional Economic Development and Poverty Alleviation

It is important to break the vicious circle of disaster occurrence, damage, low economic activity, poverty, and no preparedness against disasters, that occurs within the study area, in order to achieve regional development and poverty alleviation. The disaster prevention measures formulated in the master plan are considered to be some of the major solutions for breaking this vicious circle.

Currently, the National Economic and Development Authority (NEDA) Region 3 (Central Luzon) has a "W"-shaped growth corridor strategy in their Medium Term Regional Development Plan (2002-2004) as shown in Figure 4.3.2. The first line of "W" starts from the northernmost towns in Zambales and goes southward along the coastal area. This line is regarded as the tourism belt. This tourism belt runs through the study area and therefore the master plan takes tourism development into account as one of the important factors. In addition, agriculture and fishery are the main economic sectors of Zambales. Hence, it can be said that the economic development of Zambales is anchored on agriculture and tourism. To support their development, security of the road network in the Province is vital.

The master plan for sabo and flood control in the study area will integrate development in the sectors of agriculture, tourism and road network.

4.3.5 Target Year and Planning Scale

The target year of the master plan is set to be 2022, which is 20 years after the end of the study.

The planning scale of the structural measures has been determined to be the magnitude of a 20-year probable flood in order to maximize the investment effect.

4.4 Points to be Considered in Formulating the Master Plan

4.4.1 Overall Disaster Prevention Plan around Mount Pinatubo

It is essential to have consistency between the master plan for the western river basins of Mount Pinatubo and the plans for the eastern areas. This concept will enable consistent implementation of an overall disaster prevention plan in the areas affected by the Pinatubo volcano.

The sabo and flood control plans for the eastern areas of Mount Pinatubo include those for the Sacobia-Bamban River, Abacan River, Pasig-Potrero River, O'donnell River and Porac-Gumain River.

4.4.2 Formulation of Realistic and Economical Plan

(1) Integration with the Existing Sabo and Flood Control Structures

Sabo and flood control works, such as dikes, have been implemented by the GOP based on the "Mount Pinatubo Recovery Action Plan for Eight River Basins". The structural measures in the master plan are formulated with a maximum use of the existing facilities. The existing facilities include mainly dikes and revetments in the Bucao, Maloma and Sto. Tomas Rivers.

(2) Realistic Planning

Projects, plans and measures to be incorporated in the master plan should be formulated from the viewpoints of not only technical, economical and environmental viability but also financial feasibility, especially the ability to repay loans and provide local currency.

CHAPTER 5 FLOODS AND DAILY RUNOFF

5.1 Floods

5.1.1 Probable Rainfall

Figure 5.1.1 shows the location of present or former rainfall stations within or around the study area. There are five present or former PAGASA rainfall stations and three former PHIVOLCS rainfall stations situated on the western side of Mount Pinatubo. The PAGASA stations are situated along low-lying coastal areas, all no greater than 30 m in elevation, while those for PHIVOLCS were at higher elevations.

Most of the PAGASA stations collect daily rainfall using a manned gauge keeper. For the Iba Synoptic Station, hourly rainfall data is also collected by use of a tipping bucket and automatic wind-up logger. Unfortunately, during the investigation it was discovered that most of the rainfall charts past 1990 were unprocessed and their location was scattered between the various offices of PAGASA, severely affecting the analysis.

The rainfall data from the PHIVOLCS stations was found to be for too short a period to utilize it for probable rainfall analysis. However, it was observed that the amount of rainfall on the side of the mountain was much higher than the amount recorded in coastal locations.

Based on a check and review of corrected rainfall data, it was concluded that the daily data from the three rainfall stations at Iba, Santa Rita, and San Marcelino were available for analysis to establish probable rainfall. This judgement was made based on the recording period and location. The available period for probable rainfall analysis was for the 19 years from 1976 to 1995. Table 5.1.1 shows the annual maximum daily rainfall record for the three stations.

The basin mean rainfall was computed for each of the three river basins. The Thiessen polygon method was adopted for calculating the basin mean rainfall. The stations used were PAGASA's, Iba, Santa Rita and San Marcelino stations, which are all located at an elevation of less than 30 m. Therefore, the PHIVOLCS' 204 station was also utilized to take account of the elevation effect in rainfall pattern. For the 204 station, it was assumed that the rainfall would be a 20% increase from the Santa Rita station. The Thiessen Polygon for the study area is shown in Figure 5.1.2. The weight distributions of the Thiessen polygon and basin mean rainfall are shown in Table 5.1.2.

Subsequently, annual maximum daily rainfall data from the four rainfall stations (Iba, Santa Rita, San Marcelino and No.204 gauges) for 18 years (1976-1995) after screening, was used for rainfall probability analysis.

The probable basin mean daily rainfall for the three river basins, Bucao, Maloma, and Sto. Tomas is tabulated in the following table.

Probable Basin Mean Rainfall in the Bucao, Maloma, and Sto. Tomas River Basins

Unit (mm)

Basin	Return Period (Year)						
	2	5	10	20	30	50	100
Bucao	257	378	473	577	642	730	861
Maloma	203	309	399	502	570	665	811
Sto. Tomas	200	305	395	500	568	665	814

For estimation of the above probable rainfall, three theoretical probable distributions, Gumbel, Log-Pearson III and Iwai methods, were compared. Based on the comparison, it was judged that the Log-Pearson III is the best fit with the data as shown in Figure 5.1.3, and it has been applied to the three basins.

A model hyetograph for the basin mean rainfall was developed taking into account the duration period of the 10 largest recorded storms from 1970 to 1980 with more than 100 mm at the Iba station, which is the only available automatic raingauge with a long-term recorded period in the study area. Figure 5.1.4 presents the model hyetograph developed by the study team. Consequently, the entire duration of the model hyetograph for the basins was set at 24 hours based on the duration of recorded floods. The rainfall distribution of the model hyetograph was determined in the form of what percentage each hourly rainfall is of the total amount of 24-hour rainfall.

5.1.2 Probable Flood

As there were no long-term flood discharge records available for the study area, the probable flood was analyzed through the development of a flood run-off model.

Flood analysis was conducted for the three basins, Bucao, Maloma, and Sto. Tomas, using the HEC-HMS model. The HEC-HMS is software developed by the United States Army Corps of Engineers (USACE) and is available free of charge. The Unit Hydrograph Method was selected in this study for the following reasons:

1) The Unit Hydrograph Method was used for runoff analysis in the eight river basins surrounding Mount Pinatubo in the Recovery Action Plan conducted by the USACE in 1994.
2) This method was also used for runoff analysis in the Porac-Gumain river basin and the Pasig-Potrero river basin conducted after the USACE study.
3) In addition, the Unit Hydrograph method would be appropriate for transfer of technology to the counterparts, one of the most important aspects of this study, because the model can be transferred completely to them.

With the parameters set, the model was run using the design storm mentioned in the previous sections to estimate the probable flood. Model diagrams for the Bucao, Maloma, and Sto. Tomas Rivers are shown in Figure 5.1.5. The design floods for a 1 day storm for return periods between 2 to 50 years were computed using the HEC-HMS software. Due to the small size of the basins and the relatively large range of coverage of rain clouds during typical monsoon rainstorms, no areal reduction factor was applied.

It is noted that, based on U.S. Weather Bureau Technical Papers 38 and 49 concerning depth area relationships, a 24 hour storm will only be reduced to 85% of its point of rainfall for distances of 15 km and beyond. Given that this only slightly reduces the depth, the more severe situation was assumed. Computed hydrographs for 1 day rainfall duration are shown in Figure 5.1.6 for the Bucao, Maloma and Sto. Tomas Rivers. The flow distribution diagrams throughout each basin are shown in Figure 5.1.7, 5.1.8 and 5.1.9. The probable peak discharges at the bridges along national highway No.7 are summarized as follows:

Probable Peak Discharges at the Bridges along National Highway No.7 (Unit:m^3/s)

Basin	Return Period						
	2-year	5-year	10-year	20-year	30-year	50-year	100-year
Bucao	1,600	2,500	3,100	3,800	4,300	4,900	5,800
Maloma	310	490	640	810	920	1,100	1,300
Sto.Tomas(*1)	440	710	940	1,200	1,400	1,600	2,000
Sto.Tomas (*2)	730	1,200	1,500	1,900	2,200	2,600	3,200

Note: (*1) with the retarding effect of the Mapanuepe Lake

(*2) without the retarding effect of the Mapanuepe Lake

In addition, Figure 5.1.10 shows the water level change of Mapanuepe Lake during probable floods. It shows that the 100-year flood would not overflow into the Marella River.

In order to verify if the magnitudes of the discharge estimates are reliable, the 20-year and 50-year specific discharge was computed for each river. Then, they were compared to those of other rivers which drain Mount Pinatubo. The values are shown in Figure 5.1.11. The specific discharge in the Bucao River basin is the highest, followed by the Maloma River basin. The specific discharge in the Sto. Tomas River basin is the smallest specific discharge of the three river basins due to the storage effect of Mapanuepe Lake. When compared to the other rivers, it was shown that the specific discharges in the study area are comparable to those of the Sacobia-Bamban and Abacan Rivers.

Another parameter, Creager's C value, which is normally used for extreme events, was also calculated for the 20- and 50-year events and is also shown in Figure 5.1.11. The value shows an empirical relationship relating the basin area and discharge. It indicates that the Bucao River has higher values than that of the Sacobia-Bamban and Abacan Rivers. This is likely due to the rainfall pattern difference between the western and eastern slopes.

Based on the above, it was concluded that the estimated probable flood peak discharges are reasonable. This verifies that the estimated parameters and model are acceptable for the study area.

Next, historical maximum specific discharges were taken for streams in various basin areas in the Philippines and plotted as the unit maximum discharge against area. While the maximum gives no indication of return interval, some of the basins are those with data with periods of up to more than twenty years. These plots, together with those of the three rivers are shown in Figure 5.1.11. They show that for all 20-year and 50-year floods, the unit discharge falls within an acceptable range.

5.2 Daily Flow Duration Curve

5.2.1 Water Balance Analysis

Over long periods, the validity of the daily discharge data for a long period was checked by a water balance analysis using annual rainfall and annual evapo-transpiration.

The reliability of the daily discharge data can be judged by annual loss. By dividing the total annual discharge volume by the catchment area, the annual run-off height is calculated. Rainfall changes into run-off, and the difference between annual rainfall and annual run-off is called annual loss. Annual loss corresponds to evapo-transpiration from the land surface. In general, evapo-transpiration is equal to 50 to 90% (average 70%) of pan evaporation. Consequently, a reasonable annual loss must be in the range of 900 to 1,600 mm/yr, as follows:

Pan Evaporation = 1,736 mm/yr (Floridablanca in Pampanga, 1985-1987)

Annual Loss = 1,736 * (0.5 to 0.9) = 900 to 1,600 mm/yr

A complete daily discharge record, without missing data, is available over some years for the Bucao River as shown in Table 5.2.1, and three years for the Sto.Tomas River as shown in Table 5.2.2. The water balance in the Bucao and Sto.Tomas River basins are examined in those tables. It is clear that the data in 1963 and 1984 for the Bucao River is reasonable, but the other data was determined to be unusable.

The monthly rainfall and discharge data in 1963 and 1984 are graphed in Figure 5.2.1, and seem to be acceptable based on the relationship between discharge and rainfall.

5.2.2 Flow Duration Curve

Representation of the daily discharge in a year in decreasing order gives the daily flow duration curve. Table 5.2.3 shows the detailed data for 1963 and 1984. The average data for two years was adopted. Figure 5.2.2 shows a comparison between the Bucao River and the flow duration curve for the Porac River (from the JICA Report in 1996). The Bucao River has a tendency for more high flow days and less low flow days compared with the Porac River.

5.3 Floods in July 2002

5.3.1 Overview

Due to the stagnation of low pressure stimulated by a series of typhoons “Gloria”, “Hambalos” and “Inday” off-shore of Zambales Province, heavy rainfall was observed in the study area for 12 days from July 4 up to July 15, 2002. The accumulated rainfall for those 12 days was recorded as approximately 1,500 mm at the Baquilan raingauge station (newly installed by JICA) in the Bucao River basin.

At the Bucao River, lahar flow was observed at 8:30 a.m. on July 10. Local people reported that the height of the lahar wave was more or less 3 m. This was the amount by which the flood water level rose up suddenly. Two people and 5 carabaos were swept down when they crossed the Bucao River at Barangay Baquilan. The people were carried down by lahar flow to the Bucao Bridge, 7 km downstream from Barangay Baquilan, and were rescued at the bridge. However, the five carabaos were swept down to the rivermouth. The study team members visited the bridge site at 11:00 a.m., when the floodwater level was El. 2.1 m, approximately 70 cm higher than 1 day before as shown in Figure 5.3.1.

Inundation was observed in the villages near the Maloma Bridge on July 7 and July 14. The floodwater overflowed across the National Highway flowing down as shown in Figure 5.3.1. On the right side of the Maloma River, floodwater overtopped the banks along the highway just upstream of the Maloma Bridge in the afternoon of July 7. The backfill material of the revetment was partially scoured away.

The riverbed aggradation at the Maculcol Bridge over the Sto. Tomas River was remarkable on 7 July 2002 and the floodwater hit the girder of the bridge as shown in Figure 5.3.1. It was observed that the floodwater reached the bridge girder many times during the flood. It sometimes splashed the slab of the bridge. The clearance between the bridge girder and the riverbed became more or less 1 m for the whole section. The course of the flood under the bridge was continuously changing from left to right.

Sand bars were formed and washed away frequently near the bridge section at different locations.

5.3.2 Rainfall Observation

The daily rainfall record in and around the study area during the series of typhoons was as follows:

Daily Rainfall Record from 4 July to 15 July (Unit: mm)

Sta. Name	Iba	Baquilan	San Felipe	Mapanuepe	San Fernando	Apalit
Province	Zambales	Zambales	Zambales	Zambales	Pampanga	Pampanga
River		Bucao	Maloma	Sto. Tomas	Pasig-Potrero	Pampanga
Owner	PAGASA	JICA	JICA	JICA	JICA	Nippon Koei
7/4	38.4	91.7	104.1	86.4	12.19	3.2
7/5	164.2	115.3	178.1	199.6	24.38	52.0
7/6	204.0	129.0	205.8	177.5	80.27	157.0
7/7	231.4	404.4	385.3	369.1	257.31	170.4
7/8	13.7	41.9	90.2	33.8	104.64	39.0
7/9	68.7	60.2	64.7	15.7	71.37	9.4
7/10	121.4	181.6	81.5	10.4	61.46	17.6
7/11	-	54.4	102.6	4.5	91.43	-
7/12	-	143.8	113.5	127.3	34.29	-
7/13	-	189.0	146.0	186.4	142.49	-
7/14	-	13.7	56.6	43.4	31.23	-
7/15	-	72.6	70.4	66.8	4.29	-

Note: “-“ indicates no available data

The cumulative rainfall for the Mapanuepe Lake, Baquilan and San Fernando are shown in Figure 5.3.2.

Based on the recorded rainfall above, the following have been observed:

1) The return period of rainfall for both 3-day and 4-day periods in Iba was between 5 and 10 years. At Apalit in Pampanga, eastern Pinatubo, rainfall was also recorded at the same return period of 5 to 10 years.
2) Rainfall on the western side was much greater than on the eastern side. The 5-day rainfall at Mapanuepe in the Sto. Tomas River basin was 68% greater than the recorded rainfall in San Fernando, Pampanga.
3) A triple peak of the rainfall pattern was observed on July 7, July 10, and July 13. These peaks were directly affected by the south-west monsoon clouds stimulated by the series of typhoons, “Gloria” on July 7, “Hambalos” on July 10 and “Inday” on July 13.

5.4 Discharge Measurement

5.4.1 Discharge Measurement Record

During the 2002 wet season, attempts were made to measure the peak flows by use of floats in order to refine the H-Q rating curve. It is also mandatory to continue shallow water discharge measurements with the present procedures. Surface floats were used to measure the discharge at the Bucao, Maloma and Maculcol Bridges.

Table 5.4.1 shows the results of discharge measurements from 4 July to 8 July 2002. The cross sectional surveys at the Bucao Bridge on July 3 and at the Maloma Bridge on June 20 were used as representative sectional areas in the calculation. It was impossible to estimate discharge at the downstream of the Maculcol Bridge after July 7 because the water level was already over the height of the girder.

5.4.2 Changes of Cross Sections

Before the flood in July 2002, cross sectional surveys were carried out downstream of the Bucao, Maloma and Maculcol Bridges on July 3, June 20, and June 25, respectively.

Another cross sectional survey was conducted from 25 August to 27 August 2002 at the three bridges to examine the change of riverbed elevation. The results of cross sectional surveys in the Bucao, Maloma, and Sto. Tomas Rivers are shown in Figure 5.4.1.

Comparing the results of cross sectional surveys in June, July, and August, there is a similar trend in the Bucao and Maloma Rivers that riverbed degradation is predominant in the low water channel. On the other hand, riverbed aggradation was also observed in the high water channel. Riverbed aggradation was remarkable downstream of the Maculcol Bridge with a rise of more than 2 m on average.

5.4.3 Discharge Rating Curve

Figure 5.4.2 shows the rating curves in the Bucao and Maloma Rivers. The relationship of water level and discharge (H-Q) is plotted based on the entire series of discharge measurements downstream of the Bucao and Maloma Bridges during the flood in July 2002. The rating curves are shown as regression curves for each plot. Estimated discharges using the results of velocity measurements during the flood in July with the cross sectional areas in August are also plotted as a reference.

It was found that a single rating curve cannot be adapted to any river in the study area. That is because the three rivers in the study area indicate significant changes of cross section during the rainy season due to dynamic riverbed aggradation and degradation caused by floods with high concentrations of sediment.

For the Sto. Tomas River, it was impossible to create a discharge rating curve downstream of the Maculcol Bridge because there is a clogging of the water flow during floods due to limited clearance at the bridge.

5.4.4 Abnormal Runoff Coefficient of Flood in July 2002

The observed discharge during the flood in July 2002 was compared to the discharge simulated with the HEC-HMS established for this study area. The observed discharge and simulated discharge are shown in Figure 5.4.3. The runoff coefficient was calculated for both kinds of discharge in the Bucao River basin to verify the validity of observed and simulated discharges. As a result, the simulated discharge indicates a large coefficient of runoff (80%). The observed discharge shows a significantly small coefficient of runoff (40%). This is too small to verify the characteristic of high runoff in the study area due to heavy rain. It is estimated that the abnormal runoff coefficient in the observed discharges was caused by the following:

(1) Riverbed Degradation during Flood

The results of cross sectional surveys indicate that the flood in July 2002 caused riverbed degradation in the low water channel. This implies that riverbed scouring would be greater during floods. Without riverbed degradation, it is possible that a higher water level would have been observed during the flood resulting in greater discharge.

(2) Storage Effect of Lahar Deposits

It was found that a huge amount of lahar deposit exists along reaches in the study area, especially in the Bucao and the Sto. Tomas Rivers. There should be large amounts of seepage into such lahar deposits during floods if the deposits are dried before floods. Such storage effects in lahar deposits contribute to the loss of runoff resulting in a small coefficient of runoff observed during the flood in July. The presumed phenomenon of the storage effect of lahar deposits is shown in Figure 5.4.4.

Considering the seepage phenomenon, the discharge data since 1990 would not be applied because of the big storage effect of lahar deposits. It is recommended that further study be undertaken into the storage effect of lahar deposits in order to estimate the discharge in the Bucao and Sto. Tomas Rivers more accurately.

CHAPTER 6 SEDIMENT BALANCE

6.1 Mechanism of Sedimentation

With respect to sediment balance, the river basin area can be divided into three areas, 1) sediment source zone, 2) sediment deposition / secondary erosion zone, and 3) sediment conveyance zone.

The above classification was made based on the existing conditions of sediment deposits and river gradient in the study area, which are the main factors determining the mechanism of sediment balance in the rivers.

The characteristics of the three different zones in the study area are given as follows:

(1) Sediment Source Zone

The basin from Mount Pinatubo down to the lower limit of the pyroclastic deposit area on the mountain slope is defined as the sediment source zone.

From immediately after the eruption of 1991 to 1995, secondary explosions frequently occurred in the sediment source zone, and the pyroclastic material flowed down as hot lahar and deposited in the downstream stretch of the river basin. Since 1995, unstable pyroclastic deposits in the sediment source zone have been eroded by rainfall or largely collapsed due to scouring by flooding. The eroded or collapsed pyroclastic material is the source of sedimentation to the downstream area.

(2) Sediment Deposition / Secondary Erosion Zone

The river stretch, including the river terrace from the downstream end of the pyroclastic deposit area down to the sediment deposit area is defined as the sediment deposition/secondary erosion zone. Most of the sediment currently deposits within this zone. The sediment was widely spread in this area and secondary erosion has frequently been observed, caused by the flooding. Although the sediment deposit level rose year by year, it has also been observed that secondary erosion of the sediment deposition started a few years ago, mainly at the upper part of the sediment deposition / secondary erosion zone.

(3) Sediment Conveyance Zone

The river stretch, including the river terrace, from the downstream end of the sediment deposition / secondary erosion zone down to the river mouth is defined as the sediment conveyance zone. In this stretch, the sediment delivered from upstream is deposited and partially transported down to the mouth by river flow. The sediment transportation capacity in this area is subject to the volume, depth and gradient of the river flow and the properties of the riverbed materials. This zone still tends to deposit sediment, rather than transport it to the mouth, as the volume of sediment delivered to the zone is beyond the capacity of sediment conveyance there.

Figure 6.1.1 and Figure 6.1.2 show the three zones in the Bucao and Sto.Tomas Rivers, respectively. They are classified as follows based on the results of field investigation:

Classification by Sediment Characteristics in the River Stretch

Classification	Bucao River		Sto.Tomas River	
	Upstream End	Downstream End	Upstream End	Downstream End
Sediment Source Zone	Summit of Mount Pinatubo	End of pyroclastic deposit area	Summit of Mount Pinatubo	End of pyroclastic deposit area
Sediment Deposition / Secondary Erosion Zone	End of pyroclastic deposit area	Malomboy	End of pyroclastic deposit area	Vega Hill
Sediment Conveyance Zone	Malomboy	River Mouth	Vega Hill	River Mouth

For the Maloma River there is no significant area of sediment deposition. The pyroclastic flow after the eruption of Mount Pinatubo did not reach the Maloma River. The main source of sediment in the Maloma River consisted of the direct fall of pyroclastic material deposited on the mountain slopes of the Maloma River basin. Almost all the pyroclastic fall material flowed downstream within one year of the eruption. The current main sediment source is therefore the old pyroclastic material deposited during the pre-eruption period on the mountain slopes. The volume of erosion is not significant as the source of sedimentation.

6.2 Future Sediment Yield

In this section, future sediment yield from the sediment source zone was estimated for plan formulation of the sabo control structural measures in the master plan.

6.2.1 Sediment Source

Over 11 years from the Mount Pinatubo eruption vegetation has started to encroach on some of the pyroclastic-flow deposits with tolerance to erosion. However, some other areas still remain unstable where serious gully erosion and cliff collapses have occurred. From these areas, a large amount of sediment is released into the river as a sediment source.

Future sediment yield in the basin was estimated in the following manner:

1) Actual sediment yield in 2001 was estimated through reading aerial photographs,
2) Actual sediment yield in 2002 was estimated through river cross sectional surveys conducted before and after the flood of July 2002, and
3) Future sediment yield in the basin was calculated through regression analysis of the observation data from 1994 to 1997 by PHIVOLCS and 2001 and 2002 by the study team.

6.2.2 Sediment Yield in 2001

In this study, the sediment yield from the mountain slopes during 2001 was estimated using aerial photographs taken in May 2002.

The catchment area of the three rivers was initially classified into three categories based on the condition of stability of the slope and the recovery condition of the slope vegetation. The following are the initial classifications:

i) Normal slopes: where no gully erosion has developed and herbaceous plants have been observed on the slopes,
ii) Moderately unstable slopes: where unstable gully erosions have developed but some herbaceous plants have also been observed on the slopes, and
iii) Unstable slopes: where unstable gully erosions have developed and no herbaceous plants have

been observed on the slopes.

The area classification is shown in Figure 6.2.1 and summarized as follows:

Initial Area Classification of Mountain Slope by Reading of Aerial Photographs 2002

Slope Classification	Bucao		Maloma		Sto.Tomas		TOTAL	
	km^2	Ratio	km^2	Ratio	km^2	Ratio	km^2	Ratio
Normal Slope	599	91.5%	151	99.5%	250	95.5%	1,000	93.5%
Moderately Unstable Slope	46	7.0%	1	0.5%	8	3.0%	55	5.0%
Unstable slope	10	1.5%	0	0.0%	4	1.5%	14	1.5%
TOTAL	655	100.0%	152	100.0%	262	100.0%	1,069	100.0%

(1) Sediment Yield from Normal Slope Area in 2001

As shown above, 93.5% of the three basins were classified as normal slopes or stable slopes, where no gullies have developed and natural vegetation such as trees, shrubs and grasses have been observed on the slopes. The sediment yield on the normal slopes was calculated based on the standard collapse area ratio, depth and denudation rate per flood on each kind of geology as shown in Table 6.2.1 through Table 6.2.3. Those parameters were derived from the Japanese Technical Standard to estimate sediment yield. As all sediment source areas in the study area have been classified as pyroclastic deposit areas, the sediment yield in the normal slope area was calculated as follows:

Average collapse area ratio: 0.22%
Average collapse depth: 2 to 3 m
Average denudation depth: 0.006 m/km^2
$V1 = A1 \times 0.006$ m/km^2
where,
V1: Sediment yield volume in normal slope area,
A1: Area of normal slope

(2) Sediment Yield from Moderately Unstable and Unstable Areas in 2001

The remaining 6.5% of the basin was classified as moderately unstable or unstable, from which the majority of sediment may be delivered. For estimating the sediment yield, the actual collapse area ratio was measured from the aerial photographs taken in May 2002.

In the process, however, the actual collapse area ratio was found to be very different between the areas along the unstable slope area and the river bank. The difference was more marked than the difference between moderately unstable and unstable areas. The areas were therefore re-classified into two, unstable slope areas and river bank erosion areas, through inspection of aerial photographs. The area re-classification and actual collapse area ratio were then described as follows:

Re-classification of Moderately Unstable and Unstable Slope Areas

Re-classification	Re-classified Unstable Slope Area (km^2)				Average Collapse Area Ratio
	Bucao	Maloma	Sto.Tomas	Total	
Unstable Slope Area	53.9	1.2	11.1	66.2	3%
River Bank Erosion Area	1.8	0.0	0.7	2.5	25%
Total Unstable Area	55.7	1.2	11.8	68.7	

The average width and length of erosion in the collapsed area was determined to be 20 m from reading the horizontal aerial photographs and this should be converted into the actual area by taking into account the actual average slope angle of 60 degrees. The average depth of erosion in the collapsed area was measured on site as approximately 4 m.

Based on the above observation results, the sediment yield from unstable areas and river bank erosion areas are calculated as follows:

(a) Sediment Yield from Unstable Slope Area in 2001

V2 = V2u + V2s
where,
V2: sediment yield from unstable slope (m^3/yr)
V2u : sediment yield from collapsed area of unstable slope (m^3/yr)
V2s: sediment yield from un-collapsed area of unstable slope, (m^3/yr)

In the estimation of V2u, the horizontal collapsed area, which was assumed to be 3% of the unstable area, should be converted to the actual area considering the actual average slope of 60 degrees as follows:

V2u = A2 x 0.03 / cos (60deg.) x H
where,
A2: collapsed area in unstable slope
H: average actual depth of collapse (H = 4 m)

On the other hand, sediment yield from the un-collapsed area of unstable slope areas (97% of the unstable area) is calculated by the same procedure as used for the normal slope area:

V2s = A2 x 0.97 x 0.006

Finally, the sediment yield from the unstable slope area is calculated as follows:

V2 = V2u + V2s = A2 x 0.03 / cos (60deg.) x 4 + A2 x 0.97 x 0.006

(b) Sediment Yield from River Bank Erosion Area in 2001:

Sediment yield from the river bank erosion areas can be estimated in the same manner as the unstable slope areas. The collapsed area ratio is to be 25% instead of 3%:

V3 = A3 x 0.25 / cos (60deg.) x 4 + A3 x 0.75 x 0.006
where,
A3: River bank erosion area

(3) Total Sediment Yield

Total sediment yield (V) is as follows:

V = V1 + V2 + V3

The results of estimation of sediment yield in 2001 for the three river basins are shown in Table 6.2.4 and summarized as follows:

Estimated Sediment Yield in 2001

River Basin	Total Catchment Area	Normal Slope Area (A1)	Unstable Slope Area (A2)	River Bank Erosion Area (A3)	Sediment Yield from A1 (V1)	Sediment Yield from A2 (V2)	Sediment Yield from A3 (V3)	Total Sediment Yield (V)
	km^2	km^2	km^2	km^2	10^6 m^3/yr	10^6 m^3/yr	10^6 m^3/yr	10^6 m^3/yr
Bucao	655	599	53.9	1.8	3.6	13.3	3.6	20.5
Maloma	152	151	1.2	0.0	0.9	0.3	0.0	1.2
Sto.Tomas	262	250	11.1	0.7	1.5	2.7	1.4	5.6
TOTAL	1,069	1,000	66.2	2.5	6.0	16.3	5.0	27.3

Based on reading the aerial photographs, which were taken in May 2002, the sediment yield in 2001 was estimated at 20.5 million m^3 in the Bucao River basin and 5.6 million m^3 in the Sto. Tomas River basin. These values are nearly the same as the values predicted by PHIVOLCS in 1998, 18 million m^3 and 5 million m^3, respectively (Refer to Figure 6.2.2).

6.2.3 Sediment Delivery in 2002

(1) Sto. Tomas River Basin

a) Upstream Stretch (Marella River)

The volume of sediment deposits in the Marella River due to the flood at the beginning of July 2002 was estimated based on the field investigation conducted before and after July 2002.

For the upstream stretch, no river cross sectional survey was conducted before and after the flood of July 2002. The sediment deposit volume was then presumed based on visual observation at the check points. There are two check points where the study team visited and marked the riverbed elevation before and after the event. The condition of sediment deposition is described in Figure 6.2.3 and summarized as follows:

(i) Check Point No.1: Mt. Bagang

Around Mt. Bagang the river terrace has developed sedimentation over the whole river area. The deposition depth caused by the flood in July 2002 was approximately 0.5 m, which was estimated from the height of trees on lahar deposition areas compared before and after the flood (See Photo-1 and Photo-2 of Figure 6.2.3).

(ii) Check Point No.2: Right Bank Nose (6 km upstream from Mt. Bagang)

At check point No.2, 6 km upstream from Mt. Bagang, the river terrace has developed with sedimentation over the whole river area. In May 2002, a natural channel was formed by erosion of the riverbed with a depth of 4 m from the sediment terrace. In September 2002, the channel was completely buried.

The deposition depth of the entire sediment terrace was approximately 0.5 m, which was estimated by field investigations conducted before and after the flood (See Photo-3 and Photo-4 of Figure 6.2.3).

Based on the above investigation results, the volume of sediment deposit in the upstream part of the Sto. Tomas River (the Marella River) was estimated as follows:

Volume of Sediment Deposit in the Marella River during Flood in July 2002

Sub-section	Sediment on River Terrace			Sediment on River Channel			Total Sediment Deposition
	Riverbed Change	Sediment Area	Sediment Volume	Riverbed Change	Sediment Area	Sediment Volume	
	m	10^6 m^2	10^6 m^3	m	10^6 m^2	10^6 m^3	10^6 m^3
Check Point No.1~No.2 (downstream)	0.5	7.0	3.5	4.0	0.0	0.0	3.5
Check Point No.2~upstream (upstream)	0.5	3.5	1.8	4.0	0.6	2.4	4.2
Total			5.3			2.4	7.7

b) Downstream Stretch (Sto. Tomas River)

In order to estimate the volume of sediment deposit in the lower stretch of the Sto. Tomas River (River Mouth ~ Mt. Bagang) caused by the July 2002 flood, the river cross sections before and after the flood were compared as shown in Figure 6.2.4. The sediment deposit volume in the Sto. Tomas River caused by the flood was estimated at approximately 8.1 million m^3 as described below:

Volume of Sediment Deposit in the Sto. Tomas River caused by the July 2002 Flood

Line No.	Distance from River Mouth (m)	Average Riverbed Rise H: (m)	River Width B: (m)	Sediment Deposition Area A=H x B: (m^2)	Sediment Deposition Volume V: (m^3)	Remarks
Line-1	0	0.400	551	221		*Estimated from Line-08
Line-8	1,535	0.401	363	146	280,956	
Line-16	4,801	0.018	775	14	260,923	
Line-25	7,801	0.241	625	151	247,159	
Line-27	8,394	0.531	745	396	162,032	
Line-35	11,444	0.550	1,371	754	1,752,456	
Line-45	16,444	0.256	1,738	445	2,997,389	
Line-56	21,981	0.250	1,738	434	2,435,654	*Estimated from Line-56
TOTAL					8,136,569	

Note : Sediment Deposit volume from River mouth to Confluence of Marella River and Mapanuepe Lake

c) Sediment Delivery in the Sto. Tomas River in 2002

Accordingly, the total sediment delivery in the Sto. Tomas River is as follows:

River Mouth – Mt. Bagang : 8.1 million m^3
Marella River : 7.7 million m^3
Total : 15.8 million m^3

(2) Bucao River Basin

In order to estimate the volume of sediment deposit caused by the July 2002 flood in the Bucao River, field investigations and interviews with local people were undertaken. Figure 6.2.5 shows the presumed sediment deposition in the river course due to the flood. There are five check points to assess the sediment deposits along the Bucao River. The observation results are summarized as follows:

(i) Check Point No.1: Bucao Bridge

River cross sectional surveys were conducted at the Bucao Bridge for discharge measurement before and after the flood. Figure-2 in Figure 6.2.5 indicates that the average riverbed rose approximately 1 m after the flood. From the survey results above, the riverbed aggradation at the Bucao Bridge was estimated at 1 m.

(ii) Check Point No.2: Culvert Outlet at Barangay San Juan

The culvert outlet is on the right dike of the Bucao River approximately 3km upstream from the Bucao Bridge. The outlet structure was visible before the flood, but it was completely buried by the sediment deposits after the flood as compared in Photo-2 and Photo-3 in Figure 6.2.5.

(iii) Check Point No.3: Baquilan Bridge

Photos 3 and 4 compare the view of the Baquilan Bridge located approximately 6 km upstream from the Bucao Bridge. It was found that the river terrace elevation after the flood was higher than before by approximately 2 m at that point.

(iv) Check Point No.4: Barangay Malomboy

There is a sediment measurement gauge established by PHIVOLCS at Barangay Malomboy, which is located approximately 9 km upstream from the Bucao Bridge. It was reported that the sediment deposit due to the flood was 4 m based on the gauge reading by PHIVOLCS.

(v) Check Point No.5: Bucao / Balin Baquero Confluence

The confluence of the Bucao and the Balin Baquero Rivers is located approximately 13 km upstream from the Bucao Bridge, which was the upper most accessible area during the rainy season. The study team undertook interviews with local people after the flood at that point. The local people reported that the visible height of coconut trees on the sediment deposition area shown in Photo-5 of Figure 6.2.5 decreased by approximately 4 m, which was the basis of the estimation of riverbed aggradation at Check Point No.5.

For upstream of the confluence, interviews with local people from the upstream barangays were also conducted at Check Point No.5. According to them, the riverbed aggradation due to the flood was also approximately 4 m.

The sediment deposit volume in the Bucao River from the flood was then estimated at approximately 65 million m^3 as summarized below:

Sediment Deposit Volume in the Bucao River caused by the July 2002 Flood

Area No.	Stretch	Sediment Area (mil.m^2)	Sediment deposit Depth (m)	Sediment deposit Volume (mil.m^3)
1	Mouth ~ Bucao Bridge (CP-1)	0.91	1.0	0.9
2	Bucao Bridge ~ Baquilan (CP-3)	4.65	2.0	9.3
3	Baquilan ~ Malomboy (CP-4)	2.41	4.0	9.6
4	Malomboy ~ Upstream	11.35	4.0	45.4
TOTAL				65.3

6.2.4 Future Sediment Yield

The future sediment yield was estimated by regression line analysis on the past data. A regression line by PHIVOLCS used the sediment delivery until 1997. A regression line by the study team applied the same data from 1994 to 1997 and the data obtained in this study for 2001 and 2002. Data for 2002 for the Bucao River basin was excluded because one of the major floods was caused by the overflowing of water from the lake after the breaching of the Crater Lake at Maraunot Notch in July 2002. It was judged to be an extreme event.

The annual measured and estimated sediment delivery by PHIVOLCS and this study are compared in Figure 6.2.2. The regression line by the study team shows slightly higher values than those by PHIVOLCS. However, the differences were assumed to be negligible.

6.3 Sediment Transport Capacity

6.3.1 Riverbed Material

The study team conducted riverbed material sampling in 2002 to obtain data on sediment properties in the study area, which is required for sediment hydraulic analysis. The location map for sampling the riverbed material in the three rivers is shown in Figure 6.3.1. The total number of samples was 24; eight locations multiplied by three points, right, center and left side in each river cross-section.

The test results of specific gravity and grain size are tabulated in Table 6.3.1 and Table 6.3.2. The average value for the specific gravity in the three rives is Gs = 2.58, which is slightly lower than the default value of 2.65 in Japan. The average grain sizes for the sampling locations are illustrated in Figure 6.3.2. The lower reaches of the river have a smaller grain size (D = 0.35 mm), while upper reaches have a larger grain size (D = 0.7 mm). The average value for the representative grain size (60% passable) is D60 = 0.54 mm, which is classified as coarse sand, defined as D = 0.5 to 1.0 mm. The grain size in this study area is smaller than that in the eastern area as shown in Figure 6.3.3.

6.3.2 Annual Sediment Transport

The flow chart of calculation of sediment discharge is illustrated in Figure 6.3.4. The annual daily flow duration curve was approximated as a step graph as shown in Figure 6.3.5. Annual sediment transport volume was calculated by multiplying the sediment discharge and the duration time, and summing up the products over 365 days.

6.3.3 Sediment Transport Formula

Brown's formula was adopted for calculation of the sediment discharge in accordance with the previous JICA study for the eastern basins of Mount Pinatubo. This formula is simple and has the advantage that it is possible to estimate the total sediment load including bed load and suspended load. The detailed methodology is presented in Appendix IV in this report.

The sediment discharge at a reference point was calculated from the daily flow duration curve mentioned with the catchment area ratio. An applied flow duration curve was developed based on the data before the eruption of Mount Pinatubo.

However, flow discharge after the eruption of Mount Pinatubo was assumed to be lower than that in 1980s due to the seepage into the sediment depositions especially in the Bucao and Sto.Tomas Rivers. Therefore, the daily flow was adjusted to fit the actual sediment balance as of year 2001 for the calibration of the sediment balance model.

In addition, it was observed that there was no surface water in the downstream reaches of the Sto. Tomas River during the dry season in 2002 and 2003. Accordingly, the discharge on the flow duration curve within 120 days, which is equal to the number of annual rainy days at San Marcelino from 1991 to 2000 was considered in the Sto. Tomas River.

6.3.4 Annual Sediment Transport Capacity

To estimate annual sediment transport capacity in 2002, the gradient of riverbed slope in 2002 was obtained from the cross section survey conducted during the study. Porosity of 40% was considered in the estimation of sediment transport. The other parameters were the same as those in the calibration. The conditions and results of the estimation are summarized in the following table.

Annual Sediment Transport Capacity in the Study Area

River and Site	Catchment Area A (km^2)	Grain Size D (mm)	For Calibration (as of 1991)		For Estimation (as of 2002)	
			Bed Slope I	Sediment Qb ($10^6 m^3/yr$)	Bed Slope I	Sediment Qb ($10^6 m^3/yr$)
Bucao River						
Bucao Bridge	655	0.35	1/300	24.0	1/250	33.0
Middle Bucao	309	0.40	1/150	21.5	1/120	31.8
Upper Bucao	97	0.70	1/60	22.1	1/80	13.3
Lower Baquero	216	0.40	1/150	13.9	1/100	28.4
Upper Baquero	151	0.70	1/80	23.5	1/90	19.1
Maloma River						
Maloma Bridge	152	0.60	1/720	0.92	1/700	0.97
Middle Maloma	99	0.60	1/500	1.01	1/500	1.01
Gorongoro River	42	0.60	1/550	0.30	1/550	0.30
Sto.Tomas River						
Maculcol Bridge	262	0.35	1/580	1.3	1/300	3.5
Vega Hill	253	0.70	1/130	6.9	1/150	5.4
Mt. Bagang	91	0.70	1/60	21.1	1/70	16.1
Upper Marella	54	0.80	1/40	25.2	1/40	25.2

The change in sediment deposit volume in each reach of the three rivers was calculated as the balance between the inflow and outflow of sediment. Results are illustrated in Figure 6.3.6 to Figure 6.3.8. The average change of the deposits in the Maloma and Sto. Tomas Rivers has a tendency to increase by 0.10 to 0.50 m/year. In addition, the depth of sediment deposition in the lower reach of the Bucao River would increase by more than 1.0 m/year based on the estimated annual sediment transport capacity. The result also shows that the depth of the deposition in the upstream of the Bucao River would annually decrease.

However, the model used in the sediment balance analysis has some limitation. For example, it does not include the dynamic change of riverbed slope between different time steps when calculating river flow and sediment transport or the influence of the river width change along the longitudinal profile. Therefore, detailed one-dimensional and two-dimensional sediment transport analyses were conducted to predict future riverbed movement. The results are described in the following section.

6.4 Riverbed Movement Analysis

The future riverbed movement was analyzed to reflect the results of the prediction in the design of proposed structural measures for the Bucao and Sto. Tomas Rivers. For example, the predicted riverbed movement was taken into account in computation of design high water level which is critical for the design of river structures.

Riverbed movement was simulated for two different events. Short term riverbed movement analysis was conducted with a two-dimensional mudflow model for a lahar event with a duration of two days or 48 hours. In addition, long term riverbed movement was simulated with a one-dimensional sediment transport model for long term runoff with a duration of 20 years.

Design riverbed elevation should be determined as a stable slope to formulate a master plan for sabo and flood control. However, riverbeds in the study area tend to fluctuate due to movement of a huge amount of sediment deposit with floods and it seemed to be impossible to determine a permanently stable riverbed slope. However, it was assumed that the riverbed slope after 20 years would be the most naturally stable within the target period of the master plan.

6.4.1 Short Term Riverbed Movement

(1) Two-Dimensional Mudflow Model

In order to assess the short term riverbed movement with the existing and proposed structures in the Bucao and Sto. Tomas Rivers, a hyper-concentrated flow during a single lahar event was analyzed using a two-dimensional flow and a sediment transport model.

The simulation was conducted based on the hydrographs of probable floods obtained in Section 5.1. The numerical simulation applied the two-dimensional mudflow model, which was developed by the Public Works Research Institute and the Sabo and Landslide Technical Center of Japan and improved by Nippon Koei Co., Ltd.

The whole study area is divided into meshes with a proper size. The finite difference forms of the above flow and sediment transport equations were derived from the staggered mesh system and were solved explicitly using the Leap-Frog scheme. The calculation procedure is shown in Figure 6.4.1. All parameters used in the two-dimensional model are summarized in Table 6.4.1.

The detailed methodology is presented in Appendix-IV in this report.

A sediment volume of 16 million m^3 (defined as bed sediment and suspended sediment) was defined as the inflow sediment volume for a 20-year probable event, considering a bed-deposition concentration (C_b) of 0.6.

Figure 6.4.2 shows the input of hydrograph and sediment discharge in the model of the Bucao and Sto. Tomas Rivers to simulate riverbed change caused by a mudflow event. Total flood volume and peak discharge and sediment volumes are described as follows:

Volume and Peak Discharge of 20-Year Probable Flood and Sediment Volume for Simulation

Rivers		Flood		Sediment
		Total Volume	Peak Discharge	Total Volume
		(million m^3)	(m^3/sec)	(million m^3)
Bucao	Bucao	245	2,930	60
	Baquilan + remaining basins	76	920	4
Sto.Tomas	Marella	45	680	12
	Mapanuepe 1 (without Storage Effect)	43	1,020	0
	Mapanuepe 2 (with Storage Effect)	27	220	0

The sediment hydraulic parameters for the simulation are summarized as follows:

Density of water: ρ = 1.0 (normal flood) and 1.4 (in lahar event) g/cm^3

Specific gravity of sediment: σ_s = 2.60 g/cm^3

Mean grain sizes of sediment: d_{60} = 0.30 mm (for the Bucao River)

d_{60} = 0.50 mm (for the Sto. Tomas River)

Manning's roughness coefficient: n = 0.03 (average value for natural rivers)

Max erosion depth: max_e = 5.0 m

The specific gravity (σ_s) and the grain size distribution curve were obtained from the laboratory test results of the sediment sampling for the Bucao and Sto. Tomas Rivers performed in 2002 by the study team. The mean grain size of the sediment (d_{60}) was used assuming uniform sediment. The density of water (ρ) is estimated at 1.0 g/cm^3 for usual flood flow and more than 1.0 g/cm^3 up to 1.4 g/cm^3 for the hyper-concentrated flow.

(2) Calibration of Two-Dimensional Mudflow Model

To calibrate model parameters, the actual flood in July 2002 was applied to the Bucao River model. A couple of flood discharge peaks were observed in July 2002. One was due to the heavy rain on July 08 and the other was due to the collapse of the Maraunot Notch on July 10. The water volume for the latter was estimated at 46 million m^3 with the volume of the re-mobilized sediment of 44 million m^3. The depth of sediment deposition was observed to be 1-2 m along the existing dike and 5-6 m at Malomboy.

Figure 6.4.3 shows the calibration results for the two dimensional mudflow model. The results show that the river channel with relatively low riverbed elevation would be buried with sediment during the former flood and the remobilized lahar deposit would be spread over the whole width of the river channel from the Baquilan River to Malomboy during the latter flood.

In addition, Figure 6.4.4 shows the longitudinal profile of changes in riverbed elevation before and after the flood in July 2002. It indicated that the trend of simulated sediment deposition is similar to the observed value though the simulated values are slightly lower.

(3) Short Term Riverbed Movement in the Bucao River

The Bucao River model for short term riverbed movement analysis consists of two rivers, the Bucao River as a main river and the Baquilan River as a tributary. The downstream end was set at the river mouth and the upstream end near Malomboy.

A simulation for the Bucao River was conducted under the present river condition and confined flow without any inundation. The result of the simulation is given in Figure 6.4.5 in terms of the maximum deposit during the occurrence of a 20-year probable flood. As shown in this figure, the maximum sediment deposit in the lower stretch of the river was estimated at approximately 1 m along the existing dike of the Bucao River on the right side and the depth of the sediment would increase gradually upstream.

(4) Short Term Riverbed Movement in the Sto. Tomas River

The Sto. Tomas River model for short term riverbed movement analysis is composed of two rivers, the Marella River with a huge number of lahar deposit drains from Mount Pinatubo and the Mapanuepe River flowing from the Mapanuepe Lake basin. The downstream end was set at the river mouth and the upstream end was set 5 km upstream of Mt. Bagang.

A simulation for the Sto. Tomas River was conducted under the present river condition and confined flow without any inundation. The result of the simulation is given in Figure 6.4.5 in terms of the maximum deposit during the occurrence of a 20-year probable flood. According to this figure, sediment from the Marella River is transported smoothly to the downstream stretch with a maximum deposit of approximately 1 m downstream and 2 m in the middle reach from Vega Hill to Mt. Bagang. There would be overflow of sediment into the Mapanuepe Lake from the Marella River with a maximum deposit of 1 m.

6.4.2 Long Term Riverbed Movement

The long term riverbed movement in the Bucao and Sto. Tomas Rivers was analyzed for 20 years with the one-dimensional sediment transport model using the HEC-6 Version 4.1 program, Scour and Deposition in Rivers and Reservoirs.

(a) Bucao River Model

Figure 6.4.6 shows the longitudinal profile and riverbed width of the Bucao River model. In the model, the downstream end was set at the river mouth (Sta. -2.4 km) and the upstream end was set at the upstream of the Balin Baquero River (Sta. 23.0 km). The Balin Baquero River was regarded as a main reach in the model and the Upper Bucao River was considered as a tributary because it was assumed that sediment yield in the Balin Baquero River basin would be greater than that in the Upper Bucao River basin. The Upper Bucao River ends 19.0 km upstream from the Bucao Bridge. The Baquilan River flows into the main reach at Sta. 5.5 km and the Balintawak River joins the Upper Bucao River at Sta. 13.0 km. It is noted that the riverbed becomes extremely narrow at the site of the Bucao Bridge in comparison with the width from Sta. 2.0 km to Sta. 5.0 km.

(b) Sto. Tomas River Model

Figure 6.4.7 shows the longitudinal profile and riverbed width of the Sto. Tomas River model. In the Sto. Tomas River model, the downstream end was set at the river mouth (Sta. -1.5 km). The upstream reach of the Marella River ends 30.0 km upstream from the Maculcol Bridge. There are two tributaries flowing into the main reach: the Mapanuepe River at Sta. 21.0 km and the Santa Fe River at Sta. 11.5 km. The riverbed is extremely wide with a maximum 2.0 km in the mid-stream portion where a large amount of lahar deposit remains.

(c) Conditions for Simulation

The conditions for the one-dimensional sediment transport simulation are summarized in Table 6.4.2. The annual inflow sediment volume was set as constant for the 20-year simulation. The estimated sediment yield in 2007 was assumed as representative to be applied for both the Bucao and Sto. Tomas Rivers. Inflowing sediment in each time step was computed as a function of discharge at the upstream end in the model.

Because of a lack of daily runoff data in the study area, the hydrograph pattern was designed based on the flow duration curve and runoff patterns in 1963 and 1984 in the Bucao River basin. This is the only reliable runoff data, as discussed in section 5.2, Daily Flow Duration Curve. The annual hydrograph pattern for the one-dimensional sediment transport analysis is shown in Figure 6.4.8. It was applied for both Bucao and Sto. Tomas River models.

The sediment load was calculated with Yang's Formula (1973), which was developed for total-load transport capacity with an approach based on the excess of stream power over a critical value. It is said that the formula can be applied for small or medium size rivers with sand-beds.

The simulation was conducted for the following three hydrological cases to include the effect of a 20-year probable flood in the long term riverbed movement:

1) Case 1: No flood occurs in 20 years

The annual hydrograph pattern in a normal year without floods was repeatedly computed twenty times in the model.

2) Case 2: 20-year probable flood occurs in 5th year

The annual hydrograph pattern in the flood year with a maximum discharge of a 20-year probable flood was input in the 5th year instead of the normal pattern.

3) Case 3: 20-year probable flood occurs in 15th year

The annual hydrograph pattern in the flood year was input in the 15th year instead of the normal pattern.

There was no reliable record of long-term riverbed movement available for the purpose of calibration of the established one-dimensional sediment transport model. Therefore, the model was only compared with the sediment balance analysis presented in section 6.3 to examine its reliability. The results of the one-dimensional sediment transport analysis would be reasonable as shown in the following table.

Comparison of Results of Estimated Sediment Transport in the Lower Reach

	Sediment balance analysis with Brown's Formula (x 10^6 m^3/year)	One-dimensional sediment transport analysis (x 10^6 m^3/year)
Bucao River	9.8 [(1)] (at the Bucao Bridge)	8.2 (Average from Sta. 0.0 km to 12.0 km)
Sto. Tomas River	3.5 (at the Maculcol Bridge)	3.5 (Average from Sta. 0.0 km to 10.5 km)

(1) Computed with riverbed gradient revised to 1/500 near the Bucao Bridge

(1) Long Term Riverbed Movement in the Bucao River

Long term riverbed movement in the Bucao River was examined under the present conditions with confined flow in the river channel without inundation.

Figure 6.4.9 presents the results of riverbed movement simulation under present conditions after 20 years from the river mouth up to the Balin Baquero River. Riverbed change is defined as the difference between the simulated lowest riverbed elevation and original lowest riverbed elevation in 2002. The simulated riverbed movement in the Upper Bucao River is shown in Figure 6.4.10. As a result, there is no significant difference in fluctuation trend among the three cases: Case 1 (no flood in 20 years), Case 2 (flood occurs in 5th year), and Case 3 (flood occurs in 15th year). The long term riverbed movement in the Bucao River is described for the downstream, mid-stream and upstream as follows:

1) Downstream: River Mouth – Bucao Bridge – Baquilan River (Sta. 5.5 km)

Under present conditions, it is estimated that the riverbed would rise from the downstream of the Bucao Bridge to the confluence of the Baquilan River after 20 years. The aggradation in 20 years is approximately 4.2 m immediately upstream of the Bucao Bridge. On the other hand, the riverbed upstream of the confluence with the Baquilan River would be stable or eroded, because of the influence of the Baquilan River, without serious sedimentation.

2) Mid-stream: Baquilan River – Malomboy – Confluence (Sta. 12.0 km)

The riverbed aggradation would be the most dominant near the confluence of the Balin Baquero and Upper Bucao Rivers with an aggradation of 4.8 m. It is recognized that the topographic feature near Malomboy, where the river width decreases suddenly as it flows downwards, would cause serious riverbed aggradation at the site.

3a) Upstream: Confluence – Balin Baquero River (Sta. 23.0 km)

The riverbed change would be stable with a balance between inflowing and transported sediment under normal conditions. On the other hand, the riverbed would be elevated by 2.1 m if a 20-year probable flood occurs in 20 years.

3b) Upstream: Confluence – Upper Bucao River (Sta. 19.0 km)

The simulation results show that riverbed degradation would be dominant upstream of the Upper Bucao River. Erosion would occur at the upstream end of the reach and propagate downwards. However, the confluence between the Balin Baquero and Upper Bucao Rivers would not be affected by the erosion in 20 years.

The riverbed profile after 20 years in the Bucao River is summarized in Table 6.4.3.

(2) Long Term Riverbed Movement in the Sto. Tomas River

Long term riverbed movement in the Sto. Tomas River was examined under the present condition, but with no inundation by confining floods in the river course.

Figure 6.4.11 shows the simulated riverbed movement under the present river condition in the Sto.Tomas River after 20 years. The simulation shows that the riverbed in the downstream reach would rise after 20 years from the Maculcol Bridge up to Paete Hill (Sta. 7.25 km) with a maximum aggradation of 1.5 m. Outstanding riverbed aggradation would not occur after 20 years in the mid-stream though the riverbed would rise by less than 1.0 m around Sta. 16.0 km where the riverbed suddenly becomes wide. The riverbed would be lowered from erosion in the Marella River. The maximum degradation near the Mapanuepe Lake is approximately 3.0 m, which is within the safety range against breaking the natural dike between the Mapanuepe Lake and the Marella River. The great erosion of riverbed in the upstream of the Marella River would be due to the steep slope of this part of the river.

The riverbed profile after 20 years in the Sto. Tomas River is summarized in Table 6.4.4.

6.4.3 Comparison of Short Term and Long Term Riverbed Movement Analysis

The following table compares the results of short term and long term riverbed movement for the Bucao and Sto. Tomas Rivers under the present conditions:

Comparison of Results between Short Term and Long Term Riverbed Movement Analysis

	Short Term	Long Term
Model	Two-Dimensional Mudflow Model	One-Dimensional Sediment Transport Model
Duration of Input Hydrograph	48 Hours	20 Years
Bucao River		
Downstream (River Mouth – Baquilan River)	Aggradation (Max. +2.0 m)	Aggradation (Max. +4.2 m)
Mid-Stream (Baquilan River – Malomboy- Confluence)	Aggradation (Max. +6.0 m)	Aggradation (Max. +4.8 m)
Upstream (1) (Confluence – Balin Baquero River)	-	Aggradation (Max. +2.4 m)
Upstream (2) (Confluence– Upper Bucao River)	-	Degradation (Max. -15.0 m)
Sto. Tomas River		
Downstream (River Mouth – Vega Hill)	Aggradation (Max. +1.0 m)	Aggradation (Max. +1.5 m)
Mid Stream (Vega Hill – Mt. Bagang)	Aggradation (Max. +4.0 m)	Fluctuation (Max. +1.0 m)
Upstream (Mt. Bagang – Marella River)	Aggradation (Max. +4.0 m)	Degradation (Max. -3.0 m)

Note: “-“ was not included in the simulation

It is characteristic of the short term riverbed movement that riverbeds in all sections tend to rise with a lahar event with a 20-year probable flood. On the other hand, in the long term some portions of the riverbeds, such as the upstream of the Marella River, would be eroded as indicated by the one-dimensional sediment transport analysis.

It is noted that the maximum riverbed aggradation in the long term is greater than that in the short term downstream of both the Bucao and Sto. Tomas Rivers. This would be because of the following two reasons: difference in the total volume of inflowing sediment and the effect of secondary erosion in the middle and upstream reaches.

The total inflowing sediment volume in the long term, 112 million m^3 for 20 years in case-1 and 134 million m^3 in case-2 and case-3, is almost double that in the short term, 64 million m^3 for one mudflow event.

The other reason is that secondary erosion in the middle and upstream in the long term contributes to more aggradation downstream as additional sediment delivery. On the other hand, 48 hours in the short term simulation would not be long enough to cause the secondary erosion effect in the upper reach as seen from the increased aggradation in the upper stretch in the above table.

6.5 Monitoring for Riverbed Movement

A great concern in the study area is whether the riverbed elevation would still have a tendency to rise or not. The proposed structural countermeasures fully depend on further riverbed movement. Two kinds of detailed riverbed movement analysis were conducted to predict the future trend of sediment balance in the short term with one extreme lahar event and long term with 20 year normal stream flow. However, the models indicate the future trend with limited conditions. Results are subject to initial conditions, boundary conditions, and the scenario of sediment transport. On the other hand, rivers in the study area are facing dynamic change of riverbed during the rainy season due to movement of thick lahar deposits.

Therefore, continuous monitoring of further riverbed movement in the study area is strongly recommended, especially in the Bucao and Sto. Tomas Rivers, because more data obtained from monitoring will result in more reliable calibration of the models. Then it would be possible to simulate future riverbed change with a more accurate sediment transport model prior to implementation.

To measure the change of riverbed elevation, staff gauges were installed by the study team in the Bucao and Sto. Tomas Rivers at the beginning of 2003. Two gauges are located near the right and left side banks in each section to obtain averaged riverbed fluctuation trends and to prevent distortion of the results due to scouring caused by the flow in the center of the river course.

The results of further monitoring for riverbed movement in the future should be compared with simulation results from one-dimensional sediment transport analysis as shown in Table 6.4.3 and Table 6.4.4 for the Bucao and Sto. Tomas Rivers, respectively. If there is significant difference between observed and simulated riverbed movement, the sediment transport model should be revised and improved with more accurate calibration. For example, it is desirable to review the model after 5 years or 10 years when detailed design is to be conducted.

CHAPTER 7 MUDFLOW PRONE AREA

7.1 Two-Dimensional Flood/Mudflow Analysis

7.1.1 Approaches

In order to predict the possible flood inundation area and to assess the hydraulic performance of theexisting and proposed structures in the area (as surrounded by dike systems), an extreme sediment transport during a single lahar event was simulated using a two-dimensional flow and sediment transport model. It is very important to predict the flood depth and the depth of deposited materials, because the extreme re-mobilization or deposition of sediment may increase the possibility of inundation outside the dike system or breaching of the dike.

The simulation was done using the hydrographs obtained in Chapter 5 (Floods and Daily Runoff) and Appendix III (Meteorology and Hydrology). For the numerical simulation, the two-dimensional mudflow model developed by the Public Works Research Institute and Sabo and Landslide Technical Center of Japan and improved by Nippon Koei Co., Ltd., was used.

7.1.2 Methodology

(1) Two-dimensional Flow and Sediment Transport Model

In the two-dimensional mudflow model, water depth for the average flow was calculated by applying a two-dimensional shallow water flow equation, while the bed fluctuation was calculated using the continuity equation for bed load transport.

The entire study area is divided into meshes with a size of proper length. The finite difference forms of the above flow and sediment transport equations were derived from the staggered mesh system and are solved explicitly using the Leap-Frog scheme. The calculation procedure is shown in Figure 6.4.1.

(2) Topographic Data

Topographic data was produced from a DTM (Digital Topographic Map of 1:10,000 scale) in 2002 using a GIS (Geographical Information System). The model domain was divided into a 40 m square grid of data segments. Where the river channel or a dike was located in the grid segment, the elevation of this feature was selected as the representative value for the grid segment. In other grid segments, the elevation at the center point of the block was selected.

(3) Sediment Hydraulic Parameters

The sediment hydraulic parameters for the simulation are summarized as follows:

Density of water, ρ = 1.0 g/cm^3 (in lahar event ~1.6 g/cm^3)
Specific gravity of sediment, σ_s=2.6 g/cm^3
Grain sizes of sediment: d_{60} = 0.3 mm (for the Bucao River)
d_{60} = 0.5 mm (for the Sto. Tomas River)
Manning's roughness coefficient, n = 0.03 (average value for natural rivers)
Max erosion depth, max=10.0 m

The specific gravity (σ_s) and the grain size distribution curve were obtained from the laboratory test results of the sediment sampling for the Bucao and Sto. Tomas Rivers, performed in 2002. The mean grain size of the sediment (d_{60}) was used. The density of water (ρ) was estimated at 1.0 g/cm^3 for usual flood flow and at more than 1.0 g/cm^3 (up to 1.6 g/cm^3) for the hyper-concentrated flow (40% is the popular concentration as Mount Pinatubo lahar): 2.6 g/cm^3 (specific gravity of sediment) x 0.4 +1.0 g/cm^3 (density of pure water) x 0.6 = 1.6 g/cm^3.

(4) Formulation of Flood Inundation Scenario

Setting the flood inundation scenario is the most important aspect for project evaluation, as the results of the feasibility study will be significantly affected by it. For formulation of a flood/mudflow control plan, it is important that the probable maximum damage should always be considered under the theoretical assumptions for flood and mudflow inundation analysis.

Principal factors to be determined for flood and mudflow inundation analysis are as follows:

a) Setting the inundation block,
b) Estimation of safety discharge (damage-less discharge),
c) Setting dike breach points,

The detailed procedures to determine the above principal factors are mentioned below:

a) Setting Inundation Block

The inundation block should be identified by considering the topographic conditions, inundation characteristics and patterns based on the present conditions of the river channel and flood control structures.

For the Bucao River, the inundation area is located only on the right side downstream stretch. The mountain range is located along the left side and no remarkable inundation areas exist on both sides upstream from the Bucao-Baquilan Rivers confluence. Considering the characteristics, one inundation block on the right side downstream portion of the river is identified as an inundation block for the Bucao River.

For the Maloma River, the river flows down from the eastern mountain, westward to the South China Sea, and inundation areas are located only on the downstream stretch. There is one inundation block covering both banks on the downstream stretch of the Maloma River.

For the Sto. Tomas River, a large area of flood plain has been developed on the left bank side of the middle and lower stretches. The inundation characteristics on the left side area are different between the middle reach and the lower stretch. This is because, Vega hill, located 12 km upstream from the river mouth on the left side, separates the flood inundation area into two parts. In addition, the right bank side on the downstream stretch is also identified as an inundation block. Accordingly, three inundation blocks are identified for the Sto. Tomas River for flood/mudflow inundation analysis.

b) Estimation of Safety Discharge and Bank-full Capacity

To determine the criteria for dike breach for flood/mudflow inundation analysis, it is necessary to estimate the safety discharge, which is defined as the maximum capacity of the river for which no damage is expected in the flood prone area. The safety discharge is generally estimated as follows:

- The discharge which can be contained by the existing river channel and dike after deduction of freeboard and other defect factors in the existing river facilities: (Defined as Q1)

- The discharge for which the water level is lower than the existing elevation of the land in the adjacent area protected by the dike: (Defined as Q2).

The safety discharge is identified as the lower value of Q1 or Q2. Definition of the safety discharge in the river basins of western Pinatubo area is illustrated in Figure 7.1.1.

Bank-full capacity is defined as the maximum discharge of the river channel with dikes. The bank-full capacity is calculated by non-uniform flow analysis for the Bucao, Maloma and Sto. Tomas Rivers as shown below.

Bank-full Capacity for the Bucao River

Section	Bank-full Capacity			
	at present		after 20 years	
	discharge (m^3/s)	return period	discharge (m^3/s)	return period
Mouth - Bucao Bridge	200	< 2year	0	None
Bucao Bridge	5,200	50-100 year	300	< 2 year
Bucao Bridge - Baquilan	1,900	2-5 year	0	None

Bank-full Capacity for the Maloma River

Section	Bank-full Capacity	
	at present	
	discharge (m^3/s)	return period
Mouth - Maloma Bridge	290	<2 year
Maloma Bridge	500	5-10 year
Maloma Bridge - Gorongoro River	60	<2 year

Bank-full Capacity for the Sto. Tomas River

Section	Bank-full Capacity			
	at present		after 20 years	
	discharge (m^3/s)	return period	discharge (m^3/s)	return period
Mouth - Maculcol Bridge	>2,000	>100 year	1,400	30 year
Maculcol Bridge	1,100	10-20 year	0	None
Maculcol Bridge - Paete Hill	700	5 year	0	None
Paete-Hill - Vega Hill	600	2-5 year	0	None
Vega Hill - Mt. Bagang	>2,000	>100 year	>2,000	>100 year

For the Bucao River, the safety discharge was defined as zero because the riverbed elevation is higher than the land elevation and the bank-full capacity will become zero at the upstream stretch from the Baquilan River after 20 years due to continuous riverbed aggradation.

For the Maloma River, the safety discharge was defined as 60 m^3/s because the minimum bank-full capacity is estimated at 60 m^3/s upstream the Maloma Bridge.

For the Sto. Tomas River, the safety discharge was defined as zero because the riverbed elevation is much higher than the land elevation protected by the existing dike and the bank-full capacity will become zero upstream the Maculcol Bridge after 20 years.

c) Setting Dike Breach Points

A single 2-day hydrograph, for 2-year to 100-year probable floods has been applied for flood inundation analysis under the assumption that flood/mudflow inundation would occur on all the inundation blocks as a result of the breach of dikes. The breach points of the dikes were determined based on the maximum damage on the respective inundation blocks. Based on the topographic conditions of the river stretch and flood prone area, the upstream end portion of the respective inundation block was defined as the breach points of the dike. In addition, the disconnected portion of the existing dike along the left side of the Maloma River is also considered as the breach point of the dike for flood inundation analysis.

The inundation blocks and the breach points of the dikes are shown in Figure 7.1.2 for the Bucao and the Maloma Rivers and Figure 7.1.3 for the Sto. Tomas River.

7.2 Flood/Mudflow Hazard Area

7.2.1 Bucao River Basin

(1) River Conditions

The Bucao River basin extends in a northwesterly direction from Mount Pinatubo and southwesterly from the Zambales Mountains to the South China Sea. The basin incorporates the Bucao River and its two major tributaries, the Balin Baquero and Balintawak Rivers.

The headwaters of the Bucao River originate approximately 3 km north of the crater at an elevation of 800 m. The river flows in a generally westerly direction through rugged terrain for 30 km to its confluence with the Balintawak River at an elevation of 50 m. The Bucao River then enters a broad flat valley and continues to flow in a western direction for approximately 4 km to its confluence with the Balin-Baquero River. In 1991, the upper reaches of the Bucao River basin were covered with thick pyroclastic flow deposits with a volume of 3.1 billion m^3.

(2) Existing Structure

A protection dike was constructed by DPWH in accordance with the alignment proposed in the study (USACE, 1994). It was constructed along the right bank in the lower stretch of the Bucao River. The dike is 4 m high and 6 km long.

(3) Breach of the Mudflow Protection Dike

A mudflow simulation was carried out to test the effects of the upstream portion of the dike (5 km upstream from the Bucao Bridge) collapsing during a large-scale mudflow of various return periods. The length of the breach (L_b) was estimated by the empirical equation:

$$L_b = 1.6 \text{ x } (\text{Log}_{10}W_r)^{3.8} + 62$$

where, L_b : length of breach (m), and
W_r : width of river (m)

The discharge through the breached portion was calculated by Honma's equation:

$$Qw = 0.35\ L_b\ h_l\ \sqrt{2gh_l}$$

where, h_l : water depth at breach point (m)

(4) Results of Simulation

Figure 7.2.1 shows the results of the mudflow hazard area simulation. The simulated hazard area for each return period is enumerated below:

Probable Mudflow Hazard Area in the Bucao River Basin

Return Period (years)	2	5	10	20	30	50	100
Peak discharge (m^3/sec)	1,600	2,500	3,100	3,800	4,300	4,900	5,800
Hazard area (km^2)	7.67	8.69	9.56	11.12	11.85	12.92	14.43

During a 100-year probable flood, the peak discharge through the breached portion of the dike would be 720 m^3/sec and the town of Botolan would be wholly inundated with the highest flood water depth of 3.5 m.

7.2.2 Maloma River Basin

(1) River Conditions

The Maloma River basin originates to the southwest of Mount Pinatubo and extends westerly to the South China Sea. The river basin includes two major rivers, the Maloma and the Gorongoro Rivers, which join each other approximately 6 km upstream of the Maloma Bridge on Highway Route No.7.

The Maloma River basin is essentially a relatively narrow valley through mountains. Most of the sediment in the basin came from ash deposits immediately after the eruption. There has been no lahar occurrence since 1992.

(2) Existing Structure

The mudflow protection dike was constructed along the right bank of the lower stretch of the Maloma River. The dike is 4m high and 1.6 km long.

(3) Simulation

A two-dimensional mudflow analysis was carried out based on the existing topographical conditions. The Maloma River channel has low flow capacity, namely, less than a 2-year return period event. A flood would spill out approximately 3.5 km upstream of the Maloma Bridge with spilled water spreading mainly over the right bank, flowing over National Road No.7 and finally pouring into the sea. The disaster map from the previous flood on 8 July 2002 is shown in Figure 3.6.4.

Flow conditions were simulated based on the observations made during the previous flood. Figure 7.2.2 shows the results of the mudflow hazard area simulation. The simulated hazard area for each return period is enumerated below:

Probable Mudflow Hazard Area in the Maloma River Basin

Return Period (years)	2	5	10	20	30	50	100
Peak discharge (m^3/sec)	310	490	640	810	920	1,100	1,300
Hazard area (km^2)	4.80	5.14	5.29	5.45	5.55	5.71	5.86

7.2.3 Sto. Tomas River Basin

(1) River Conditions

The Sto. Tomas River basin extends in a southwesterly direction from Mount Pinatubo to the South China Sea. Two tributaries, the Mapanuepe and Marella Rivers, converge to form the main channel of the Sto. Tomas River.

The headwaters of the Marella River originate near the crater of Mount Pinatubo at an elevation of approximately 1,500 m. The Marella River drains the southwest slopes of Mount Pinatubo, which have been covered with thick pyroclastic flow deposits of 1.3 billion m^3.

The Marella River combined with the Mapanuepe River at an elevation of approximately 120 m in 2002. The sub-basin of the Mapanuepe River includes a large mine site, a mine tailings dam, and Lake Mapanuepe, which was dammed up with the lahar deposits from the Marella River.

(2) Existing Structure

A mudflow protection dike of 7.4 km in length was constructed along the right bank in the lower stretch of the Sto. Tomas River, while a protection dike of 18.9 km was constructed along the left bank.

(3) Simulation

A two-dimensional mudflow analysis was carried out based on the possibility of breach along the entire length of the dike.

Figure 7.2.3 shows the results of the mudflow hazard area simulation. The simulated hazard area for each return period is enumerated below:

Probable Mudflow Hazard Area in the Sto. Tomas River Basin

Return Period (years)	2	5	10	20	30	50	100
Peak discharge (m^3/sec)	440	710	940	1,200	1,400	1,600	2,000
Hazard area (km^2)	39.85	48.49	53.95	58.94	62.20	65.89	71.40

Note : The flood retarding effect of Lake Mapanuepe has been taken into account in the estimation of the peak discharge.

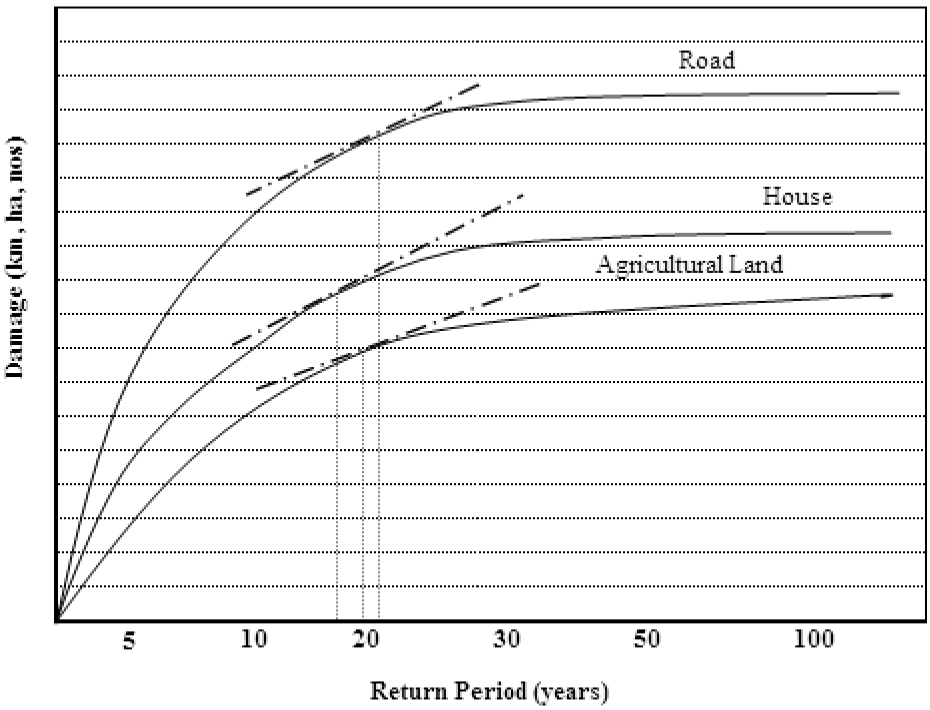
CHAPTER 8 STRUCTURAL MEASURES IN MASTER PLAN

8.1 Assessment of Planning Scale

For the purpose of this study, the benefit gained through the implementation of a project is defined as the reduction in the direct and indirect damage that would otherwise be caused by the flooding and/or mudflow.

The probable direct damage was evaluated under the “without-project” conditions. The damage under the “with-project” conditions was assumed to be zero under the design flood of a specified return period. Thus the project benefit constitutes the probable damage that would occur from flooding and/or mudflow with the design scale of flood.

The numbers of houses, roads and paddy fields in the three river basins were computed as described in Appendix V in this report. The damaged asset curves based on damaged asset numbers due to the probable flood show almost the same tendencies in all three river basins. The gradient of the curves in the schematic diagram below show that the incremental numbers of direct damage occurrences are not significant beyond the 20-year return period. Hence, the return period of 20 years is reasonable for the planning scale of the structures.



Schematic Diagram for the determination of Planning Scale

8.2 Possible Structural Measures

The list of possible structural measures for each river basin is given in Table 8.2.1. The design concept for each possible structural measure is described below.

8.2.1 Sediment Source Zone: to reduce the volume of sediment at the source

(1) Structure at Mount Pinatubo Crater

The water in the crater of Mount Pinatubo filled up to the edge of the Maraunot Notch in September

2001, with an estimated storage volume of approximately 300 million m^3. Due to a heavy storm and a continuation of overflow from the Crater Lake, the Maraunot Notch collapsed in July 2002 and the water level of the crater lake was drawn down by about 23 m.

The discharged water volume was estimated as approximately 46 million m^3. The water channel in the fractured rock was deeply incised due to the spilling water.

An overflow structure and protection works may be required to avoid further channel erosion if the results of the geological investigation show the possibility for further erosion and/or collapse.

(2) Re-vegetation

Seeding and planting of suitable vegetation on the sediment source is one of the effective methods, not only to reduce the sediment yield due to gully development, but also to contribute towards environmental conservation of the mountain slopes. The appropriate species for this purpose are recommended as robust perennials with vigorous rhizomes and extensive root systems.

(3) Small-scale Sabo Dam

A series of small-scale sabo dams at the downstream end of small tributaries would be effective in reducing the sediment yield from tributaries in the areas consisting of pyroclastic material.

(4) Large-scale Sabo Dam

A large-scale sabo dam crossing the major tributaries would be effective in storing surplus sediment, stabilizing channel beds upstream from the dam and avoiding sudden riverbed degradation in the channels and lateral erosion of the riverbanks.

8.2.2 Sediment Deposition / Secondary Erosion Zone: to stabilize unstable sediment

(1) Consolidation Dam

A consolidation dam would be effective in stabilizing deposits in the channel and controlling sediment discharge to the downstream stretches.

(2) Sand Pocket Structures

A remarkable volume of sediment remains within the channel in the middle reaches of the Bucao River and the Sto. Tomas River. The lahar deposits will be remobilized from secondary erosion during every flood event.

To cope with the excessive sediment flowing down through the sediment conveyance zone in the rivers, a sand pocket structure is proposed to trap remobilized sediment deposits at the downstream end of the secondary erosion zone or at the upstream end of the sediment conveyance zone.

(3) Groundsills

A series of groundsills is one of the alternatives to regulate the secondary erosion of deposits and control the watercourse in the channel.

(4) Training Works

At Malomboy, 10 km upstream from the river mouth of the Bucao River, the river channel is frequently shifting after flood events. Also, the lower reaches of the Marella River are the same as the area in the vicinity of Malomboy in the Bucao River.

Therefore, it is recommended that river training work is one of the effective structural measures to fix the course of a river channel.

8.2.3 Sediment Conveyance Zone: for smooth transportation of sediment to the river mouth

(1) Dike System

A dike system is provided to protect landside areas from flooding and/or mudflow.

In the lower- middle reaches in the Bucao River, the existing dike height is lower than the proposed design water level. The existing revetment on the existing dike has been damaged in some portions of the dike due to annual flooding. Therefore, the existing dike in the Bucao River would also be improved with reinforcement/ rehabilitation work.

In the middle stretch of the Sto. Tomas River, land elevation is lower than riverbed elevation and the height difference between the land elevation beside the dike and the water surface has reached several meters. In the upper stretch of the Sto. Tomas River, a maximum 12 m high difference has been created with annual sediment deposits.

Therefore, reinforcement/ rehabilitation work on the existing dike system has been proposed to protect the flood prone area in case a breach of the dike system occurs.

(2) Spur Dike

A spur dike is generally positioned at an outer curve of the watercourse to the riverbank to control the flow direction towards the center of the channel. A series of spur dikes is an effective means of protecting the dike system from local scouring in footings of the slope protection works.

(3) Channel Excavation

The purpose of channel excavation is to maintain the flow capacity of the river channel, especially in the downstream stretch from the bridge to the river mouth.

However, this measure is not recommended in channels where heavy sediment flow occurs because the excavated channel may be buried and become ineffective immediately due to sediment deposits swept down from the secondary erosion zone and/or sediment source zone during one flood event.

8.3 Structural Measures Recommended by USACE

A comprehensive Recovery Action Plan (RAP) prepared by USACE in 1994 evaluated the methods for controlling sedimentation within the eight major river basins surrounding Mount Pinatubo. It also evaluated the higher risk of flooding due to sediment–clogged drainage channels caused by the eruption of Mount Pinatubo.

In the western river basins, the following structural measures were recommended (Refer to Figure 3.7.1 in Chapter 3):

Bucao River Basin :
(1) Heightening of the existing dike system along the right bank in the lower stretch of the Bucao River.
(2) A sediment retention structure at Malomboy with a capacity of 1,000 million m^3 to reduce downstream sedimentation.

Maloma River Basin :
(1) Widening and straightening of the river channel with a dike system in the downstream stretch.
(2) A sediment retention structure with a capacity storing a sediment

volume of 12 million m^3 in the upper reaches.

Sto.Tomas River Basin: (1) A dike system along both banks, 6 km along the right and 18 km along the left bank.

(2) Channel excavation work instead of a dike system, and

(3) A sediment retention structure with a capacity of 40 million m^3 in the upper stretch of the Marella River.

The alignment of the existing dike system constructed by the DPWH principally coincides with the recommendation plan by RAP. However, the sediment retention structures have not been constructed yet.

8.4 Hazard Scenarios by PHIVOLCS

The potential hazards were defined as 'Hazard Scenarios' by PHIVOLCS in 1998 for the Bucao and Sto. Tomas River basins. The synopsis is summarized below:

8.4.1 Bucao River Basin

(1) Deposited area/lahar situation:

- Primary lahar deposition continues to occur, mostly upstream of Malomboy.
- Flows will probably remain confined to the valley, especially in the upper and middle reaches of the river.
- Remobilization of pre-eruption and post-eruption lahar materials may also be expected, as in the case of the Pasig-Potrero River.

(2) Hazard Scenarios:

- In the event of more rain, lahar deposition resulting from erosion and remobilization of lahar deposits toward the lower reaches of the river may be expected.
- Dilute lahars and stream flows may undermine the northern part of the Bucao Bridge.
- Existing dikes are still prone to piping and erosion of basal support.
- In the long-term, flows may encroach towards Botolan as a result of the perched condition of the lahar field.

(3) Comments and Recommendation by PHIVOLCS

- Repairs, maintenance or completion of armoring of three portions of the existing dike system should be done before the 1998 rainy season to reduce the risk of breaching/avulsion due to lahars.
- Residents adjacent to the dike system should be aware that, even with a properly constructed and aligned dike, there is always the potential for failure and as such, they should not be complacent and should always be on the alert especially during the rainy season.

8.4.2 Sto. Tomas River Basin

- Should the flow continue to deliver sediment into Mapanuepe Lake, it may pose an imminent danger through clogging of the artificial outlet of the lake. The damming effect may then increase the level of the lake, and ultimately cause breaching of the lake with a tremendous volume of water and sediment overflowing from the lake area.

- In the event of more rain, major lahars may still be expected to occur along the lower reaches of the channel downstream of Mt. Bagang.
- Dilute lahars are expected to be more dominant especially during low flow periods, and may result in remobilization of pre-eruption and post-eruption lahar material along the upper and middle reaches of the river that would flow towards the lower reach of the river.
- Should lahars flow along the south side (Castillejos side) of the dike system, there is potential for breaching and/or overtopping at the Lawin-Vega Hill stretch, threatening barangays within this dike and the secondary dike.
- Major deposition along the Mt. Bagang stretch of the Sto. Tomas River may force lahars to pass through the back (north) side of Mount Bagang which could threaten Santa Fe and Umaya.
- Where the river flow is adjacent to the dike, the dikes are prone to erosion of the basal support even by streams of normal volume.
- Due to the minimal freeboard at the Maculcol Bridge, there is the potential for overtopping, bridge damage, and road closure due to lahars.

8.5 Flood/Mudflow Control in the Bucao River Basin

8.5.1 Sabo Dams in Sediment Source Zone

A series of sabo dams (sediment retention dams) can be provided at the downstream end of the sediment source area. A location map of the prospective sabo dam site is shown in Figure 8.5.1. However, since the depth of lahar deposits is greater than 20 m at the dam axis, only a floating type of dam is applicable and serious erosion at the downstream face of the dam would be expected. The typical layout of a sabo dam is shown in Figure 8.5.2.

The relationship between the sediment storage and the volume of dam body is given as follows:

Relationship between Sediment Storage and Volume of Dam Body

Priority	Dam Site	Dam Height (m)	(C) Dam Volume (MCM)	(B) Sediment Storage (MCM)	(B)/(C) Index	Unstable Sediment underneath dam (MCM)
1	No.6	5.0	0.007	3.895	556.4	22.1
2	No.3	5.0	0.021	5.040	240.0	32.6
3	No.4	5.0	0.022	3.250	147.7	11.4
4	No.5	22.0	0.011	1.157	108.2	2.8
5	No.8	5.0	0.006	0.528	88.0	3.1
6	No.7	5.0	0.006	0.307	51.2	0.2

Note : MCM means million cubic meters.

In the preparation of the above table, the optimum development scale was determined for each dam site. A comparison was made between the volume of sediment storage and the volume of the dam body. If the optimum height was determined to be lower than 5.0 m, the preferred type of dam was considered to be a consolidation dam.

Based on the results, Sabo dam No.6 (consolidation dam) was ranked as the highest priority. It should be noted, however, that the construction cost of sabo dams is significant due to the provision of steel sheet piling (underneath the dam foundations) required to cope with the deep lahar deposits. The implementation of sabo dam construction might be a good plan for the future.

8.5.2 Alternative Flood/Mudflow Control Measures in Sediment Conveyance Zone

(1) Proposed Alternatives

The results of mudflow hazard analysis show that the land areas beside the river in the lower reaches of the Bucao River are prone to damage caused by lahar sediment flowing out of existing dikes if they are breached due to flood and/or mudflow. The hazard area is predicted as more than 11 km^2 under a 20-year probable flood. In particular, the eastern part of downtown Botolan may be seriously damaged.

The following three alternatives were adopted for a comparative study. A schematic diagram showing the structural arrangement is given in Figure 8.5.3.

(a) ***Alternative-1***: Heightening of the existing dike (Figure 8.5.4)

The existing dike is located along the right bank for a 6 km stretch from the Bucao Bridge. The possibility of a dike breach remains for this stretch as evaluated in Chapter 7 in this report. Heightening of the dike would be required to ensure safety against mudflow.

(b) ***Alternative-2***: Heightening of the existing dike and Malomboy consolidation dam (Figures 8.5.5 and 8.5.6)

Proposed structural measures in this alternative consist of a Malomboy consolidation dam and existing dike heightening.

The downstream end of the sediment deposits and secondary erosion zone is located at Malomboy. A spindle-shaped valley has formed for the upstream stretch from Malomboy to the confluence of the Bucao and Baling-Baquero Rivers. A huge volume of unstable lahar deposit remains in the valley. A consolidation dam at Malomboy would be effective in stabilizing the unstable lahar deposits. The location of the dam site would be exactly the same as that of the sediment retention structure recommended by the USACE in 1994.

(c) ***Alternative-3***: Heightening of the existing dike, Malomboy consolidation dam and sand pockets (Figures 8.5.7 and 8.5.8)

Proposed structural measures in this alternative consist of the Malomboy consolidation dam, two rows of lateral dike, three sand pockets, a separation dike and heightening of the existing dike, respectively.

Sand pockets could be provided in the downstream stretch of the Malomboy consolidation dam. The area of the suggested sand pockets is estimated at 16 km^2 between the Malomboy consolidation dam and the separation dike.

The purpose of the proposed structures is:

- To accelerate sediment deposits,
- To protect the confluence of the Baquilan River and the existing dike from re-mobilized mudflow (this generally flows straight),
- To fix the river channel to the left bank, and
- To decrease the sediment load in the downstream stretch.

The river course would be fixed on the left side and the lahar deposit area on the right side would be expected to recover as agricultural land in the future.

8.5.3 Comparative Study through Two Dimensional Mudflow Analysis during Flood

The individual effectiveness on sediment control of the alternatives mentioned above and shown in Figure 8.5.3 was evaluated using two-dimensional mudflow analysis model explained in Chapter 6 of this report.

In the alternative-2 and -3, the two-dimensional mudflow analysis was conducted on the condition that the riverbed in sections where the proposed structures were located was fixed at the present elevation.

The simulation results for the three alternatives in the Bucao River are shown in Figure 8.5.9 in terms of the maximum deposit during the occurrence of a 20-year probable flood. A summary of the results are described below.

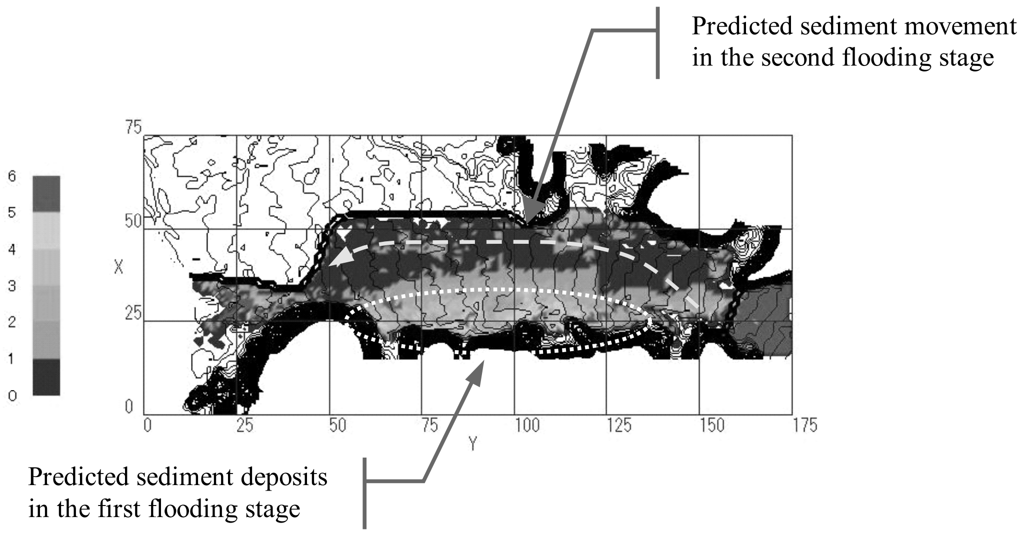
(a) Alternative-1: Heightening of existing dike

A simulation was made under the condition of one lahar event with a 20-year probable flood. The increase in sediment deposits in the middle - upper reaches was estimated at a maximum of 3 - 6 m, and at lower reaches, significant sediment deposits appeared in places. Such localized sediment deposits could occur anywhere in the river channel. Hence, heightening of the existing dike is recommended.

(b) Alternative-2: Alternative-1 and Consolidation dam

The results of the simulation showed that the pattern of sediment deposits has a tendency to move along the left mountain side. It is judged that this state was due to the effectiveness of the controlled watercourse with a consolidation dam in Malomboy.

However, in the next flooding stage, sediment deposits from the upper reaches may swerve to the right existing dikes, because a new watercourse may be created and the sediment deposits from the first flooding stage may still be remaining along the foot of the mountains on the left. Therefore, dike heightening, which would be almost on the same scale as that in alternative-1, is recommended to protect the land area beside the river from flood and/or mudflow damage. The following figure shows the predicted movement of sediment deposits in the second flooding stage:



(c) *Alternative-3:* Alternative-2 and Sand Pockets

The sand pocket structures with two rows of a lateral dike and a separation dike would be very effective in trapping sediment with a depth of more than 6 m. The depth of sediment deposits along the existing dike is less than that in alternative-1 and alternative-2.

Adequate openings in the lateral dikes and separation dike would be provided to fix the river flow along the foot of the mountains (left bank). As a result, the safety of the right bank against flooding and/or mudflow is increased.

Figure 8.5.10 shows the difference of presumed riverbed changes among the three alternatives under the probable flood. As mentioned above, the amount of dike heightening in alternative-3 is the lowest among the alternatives as the sediment retention capacity is the largest. Taking into account the simulation results from the two-dimensional mudflow analysis, the required height of the dike (from the existing average river bed) is as follows:

Required Height of Dike in three Alternatives

Alternative	Averaged Sediment depth	Water depth	Freeboard	Proposed Average Dike Height from Existing Riverbed
Alternative-1	1.9 m	2.6 m	1.2 m	5.7 m
Alternative-2	1.9 m	2.2 m	1.2 m	5.3 m
Alternative-3	1.1 m	2.6 m	1.2 m	4.9 m

Note : Proposed water depth indicates average water depth with non-uniform flow analysis.

The above table shows that the difference of riverbed movement between Alternatives 1 and 2 in Malomboy is not large in terms of reduction of proposed dike height in the lower reaches.

Alternative-3 would provide the lowest dike height, which is 0.8 m lower than alternative-1. However, compared with alternatives 1 and 2, alternative-3 would require more structural work and higher construction cost.

It is conceivable that adoption of a consolidation dam, sand pockets and/or training channel as proposed in alternatives 2 or 3 would still be no more advantageous than alternative-1 as an urgent scheme under present normal conditions. The respective construction costs of alternatives 2 and 3 have been estimated at 2.2 and 4.8 times alternative-1.

8.6 Structural Measures in the Maloma River Basin

In the Maloma River basin, lahars were observed in 1991. However, since 1992 no further lahars have occurred because the pyroclastic deposits in the sediment source zone were almost swept away to the South China Sea due to heavy rain up to 1992. In the master plan study, river channel improvement was proposed as more important measure than mudflow control work.

The most serious concern from the viewpoint of flood control is insufficient flow capacity in the river channel 3.5 km upstream from the Maloma Bridge. The river channel has a flow capacity of less than the 2-year flood discharge. Floods spill over the right riverbank, overflow National Road No.7 and spread over the agricultural land between National Road No.7 and the seashore.

Hence, widening and straightening of the river channel with a scale of a 20-year probable flood and the reconstruction of the Maloma Bridge are recommended to ensure enough flow capacity as shown in Figure 8.6.1. The longitudinal profile of the proposed river improvement work is shown in Figure 8.6.2.

In addition, rehabilitation of the dike will be required at the confluence of the Gorongoro/ Kakilingan River.

At the river mouth portion, a short-cut channel was also considered to induce sediment flushing effect and to lower the flood water level. However, it is concluded that the river mouth short-cut channel is not feasible from a technical viewpoint. The coastal sediment flow direction is from the north to the south and the proposed river mouth area will be easily buried due to the coastal sediment transportation to the mouth.

8.7 Structural Measures for the Sto. Tomas River Basin

8.7.1 Alternative Flood /Mudflow Control Measures

The results of mudflow hazard analysis show that land areas beside the lower- middle reaches of the Sto. Tomas River are prone to damage caused by lahar sediment flowing out if the existing dikes are breached due to flood and/or mudflow. The hazard area has been predicted as more than 58 km^2 under a 20-year probable flood. The scale of predicted hazard area is the largest among the three basins.

In the upstream stretch of the Marella River, there is a possible sabo dam site to store surplus lahar sediment. However, the ratio of proposed sediment storage to the concrete volume of dam body is significantly lower than that in the Bucao River. Therefore, the following three alternatives have been considered as shown in Figure 8.7.1.

(a) Alternative-1: Heightening/ Strengthening of the Existing Dike

During the flood on 8 July 2002 the land area beside the left bank for the stretch from the Maculcol Bridge to the river mouth was inundated with 1.0 m thick sediment due to the dike breaching. In the Sto. Tomas River basin, because the riverbed elevation is higher than the elevation of the land beside the river, the mudflow would swerve to the land area beside the river causing a considerable volume of sediment deposit if the dike breached. The general layout of the dike system is shown in Figure 8.7.2 and a typical cross section of the dike is shown in Figure 8.7.3.

(b) Alternative-2: Heightening/ Strengthening of the Existing Dike,
Consolidation Dam and Training Channel

Lahar deposits from the upstream reach of the Marella River created Lake Mapanuepe. The volume of water storage is estimated at 30 million m^3. The height difference between the normal water level and the surface elevation of the lahar deposits is about 10 m. At present, the lake functions like a flood mitigation dam. The 20-year probable flood peak discharge can be reduced from 1,000 m^3/s to 250 m^3/s due to the effectiveness of flood mitigation in the lake.

For the Sto. Tomas River channel, the long-term forecast of sediment balance in Chapter 6 shows riverbed degradation in the Marella River from Mount Bagang to the upstream stretch. If serious riverbed degradation occurs, the lake dikes will collapse due to erosion of natural levees created by lahar deposits.

To ensure the flood mitigation effect of the lake continues, erosion of the natural levees should be prevented or controlled. The construction of a consolidation dam 4 km upstream from Mount Bagang and a training channel would be effective in maintaining the existing riverbed elevation in the lower reaches of the Marella River. The training channel is designed to safely accommodate a 20-year design flood as shown in Figure 8.7.4. A typical cross section of the structures is shown in Figure 8.7.5.

(c) ***Alternative-3:*** Heightening/ Strengthening of the Existing Dike and Sand Pocket Structure

The purpose of this alternative is the same as alternative-2. The sand pocket structure with three rows of lateral dikes 3 m high and a ring dike 8 m high would be provided to avoid riverbed degradation and for trapping sediment as shown in Figures 8.7.6 and 8.7.7.

The lateral dikes would have several openings. The locations of the openings would be arranged alternately for each lateral dike in order to accelerate sediment deposits. The consolidation dam would be provided at the downstream end of the sand pockets to stabilize the unstable lahar deposits underneath the sand pocket structures.

The advantages of sand pocket structures are to protect Lake Mapanuepe from erosion as explained in alternative-2 and to halve the construction costs of alternative-2.

The disadvantage of this plan is that it would not able to fix a river channel inside the sand pocket. It is possible that the river channel would shift inside the sand pocket after every flood. Also, the area of the sand pocket could not be utilized as productive land.

8.7.2 Comparative Study through Riverbed Movement Analysis

The individual effectiveness on sediment control of each of the above alternatives is evaluated using results of the two-dimensional mudflow analysis and one-dimensional sediment transport analysis. In alternative-2 and alternative-3, the analysis was conducted with the condition that the riverbed where the proposed structures were located was fixed at the present elevation. The examination from the viewpoint of structural measure effectiveness is described for the Sto. Tomas River with results of both sets of analysis as follows:

(1) Results of Two-Dimensional Mudflow Analysis

Results of the analysis for the three alternatives (Figure 8.7.1) show almost the same tendency to riverbed aggradation in the downstream from Mount Bagang as illustrated in Figures 8.7.8 and 8.7.9. The sediment deposit is almost less than 1.0 m high downstream from Mount Bagang.

It is conjectured that:

- In the early flooding period, sabo structures crossing the river in alternatives 2 and 3 may be buried by surging lahar sediment upstream in the Marella River and the structural functions would be lost due to lahar flow conveying huge sediment deposits. Consequently, during middle to ultimate flooding stages, the states of the downstream portions of the Marella River in alternatives 2 and 3 stay the same as the existing riverbed state. However, the proposed sand pockets show their effectiveness in trapping sediment deposits, comparatively.
- The above predicted process shows that huge amounts of sediment would still be transported from the sediment source zone in the upstream of the Marella River and there would be inadequate structural effectiveness (fixing watercourse, catching sediment deposits, etc) for significant advantage under present conditions.
- For the lower-middle reaches of the Sto. Tomas River, the results exhibit no significant difference among the three alternatives.

The following table shows interval averages of maximum riverbed aggradation in each of the three alternatives:

Interval Average of Maximum Riverbed Aggradation

River Stretch	Alt-1	Alt-2	Alt-3
River mouth to Paete Hill	1.1 m	1.1 m	1.1 m
Paete Hill to Vega Hill	2.0 m	2.1 m	2.1 m
Vega Hill to Mount Bagang	1.9 m	1.8 m	2.3 m

(2) Results of One-Dimensional Sediment Transport Analysis

The results of one-dimensional analysis for the three alternatives in Table 8.7.1 and Figures 6.4.11 and 8.7.10 to 8.7.14 showing the riverbed movements after 20 years are divided into two tendencies. One tendency is riverbed aggradation between the river mouth and Vega Hill and the other is riverbed degradation between Vega Hill and the Marella River.

The following table shows averaged change of riverbed movements in each of three alternatives:

Averaged Change of Riverbed Movements

River Stretch	Alt-1	Alt-2	Alt-3
River mouth to Paete Hill	0.7 m	0.5 m	0.5 m
Paete Hill to Vega Hill	0.6 m	0.7 m	0.7 m
Vega Hill to Mount Bagang	-0.5 m	-0.5 m	-0.4 m

It is conjectured that:

- Between the river mouth and Paete Hill, the results show almost the same tendency to riverbed aggradation for 20 years among three alternatives. However, downstream from the Maculcol Bridge, in alternative-1 sediment is transported a little faster to the river mouth than with the others. In terms of sediment transport ability in the channel, it is judged that alternative-1 is a little better than other alternatives.
- Between Vega Hill and Mount Bagang, the results show the same tendency of riverbed degradation among three alternatives. This tendency would improve the present state which has a risen riverbed and it is expected that it would enhance the safety of the river dikes with respect to flooding and/or mudflow control ability. However, the lower reaches of the Sto. Tomas River are affected by sediment transport from this section.
- In the lower reaches of the Marella River, the results show a tendency to riverbed lowering with the proposed structures except for alternative-2. The predicted degradation depth is in the range of 3 to 4m. This degradation may effect the natural levee of Lake Mapanuepe. However, the natural levee has an averaged height of 6 m between the lake surface during floods and the crest at present. The natural levee, which divides the Marella River and Lake Mapanuepe, may retain its function by remaining at a height of about 2 m for the next 20 years.

According to the results of the above two riverbed movement analyses, the riverbed movement with/without structural measures in the Sto. Tomas River would not be remarkably different among three alternatives during the next 20 years in the lower- middle reaches of the Sto. Tomas River.

Consequently, it is conceivable that adoption of the proposal of a consolidation dam, sand pockets and/or training channel in alternatives 2 or 3 are still no more advantageous than alternative-1 as an urgent scheme under the present natural conditions.

However, if the sediment source zone in the upstream of the Marella River is likely to proceed to a more stable zone by the forces of nature in the future, then the proposed structures of alternative 2 or 3 would be applied to further strengthen flood management and accelerate future agricultural development in the channel.

Additional simulation was conducted under the following conditions, as a reference, although these alternatives were not included in the alternative structural measures in the master plan. These are 1) Alternative-2*: Consolidation Dam + Training Channel from Sta. 21.5 km to Sta. 30.0 km and 2) Alternative-3*: Large Scale Sand Pocket + Sabo Dam at Sta. 21.5 km.

1) Alternative-2*: Consolidation Dam + Training Channel from Sta. 21.5 km

To examine the effect of complete prevention of secondary erosion in the Marella River, simulation with alternative-2* was conducted. Riverbed movement with alternative-2* was analyzed with the condition that a training channel was extended up to the upstream end of the Marella River.

Figure 8.7.12 shows the result of riverbed movement after 20 years with alternative-2*. It indicates that extension of a training channel would prevent riverbed aggradation in the middle reach. However, the riverbed movement downstream is similar to alternative-1 with a maximum aggradation of 1.4 m. It is assumed that secondary erosion in the middle reach would cause riverbed aggradation in the downstream portion.

2) Alternative-3*: Large Scale Sand Pocket + Sabo Dam at Sta. 21.5 km

Riverbed movement was analyzed with the condition that the total sediment load from the Marella River is completely stored immediately upstream of Mt. Bagang with a large scale sand pocket and sabo dam at Sta. 21.5 km. The riverbed elevation of the upstream end was fixed at the existing level in 2002 at Sta. 21.5 km in the model. A maximum erosion depth immediately downstream of the structure was set at 15 m in the model based on the riverbed elevation in 1977. In addition, it was assumed that there was no inflowing sediment at the upstream boundary.

Figure 8.7.13 shows the result of riverbed movement after 20 years with alternative-3*. There would be serious riverbed scouring immediately downstream of Mt. Bagang with a maximum erosion depth of 15.0 m. It indicates that the riverbed would not rise in any section, even downstream, if sediment flowing into the Sto. Tomas River was negligible.

8.8 Maraunot Notch of Pinatubo Crater Lake

8.8.1 Topographic/Geological Conditions

Around the Maraunot Notch, the oldest geology is an andesite dome which has developed on the left bank (west side) of the Maraunot Notch. The andesite, massive but partly highly jointed, is overlain by a fluvio-lacustrine deposit which may be the old Crater Lake deposit. It is composed of bedded tuffaceous sandstone, siltstone and mudstone (Figure 8.8.1, Photo 9). After that, some tectonic activity occurred in Mount Pinatubo, and then dacite lava intruded along the fault (Figure 8.8.1, Photo 8, 10). Along the fault, the dacite was strongly sheared and the width of the crush zone is about 10 to 20 meters.

After these phenomena, some volcanic activities occurred and then breccia and lava flow deposit developed in this area (Figure 8.8.1, Photo 10).

Subsequently, old Pinatubo volcano erupted and formed the old Crater Lake, which was similar to the present Crater Lake. Then some tufferceous sand, silt, mud and breccia deposited in the old Crater Lake (Figure 8.8.1, Photo 7).

Recent Pinatubo volcanic activity covered the mountains with some falling ash, pumice and breccia. After the eruption of Mount Pinatubo about 500 years ago, the Maraunot River formed on the north-west part of the mountain surface.

According to the topographical map published by NAMRIA on a scale 1/50,000 in 1977, the Maraunot River, topographically similar to the Maraunot Notch, had a gentle riverbed and wide valley (Figure 8.8.2). These topographical features indicate that the valley of the Maraunot River had been sedimentary in condition and many fluvial sediment deposited in this valley.

A comparison with the aerial photographs taken in May 2002 shows that it is not so different to the topography before the 1991 eruption of Mount Pinatubo near the Maraunot Notch (Figure 8.8.2). It indicates a small topographical change before and after the eruption.

This means that the sediment caused by the 1991 eruption was not so significant near the Maraunot Notch and no fundamental change of topography occurred at the time of 1991 eruption. The only difference was that falling ash covered the mountain surface. Traces of these phenomena can be seen at the downstream end of the Maraunot Notch (Figure 8.8.1, Photo 2).

However, downstream in the Maraunot River, at an elevation of approximately 500 m, the river changed its course to the old Lubao River side (southern part of the old Maraunot river) because of the pyroclastic deposits of the 1991 eruption. PHIVOLCS called this river "the new Maraunot River".

8.8.2 Breach of Maraunot Notch

From the information gathered during field inspection, it became evident that a huge lahar occurred along the Bucao River and carried away five carabaos and two men on 10 July 2002. By comparison of photographs taken during the aerial survey on 18 May (before breaching of the Maraunot Notch) and from 18 July to 30 July (after breaching of the Maraunot Notch), shown in Figure 8.8.3, we concluded that the occurrence of the lahar was caused by water overflowing from the Crater Lake after the breach of the Maraunot Notch.

A breach at the Maraunot Notch was made immediately evident by a drop in lake level leaving a distinct high water mark circumscribing crater wall. The height of the water mark from the lake level is 23 meters (Figure 8.8.4). Based on the released lake water volume of about 6.5×10^6 m^3, the volume of lahar was estimated at 160×10^6 m^3 assuming the ratios of sediment to water (3 : 2) proposed by PHIVOLCS.

8.8.3 Detailed Field Investigations

(1) Geo-Resistivity Survey

The study team conducted a geo-resistivity survey around the Maraunot Notch from January to February 2003 in collaboration with the DPWH. The results of the geo-resistivity survey are summarized as follows:

1) The fracturing of dacite within the sheared zone was erratic and not uniform. Within the sheared zone, the degree of fracturing was more in the central portions. The massive dacite as shown in the resistivity profiles may be blocky rocks within the fractured rocks.
2) No discrete cavities or underground channels were detected within the sheared zone since the variation in resistivity results can be correlated from resistivity station to station. Instead, the resistivity results suggest that the permeability of the fractured rock varied considerably from loose to tight.

3) The low resistivity layers denoted highly fractured zones that were saturated with water.

According to the interpretation of the results of the geo-resistivity survey, it seems that there is no wide seepage zone under the ground near the Maraunot Notch.

(2) Schmidt Hammer Test

The results of the Schmidt Hammer test are as follows:

1) Massive sandstone of fluvio-lacustrine sediment has more than 35 values of coefficient restitution of Schmidt Hammer.
2) Sheared dacite had a value of coefficient restitution less than 15, but partly sheared dacite had values of coefficient restitution of 25 to 30.
3) Massive dacite had a value of coefficient restitution of almost 40.
4) Old breccia developed at the mouth of the notch had a value of coefficient restitution from 22 to 30.

According to the result of the Schmidt Hammer Test, the sheared dacite is classified as soft rock and C_L class, the massive dacite is classified as hard rock and C_M to C_H class, massive sandstone of fluvio-lacustrine sediment is classified as hard rock and C_M class, and old breccia is classified as hard rock and C_L class.

8.8.4 Mechanism of the Breach

A cave exists on the foot of the ridge located on the right bank of the Notch mouth behind the lake, and its surface is smooth.

This indicates that the river water of the old Maraunot River flowed in the cave, and dacite cliff was eroded by the water flow. Hence, a smooth surface cave was formed there. Subsequently, a very thick fluvio deposit, about 50 m thick, accumulated in the valley.

During the 1991 eruption, the pyroclastic fall around the notch was estimated to 2 m to 5 m thick on the basis of the trace of sediment on the cliff on the opposite side of the waterfall downstream of the pool (see Figure 8.8.5). The upper part of a V shaped deposit showed gray, and the lower part is gravel and brown in color. It is assumed that the gray colored deposit is the pyroclastic fall of the 1991 eruption and the lower part with brown deposit is fluvio-lacustrine sediment from old eruptions before the 1991 eruption.

After the 1991 eruption the water level of the Crater Lake rose up. For the purpose of smooth drainage, a drain canal, about 200 m long, 2 to 4 m wide and about 2 m deep was excavated on the flat area of the Maraunot Notch in September 2001.

The profile of riverbed 500 m downstream from the Notch was somehow steeper than upstream and downstream before the breach. From the end of June 2002 to 10 July 2002, heavy rainfall occurred. It was assumed that riverbed scouring occurred at this steeper portion first and then extended upstream in the Maraunot River reaching the Maraunot Notch.

At that time heavy rainfall continued and the water level was rising up in the Crater Lake. In these conditions high water pressure affected the wall of the Maraunot Notch and seepage occurred inside the fluvio deposits in the valley of the Maraunot River.

Suddenly fluvio deposits rushed out with a height of almost 20 meters and water from the Crater Lake flowed down at high speed. Almost all the fluvio deposit was washed away downstream and erosion of the Maraunot valley occurred reaching a depth of approximately 50 meters.

8.8.5 Proposed Activity

The mechanism of the breach of the Maraunot Notch is presumed as described above.

Almost all the non-consolidated deposits have been washed away, and now surfaces are covered with consolidated materials like old breccia, intrusive dacite and lacoste-fluvio deposits. So it seems that another large sized breach like the breach in July 2002 is unlikely to occur.

However, a fault has been developing near the Maraunot Notch extending in the W-N-W direction of the river and intrusive dacite has been sheared along the fault. If large scaled seepage was to occur, the potential peril of a breach increases because the depth to the valley from the water level of the Crater Lake keeps at about 30 meters and a decrease of strength of the sheared dacite would occur.

Therefore, it is proposed that core drilling be conducted, with direct observation of the boring core, that ground water level gauges be installed using the boreholes, and that observation of ground water level be carried out. Installation of a raingauge and a water level gauge is recommended to monitor rainfall and lake water level. Regular inspection by the geologist is also recommended to monitor conditions of the notch and crater wall to take immediate actions needed.

8.9 Road Network

8.9.1 Proposed Master Plan for the Road Network

The traffic volume surveyed at present and estimated in the future is shown in Figure 8.9.1. The present annual average daily traffic is 3,000 to 4,500 along the Iba South Road (National Road No. 7). The traffic volume of about 9,000 at TS1 is very high because this site is the municipal center of San Narciso and includes local traffic volume.

The proposed master plan of the road network for the study area is shown in Figure 3.9.1.

Five road sections were considered for new construction. These are: the road along the Sto. Tomas River, the access road going to the Mapanuepe Lake, the road along the Bucao River, the road along the Balin Baquero River, and the road along the Maloma River. These roads serve as access roads to the residential areas on the upper river reaches of Mount Pinatubo. Another road section, which will be a tourist road, will be constructed and linked to a cable-car to be extended up to the crater lake of Mount Pinatubo.

8.9.2 Proposed Master Plan for Bridge Reconstruction

The proposed master plan for bridge reconstruction is shown in Figure 3.9.1.

Three bridges were considered for reconstruction based on the bridge prioritization and ranking criteria. These are the Bucao Bridge at km193+502 which received the highest ranking, the Maculcol Bridge at km165+363 which was ranked second, and the Maloma Bridge at km174+531 which was ranked third. All these bridges are located along the Iba South National Highway.

The details of the under clearance, finished grade, bridge length and bridge site for each proposed bridge compared to the existing bridge is shown in Table 8.9.1.

The under clearance required has been determined to be more than 1.5 m for the Bucao, Maculcol and Maloma Bridges. The finished grade of the proposed bridge is plus 2.4 m to 9.3 m against the existing bridge. The increase in bridge length from the existing bridge to the proposed bridge is plus 21 m for the Bucao Bridge, 150 m for the Maloma Bridge and 49 m for the Maculcol Bridge. The large increase for the Maloma River is proposed because widening of the Maloma River is planned with the river improvement work.

The proposed Bucao Bridge site is downstream from the existing bridge site. This is because construction of a bridge at a new upstream site would require a longer bridge, and to replace the bridge at the existing location would require a long detour bridge to be constructed. The proposed Maloma Bridge will be located at the existing bridge site. Because there are many residences on the approach road to Manila, the proposed Maculcol Bridge site will be located on the upstream side of the existing bridge.

CHAPTER 9 NON-STRUCTURAL MEASURES IN MASTER PLAN

9.1 General

Non-structural measures against flood and mudflow damage are one of the important components for formulation of the master plan from the following viewpoints:

1) As immediate measures to mitigate flood and mudflow damage,
2) As measures to mitigate damage caused by a flood exceeding the design flood of the structural measures.
3) As measures to reduce natural hazard and social vulnerability in the flood/mudflow prone areas.

In this study, the following non-structural measures are taken into account as components of the master plan. The expected roles of each non-structural measure are listed:

Roles of Non-structural Measures

No.	Non-structural measures	Roles under Flood/Mudflow Control Master Plan		
		To mitigate damage immediately	To mitigate damage exceeding design flood	To reduce natural hazard and social vulnerability
1	Flood / Mudflow Monitoring & Warning System	◎	◎	×
2	Evacuation System	◎	◎	○
3	Watershed Management	×	×	◎

Notes: ◎: Main role of the measures, ○: Applicable role of the measures, × : Measures not applicable

This chapter pertains to the existing Flood/Mudflow Monitoring and Warning System, the Evacuation System and Watershed Management, with the following contents:

1) Flood/Mudflow Monitoring and Warning System

- Present conditions and history of previously installed systems
- Recommended systems, and required cost
- Operation and maintenance method

2) Evacuation System

- Present conditions
- Improvement of evacuation system

3) Watershed Management

- Legal definition of watershed management
- Recommendations for watershed management at the project site

Resettlement activities and Community-Based Forest Management (CBFM) are explained briefly in this chapter, but the details are described in other relevant chapters and appendices.

9.2 Monitoring and Warning System

9.2.1 Present Conditions

PHIVOLCS, OCD, PAGASA and the AFP/PNP are the agencies that had installed and had been maintaining equipment to obtain basic information for flood and mudflow monitoring and warning in the study area. Aside from these agencies, the DPWH-BRS and the NIA have their own observatories, but these are for the monitoring of bridge security and irrigation water, not for flood and mudflow forecasting and warning purposes.

Basically, the information collected through these agencies is gathered and summarized by OCD (particularly, RDCC-III, the interagency disaster coordinating body in the study area). OCD disseminates the information/warning to its subordinate agencies and the broadcasting media. However, in cases of emergency, PDCC, MDCC and BDCC in each province also issue warnings based on their own judgment.

Figure 9.2.1 shows the locations of observatories under OCD/JICA (the lahar monitoring system of the OCD donated by JICA in 1991), PAGASA, AFP/PNP and the study team. Locations of equipment installed and dismantled by PHIVOLCS are not shown in this figure, because the locations of original installations could not be pinpointed during the survey.

The following gives the present conditions of the systems/stations under the above stated four agencies in the area on the western side of Mount Pinatubo, the Study Area.

(1) PHIVOLCS

With assistance from USGS, PHIVOLCS installed six telemetered rain gauges and seven telemetered experimental acoustic flow monitors (AFMs) around Mount Pinatubo immediately after the eruption on June 15, 1991.

The combined network of flow sensors and rain gauges served three roles, as follows:

- To provide immediate warning on lahar hazards;
- To collect data for the studies on the hydraulic aftermath of the eruption; and,
- To test technical aspects of the system itself.

The rain gauges were installed at high elevations in the lahar source region but far enough from populated sites so as to maximize the lead-time for warning.

Precautions notwithstanding, the monitoring system was damaged by heavy rainfall, lightning, wind, volcanic ash and thieves that aimed at the solar panel and battery. As of 2000, all equipment was malfunctioning, and PHIVOLCS decided to dismantle all equipment from the sites to avoid further damage.

In view of the foregoing, real time forecasting and warning from PHIVOLCS is not available at present. Currently, PHIVOLCS dispatches a task force to the presumed hazard area when further heavy rainfall is forecast by PAGASA, and issue advisories to agencies concerned on the basis of the findings of the task force.

(2) OCD

The lahar monitoring system of the OCD donated by JICA in 1991 consists of eight units of telemetered rain gauges and trap-wire type mudflow sensors and two units of repeater and monitoring devices. Of that equipment, three units of rainfall gauges and trap-wire type mud flow sensors and one unit of repeater and monitoring devices were planned for installation on the western side of the Mount Pinatubo area within the Japanese Fiscal Year 1991. Operation and maintenance, as well as responsibility for the dissemination of the obtained data, had been placed under the responsibility of PDCC in Iba through OCD and RDCC-III.

During the survey, only two units of rainfall gauges, one unit of repeater device and one unit of monitoring device were found in the field. According to PDCC in Iba, the units had been maintained and operated until 1997. However, these were also vandalized by thieves. Solar panels and batteries were stolen. All the devices in the field have been vandalized except the monitoring station in Iba.

The stations had been collecting data until 1997, but accumulated data was lost because the office was flooded.

(3) PAGASA

PAGASA had installed/established the telemetered flood forecasting and warning systems for the Agno, Bicol, Cagayan and Pampanga river basins. All of these basins have relatively large catchment areas and receive high priority in the country.

In the study area, four rain gauges have been installed, mainly on the flat land near the coast and in the lower reaches of the river. Data is collected manually.

Although weather information based on data obtained through the observatories nationwide is important for flood and mudflow monitoring and warning in the study area in general, the information is not directly applicable to the particular and specific hazard in the study area with respect to lead-time.

(4) AFP/PNP

Two watch points in the study area are being maintained and operated by AFP/PNP. The staff observe flow conditions for 24 hours per day, especially in the rainy season, and whenever they judge that flood and/or mudflow will cause damage in the lower reaches, they transmit the information to the PDCC which will take the appropriate action, disseminate the information and give warnings to subordinate agencies, the MDCC and BDCC.

However, it is pointed out that:

- The judgment itself is being done on the basis of personal experience without objective standards for items such as accumulated rainfall volume, intensity of rainfall, or water level of the river, and
- There is concern over the reliability and judgment for warnings during night time.

9.2.2 Alternative Plans for Warning System

Basic Concept

Based on the above, it is concluded that no effective warning system currently exists. The ongoing PHIVOLCS procedure seems to be giving a rather general warning to the people, and warnings transmitted by the watch point personnel are strongly dependent upon the persons transmitting the warning.

The following items should be taken into consideration when a real time flood and mudflow monitoring and warning system is to be planned and implemented in the study area.

(1) Establishment of Real Time Data Transmission System

For flood and mudflow monitoring and warning, real time observation data should be obtained in every way possible to enable comprehensive judgment and to facilitate the issue of accurate information. The importance of a consolidated information system in the East Pinatubo area was noted under the Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River Drainage from Mount Pinatubo. However, in the West Pinatubo area, which is under the same organization as the East Pinatubo area, RDCC-III, the level of information integration is judged to be lower than that of the East Pinatubo area.

(2) Solution of Problems brought out by PDCC

Under the present conditions of the study area, PDCC had informed that there are many inadequacies with respect to:

- The integration/unification of information;

- The common and effective utilization of information; and
- The periodical compilation and aggregation/analysis of the obtained information.

These problems should be solved through a monitoring and warning system proposed in this study.

(3) Countermeasures to Prevent the Vandalism of Observatories

When the flood and mudflow monitoring and warning system has been established in the study area, measures should be taken to prevent the commonly arising vandalism of installed equipment and devices.

(4) Possible Use of Rain Gauges Installed by the Study Team

The study team had installed four units of rain gauges and three units of staff gauges for measuring water level in the study area and is maintaining them periodically to obtain additional hydrological information. It is expected that data collection and appropriate maintenance will be continued by the agency concerned even after the demobilization of the team.

Alternative Development Plans

There is a high possibility that flood and mudflow will occur in adverse weather conditions. However, there is no real-time monitoring and warning system in the study area at present.

As part of the non-structural measures, it is recommended that a real-time flood and mudflow monitoring and warning system be established featuring the observations of rainfall and water level for the safety of inhabitants. Through the data collected by this system and the data accumulated up to the present, it is expected that the correlation between rainfall and flood, as well as the mechanism initiating mudflow, will become clearer, and this may assist in the design of long-term structural measures.

The following measures are described as possible devices for a flood and mudflow monitoring and warning system in the study area:

(1) Rehabilitation of Installed Facilities by OCD/JICA

The telemetered rainfall and water level data transmission system for flood and mudflow monitoring and warning has been applied widely all over the world because of the immediacy and certainty of data collection and transmission. PAGASA also has applied this system as its raw data collection measure.

In the study area, a telemetered rainfall and water level data (hereinafter called hydrological data) transmission system was installed in 1991 for flood and mudflow forecasting and warning as described earlier.

The survey conducted by this study on two rainfall gauging stations, one repeater station and one monitoring station, has confirmed that the foundations for antennas and the antenna poles are available for reuse. The location of these stations has also been confirmed suitable in view of their hydrological positions and radio wave propagation paths. Therefore, the rehabilitation/renewal of electrical devices will make these stations available for further use. Besides, the total cost of rehabilitation will be lower than that of the installation of new facilities. If the system is installed at the same location as in 1991, the rehabilitation cost is estimated to be around JPY 60 million.

For the implementation of this plan, the following items shall be taken into account:

- For the system stated above, only PDCC Zambales may obtain the collected data. For the purpose of consolidated control and monitoring, collected data shall be disseminated to RDCC-III in San Fernando City, Pampanga, and other related agencies in Metro Manila. Such enhancement of the equipment will increase installation cost, because of the installation of new repeater station(s) and data receiving devices for each agency.

- The previous system has been damaged, mainly because of theft. To prevent vandalism, it will be necessary to assign somebody from the neighboring areas concerned, through the subordinate organization of PDCC, for security responsibility.
- Among the four stations stated above, there are no residential houses near the rainfall gauging stations and the repeater stations. At these remote stations, guardhouses with watchmen need to be stationed.
- For further development of the system, additional cost may be necessary, aside from the installation cost of stations, such as the cost for installation of new repeater stations, modification of software, etc.
- If the collected data needs to be disseminated to the Manila area for the integration of collected information, PAGASA is considered to be the main receiving agency for information, because PAGASA has longer and richer experience in the fields of monitoring and warning systems in comparison with the other agencies such as OCD/RDCC-III.

However, the western part of Mount Pinatubo is not specified as a target area in accordance with the Six-Year Modernization Program.

(2) Installation of New Radar Rain Gauge System

If an adequate high land point is selected as a radar site, one radar rain gauge can cover all of the study area and the dissemination of data will also be possible through a simple transmission system.

Since the system will be limited to one site, maintenance and operation can be carried out by stationed personnel, avoiding the difficulty of access to locations scattered in remote areas. A single site will also be beneficial in view of the integration of data and prevention of theft.

If this system is to be operated and maintained by appropriate experts, the apparatus could be the key to the flood and mudflow monitoring and warning system for the western side of Mount Pinatubo.

The cost of installation of a radar rain gauge system is estimated to be JPY 300 million to JPY 400 million, but the cost will vary depending on the location.

For the implementation of this plan, the following items shall be taken into account:

- For almost the same reasons as those of the telemetered rainfall and water level data transmission system, PAGASA is nominated as the main receiving agency of the data. However, the western side of Mount Pinatubo is not included in the development program of PAGASA.
- For the effective use of a radar rain gauge system, the station should be located at a high elevation with full coverage of the study area. The location of the radar rain gauge station is presumed to be in the mountainous region in this study area. Some additional costs will be necessary to provide a power supply system and other supplementary facilities.
- Once the radar rain gauge station has commenced operation, a calibration period of around one year will be necessary for adjusting the various coefficients of the software. On-the-job training by expatriates will be needed throughout this period.

(3) Installation of New Rain and Water Level Gauge with Cellular-Phone for Data Dissemination

This is a combined unit containing rain and water level gauges and a cellular phone. A dedicated circuit system (telemetering) will not be required. As long as the field station is located within the coverage area of a cellular phone service, this system can disseminate the collected data to any monitoring station and has the flexibility to allow proliferation and easy relocation of the station. At the monitoring stations, the data will be conveyed by modem to the computers. The installation cost per station is commonly much lower than that of the system featuring a dedicated circuit system (telemetering).

For the implementation of this plan, the following shall be taken into account:

- Compared with a dedicated circuit system (telemetering), cross talk and/or difficulties with the contact line tend to take place. It may be concluded that this system is rather unstable from the information dissemination point of view.
- The cellular coverage area on the western side of Mount Pinatubo was surveyed, and in some area(s), communication through cellular phone is not available. In non-communicable area(s), other measures for data dissemination shall be taken by using: a) Ordinary radio waves to the nearest monitoring station, or b) Installation of a new transponder in conjunction with the telecommunication company.
- If the equipment is imported from Japan, the communication system needs to be converted to GSM (Global System for Mobile Communications).
- Utilization of a solar panel and battery as the power source at the stations seems essential. Therefore, the same countermeasures described in Item (1) above will be needed to deal with potential thefts.

9.2.3 Recommended Monitoring and Warning System

Judging from the priority of nationwide balance in flood and mudflow forecasting and warning systems, and other economic and property conditions, the application of a telemetered flood forecasting and warning system as well as a radar rain gauge system seems out of balance on the western side of the Mount Pinatubo area.

At present, the lowest cost system, being the installation of a new rain and water level gauge, with a cellular-phone for data dissemination, is recommended for a flood and mudflow forecasting and warning system in the study area, though this system has some weaknesses in access and reliability.

Figure 9.2.2 shows the general idea of a data dissemination system by cellular phone.

- This system could be considered as an urgent/remedial facility or a transitional system until the permanent facilities are implemented, such as a telemetered rainfall and water level data transmission system for flood forecasting and warning, and/or a radar rain gauge system under the organizations of PAGASA/NDCC (RDCCs). Therefore, the simplest and cheapest but still effective system is recommended for a flood and mudflow forecasting and warning system in this area.

- This appears to be the first application of such a system in the Philippines. The conditions of the commercial telecommunication status and other related factors must be examined by a telecommunication expert. However, it is expected that any major technical problems in the transmission system could be solved. Even though the development of such a counter measure will cause an increase in cost, it is minor in comparison with the installation costs of the other two systems.

- If the existing cellular phone system is available in the major part of the study area, many gauging stations could be established with a small amount of expense. Even if communication troubles may occur at any station, other station(s) located nearby may tentatively supplement its expected functions.

- This system remains flexible for the proliferation and relocation of stations on demand, as long as the device can be located within the communicable area. If this can be achieved, it is proposed to facilitate water level observation points at a.) the col at the outer rim of Mount Pinatubo volcanic crater where there is the potential for further erosion of the outlet, and b.) the Dizon mining dam reservoir that was constructed by a private company but its spillway is in a dangerous state at present due to the erosion,

- As detailed above, it is easy to replace the devices with other facilities if any serious problems occur.

9.3 Evacuation System

9.3.1 Present Condition

The exact number of evacuees is hard to determine as it is envisioned that some people would evacuate to the homes of their relatives and some of the population are not counted in the records. Based on the results of interviews conducted at the locations of evacuation centers, the following are noted.

(1) Evacuation Status Since 1992

Table 9.3.1 shows the interview/observation results from the 63 evacuation centers.

Through an interview survey in 24 elementary schools that are designated as evacuation centers by the Department of Education, Culture and Sports (DECS), and 19 other official evacuation centers, it was concluded that some of them acted as evacuation centers in the years of 1992, 1993, 1994, 1995, July, August and September in 2001, and July 2002.

In considering the utilization of the facilities designated, the extensive evacuation in September 2001 was different in nature from other evacuations. Some 35,000 people were evacuated for two days mainly to Iba, transported by eight commercial buses and 14 military trucks. This evacuation had been planned before releasing the water in the caldera's lake and its schedule was informed officially in advance of excavation works on the col at the outer rim of Mount Pinatubo volcanic crater, where there was a fear of further erosion of the outlet.

It is clear that evacuation centers are still frequently in use as emergency shelters against flood and mudflow disasters. However, judging from the small number of evacuated families and the number of simultaneously utilized evacuation centers, these acts of evacuation are practiced through the decision of rather small independent units, and/or Barangay bases.

(2) Evacuation Procedure

Judging from the interview results from the Municipalities, the procedures to be followed in the event of calamities are well established under the MDCC/BDCC levels. However, these stated procedures seem to be activated after the occurrence of the disasters.

At present, the evacuations are carried out using the following steps, based on the information provided by PHIVOLCS and PAGASA:

1) Individuals: detection of the possibility of disaster by residents
2) Individuals: transmission of alert to Barangay Office
3) Barangay Office: transmission of alert to MDCC and PDCC by radio or telephone
4) MDCC and PDCC: transmission of alert to other related Barangays and MDCC as well as RDCC-III by radio or telephone

5) RDCC-III: report to OCD

Some municipalities have established their own evacuation procedures and have been taking action on the basis of disaster information obtained through a Barangay base. The concept of evacuation procedure at municipal level is as follows:

"A Barangay by Barangay, simultaneous evacuation will be undertaken from pick-up points to the identified evacuation center by the overall Marshall (Mayor). The farthest Barangay will be evacuated first followed by Barangays by degree of threat. Residents will be organized into ages with priorities for evacuation. The series of available vehicles, one family per vehicle or otherwise, may be hauled from designated pick-up points to evacuation sites."

(3) Present Condition of Evacuation Centers and their Problems

Before 1997, when the flood and mud flow forecasting and warning system donated by JICA to OCD and transferred to PDCC through RDCC-III was active in the study area, PDCC took the position of organizing the issue of flood and mudflow warnings based on the information obtained from the system. Since then, acts of evacuation are under the judgment of Barangays/individuals.

Ordinary people have not been given information about the latest hazard map. Accordingly, they are not familiar with the latest information about presumed hazardous areas. Nor are they aware of the nearest location of an evacuation center where there will be shelter when advice of flood and mudflow with a short lead-time comes. (Though some municipalities have fixed the location of the evacuation site for each Barangay, it seems some of them are not in appropriate locations.)

In the coastal area, it is presumed that there are many other private or public facilities to be utilized at the time of calamities, such as churches, community centers, other public facilities and private houses. In consideration of previous evacuation patterns, especially in the evacuation in September 2001, it is judged that the capacity of evacuation centers is almost adequate. However, the quality of some evacuation centers is not appropriate. It was reported that some of them are inundated during floods, some are tottering, some need repair work, and some have not been set up with water and electric power supply.

In areas away from the coastline, a few kilometers towards the hilly/mountainous areas, established evacuation centers are very sparse. Though the population density is low in these areas, residents may not have any safety zone apart from the hills/mountains located both to the north and south of the rivers. In comparison to the speed and short lead-time at the time of a calamity, some people residing along the river course might not reach a safety zone within the limited time available.

9.3.2 Improvement of Evacuation System

To prevent/mitigate damage to human lives, an improvement of the evacuation system, as well as the establishment of a hydrological monitoring system, is necessary.

In this subsection, an improvement of the evacuation system is described from the following viewpoints:

- Construction of new evacuation centers;
- Renovation of evacuation centers;
- Enlightenment campaign on disasters;
- Cooperation with NGOs; and,
- Application of Hazard Map.

(1) Construction of New Evacuation Centers

In consideration of previous evacuation patterns, especially the evacuation in September 2001, it is judged that the capacity of evacuation centers is almost adequate.

However, based on the above event, evacuees do not have enough lead time to move to safety in the case of a natural disaster. That is, under the present flood conditions the number of evacuation centers (churches, relatives' houses and other public facilities) at the proper locations is limited from the viewpoint of the relationship between lead time and distance.

Therefore, the construction of new evacuation centers at proper locations is necessary for evacuees' safety from floods. The location and number of evacuation centers can be determined as follows:

(a) Basic Conditions to Decide the Location of Evacuation Centers

Generally, the location of an evacuation center is selected under the following conditions:

- Flood/mudflow is presumed to dissipate in the lower river basin where roads are generally maintained better than those in the upper river basin. Therefore, it is assumed that inhabitants will seek evacuation centers that are around 2 kilometers away from their houses. (According to the results of the interview survey, the escaping speed in these areas is 2 to 4 km/hr).
- Based on the above, if an evacuation center exists in the lower reaches, the facility may accommodate the people residing within 2 km of the said facility.
- The evacuation facilities are adequate for the population at present. However, if the installation of new evacuation centers is carried out in the future, an increase in population should be taken into account.
- The number of new evacuation centers should be determined by consideration of the difference between the potential evacuees and the capacity of the center.
- The distribution of new evacuation centers needs to coincide with the population density.
- According to the results of interview/observation survey, there are 63 evacuation centers around the study area (see Figure 9.3.1).

(b) Target Area of the Evacuation System

Generally, an evacuation system is established as well as a flood warning system as a countermeasure for floods of high probability. Therefore, although the structural measure in this study was set at a scale of 20 years, the inundation area in the case of a 100-year return period flood (refer to Appendix V) was identified as the target area for improvement of the evacuation system for the Bucao, Maloma and Sto. Tomas flood plains. The inundation area and the number of evacuees in the area were estimated for each basin, as shown in the table below.

Probable Maximum Inundation Area and Number of Evacuees

River Basin	Inundation Area (km^2)	Number of Evacuees	Remarks
Bucao	14.4	8,118	16 Barangays
Maloma	5.8	1,108	5 Barangays
Sto. Tomas	71.1	24,269	40 Barangays, Part of San Antonio Municipality
Total	91.3	33,495	

The number of evacuees was estimated taking the total population of barangays and the number of houses in the inundation area into account.

(c) Minimum Requirement for Distribution of Evacuation Centers

Inundation areas out of the coverage area of each existing evacuation center (see Figure 9.3.2) have the highest priority for additional evacuation centers to be constructed in the initial stage, as shown Figure 9.3.3. The additional number of evacuation centers to meet the minimum requirement is 10.

(d) Capacity of Evacuation Centers

The capacity of existing evacuation centers is low compared with the number of potential evacuees, even if only considering the number of centers for the minimum requirement, as shown in table below.

Comparison between Number of Evacuees and Capacity of Evacuation Center

River Basin	Number of Evacuees	Capacity	
		Existing Evacuation Centers	To be Absorbed by Additional Centers
Bucao	8,118	1,800	700
Maloma	1,108	50	200
Sto. Tomas	24,269	10,300	1,600
Total	33,495	12,150	2,500

The capacity of each evacuation center located within a radius of 2 km (refer to item (a) for the reason for 2 km) from the inundation area has been estimated as given in Table 9.3.2. The number of evacuees from each barangay and inundation area has also been estimated as shown in Table 9.3.3.

(e) Location of Evacuation Center for All Evacuees

The location of evacuation centers for all evacuees from an inundation area has been determined as the difference between the number of potential evacuees and the capacity of evacuation centers. As a result, some 50 additional evacuation centers need to be constructed to accommodate evacuees from inundation areas where the evacuation centers are sparsely distributed, as shown in Figure 9.3.4. The capacity of each center is limited to 1,000 people, which is the maximum capacity of the existing evacuation centers (except for Vega Hill in San Marcelino, which has a capacity of 7,500 people).

(2) Renovation of Existing Evacuation Centers

At present, many of the existing officially nominated evacuation centers are dilapidated and require renovation. Some facilities also do not have tap water and/or electricity supply systems. In some instances, the survey of inundation areas and locations of evacuation centers has found that evacuation centers themselves are under the threat of floods (refer to Table 9.3.2).

Renovation of Existing Evacuation Centers

River Basin	Total Number of Evacuation Centers	Number of Centers Probably Inundated
Bucao	8	7
Maloma	1	1
Sto. Tomas	27	24
Total	36	32

(3) Enlightenment Campaign

Many administrative and individual sessions in different fields are being executed centering on the Barangay as the basic unit of the administrative system. Hence, the activities of any campaign concerning flood and mudflow monitoring and warning, as well as route and timing, etc., should be activated through these units.

The campaign on "how to avoid becoming a victim of a mudflow" offered suggestions, through illustrated flyers, posters and leaflets prepared and distributed by RDCC-III, for what residents should do before and when they are warned of flood and mudflows.

Additionally, the relatively large-scale hazard map [see Item (5) below] will enable officials and residents to judge whether their Barangay, town streets and secondary roads are in relatively high or relatively low danger levels.

(4) Cooperation with NGOs

The activities of many NGOs in various fields related to the eruption of Mount Pinatubo are highly appreciated. The government agencies concerned should keep closer relationships with them as other disaster prevention organizations that will supplement the official activities.

Although not all NGOs are founded for the purpose of flood and mudflow disaster mitigation, as many as 92 organizations are listed as officially accredited NGOs and 38 other organizations are applying for accreditation. NGO activities are expected to supplement difficult official activities, and if these organizations could be appointed to discuss their appropriate fields of expertise and try to bring out their potential efficiency, remarkable outcomes in relevant fields may be achieved.

It is necessary for government agencies, especially the NDCC and OCD through RDCC-III and PDCC in Zambales, to coordinate with such networks of NGOs for efficient relief operations and evacuation activities.

(5) Application of Hazard Map

Based on the basic data, hazard maps have to be prepared showing the present condition for each inundation area, as shown from Figure 9.3.5 to Figure 9.3.9. It is recommended that the hazard maps be used for the campaigns mentioned in Item (3) above to familiarize people with the evacuation routes, location of evacuation centers and so on.

The hazard maps should be updated by each barangay, taking into account the specific conditions of the infrastructure, lead time, vulnerability to disasters, past flood records, impassable areas during flood, and allocation of evacuees to the evacuation areas.

An example of a hazard map describing the allocation of a group of evacuees to each evacuation center is given in Appendix XIV.

9.4 Basin Management

9.4.1 Legal Basis of Watershed Management

(1) Definition of Watershed and Watershed Management

Presidential Decree (PD) 705 defines Watershed as the "land drained by a stream or fixed body of water and its tributaries having a common outlet for surface run-off", and DENR Administrative Order (DAO) 99-01 defines Watershed as "an area of land from which rainwater can drain, as surface run-off, via a specific stream or river system to a common outlet point that may be a dam, irrigation system or municipal/urban water supply take off point or where the stream or river discharges into a larger river, lake or sea.".

Watershed Management is defined under the Guidelines for Watershed Management and Development in the Philippines as follows:

(a) The process of guiding and organizing the use of land and other resources found inside the watershed to provide desired goods and services without adversely affecting soil and water resources;
(b) The application of business methods and technical principles to the manipulation and control of watershed resources to achieve desired results such as maximum supply of usable water, minimization of soil erosion and siltation, and the reduction of occurrence of floods and droughts.

(2) Jurisdiction of Watershed Management through Legislation

National Integrated Protected Areas System (NIPAS) Act is under the administration and control of DENR and the policy of NIPAS is to secure all native plants and animals, and to conserve soil and water in critical watersheds through the establishment of a system of integrated protected areas.

The Indigenous Peoples' Rights Act (Republic Act 8371, 1997) recognizes the rights of indigenous people to own, manage, develop and conserve their ancestral domains and all natural resources found therein. This vests the management of ancestral domains on the indigenous cultural communities/indigenous people. These people have the right of self-governance and self-determination over the use, management and conservation of their domains. A Certificate of Ancestral Domain Claim covers the jurisdiction over the management of watersheds and protected areas.

The Philippine Mining Act (Republic Act 7942, 1995) provides that, subject to existing rights, reservations and prior agreements, all mineral resources in public and private land, including timber and forestland may be opened to mineral agreements and financial and technical assistance agreements. It also defines areas excluded from mining agreements such as military and government reservations, areas covered by small mining claims, old growth or virgin forests, all areas prohibited under the NIPAS Act and areas under the Republic Act 8371.

(3) Land Uses and Occupancy in Watershed Areas

As stated above, specified land uses are allowed in watershed areas. The NIPAS Act allows the establishment of protected areas. Similarly, the Philippine Mining Act provides for the granting of mineral agreements in certain areas. The Indigenous Peoples' Rights Act recognizes the establishment of ancestral domains.

DENR has issued administrative orders that allow various land uses and occupancy in watershed areas. It also grants tenure rights over these areas. Department Administrative Order 96-29, which implements Executive Order 263, grants tenure to qualifying communities through the Community Based Forest Management (CBFM) Agreement. It aims also to consolidate all the previous tenure instruments under the CBFM Agreement.

Department Administrative Order 98-41 allows the establishment of CBFM projects within watershed reservations and Department Administrative Order 2000-44 provides specific guidelines for the establishment and management of community-based projects within a Protected Area.

Other land uses that are allowed within watersheds include Integrated Forestland Management for corporate forest plantation development, Socialized Industrial Forest Management for small-scale commercial plantation development, and the Forestland Grazing Management Agreement promoting the development, improvement and sustainable use of grazing land within watershed areas.

The duration of tenure in all of these agreements is 25 years renewable for another 25 years except those with specific agreements that prescribe other periods of tenure such as those covered by a Memorandum of Agreement.

(4) Jurisdiction over Forest Products

Presidential Decree 705 states that no person may utilize, exploit, occupy, possess or conduct any activity within any forest and grazing land or install wood processing plants unless authorized to do so under a license agreement, lease, or permit issued by the Bureau of Forest Development.

The authority over the collection and disposition of forest products is not relinquished by DENR even in forest areas managed by other agencies and organizations.

One product of watersheds is water. However, this is often not under the purview of the DENR's authority to supervise and control its use because other government agencies such as the National Water Resources Board (NWRB) have been given authority to distribute and tax its use.

9.4.2 Watershed Management in the Study Area

As described above, watershed management covers a wide range and the items to be applied to watershed management can be selected depending on the characteristics of the area.

Through the studies carried out for the master plan, forest management, foothill management (Indigenous Peoples' Rights Act and Aeta people) and sediment control are recommended for consideration in the study area.

In addition to the above, particular issues together with the brief comments forwarded in the previous studies, namely, findings for the Maraunot Notch, and Dizon Mines Tailings Dam and Mapanuepe Lake, are also presented from the non-structural measures point of view.

9.4.3 Forest Management

Forest management is a national issue in the Philippines, especially in the study area where the establishment of a reforestation program is important. Given below is a general idea of the reforestation scheme for the study area.

(1) Present Condition of the Study Area

Based on the present land use map, the study area can be roughly divided into three categories, namely, (1) the steep slope area surrounding the summit of Mount Pinatubo, (2) the foothill area (the outskirts of Mount Pinatubo), and (3) the cultivated land along the coastline.

In the steep slope area, a number of gullies have developed. At present, most of this area is judged to be generally stable compared with the situation in 1991, because some natural vegetation can be observed on relatively flat areas on the mountain. However, there may be a high risk with the implementation of a reforestation program on the mountain slope. Furthermore, erosion of gullies on the slope may occur in the event of heavy rain.

In the foothill area, forest areas have developed or are developing in some portions where the effects of pyroclastic flow are not significant. However, almost all of the remaining portions are still in a bare condition or are grassland.

On the other hand, land along the coastline has been recovered as cultivated land in general, although the level of cultivation is still lower than that before the eruption.

Therefore, it is recommended that a reforestation program be promoted on the foothill areas with the application of Community-Based Forestry Management (CBFM) as the practical method of reforestation.

(2) History and Concept of Community-Based Forest Management

Based on foreign aid programs from the USA, Japan and other countries, the Philippines has taken the initiative in implementing many kinds of forest development projects since the 1980's. However, the protection of forests has not been given much consideration against the inroads of slash-and-burn farming, the destructive tendency of residents opposed to project implementation, and the continuous intrusion of people to gather firewood.

Therefore, the Philippine Government has adopted the Community-Based Forest Management (CBFM) program as a national strategy in accordance with Presidential Decree 263 issued on July 19, 1995 to accomplish the sustainable management of forest resources under the slogan of "people first and sustainable forestry will follow".

The decree stipulates that residential communities are given the autonomy to preserve and manage the national forest in their localities, since forests contain various resources for their livelihood.

The CBFM program is intended for areas where the introduction of participatory reforestation is easy, for example, in areas with gentle slopes, previously properly used for agriculture, and in areas that have been forests in the past. The CBFM implementation Framework is shown in Figure 9.4.1.

Through this program, it is expected that a part of the increasing population will be absorbed in a sustainable mountain village, resulting in the improvement of living conditions in the gentle slope area near the mountain village together with an increase of farm production and public utility functions.

Aside from the above, reforestation projects funded with national and/or ODA funds will:

(a) Create employment opportunities for local residents or organizations. (Residents/organizations may avail themselves of the funds for their initial operating expenses.)
(b) Promote knowledge and awareness on the importance of forest management. (Preservation of the ecosystem is necessary for the sustainable development of mountain villages.)

A detailed evaluation of the existing CBFM programs and identification of potential CBFM sites, including the location of community and recommended activities, are given in Appendix IX, Community Disaster Prevention System.

9.4.4 Indigenous Peoples' Rights Act and the Aeta People (Foothill Management)

Areas where foothill management could be applied are:

(a) Areas where pyroclastic deposits are in a stable condition;
(b) Areas where communities are judged to be relatively safe in terms of hazard assessment; and
(c) Areas where the participation of local people is confidently expected.

In accordance with the Indigenous Peoples' Rights Act, the Aetas are recognized as indigenous people who may own, manage, develop and conserve their ancestral domain and all natural resources found therein. The Aetas have been residing in certain communities even before the eruption of Mount Pinatubo and they were the ones most severely affected by the eruption of Mount Pinatubo, because they lost not only their homes, farmlands, family members and friends, but also their culture and identity. Therefore, they have the right of self-governance and self-determination over the use, management and conservation of their domains. The Certificate of Ancestral Domain Claim covers jurisdiction over the management of watersheds and protected areas.

Foothill management in the study area involves, more or less, the resettlement of Aeta people in the locality. Figure 9.4.2 shows the territorial boundary of the ancestral domain claimed by the Aeta people. Appendices IX and XI describe in detail the methodology of promoting foothill management through the assistance of Aeta people.

9.4.5 Sediment Control

The sediment control measures mentioned in subsection 4.3.3 may be divided into two categories: (1) Structural Measures, and (2) Non-structural Measures (Sediment control in mountainous areas and foothills).

Structural sediment control measures identified through the studies made concerning the sediment source zone are described in detail in Appendix VI, Sabo/Flood Control Structural Measures. The structural measures from the sediment control viewpoint have been divided into three categories depending upon location, as follows:

(a) Structural countermeasures in the sediment source zone to reduce the sediment volume at source;
(b) Structural countermeasures in the sediment deposition/secondary erosion zone to stabilize unstable sediment; and
(c) Structural countermeasures in the sediment conveyance zone to attain the smooth transport of sediment to the river mouth/sea.

Through economic analysis, heightening of the existing dike has been selected as the most feasible structural countermeasure for the Bucao and Sto. Tomas Rivers.

As for sediment control by non-structural measures, they are described in the preceding subsections 9.4.3, forest management, and 9.4.4, foothill management.

9.4.6 Particular Issues

(1) Crater Lake Management (Maraunot Notch)

The present conditions of topography and geology in and around the Crater Lake and the Maraunot Notch are described in section 8.8 Maraunot Notch of Pinatubo Crater Lake and in detail in Appendix II, Topography and Geology.

Based on the stated conditions, a rain gauge and a water level gauge are recommended to monitor the rainfall and water level of the Crater Lake as stated in Chapter 2 of the Appendix VIII.

(2) Dizon Mine Tailings Dam and Mapanuepe Lake

1) Present Condition of Dizon Mine Tailings Dam

The Dizon Copper Mine is located in the upstream portion of the Mapanuepe River, which is called Sto. Tomas River after it joins the Marella River. Mining activities started in 1989 but closed in 1997 due to the scarcity of copper to mine. For treating the tailings, the copper mine tailings dam with a height of approximately 120 m and a reservoir area of approximately 1 km^2 has been provided.

In May 2002, however, it was observed that the lower portion of the spillway had collapsed and the spillway foundation had severely eroded. In August 2002 or three months after the first inspection, the collapsed portion had developed up to the half section of that spillway portion. The cause of collapse was believed to be the flood on 7-8 July 2002, which was estimated to have a 10-year return period.

By September 2002, no structure of the spillway remained and all portions of the spillway foundation were severely eroded by the continuous overflow from the reservoir. Figure 9.4.3 shows the progress of collapse of the spillway portion of the dam.

Since the progress of collapse was quite fast and there was apprehension that it may reach the dam body, the study team recommended that the DPWH should take the following action immediately:

(a) Dispatch watchmen to the dam site and conduct continuous monitoring activities;
(b) Facilitate radio communication between the dam site and each of the four municipalities downstream for real time information regarding the condition of dam; and
(c) Arrange the evacuation of communities located around the Mapanuepe Lake.

2) Present Condition of Mapanuepe Lake

Mapanuepe Lake was created at the confluence of the Marella and Mapanuepe rivers in 1991 due to lahar deposits from the Marella (cf. Figure 9.4.4). The lake had no outlet, and the water level continued to rise up.

In 1992, the stored lake water overflowed and breached the natural dam. Severe flood damage was inflicted to the downstream residential area along the Sto. Tomas River.

In 1993, the DPWH excavated the downstream mountain to provide a new outlet from the lake. Subsequently, the lake water level was kept at El. 123 m during the non-flooding periods and no natural dam break was experienced after that. The difference between the top elevation of the natural dam (existing elevation of lahar fan area developed by the Marella lahar deposits) and the normal lake water level is approximately 10 m, which can be considered as the flood regulating storage of the Mapanuepe Lake basin.

The reservoir capacity of the Mapanuepe Lake is estimated to be 30 million m^3. On the other hand, the sediment yield in 2002 from the Marella basin was 16 million m^3.

Currently, the Mapanuepe Lake is functioning as the retarding basin for the copper mine tailings dam.

3) Presumed Problems

The above-stated unexpected phenomena could not be treated as a part of the study, and imprudent judgment should not be made by the study team. It is presumed, however, that people residing on the lakeshore and along the downstream portion of the Sto. Tomas River from the confluence will encounter two different but complicated problems should the undesirable events mentioned below occur.

i) Collapse of Dam Body

If the dam body should collapse, water will rush into the Mapanuepe Lake and inflict heavy damage on the lakeshore residents and even on the residents residing downstream. There is apprehension that a hydraulic bore may even occur.

As to the issue of safety of the dam against dam break, DENR commented that countermeasures should be taken by the owner of the dam. In this regard, implementation of those countermeasures at the earliest possible time is strongly recommended.

ii) Proliferation of Heavy Metals

Due to lack of purification to process water from the mine, the Dizon Mine Tailings Dam may be contaminated with heavy metals, and the water stored by the dam may also contaminate the water in the Mapanuepe Lake.

Therefore, if the dam body collapses, contaminated water and contaminated slime in the lakebed will spill out to the lake. Further, this contaminated matter from the lake may contaminate the water in the mainstream of the Sto. Tomas River.

Regardless of the number of serious experiences of this kind of problem, treatment or countermeasures for any specific issue is also strongly recommended.

4) Recommendations for Present Urgent Issues

Stated below are the recommendations for the present urgent issues only.

i) Hydrological/Hydraulic Data

As described in item (2), the spillway was seriously damaged during the rainy season in 2002, and the deposited heavy metals have been flowing down to the Mapanuepe Lake located downstream adjacent to the Dizon Mine Tailings Dam.

To obtain hydrological/hydraulic data for warning purposes at these locations, water level gauges and rainfall gauges are recommended, as stated in the section 9.2, Flood/Mudflow Monitoring and Warning Systems.

ii) Water Contamination by Heavy Metals

Based on the results of a water quality survey conducted at the Dizon Mine Tailings reservoir, the contamination level of mercury, lead, manganese, fluoride and copper exceeds the Philippine water quality standards. As for the Mapanuepe Lake, the contamination level of mercury, lead, iron, manganese, phenol and copper is over the standards, while the organic contents as indicated by BOD and COD are fairly low so that organic pollution of the Mapanuepe Lake is judged not to be a problem at present.

Based on the above situation, the following actions are recommended:

a) Additional sampling and laboratory analysis should be conducted to confirm the values obtained in this study and provide measurements that can be used as supplementary baseline values, because the samples were taken only once in the survey.
b) To conduct sampling at short regular intervals, monthly or even bi-weekly, in order to detect any variation of contamination level.
c) To commission a laboratory that has a more precise limit detection device for mercury than that used during the survey.

In addition, the following actions are further recommended:

a) A regular health check up for people residing around the Mapanuepe Lake.
b) Regular monitoring and analysis of fish and crops in and around the lake, because there is apprehension that heavy metals contained in the water might accumulate in the human body through intake of food and water that may have been polluted.

After verification of the survey results, and if it is still desired to use the water for irrigation, fish hatchery or recreation, treatment prior to usage would be required. In such cases, chemical treatment such as flocculation or precipitation removal would be necessary. Such treatment processes are generally expensive and would not be economically justified. Under the present financial conditions, it may be preferable to let the concentration values decrease over time.

9.4.7 Recommended Approach for Watershed Management

As described above, the measures for watershed management in the study area are closely related to each other. The figure below shows the relationships among the measures.

Relationship of Measures for Watershed Management

The relationships among the measures and the important notices concerning watershed management in this study area are summarized as follows:

Summary for Watershed Management in the Study Area

Item	Existing Management System	Problems	Action in the Future
Forest Management	- Participatory management through CBFM	- Since the systems are regarded as the means for land acquisition, the activities of plantation do not work well	- Establishment and implementation of the long-term action plan to enhance CBFM's effectiveness in technology and fund it accordingly.
Foothill Management	- CADC's assurance for proprietary rights of Indigenous People	- Since the systems are regarded as the means for land acquisition, conservation and development of foothills has not progressed.	- Strengthening of support for Aeta people in technology and funding. - Exchange slash and burn farming for SALT.
Sediment Control	- Prevention of diffusion of sediment flow to lower river basin (Dike Construction)	- The management of sediment yield is not established.	- Continuous monitoring of sediment balance. - Management for upper river basin through CBFM and CADC.
Management of Mine	- Management is developer's own responsibility under the guidance of DENR	- There is inadequate management for structures and water quality risks in the lower river basin.	- Reinforcement of observation and guidance for monitoring. - Free access to information (information dissemination) for inhabitants on lower river basin. - Proposing and implementation of safety plan under the guidance of Government.

All the items in the above table are closely related to sabo and flood control programs for the river basin. That is, both implementation of structural measures in the lower river basin and improvement of comprehensive management in the upper river basin simultaneously will lead the river basin to stability with respect to sediment and runoff and will finally achieve the development of the whole river basin.

Thus, for sabo and flood control programs, a comprehensive approach using structural measures in the lower basin is proposed, from the viewpoint of the whole river basin, in order to mitigate or prevent flood/mudflow and other problems relating to sedimentation.

CHAPTER 10 COMMUNITY-BASED DISASTER PREVENTION AND SOCIAL DEVELOPMENT PLANS IN MASTER PLAN

10.1 Basic Concept of CDPP

The Community-Based Disaster Prevention Plan (CDPP) is defined as one of the three major components of the master plan formulation in this study, together with the structural and non-structural measures. But, there is a doubt as to why the community recovery / development activities should be included in the master plan of flood and mudflow control. Prior to discussion about the CDPP in detail, it is necessary to discuss the necessity for the CDPP program in the master plan formulation.

It has been more than ten years since the eruption of Mount Pinatubo, and the lahar flow in the western river basins were not observed any more after 1996, except in July 2002 at the Bucao River due to the collapse of the Maraunot Notch of the Pinatubo crater lake. The amount of pyroclastic material has decreased significantly on the mountain slope in the ten years since the eruption as can be seen on landsat images comparing 1992 and 2001 as shown in Figure 10.1.1. Accordingly, it is concluded that the basin conditions are improving year by year in terms of the potential of lahar occurrence.

On the other hand, the damage to communities caused by the eruption and the following lahar events has still not been fully recovered, even 12 years after the eruption. Figure 10.1.2 shows the trend of family income in the study area. This was divided into four areas, 1) Coastal area, 2) Sto. Tomas area, 3) Bucao area, and 4) Mountain area, for assessment of progress in the recovery of rural economic activities. The details are as follows:

Estimated Trend of Family Income in the Study Area

Area / Description	Samples	Year 1990			Year 2002		
		Family Income	Differ. fr. National Average	Difer. fr. Poverty Line	Family Income	Differ. fr. National Average	Differ. fr. Poverty Line
National Average(*1)	Statistic	P87,434	-	-	P161,842	-	-
Poverty Line(*2)	Statistic	P35,527	-	-	P71,493	-	-
Study Area(*3)							
1) Coastal Area	Statistic	P57,681	-29,753	+22,154	P138,952	-22,890	+67,459
2) Sto.Tomas Area	40	P79,654	-7,780	+44,127	P44,631	-117,211	-26,862
3) Bucao Area	97	P35,579	-51,855	+52	P29,764	-132,078	-41,729
4) Mountain Area	33	P25,662	-61,772	-9,865	P15,360	-146,482	-56,133

Notes: (*1) For 1990: Per Capita GRDP (P.17,522) x Family Size (4.99), For 2002: National Statistic Year 2000 x 1.06^2
(*2) National Statistic Coordination Board (NSCB) data of Year 2000 taking account of 6% of annual increase
(*3) Direct survey by the study team in Year 2003

It was found that the income growth along the coastal area had become steady as of 2002. The gap with the national average was decreased from P29,753 in 1990 to P22,890 at present. The economic activity along the coastal area in Zambales was seriously damaged by the eruption of Mount Pinatubo in 1991. This has been restored because of the great efforts by the National, Provincial and Local Governments as well as by the people by promoting agriculture-based industry as well as tourism development. The coastal area can be defined as the economic development zone which is required to be protected by reliable structural measures against further disasters related to flood and mudflow incurred by the Mount Pinatubo River basins. That would be feasible from an economic viewpoint.

On the other hand, the areas along the Sto.Tomas and Bucao Rivers and the upstream mountain basins are still suffering seriously from the damage due to the events of the Mount Pinatubo eruption.

For the Sto.Tomas area, the income level was rather higher than the coastal area. The annual family income in that area was estimated at P79,654 as of 1990, which was about 35% higher than that of the coastal area. This was because the area was well developed by gravity irrigation systems, which covered about 2,000 ha on the left side. Farmers generally practiced triple cropping of rice a year. However, the whole irrigation system was destroyed due to frequent attacks by mudflow to the area. The damage was quite serious, impacting on the agricultural communities by destroying the irrigation system and the whole farmland as well as the water resources. The irrigation facilities are still not rehabilitated as of 2002, and the farmers are currently producing rain fed or spring irrigation with single cropping of rice and other crops. The family income of the Sto.Tomas area was, therefore, dropped to P44,631 as of 2002, which is below the poverty line and still not recovered, even after 12 years from the eruption.

For the Bucao River area, the average family income before the eruption was estimated at P35,579, which was almost the same as the poverty threshold. Most of the people in this area depend on rice production utilizing the communal irrigation system with double rice cropping a year. After the eruption, however, all the paddy fields, as well as the community access road to market along the river, were buried due to the deposition of lahar material to a depth of more or less 20m. People were trying to shift their agricultural activities from rice to cash crops, such as vegetables and fruit on the mountain slope, but the problem is that they have no access to a market to sell the products due to the community road not being reinstated. As a result, the average family income dropped to P29,764, which was far below the poverty threshold of P71,493 as of Year 2002.

In the upstream mountain area, there are 22 pure Aeta communities, 16 in the Sto. Tomas and 6 in the Bucao basins. Their income level was below the poverty threshold even before the eruption. It was estimated at P25,662, only 70% of the poverty threshold of P35,527, as of 1990. As of 2002, the average family income had dropped to P15,360, which is just 60% of what it was before the eruption. The current average family income in 2002 was far below the poverty threshold of P71,493. The damage to pure Aeta people in the mountain area is not only economic but many of them lost family and community members at the time of eruption. Their entire heritage in the mountain was completed destroyed due to the thick lahar deposition. Currently, 12 years after the eruption, many of the pure Aeta people have returned their original community, but re-construction of their livelihood as well as their culture, destroyed by the eruption, has still not commenced.

The reason why community development activities under the CDPP program are required is that most of the people in the affected river basins are still suffering from the poverty incurred by the disaster events after the eruption. Disaster prevention activities against flood and mudflow would not be possible without food security for the community. Recovery of livelihood and income generation measures for further improvement are, therefore, essential in the affected river basins together with structural disaster prevention measures in the downstream areas.

10.2 Objectives and Framework of CDPP: Livelihood Support

The proposed structural measures aim to prevent disaster caused by flood and mudflow from the Sto.Tomas and Bucao Rivers. The area to be protected is mainly in the coastal lowland area, in which economic activities such as agriculture-based industry and tourism are increasing year by year. The beneficial population is estimated at 146,374 to be directly protected from flood and mudflow by dike heightening and strengthening. The indirect benefit to secure the transportation facility of National Highway No.7, which is the one and only lifeline in Zambales, is also quite important for sustainable regional economic development.

The mid-stream area of the Sto. Tomas River will be also protected by structural measures. However, a more important and urgent matter is to recover the people's livelihood as their family income was dramatically decreased due to the disaster events after the previous eruption and the people are still suffering from poverty.

No structural protection measures are proposed in the Bucao mid-stream area or the upstream mountain area as there is no significant economic activity or existing asset base in the area to meet the huge investment that would be required for structural measures. However, people in the area were the most severely affected by the disaster and they still have no way to recover their livelihood due to lack of available farmland as well as the absence of an access road to market for selling products. Their income level is currently seriously low and is much below the poverty threshold. Livelihood recovery and income generation are, therefore, urgently required under the disaster prevention programs as the poverty is a more serious disaster than flood and mudflow.

Figure 10.2.1 illustrates the objectives and framework of the CDPP. As no structural disaster prevention measures are expected in the middle and upstream of the basin, the people are required to perform disaster management mainly through the community participatory approach, for which it will be essential to set-up and strengthen the community organization. However, those communities, which are still suffering from poverty, cannot act effectively for disaster management, as they are not even secure for daily food. Therefore, livelihood recovery and income generation activities should be the direct objectives for the CDPP.

Figure 10.2.2 shows the procedures for upgrading disaster management capabilities in the community. Strengthening the community organization through community development activities should be designed through the CDPP, which will achieve an upgrade of the disaster management capacity with improvement of economic conditions.

Integration of structural measures for the lowland area as well as livelihood recovery and income generation measures in the mid-stream and the upstream mountain areas as the CDPP are therefore strongly recommended for the CDPP.

10.3 Field Investigation and Needs Assessment

10.3.1 Household Interview Survey

An interview of households was conducted within the disaster prone areas. The objectives of the household survey were to find out the problems, issues and the needs for development, and also to assess the response to the disaster prevention issues. This is the basis for formulation of the CDPP. The survey area is widespread in the eight municipalities. A sample of 40 households was selected at random from each municipality for the survey. The total number of samples was approximately 300. The results of the survey are shown in Table 10.3.1 and summarized as follows:

(1) Actual/Required Income

With respect to the actual income level, about 60% of the sample answered that their average monthly income is less than 3,000 Pesos, which is only 25% of the average monthly family income in the Philippines (at 12,000 Pesos). However, 75% of the sample indicated that they need 5,000 to 10,000 Pesos of monthly income to live on. The gap between required and actual income was significant.

(2) Income Source

The major income sources are as follows:

Major Income Sources

No.	Income Sources	Sample number	Percentage of total sample
1	Agriculture	107	38%
2	Vending	34	12%
3	Hired labor	33	12%
4	Honorarium	28	10%
5	Small business	21	7%
6	Others	60	21%
	TOTAL	283	100%

It was found that agriculture is the main income source in this area for approximately 40% of the sample. Vending and hired labor followed agriculture at 12% each. Accordingly, more than 60% of the sample depend on agriculture, vending or hired labor for their income source. Improvement of agriculture will therefore be an effective means of improving economic conditions in the area.

(3) Projects Required to Rehabilitate and Improve the Community

The interviewees were asked what projects were required to rehabilitate and to improve the community and the following responses were obtained:

Required Projects to Rehabilitate and Improve the Communities

No.	Required project for Community	Sample Number	Percentage of Total Sample
1	Livelihood	248	83%
2	Flood control	159	53%
3	Drainage improvement	138	46%
4	Water supply	83	28%
4	Road improvement	83	28%
6	Irrigation	76	25%

A livelihood development program was the top response for the communities located within the damage prone area, totaling 83% of the sample. Flood control and river improvement work followed the livelihood programs. It seems that the living standard of the affected people has still not recovered to the same level as before the eruption. Accordingly, the highest points were recorded for the livelihood program.

Flood control and drainage improvement followed the livelihood program. They should also receive a high priority as the area is in a disaster prone area and has experienced significant flood/mudflow damage since the eruption of Mount Pinatubo.

(4) Possible Disaster Prevention Activities Requiring Community Involvement

Interviewees were also questioned about the possible disaster prevention activities requiring involvement from the community. The responses were as follows:

Possible Disaster Prevention Activities Requiring Community Involvement

No.	Possible disaster prevention activity	Sample Number	Percentage of Total Sample
1	Warning / evacuation	97	39%
2	Information dissemination	41	14%
3	Livelihood programs	33	11%
4	Micro financing	17	6%
5	Public hearing / consultation	13	4%
6	Disaster prevention seminar / training	8	3%

It was found that few people have an interest in disaster prevention activities. It may prove difficult to involve the community in the implementation of disaster prevention projects where a participatory approach is required. However, the early warning and evacuation systems are expected to improve if more useful information is provided in order to better judge the timing for evacuation. Based on the above, the installation of a telemetry warning system is expected to be effective for the area.

Based on the results of the survey, the following can be concluded:

Findings from Household Interview Survey

1) A livelihood program is important to improve the living conditions for the affected people, and it will also contribute towards upgrading disaster prevention capabilities. Taking into account that the majority of the people depend on the agricultural sector for their income source, a livelihood program in the agricultural sector will be the most effective for improving the living standard in the communities severely affected by the lahar events.
2) An effective warning system may improve the evacuation activities. More useful information is required to disseminate the warning on time.

10.3.2 PCM Workshop

As it was understood that the CDPP is the essential component of the flood and mudflow control project for the western river basins of Mount Pinatubo, a detailed investigation was conducted to identify the specific problems/issues in the communities, which are scattered in the mid-stream and the upstream parts of the study area.

Project Cycle Management Workshops (PCM Workshops) were therefore conducted in five (5) different places in the following manner:

Objective of PCM Workshop

(1) To explain the proposed structural measures for flood and mudflow control in the master plan. An important issue is that the middle and upstream areas will not be protected against further disasters under the proposed structural measures. The area covered by the structural measures is mainly the low-land area along the national highway because of the area's significant economic activities and assets to provide investment for the measures.
(2) To conduct detailed investigation into the mechanism of poverty in the middle and upstream communities, and to find out the key issue to break the poverty spiral in the communities severely affected by the disasters incurred following the eruption of Mount Pinatubo.
(3) To assess the capability of the community for sustainable disaster management activities with the required support from the outside.
(4) To collect data and basic information for the evaluation of the affect of the project implementation on poverty reduction.

Target Group for PCM Workshops

The PCM workshops were conducted with the following target areas and people:

Target Area and People for PCM Workshop

No.	Date of WS	Target Area	Target People	Attendants		
				Aeta	Non-Aeta	Total
WS1	25 Jan. 2003	Resettlement Centers in Botolan	Resettled families in Baquilan, Tautog and Loob bunga.	37	15	52
WS2	28 Jan.2003	Mid-stream of Bucao River Basin	People, returned to the original barangay from resettlement centers	37	8	45
WS3	30 Jan.2003	Resettlement centers in San Felipe	Resettled people in Bantay Carmen, Lalek and Tektek	33	7	40
WS4	1 Feb.2003	Mountain Area	Pure Aeta people originally residing on the mountain	35	0	35
WS5	4 Feb.2003	Mid-stream of Sto.Tomas River	People who were most severely affected along the Sto.Tomas River and Lake Mapanuepe	3	37	40
			TOTAL	145	67	212

The location of the target area is shown in Figure 10.3.1. The target areas and people were selected from the areas where they were most severely affected by the previous disasters and where it seemed that recovery action was still not successfully implemented.

The Aeta people were also focused on because the western river basins of Mount Pinatubo were the heritage of pure Aeta people and their traditional life style was forced to change due to the eruption of Mount Pinatubo. As shown in Figure 10.1.2, the family income in the mountain area was the lowest in the study area, and it was significantly below the poverty threshold. Thus it was considered that Aeta people were the most severely affected, not only from the economic viewpoint but also with respect to sociological issues.

Problem Analysis and Assessment of Problem Tree

In the workshops, small groups of around 10 people were formed and a problem analysis was conducted. Each group developed a problem tree with different core problems. The core problems were given by the study team based on the results of the interview which was conducted prior to the workshop. The selected core problems were as follows:

1) No Livelihood

2) Lack of Social Services

3) Lack of Disaster Management Capability

In addition to the above three core problems, another core problem, 4) Disaster Damage to Indigenous People (Aeta), was also raised by the study team, and was discussed by the community leaders of the Aeta People.

After the formation of a problem tree by each group, a discussion was held by the participants, covering solutions to the problems, possible activities under the initiative of the People's Organization, and required support from others.

(1) Workshop No.1 in Resettlement Centers in Botolan

The target people in WS-1 were the resettled people in government established resettlement centers in Botolan, which is Baquilan, Taugtog and Loob-bunga. There were 52 participants including 37 Aeta people.

The participants were divided into five small groups and the problem analysis and the solutions were discussed. Groups were formed based on the life style of the people, 1) permanent resettlement group, 2) semi-permanent resettlement groups, which had two bases, in the resettlement center and the original barangays, and 3) Aeta leaders semi-permanent resettlement groups.

It was found that the majority (36 persons out of 52 or 69%) of the resettlement people have two bases, one in the resettlement center and another in original barangays. This is because of a lack of livelihood in the resettlement center, and the lack of social services and infrastructure in the original barangays.

Their lifestyle is, therefore, that the resettlement center is considered as the residential base and the original barangay as their livelihood location and their spiritual home. They generally stay some days in the original barangay for farming on the slopes and the rest of the time in the resettlement centers, which have social services available such as elementary schools and so on.

It seems that many of the semi-permanent settlers in the resettlement centers may not leave the resettlement centers even though some recovery activities are conducted in the original barangays. This is because all the resettlement centers are located in rather convenient places in the municipality and they can use them as their second house for access to the various social services. The problems with the resettlement centers are that they have a lack of livelihood and in particular no available farmland for farmers. Those who have settled permanently in the resettlement centers usually have a permanent job, other than farming, in and around the resettlement centers such as school teacher, heath worker, tricycle driver and so on.

The problem trees formulated by respective groups are shown in Figure 10.3.2. All the small groups raised the livelihood issues as the core problem. Major sub-problems are "No land title", "Lack of health & medicine", "Peace and order" and "Lack of various social infrastructures".

Since the resettlement centers are located in the downstream area of the Bucao River near the center of Botolan Township, the land had been fully developed as paddy fields and available un-used land is quite limited. Agricultural land development as a livelihood program for the resettlement centers is therefore difficult, except to utilize the huge area of lahar covered riverside or swampy lahar area along the river.

If the people are favorable to seek jobs other than farming, however, there will be more opportunities, though some skill training will be required.

(2) Workshop No.2 in the Middle Stream Area of the Bucao River

The target people in WS-2 were the ones who had permanently returned from the resettlement centers to their original locations in the middle stream area of the Bucao basin. There were 45 participants including 37 Aeta people. The original barangays that they returned to were Malomboy, Poonbato, Magisgis, Nacolcol, Palis, Burgos, Villiar, Moraza and Belbel in the Botolan municipality.

Even though the resettlement area is convenient for access to the various social services, they have closed their residences in the resettlement centers and permanently returned to their original barangay. According to the target people, the main reason to return is that no livelihood is available in the resettlement centers, which is the same reason given by the semi-permanent settlers in the resettlement centers. It is still not clear how they choose the different solutions, "Return to the original barangay" or "Dual bases in the resettlement center and the original barangays". It may be dependent on the values of the individual family.

Figure 10.3.3 shows the problem trees developed by the respective small groups. In this workshop the core problems were given by the study team because it was clear that "No Livelihood" is the most serious and core problem for all the affected families, from the results of the first workshop.

Based on the problem analysis, it seems that "Rehabilitation of community road from the Baquilan to upper Bucao", which existed before the eruption, may solve or mitigate most of the problems raised by the people. Improvement of access would make it possible to provide social services to the upstream communities and make it easier to transport material & equipment for construction of community infrastructures. The matter of "Peace and order" can also be mitigated by extension of the existing community road so that security patrols by police will be easier.

(3) Workshop No.3 for NGO Resettlement Centers in San Felipe

The target people in WS-3 were the resettlement people in NGO resettlement centers or temporary evacuation centers in Tektek, Bantay Carmen and Lalek in San Felipe. There were 40 participants including 33 Aeta people.

These areas have been identified as having the poorest conditions of social infrastructure such as water, electricity, school and so on. They were selected as the priority project of the three resettlement centers / temporary evacuation centers in the Tektek Area for improvement of community infrastructures. Many of the participants belong to the Aeta tribe, who had settled in the mountain area before the eruption.

The differences between GO and NGO resettlement centers are that GO resettlement centers are officially recognized as resettlement centers and the land ownership is under the government. The area is such that is possible to turn the land over to the resettlement people in the future as a permanent residential area. On the other hand, the status of NGO resettlement centers is not clear. There is no guarantee / agreement regarding the period of settlement, which makes them just like temporary settlement in the evacuation centers.

Figure 10.3.4 shows the problem trees developed by the small groups. Almost all the groups raised "No livelihood" as the core problem, and the cause of the problem is "No land", from which it was understood that most of the people depended on agriculture for their livelihood. In addition, "Lack of basic human needs" such as drinking water, electricity, health, education and so on, was identified as a problem.

Even though the existing resettlement area had quite poor conditions for social facilities, most of the people were rather negative to the prospect of relocating to the other areas. Instead, they hope to improve the existing resettlement site. The three areas, particularly Bantay Carmen and Lalek, are located along the national highway and it was rather better access to the township and job opportunities in the town, which might be the main reasons that they prefer to stay.

A problem solution matrix, which contains: Problem – Solution – Measures under people's initiative – Required support from outside, was developed by the small groups themselves. Their proposals showed a preference for self-reliance with minimum support from the Government or NGO. "Establish and strengthen the people's organization", and "Small credit system" rated highly interested in this area, which may be effective for solving / mitigating the existing problems.

(4) Workshop No.4 for the Mountain Area

The target people in WS-4 are the Aeta People living in the upstream mountain areas. There were 35 participants. All of them belonged to the Aeta Tribe from 19 Aeta communities (Sitio) in the mountain areas.

Figure 10.3.5 shows the problem trees developed by the small groups. Almost all the groups selected "No livelihood" as the core problem, even though some groups were provided with a difference theme for discussion by the study team. The causes of "No livelihood" were "Lack of funds", "No road" and

“Poor health conditions” according to the Aeta leaders (Chieftain) group.

In the group for discussion about disasters, “Fear” was selected as the core problem, which was based on the experiences that they have had of losing many family members or friends due to the eruption of Mount Pinatubo.

Other major issues they raised were “No land for farming” and “Lack of education”.

At the time of Problem-Solution discussion, it was found that their approach to solving the problems was basically a self-sufficient approach with less expectation of support by the Government or NGO. The following are examples of their proposed solutions to the problems:

Herbal Plantation: As a countermeasure to lack of medicine, Japanese NGOs introduced many kinds of herbal medicines for coughs, cooling, scratching, colds, diarrhoea and so on.

Volunteer Teachers for Aeta Education: To teach Aeta children the Aeta’s own tradition in addition to the standard education.

Bayanihan / Balicatan System: All the people in the community should participate in constructing the community roads and irrigation systems without payment, but some capital for food provision for the volunteers would be required.

It is noted that the Aeta leaders commented the fact that the proposed structural measures were only for low-land people and that there was no benefit for the Aeta Communities, and they proposed that another project such as an“ Integrated Development Plan for the Aeta Community” should be implemented. The study team is seriously considering their suggestion as a component of the CDPP formulation in the Project.

(5) Workshop No.5 for Middle Stream Area of the Sto. Tomas River

The target people in WS-5 were the affected people along the Sto.Tomas River in the middle stream area along the river and Mapanuepe Lake, including Barangay Laoag, Rabanes, Santa Fe, San Rafael, Aglao and Buhawen There were 40 participants and most of them were non-Aeta people (3 of the Aeta Tribe).

This area was damaged several times after the eruption, including being submerged under Lake Mapanuepe, the whole community being buried by lahar, a dike breach on the left side, significant riverbed aggradation of about 7 m, considerable seepage water through the existing dike, a break of the spillway of Dizon Mine Tailing Dam, and so on. As a result, the people are still seriously worried about further disasters, even after 12 years from the eruption.

During the open forum, four questions / comments were raised regarding the Master Plan Formulation in this study:

1) Stability of the existing Sto.Tomas dike on the left bank. People settled along the dike were very worried, particularly during the rainy season, due to significant observed seepage water from the dike.
2) The possibility of closure of the Mapanuepe Lake outlet (Dalanawan Channel). The outlet width was significantly decreased due to the flood in July 2002.
3) Collapse of the Dizon Mine Tailing Dam. The spillway completely collapsed during the last rainy season. Whether the whole dam body will collapse in coming rainy season or not.
4) The water quality in Mapanuepe Lake. There is a concern that the lake water is highly contaminated due to industrial pollution from copper mining. No fish can survive in the lake even though many Tilapia fry were released.

Figure 10.3.6 shows the problem trees developed by the small groups. The core problems discussed were again about “Lack of livelihood” as well as “Recovery of agricultural activities”. Also some other issues including “Lack of education”, “Health problems”, and “No preparation for calamity” were raised as major problems.

During the Problem-Solution discussion, various ideas were proposed. The following are the examples of the proposed solutions:

Tiger Grass Plantation as Livelihood Program: Tiger grass is the material for brooms, which is so far not produced in Zambales. Tiger grass is easy to plant along the river, and it continues to bloom for 10 years.

Barangay Drugstore: To meet the lack of medicine, the barangay will collect 20 Pesos from all the barangay families, and drugstore cooperation shall be established.

Shifting School: As there is no school building, individual houses will be utilized as a shifting school, one by one, and the educated people in the barangay will be the volunteer teachers in shifts.

Livestock Credit: Loans will be required for initial investment, and a return will be made with appropriate interest with a 10 years grace period by increasing heads of livestock instead of capital.

The most important aspect for the formulation of a community based project is how to assure the sustainability of the project. The first step to secure the sustainability is to strengthen the People’s Organization through development activities with a certain self-responsibility. From this viewpoint, the aggressive groups for development activities, such as the participants in this Workshop No.5, may have a high probability of realizing a sustainable community development project.

(6) Conclusions on PCM Workshops

“Lack of livelihood” was always discussed as the main problem in the series of PCM workshops. This is because there is no farm land for farmers and no other opportunities for income sources. Many farmers lost their farmland, which was buried by lahar together with their houses and properties in the original barangay.

Those who resettled in the resettlement centers developed by the MPC do, however, seem to be in a better condition although they are still suffering from lack of livelihood. The resettlement centers have generally facilitated the basic infrastructures such as elementary schools, water supply, health center/clinic, chapel, barangay halls and so on, some of which were not available in the original barangays. Livelihood development in the resettlement center would be the only problem remaining. On the other hand, there is a limitation to farm land availability, and some of the resettled people have semi-returned to their original barangays to seek their livelihood. To improve the productivity and accessibility to their original barangay would be rather supportive for the permanent /semi-permanent resettled people.

Strengthening of disaster management capability seems not to be immediately possible in the study area without livelihood development activities. It is better that the formation of people’s organizations through livelihood development should be focused on Community Based Disaster Prevention as the first step. Capacity building of the organization will be then realized for upgrading disaster management capability together with livelihood development through the people’s organization.

10.4 Resettlement

10.4.1 Present Conditions

The Government of the Philippines took action on resettlement activities, even before the eruption of Mount Pinatubo in 1991. The people residing along the western flank of Mount Pinatubo were targeted for the resettlement. The target areas had been severely affected by ash fall and pyroclastic flows and entire communities were fully varied. After that time, the lahar flow attacked the communities located in the lower stretch of the river, which were also changed the condition of communities. The majority of the affected people belonged to the Aeta tribe, one of the major groups of indigenous people in the Pinatubo Mountains.

Figure 10.4.1 shows the location of the resettlement centers in and around the study area. There are 10 resettlement centers for the people severely affected by the eruption of Mount Pinatubo. The features of the respective resettlement centers are summarized as follows:

Features of the Existing Resettlement Centers

Resettlement Center	Location	Area (ha)	Capacity (HH)	Resettled HH numbers	Features
Baquilan (MPC)	Botolan	317.6 ha	931 HH ($110m^2$/lot)	753 HH	
Taugtog (MPC)	Botolan	-	-	1,175 HH	
Loob-Bunga (MPC)	Botolan	328 ha	1,559 HH	1,420 HH	
Baraybay (MPC)	Castillejos	736 ha		1,870 HH	● Various livelihood programs are on-going
Cawag (MPC)	Subic	823 ha		430 HH	● 790ha of agricultural land of the residents, ● 410 persons out of 900 have job opportunities.
Dampai Salaza (MPC)	Palawig	308 ha	($200m^2$/lot)	267 HH	● 97ha of agricultural land was developed by CBFM ● Livelihood programs were conducted.
Ilam (MPC)	Olongapo	100 ha	(200m2/lot)	424 HH	● People's cooperative is functioning well. ● 70ha is used for agriculture land
Tektek (NGO)	San Felipe			50 HH	● Large scale of un-used land is located in adjacent area, ● Almost all people are Aeta.
Lalek (NGO)	San Felipe			50 HH	● Almost all people are Aeta.
Bantay Carmen (NGO)	San Felipe			50 HH	● Almost all people are Aeta.
TOTAL				6,489 HH	

There are more than 6,000 affected households in the 10 resettlement centers. Among them, seven resettlement centers were established by the Mount Pinatubo Commission (MPC) under the Office of the President. The resettlement centers established by the MPC are generally well facilitated with community infrastructure such as electricity, water supply (deep well), elementary schools, clinics, churches and community centers. The land was divided into approximately 110 m^2 to 200 m^2 lots per household. Even a large area for farming is provided in some of the resettlement centers for the livelihood of the residents.

Follow-up activities, to improve the living conditions in the resettlement centers, are also conducted by various agencies, particularly in the MPC resettlement centers. These include community forestry projects, small scale financing activities, livelihood development programs and community infrastructure development projects.

The following is the list of the existing or previous activities for improvement of the respective resettlement centers:

Previous or Existing Activities for Improvement of the Resettlement Centers

Resettlement Center	No	Project / Activity	Executing Agency
Baquilan	1	Medical service assistance program	DOH (funded by MPC)
	2	Provision of school supplies, books and furniture	MPC
	3	Various livelihood projects such as emergency employment and interest free financing for micro-enterprises	Various GO and NGO
	4	Low interest credit support to agricultural projects (P.1million for 35 HH)	GOP
	5	Micro-cottage enterprise development (P.1.6 million for 242 beneficiaries)	GOP
Taugtog	1	Health, education and other social services funded program	MPC
	2	Medical service assistance program	DOH
	3	School furnishing program	MPC
	4	Social worker provision (6-day care worker)	DSWD
	5	Various livelihood programs	NGOs
	6	Low interest rate credit assistance	GOP
Loob-bunga	1	Medical service assistant program	DOH
	2	School supplies, books and furniture	MPC
	3	Low interest credit support to agricultural projects and micro cottage enterprise development	MPC
	4	Emergency employment projects and interest free financing for micro-enterprise	MPC
Balaybay	1	Medical service assistance program	DOH
	2	Livelihood projects vary from palay production , duck raising, t-shirt production, bagoong making, re-lending and retailing	GOP
	3	Food and cash for work program	DSWD
	4	Livelihood activities included trading, agricultural-based, manufacturing and service oriented project (P.1 million)	Norfil (Norway NGO)
	5	Agro forestry, basic health and nutrition, day care services, technology training, community support infrastructures, water system and talipapa/mini market	MPC, Norfil
Cawag		Training as well as funding to the community organization	

Those activities mentioned above are just a part of the activities and there are many other activities initiated by the various GO/NGO agencies. The major previous activities are 1) livelihood development, 2) provision of medical services / small scale financing, and 3) community infrastructure such as deep wells. The MPC carried out various activities.

The reasons why the various NGOs and European donor countries participate in activities for improvement of resettlement centers are assumed to be that:

1) All the residents in the centers were the most severely damaged by the events of the eruption of Mount Pinatubo, and
2) The majority of the residents in the resettlement centers belong to the Aeta tribe, which originated from the Pinatubo Mountains, and they strongly desire to rehabilitate their traditional life style in the mountains.

In terms of poverty alleviation and support to indigenous people, it seems that various NGOs and donor countries provide support for the improvement of resettlement centers.

10.4.2 Improvement of Resettlement Centers

During the interviews with the people in the resettlement centers, the issues and development/improvement needs of the resettlement centers were discussed. The priority needs for development/improvements are shown in Table 10.4.1 and the top three priority needs are summarized as follows:

Top Three Priority Needs

Resettlement Center	Owner	Location	Priority Sector for Development / Improvement
Baquilan	MPC	Botolan	1) Livelihood
			2) Water Supply
			3) Sewage System
Taugtog	MPC	Botolan	1) Livelihood
			2) Garbage System
			3) Public Peace
Loob-Bunga	MPC	Botolan	1) Livelihood
			2) BHN Projects
			3) Public Health
Baraybay	MPC	Castillejos	1) Livelihood
			2) Water Supply
			3) Medical Facilities
Bantay Carmen	NGO	San Felipe	1) Elementary School
			2) Community Road
			3) Electricity Supply
Tektek	NGO	San Felipe	1) Elementary School
			2) Community Road
			3) Electricity Supply
Lalek	NGO	San Felipe	1) Water Supply
			2) Elementary School
			3) Community Road

Based on the results of interviews, the following were found:

1) A Livelihood Program is badly needed by the people in the resettlement centers, particularly those developed by the MPC.
2) Development for community infrastructures, such as elementary schools, community roads, electricity supply and water supply are desperately needed for the people in the resettlement centers developed by NGOs.

It was understood that the government generally takes into account the required community infrastructure for development of resettlement centers. However, the NGO resettlement centers are not always developed with the community infrastructure, which may be rather costly for development. Government support regarding infrastructure development will be essential for the NGO resettlement centers.

A question is raised regarding the previous livelihood development activities for the MPC resettlement centers. As mentioned in section 10.4.1, there were various activities in the MPC resettlement centers, which were not limited to community infrastructure development but also for livelihood development. In spite of this, it is still necessary to develop livelihood programs for the majority of residents. Detailed investigation will be needed to clarify the things required and an effective type of livelihood development program will be required including capacity building for the community.

Based on the needs above, the following basic concepts are proposed for the improvement plan of resettlement areas:

(1) Basic Concept-1

Among the MPC resettlement centers, which are located in Baquilan, it was observed that the previous livelihood development programs are not really effective, and the needs of the residents are still quite high for the implementation of such programs. Sufficient community infrastructures, such as an elementary school, electricity and water supply, medical facilities and a community road have been facilitated. In these areas, therefore, extensive livelihood development programs should be conducted. In the Balaybay resettlement center, the livelihood programs are on-going under a Norwegian NGO. In this area, the progress and effects of the project shall be monitored / studied.

(2) Basic Concept-2

Community infrastructure development projects for three NGO resettlement centers are urgently required as there is currently no electricity, no elementary school and no other basic facilities. The community infrastructure development, however, it is not a simple matter as the three resettlement centers are in scattered locations and are rather small scale at less than 100 households.

Accordingly, it is proposed that the three scattered resettlement centers shall be integrated into the Tektek Resettlement center, which is located along the coastal area. There is still a huge amount of un-used land surrounding the resettlement area, which can be used for livelihood development programs in the future, as well as for extension of the resettlement areas. The infrastructure development will be more realistic in terms of the number of beneficiaries with the integration of the three resettlement centers.

10.5 Proposed Overall Plan for Community Disaster Prevention

(1) Community Infrastructure Development at Tektek Resettlement Center

Based on the questionnaire survey of the existing resettlement centers, which was conducted in the master plan stage, the differences in the living conditions between the government established centers and NGO resettlement centers are obviously identified.

The main reasons for lack of community infrastructure is that the scale of NGOs resettlement centers is much smaller than the ones established by the government. In the three government resettlement centers in Botolan municipality, which are Baquilan, Loob-Bunga and Taugtog, the number of families is more than 1,000, while the number of families in the NGO resettlement centers is less than 100 each. The investment for community facilities for such a small number of communities is rather difficult from the viewpoint of the effective usage of the public budget. The idea of integration is therefore proposed to encourage development of community infrastructures those for the residents in the NGOs resettlement centers.

(2) Extension of On-going Community Based Forest Management (CBFM)

The nation-wide CBFM program is currently on-going as an effective measure for forest management under the concept of "People first and sustainable forestry will follow". The Government believes that, by addressing the needs of local communities, they will join hands to protect and manage the very source of their livelihood.

The CBFM program is, therefore, not a simple forestry program but integrated with the livelihood development program for the upland communities. Since livelihood development is identified as the most urgent and essential for sustainable community based disaster management activities, the extension of the CBFM program to the severely affected communities in the mountain was selected as the priority project in the master plan.

In the province of Zambales, there are 31 existing CBFM projects, 12 of them located within the study area covering the municipalities of San Felipe, Botolan and San Marcelino. In addition to the 12 projects, there are 16 CBFM projects in the study area waiting for approval by DENR. Table 10.5.1 lists the registered / un-registered People's Organization (POs) for the CBFM.

The present status and activities of the CBFM program, monitored by CENRO under DENR, are summarized in Table 10.5.2.

For the feasibility study, it is essential to assess the financial aspects for individual POs rather than the economic viability of the forest management as a whole, because the CBFM concept is to develop the livelihood of the upland community through forest management.

(3) Pilot Project for Agriculture Development on the Lahar Area

Based on the results of the interview survey and PCM workshops, the overall plan for the CDPP was assessed along with the concept mentioned in the former section 10.2. The agriculture development on the lahar area is identified as the highest need from the people severely affected by the previous lahar event.

Many of the residents lost both their farm land and income source after the eruption of Mount Pinatubo, as the majority of the affected people depended on agriculture for their income. The majority of the previous farm land is still fully covered by lahar deposits and the agricultural activities have not yet recovered. Considering this, agriculture development on the lahar area is recommended as the livelihood program for the affected people.

Figures 10.5.1 and 10.5.2 show the present condition and future image of the lahar covered river side areas along the Bucao and the Sto.Tomas Rivers.

(4) Community Development in Mapanuepe Lake Basin

It was found that the Mapanuepe Lake contributes greatly to mitigating floods downstream owing to the flood regulation effects of the lake. The lake basin has a drainage area of approximately 90 km^2 (34% of the Sto. Tomas River basin). Hydrological analysis revealed that the peak flood discharge at the downstream stretch was reduced by 40% by the regulating effect of Mapanuepe Lake.

In the initial stage of the study, the possibility of the flood regulation effect of the Marella River diverting the flood to the Mapanepe Lake was considered. However, it was not finally adopted in the master plan for the following reason:

The reservoir capacity of the Mapanuepe Lake is estimated at 30 million m^3. On the other hand, the sediment yield in 2002 from the Marella basin was 16 million m^3. The lake capacity is too small to contain further sediment delivery from the Marella River.

In addition to the above flood control functions, plenty of development functions are expected for the Mapanuepe Lake area as follows:

1) To utilize it as the water source of irrigation development for the downstream left side area of 1,900 ha.
2) To develop it as a tourist resort area, which was nominated by the Provincial Government.
3) To develop it for fish-culture farming utilizing a part of the lake area.
4) To develop lahar agriculture land on the lahar fan area at the confluence of the Mapanuepe and Marella Rivers.

The proposed development plan is shown in Figure 10.5.3. For irrigation development, the National Irrigation Administration (NIA) conducted a feasibility study in 1996 and it was concluded that the proposed irrigation development is feasible from economic and technical viewpoints.

Zambales was defined as the tourism center of Region III under the regional development master plan of Region III by NEDA/JICA, as proposed in 1996. Along this line, tourism development at the Mapanuepe Lake is acceptable based on the regional development strategy. The tourism spots along the lake were selected based on the topographic conditions and accessibility from the existing road.

Lahar agricultural and aqua-cultural development is proposed to improve the livelihood development for the local people. Four communities were completely submerged by the formation of the lake. The local people completely lost their residences and farm land. In addition, job opportunities in the area were drastically reduced due to the closing of the mining activities. Taking into account the above adverse effects on the communities, livelihood development in the Mapanuepe Lake area is an important aspect in the regional economic recovery.

In the course of the study, water quality testing at the proposed irrigation intake site was conducted and it was found that the quality was within the acceptable range for irrigation use. However, the water quality of the inflow from the copper mine area to the lake is in question. To promote various developments in the Mapanuepe lake basin it is therefore essential to conduct a detailed analysis of water quality in phase 2 of the study.

Regarding the issue of the safety of the dam against failure, DENR commented that countermeasures should be taken by the owner of the dam.

(5) Community Road Rehabilitation

Community road rehabilitation was additionally identified as a priority project under the CDPP. For example, the upstream area of the Bucao and Sto. Tomas River basins is still not accessible by vehicles even 12 years after the eruption. The social services to be provided by the provincial / municipal government therefore has not reached the area for those 12 years. In fact, most of the problems raised in workshop No.2 could be mitigated if the buried community road from the market to the area was rehabilitated.

(6) Establishment of Aeta Assistance Station

This is also newly identified during the feasibility stage of the study. Throughout the additional investigation for the CDPP, it was found that Aeta people are the most affected people due to the series of disasters related to the eruption of Mount Pinatubo, and they are still suffering from the after-effects. In fact, the damage to Aeta communities was not limited to their livelihood sources, but also affected their tradition and culture as they have lost everything as they were forced to leave Mount Pinatubo due to the eruption.

This was also raised in workshop No.4 by the leaders of the Aeta Communities, and they proposed to mobilize an " Integrated Development Plan for the Aeta Community" in addition to the proposed flood and mudflow control plan for the recovery of the upstream mountain area.

Another background to the proposal for the establishment of the AETAS program is that there might be some discrimination in the mind of the lowland people towards the Aeta communities. This was observed in various aspects throughout the study, particularly on the issue of the title of land under the CBFM as well as the allotment of the resettlement areas.

A discussion with the Aeta Development Association (ADA), one of the reputable NGOs in the Philippines for supporting the Aeta community, was conducted in the course of the study. During the discussion, it was identified that ADA is considering a strategic program for Aeta people which included the declaration of Mount Pinatubo as an Aeta Cultural Heritage, just like the Rice Terraces in Ifugao were declared as one of the World Heritages. This aims to spark Aeta culture and tradition, strengthen their cultural pride and promote national identity while promoting stronger relationships with other cultures.

As a result, establishment of an Aeta Assistance Station, called AETAS, is strongly recommended with the multiple functions as listed below:

1) To establish an Aeta Museum for dissemination of their Culture and Tradition to the public: The most important thing is to strengthen the communication between the Aeta community and the lowland people for mutual understanding. In this regard, an Aeta museum should be established in AETAS for public dissemination of Aeta culture and tradition, which can be also recognized as a new tourism spot in Zambales to be identified as the base station for access to Aeta heritage. The income of the museum should be allocated for the sustainable operation of AETAS.
2) To establish small-scale financing facilities for NGO activities: Various NGOs, including the Japanese NGOs, such as ACTION and IKGS, are supporting the Aeta community, mainly for their livelihood development. Also there would be plenty of people in the world that would be willing to assist Aeta people through financial support. AETAS is expected to be the hub of the NGOs network related to support activities for Aeta communities. Strong linkage between NGOs as well as the individual people would be useful for all the volunteers supporting the Aeta communities. AETAS is expected to be the information station for the related NGOs and the financial sources for the various activities with a certain appropriate interest for sustainable operation of financing functions for NGOs as well as the Aeta Community Organization.
3) To provide technical support for Agriculture and Agro-Forestry for the Aeta Community: AETAS is expected to be the hub of technical information to link between Aeta communities and Government Agencies, particularly the Department of Agriculture, Department of Environment and Natural Resources, and Department of Agrarian Reform. AETAS should have the function of arranging the communication based on a request from the Aeta Community to provide the necessary technical information and support by the government agencies. Periodical seminars targeting the Aeta farmers are expected to introduce effective agriculture and agro-forestry technologies.
4) To assist the claim for an ancestral domain: AETAS is also expected to assist the process for the survey, documentation and titling of the ancestral domain claims by the Aeta communities. This is essentially required to preserve the Mount Pinatubo Area as Aeta heritage in the long term.

5) To perform an Aeta Culture Show: For dissemination and study of the Aeta tradition, periodical Aeta culture shows might be performed under the coordination of AETAS, which can provide great resources of income generation for Aeta communities from tourism. The traditional festivals, dances, and singing would be performed at the Aeta museum in AETAS. Volunteer Aeta people would be recruited for actors/actresses and the show program would be formulated by AETAS together with the Aeta people. A souvenir corner would be prepared to sell the hand-made goods prepared by Aeta women, as well as various kinds of memorial things for the tourists, which would also be expected to provide major income sources for sustainable operation of AETAS.
6) To facilitate an eco-tourism tour desk: For those who are interested in experiencing the traditional life of the Aeta community, an eco-tourism program should be provided. The base camp would be AETAS, from which a mountain tour by Carabao Carts would be arranged for tourists. The various species of wild-life, such as wild-pig and goat, would be tasted in the lahar area. The natural hot-springs and dammed-up lakes can be visited through Carabao tours. Volunteer Aeta people could work as tour guides, which would be an attractive income source for the Aeta people.

CHAPTER 11 ENVIRONMENTAL IMPACT ASSESSMENT OF MASTER PLAN

11.1 IEE Methodology

11.1.1 Methodology

The Initial Environmental Examination (IEE) was prepared under the guidelines of the Procedural Manual of DENR Administrative Order No. 37, Series of 1996. The IEE covered the physio-chemical, biological and socio-economic environmental conditions. Consultations were held with the stakeholders of the facility through the barangay and municipal officials. The preparation of the IEE covers the following aspects:

- conducting consultations with LGUs and other stakeholders concerned,
- information/data collection,
- description of potential environmental effects/impacts, and
- the formulation of an environmental management plan.

The environment within the perceived impact area was investigated by a team of specialists, who assessed the existing baseline physical, biological and social conditions at the site through a field data collection program.

Primary data was gathered during the field survey in which air, water and soil samples were obtained for laboratory analysis. Secondary data was collected from the municipal records and used as background demographic information on the socio-economics of the following towns: Botolan, Cabangan, Castillejos, Iba, Maloma, San Felipe, San Narciso, and San Marcelino.

A household interview survey was also conducted, to obtain the community perception and awareness of the project. The specific methodology for each component is discussed in its particular section.

After establishment of the baseline environmental conditions, the study of the potential impacts on the baseline environmental conditions will be made. For identified potential impacts, mitigation measures will be determined and will be reflected in the countermeasure structures and/or activities concerned. The mitigation measures will include those to avoid/minimize resettlement and land acquisition. Based on the potential impacts and mitigation measures, an environmental management plan (including environmental monitoring plan) will be developed.

11.1.2 Data Sources

The primary project information was obtained through field surveys, including interviews with local people concerned. The national agencies from which the secondary data was collected include the Bureau of Soils and Water Management (BSWM), PAGASA, PHIVOLCS, National Water Resources Board (NWRB) and the National Statistics Office (NSO). At the local level, the Municipal Planning and Development offices and Municipal Health and Agriculture offices of the respective affected towns provided the data.

The matrix of primary and secondary data is presented in Table 11.1.1.

11.2 Future Environmental Conditions without the Project

11.2.1 Physical Environment

The existing conditions may be aptly described as that of a "decaying" state due to the destructive effects of the eruption of Mount Pinatubo. The lahar problem with the perennial catastrophic effects such as flooding and erosion/siltation will continue to be a part of the daily lives of the surrounding communities. There is no foreseeable improvement if the proposed project is not implemented immediately. Further destruction of the existing environment and the residential properties within the western river basins will be mitigated by the implementation.

11.2.2 Biological Environment

Massive biological (plants and animals) losses and disturbances, brought about by the eruption of Mount Pinatubo, have slowed down the capacity of the entire landscape to recover and regain its incessant primary and secondary production mechanisms. The migration of affected animals, particularly birds, to the nearby mountain ranges, consummated at the time of the eruption. Similarly, plants with open and exposed stomata may have died in the process or simply degenerated to conserve their precious food (carbohydrate) in their biomass for future growth.

After a decade of continuous healing, plants and animals are recovering to reach the climax condition again, which may not be feasible in the very near future, as fans and lahar are still occurring. Without the project, the threat of pyroclastic materials still remains. But based on the prevailing situation in the field, the population of fauna and flora is visibly in order. The apparent presence of Binayuyo (*Antidesma ghaesembi*) at the lower portion of Mount Pinatubo, facing the South China Sea, indicates that it has gradually developed from pure grassland/range-land to its current savanna plant community stage. However, based on the satellite images of 1990, 1992 and 2001, it is expected that recovery of the forest will take a relatively long time, while deforestation activities must be controlled. The dominance of cover crops along the periphery of the stream and river banks shows the active transformation of marginal substrates into a fertile state. It can accommodate more biological materials (plant and soil animals) per unit area.

11.2.3 Socio-Economic Environmental Conditions

Economic woes will be compounded with the continuous destruction brought about by the lahar causing further deterioration of the river/drainage systems in the affected areas. Social problems will increase indefinitely, due to the inherent instability of the situation which may even cause exponential growth of various problems, such as the deteriorating health conditions of the residents and the dwindling supply of food, especially in the evacuation centers. Income generating opportunities will continue to decrease.

11.3 Potential Environmental Impacts and Mitigation

11.3.1 Impact Zone and Summary of Potential Environmental Impacts

The primary impact zone consists of the entire project areas within the three western river basins of Mount Pinatubo. The rest of the surrounding communities would be indirectly affected (secondary impact zone). However, the socio-economic impacts, in terms of employment generation, increase in tax payments and improvement in basic services, will spill over into the other towns and neighboring municipalities. Table 11.3.1 shows a summary of the potential environmental impacts identified.

11.3.2 Physical Environment

(1) Geology, Topography and Soils

Increase in soil erosion risk: With the grading and scraping procedures to be carried out, the area will be highly vulnerable to both wind and water-driven soil erosion.

Loss of some topsoil: The topsoil is considered as the most fertile portion of the soil. Since the topsoil in the green areas will be replaced, the scraped soil should be transferred to the open space and other areas where special soil composition is not required.

Disposal of lahar/ashfall material: Generally, the area was covered with a few to several meters of these materials. During the construction period, these materials will have to be removed or be mixed with the natural soil in the area. These materials should be used as filler in non-sensitive areas. This will not only put these materials into use but also eliminate the problem of finding a suitable disposal site for them.

It is assumed that soil loss will be reduced in comparison with the initial vegetative stand of the area because the ground will be fully covered unlike in the previous situation where there were bare soils under the tree canopies. It is also expected that the kinetic energy (eroding capacity) of water will be reduced due to the retardation of flow as it passes through the grass areas. In the end, more water could be retained and could infiltrate through the soil due to this retardation of flow and from the retention cavities provided by the grass and its leaves. In other words, the soil will become more stable and the infiltration capacity will increase due to the longer retention time of water above the soil surface.

(2) Air Quality

Air quality deterioration: Trucks carrying construction materials are expected to lead to deterioration of the existing access roads. They will also cause dusty conditions along the roadways. In addition, emission from these vehicles is expected to slightly increase the NO_2 and SO_2 concentration in the vicinity.

No significant air pollution is expected during the construction phase. The emission from the vehicles to and from the area, and other fuel-burning equipment will be negligible and will not elevate the total suspended particles (TSP), NO_2 and SO_2 concentration in the air. Since there are no major air pollution sources in the area, the carrying capacity of the site with respect to air pollution is still high.

(3) Water Quality

During construction, the quality of the surface/river water will be negatively affected by the disposal of domestic wastes from the construction camps and/or various solid wastes from the construction if no appropriate mitigating measures are taken. The turbidity of the river water will be increased due to the same causes, which will degrade the water quality and cause harm to the young river fish. Increased turbidity of the coastal marine waters will also negatively affect the various young fish. Local fisheries will then be affected with a decrease in the catch volumes. Therefore, measures to mitigate the negative impacts on water quality will be indispensable.

(4) Noise

There will be no significant impacts on the noise environment, because of the absence of noise-sensitive receptors within the vicinity of the project sites. However, construction workers will have to be protected from the high levels of noise that will be generated by the construction machinery.

11.3.3 Biological Environment

(1) Terrestrial Flora and Fauna

Vegetation may be affected by the exposure to air pollution which may alter the structural and functional integrity of the terrestrial habitats around the project sites. However, most of the structures to be installed are basically on desolate areas. Therefore, any impact on surrounding vegetation will be minimal.

Unlike plants, animals are able to flee from environmental stress. They will readily move to other similar habitats to avoid such stress. Further to this, there are no endangered animal species known to inhabit these affected areas.

(2) Aquatic Flora and Fauna

The operation of the sabo and flood control facilities is not expected to pose a threat to fish communities. One positive impact that may occur is an increase in the diversity of fish around these structures after construction.

(3) Contamination issue of Marine Fishes

Contamination analysis of marine fishes collected was made, and a copper content of the Sto. Tomas River mouth fish was detected (0.25 ppm). However, there is not any limit value defined for copper by the Philippines nor USEPA. It is expected that there will be no contamination effect raised by the project implementation.

11.3.4 Socio-Economic Environment

From the consultations and interview surveys conducted on the concerned barangays in the eight municipalities, the sabo and flood control project received a positive response. The project is intended to secure the safety of communities in the proximity of the Bucao, Maloma and Sto. Tomas Rivers, and establish the basis of smooth economic growth in the areas concerned. However, the installation of such structures will require a certain amount of land utilization and/or the resettlement of people who may be affected. The following provides some insight into the potential issues.

(1) Agricultural / Industrial Activities and Employment Issue

With respect to employment and the source of income, temporary employment during the construction phase of the project is possible. A more acceptable scenario will occur, however, if well-planned and workable livelihood projects are incorporated in the Social, Institutional, and Resettlement Development Plan component of the overall project. In the institutional framework for the community-based livelihood program, for example, community-based forest management and community-based coastal resource management can be considered in the succeeding activities.

There will be an increase in population brought about by employment of the workforce required for the construction and building activities. Employment opportunities will increase for both directly and indirectly affected areas, depending on the skills and expertise required. This situation will lead to some degree of change in the socio-cultural atmosphere of the area due to the influx of temporary migrants of diverse origin, values, and behavior. At this stage, there will be an increase in income, flow of cash, and generation of livelihood opportunities. Income will be derived from the wages of the workers and the proceeds from the buyout of the affected lots. This temporary flow of cash will spell an increase in the purchasing power and economic position of the people.

An increase in the number of vehicles and heavy equipment machinery for the construction activities, and the movement of people in the building activities, will potentially affect traffic flow.

(2) Land Use

In securing and protecting the land of the residents living along the three rivers where the installation of the sabo and flood control facilities will take place, agricultural and various production activities in the area will be activated. Therefore, the socio-economic conditions in the western river basins of Mount Pinatubo will be improved as a whole. These are positive impacts that will be brought about by the project.

Through the review of, and discussions on, the proposed framework of the sabo and flood control measures in the project, a preliminary conclusion of the land use issues is as follows:

(i) For the Bucao River, the planned construction works including, two sabo dams in the upstream reaches, one consolidation dam, two lateral dikes, and one separation dike, will all be installed in deep valleys or in the desolated river bed full of lahar deposits. It is not expected to utilize any residential areas or sustainable farming land. Therefore, no resettlement or land acquisition will be incurred through the installation of the structures. However, the planned strengthening of the existing dike (6 km long) may require an additional 50 meters (approximately) outside of the existing dike to widen the dike cross section to enhance its stability and soundness. This may require land acquisition along the dike. Details of this issue will be identified and clarified under the feasibility study in the next phase.
(ii) For the Maloma River, only river channel excavation and revetments are being considered. Such activities will not result in any land acquisition or resettlement.
(iii) For the Sto. Tomas River, there will be a series of checkdams and one sabo dam in the deep upstream valley. These facilities will not result in any land acquisition or resettlement. On the other hand, heightening and strengthening of the existing dike along the river (up to a location near the outlet of Lake Mapanuepe) is planned. These works may require additional land acquisition and/or resettlement along the dike. Details of this issue will also be studied under the feasibility study in the next phase.
(iv) In the case of the bridge and road construction plan, there are two new road systems, for transportation between the rural barangays, being considered. This may incur some land use issues. The details of its potential impact will be studied when the priority routes are decided under the feasibility study.

(3) Public Health

There will be increased solid waste from the domestic refuse of workers and accumulated debris from the construction and building activities. The improper management of this waste may pose a danger to the health and safety of the workers themselves and the people living near and/or passing through the construction sites.

11.3.5 Resettlement

A preliminary review of the resettlement issues has been described in the land use section above. The structural facilities/installations in the master plan will have minimal impact on houses or households near the proposed locations of the structural facilities/installations. A further detailed survey, based on the final proposals for the structural facilities/installations, will be carried out under the feasibility study phase. It should be noted that the resettlement plan prepared for this phase must be restudied and revised at the time of detailed design phase to reflect the actual situations for implementation of the project.

11.4 Environmental Management Plan

11.4.1 Brief Descriptions of the Potential Environmental Impacts and their Mitigation/ Enhancement Measures

(1) Topography and Soil

Stabilization of the slopes within the project area is an important issue to be considered before the construction of the various measures.

Soil erosion has been identified as having a negative impact and should be minimized during construction. When massive earth movement activities cannot be avoided, especially during the construction of access roads where vertical cuts are done, retaining walls or rip-rap will be necessary to control localized landslides.

The development should follow the contour to ensure the minimum volume of cut and fill. To minimize spoils, a well planned cut and fill operation should be implemented. In addition, the use of cut volume as the filling material should be maximized.

If possible, the scraped lahar/ashfall should be used as a filling material to minimize the volume of disposal required of the waste generated from construction.

(2) Air Quality and Noise

Air Quality Issue

The impact of the project on air quality will be temporary, occurring mostly during the construction stage. Dust particles and exhausts from the construction equipment may be expected. Upon the completion of the project when the land surface is covered, the air quality will improve and return to the original level.

To minimize air pollution during the construction stage, the following measures must be undertaken:

- (i) Daily watering of exposed areas especially during the dry season.
- (ii) Maintenance of vehicles and equipment.
- (iii) Proper planned construction activities to limit the extent of impacts and to minimize the exposed areas at any given time.

Noise Issue

Transportation of massive amounts of material by construction vehicles and various other construction works will generate noise to the nearby surroundings and therefore an enclosure to the project area should be used. Regular maintenance of equipment and machinery has to be carried out to minimize noise generation. For particular activities, in which workers will be exposed to significant noise levels, they should be provided with appropriate personal protective equipment such as ear plugs.

(3) Biological Impacts

No significant biological impacts are perceived based on the given project information and due to the limited existence of life forms (currently consisting mainly of common and resident organisms).

There are three environmentally protected areas in Zambales Province. However, all of them are located at least 30 km away from the Study Area boundary. There are no protected or threatened wildlife habitats along the three river banks based on the preliminary field survey and interviews with rural residents. Therefore, the biological impacts of the project will be negligible.

(4) Socio-Economic and Cultural Impacts

Based on the development plan in connection with the construction of structures, it is foreseen that the socio-economic and cultural impacts will be very limited. However, further study of the areas will be conducted under the feasibility study to identify if there will be any households affected by the structures.

Through the intensive field visits and interview surveys, it was noted that socio-economic issues in the existing resettlement sites are quite significant. It is recommended that social development should be carried out to improve the living environment and livelihood of residents in the resettlement centers.

11.4.2 Summary Matrix of Proposed Mitigation and Enhancement Measures, Estimated Costs and Responsibilities

Table 11.4.1 shows a summary matrix of the Environment Management Plan for the project.

11.4.3 Summary Matrix of Proposed Environmental Monitoring Plan

The Environmental Monitoring Plan, being considered as a part of the Environmental Management Plan, has been summarized in a separate table to show its details. Table 11.4.2 shows a summary matrix of the Environmental Monitoring Plan for the project.

CHAPTER 12 ECONOMIC EVALUATION OF MASTER PLAN

12.1 Criteria, Assumptions and Methodology

12.1.1 Definition of Project Benefits

The benefits to be obtained from implementation of the project are defined as the reduction in direct and indirect damage resulting from flood and mudflow. The probable direct damage has been estimated based on the conditions without the project in place, as at the end of 2001. Indirect damage is assumed to be 100% of the direct damage, which generally ranged from 40% to 200% of the direct benefit, for the economic evaluation of the master plan study.

The damage expected to occur when the project is in place is assumed to be zero under a design flood with a return period of less than 20 years. Therefore, the project benefits are equivalent to the probable damage that will be caused by flood and mudflow of less than a 20-year return period.

12.1.2 Methodology for Estimating Flood Damage

(1) Estimate of Direct Damage

The probable inundation areas were specified for the three river basins from a hydrological simulation study for return periods of 2, 5, 10, 20, 50 and 100 years.

Damage curves were generated for the major types of property such as residential buildings, non-residential buildings, fields for paddy, and infrastructure including roads and bridges. Damage curves were also generated for the hazards, including flooding, sediment and lahar, indicating the depth of each hazard. The damage curves established in the JICA East Pinatubo River Basin Study[1] undertaken in 1996 were referred to in generating these curves. Figure 12.1.1 shows the damage curves developed in the JICA East Pinatubo Study.

Of the three damage curves, for flooding, sediment and lahar, the damage curve for lahar was applied for the evaluation based on the actual observations of damage at the damage prone areas in the Bucao and Sto. Tomas Rivers.

Figure 12.1.2 shows photographs of the flooding area due to the breach of the left dike in the downstream portion of the Sto. Tomas River, which occurred on 23 July 2002. Since the entire stretch of the riverbed is much higher in elevation than the land protected by the dike, after the breach of the dike a considerable amount of lahar deposit in the river area was spread over the prone area through flooding. After the flood had receded from the prone area, lahar more than 1 m thick remained over the entire flooded area. All the houses required re-constructed and the damaged farm lands and fishponds can no longer be used without excavation.

The probable inundation areas and damage curves were then combined and overlaid on to the Barangay database to generate percentage damage figures for each barangay for each property type and were aggregated by municipality.

The unit value of each type of damageable property was either derived from information obtained during the study or taken from the above East Pinatubo River Basin Study and then adjusted by the

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[1] The Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River Draining from Mt. Pinatubo 1996, funded by JICA.

actual or projected changes in market prices. The choice was made by assessing the relative reliability of the two sets of data.

The method of identifying and estimating damageable unit values is explained in detail in the following paragraphs.

1) Buildings

For the master plan, individual building types could not be identified from the inundation study. Therefore, the distribution of building types and values were built into the unit value to be applied. The inundation of one building was assumed to be the partial inundation of residential buildings and the identified types of non-residential buildings.

Currently, the distribution of residential and non-residential buildings in building numbers with average unit value (or average floor area from which average unit value can be calculated) is unknown. For the feasibility study, it is planned to produce a detailed map of all building types in the potential inundation area from which an accurate distribution of different building types can be obtained. Until then, some broad and approximate assumptions have been made.

First, it is assumed that the number of residential buildings in the seven municipalities where inundation may occur[2] equals the number of households of 42,661[3]. Second, it is assumed that the number of public building is equal to 1% of the residential buildings equals 427, or approximately 430 buildings. Third, it is assumed that the number of commercial, industrial and other non-residential buildings is calculated to be 1,363. This is made up of totals for the seven municipalities[4] as follows:

- Up to 1983, establishments for:
  - Trading = 772,
  - Services = 244,
  - Financing, insurance, real estate and business service = 46 (estimated from partial data),
  - Electricity, gas and water services = 4,
- Up to 1993, establishments for:
  - Manufacturing = 196,
- From about 1980 to 1995, additional establishments in:
  - Industry and services sectors = 63

The total for the above sectors up to the mid-1990s equals 1,325. Growth since the mid-1990s is assumed to be equal to the annual growth of 0.4% from 1980 to 1995, which gives a 2002 total of 1,363 establishments. Unfortunately, this total does not take into account those establishments not registered with the Department of Trade and Industry (DTI) which may be a significant, but unavoidable, omission.

From this preliminary assessment, we can conclude that in the seven municipalities:

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[2] Botolan, Cabangan, Castillejos, San Antonio, San Felipe, San Marcelino, San Narciso.

[3] From the 2000 Census of Population and Households.

[4] Data from DTI, Zambales Provincial Office, Iba. Information extracted from IEE Report for Sabo and Flood Control Project in Major Three Western River Basins of Mt. Pinatubo prepared by JBJ Consulting Inc. dated 31 July 2002. The JBJ survey was conducted on 8 municipalities, the 7 considered here plus Iba, the provincial capital.

- The total number of buildings = 44,454 of which
  - 42,661 are residential buildings (96.0% of total)
  - 430 are public buildings, and (1.0% of total)
  - 1,363 are industrial, commercial or services buildings (3.0% of total).

The next step is to obtain unit values for these three categories of buildings.

(a) Initial Attempt to Value all Buildings

From the Provincial Assessor's Office, two years of all new building assessments for all eight municipalities were obtained; these are said to be mainly residential and include some improvements. The results are given in Table 12.1.1.

Compared with the value computations for residential property (see (b) below), these values seem low. This may be due to lower value improvements and few larger buildings over the 2-year period.

Other relevant information supplied by the Provincial Assessor included:

- Market values are approximately 40% above the assessed values for residential and commercial buildings;
- No depreciation is applied to new buildings (e.g. the above assessments). However, for older buildings the average depreciation would be in the range of 32% to 40%;
- Commercial land has the highest premium over assessed value: e.g. up to P800/m^2 assessed value could be as high as P3,000 to P4,000/m^2;
- Schools are not assessed as they are tax exempt
- The lists of assessed values are increased by around 40% every 3 to 5 years (should be every 3 years).

(b) Residential Buildings

From the household (HH) survey of types of housing and house areas[5], and the Provincial Assessor's assessed values for various types of property based on values per square meter (see Table 12.1.2), the following has been produced:

i) A weighted assessed unit value per dwelling of P4,805/m^2 (see Table 12.1.3 for derivation);
ii) Average floor area (as reported by survey respondents) = 56.9m^2 (see Table 12.1.4 for derivation);
iii) Therefore, the assessed value of an average residential property = P4,805*56.9 = P273,405;
iv) Therefore, the average residential property market value = P273,405*1.4 = P382,767;
v) If iii) is depreciated at an average rate of 36%[6], the depreciated value = P273,405*.64 = P174,979;
vi) If iv) is depreciated at an average rate of 36%, the depreciated value = P382,767*.64 = P244,971 (applied for unit value)

This average assessed figure of P273,405 is far greater than most of the Total Assessed Value (TAV)/building figures in the Table 12.1.1 which are said to include some commercial

[5] Information extracted from IEE Report for Sabo and Flood Control Project in Major Three Western River Basins of Mt. Pinatubo prepared by JBJ Consulting Inc. dated 31 July 2002. The JBJ survey was conducted on 8 municipalities, the 7 considered here plus Iba, the provincial capital.

[6] From Provincial Assessor's Office

properties. The TAV/building figures were therefore ignored in the development of the unit value information.

The East Pinatubo Study[7] gave a 50% depreciated value of P51,000 equivalent to a gross value of P102,000 in 1995. If this is increased by the estimated rate of inflation since 1995 (approximately 53% in Region 3) the gross value becomes P156,060.

(c) Non-residential Buildings

The unit value for a non-residential building depends on the average floor area, the unit value/m^2 and the application of a mark-up (estimated to be approximately 40%) to reach the market value. To date, separate floor areas for public and other non-residential buildings could not be obtained. For buildings of classes (8) to (17) of average type IIA (see Table 12.1.2), which is close to the residential average determined by survey, the average assessed value would be P3,774/m^2. This was increased by 40% to a market value of P5,284/m^2. Applying this figure to an estimated average floor area of 200m^2 gave a unit value of P1,056,800 for all non-residential property. This figure is just under three times the unit value of P382,767 of a residential property.

The applied value for economic evaluation is therefore P676,352/building taking into account the depreciation of 36%.

(P1056,800 x (1-0.36)=P.676,352).

In the East Pinatubo Study, a non-residential building was valued at P265,000 after 50% depreciation which equals P530,000 before depreciation in 1995. Current value would therefore be approximately 530,000*1.53 = P810,900. This value is approximately 5 times the East Pinatubo gross residential value of P156,060 in (b) above.

(d) Household effects

From the HH survey of household appliances ownership, and the study estimate of new prices (see Table 12.1.5), the un-depreciated value was found to be P40,652/household.

The East Pinatubo Study valued household effects in 1995 at P14,000/building after 50% depreciation which equals P28,000 gross. Therefore the estimated present gross value would be 1.53*28,000 = P42,840.

(e) Inventory and equipment for non-residential buildings

No information was obtained through this study.

The East Pinatubo Study valued in 1995, after 50% depreciation, inventory and equipment for non-residential buildings at P143,000/building. If grossed up and increased for inflation, the resultant value would be P437,580/building.

2) Agricultural Crops and Livestock

Unit prices applied were based on farm prices in the Zambales Province. These were compared with values from the East Pinatubo Study after adjustment to allow for the interval between the date of that study and the present one. Livestock damage was estimated by applying an average livestock value per household to damaged buildings.

[7] The Study on Flood and Mudflow Control for Sacobia-Bamban/Abacan River Draining from Mt. Pinatubo – funded by JICA and undertaken by Nippon Koei Co., Ltd. in association with CTI Engineering Co., Ltd.

(a) Paddy Rice

The average farm price for paddy rice from January to June 2002 was calculated by the study team to be P9.78 Pesos/kg[8]. The average yield of paddy rice per hectare in Region 3 for 2000 was 3.56 tons/ha[9]. From these figures, the average farm price per hectare for damageable paddy crop was assumed to be 9.78*1,000*3.56 which equals P34,817/ha.

The East Pinatubo Study gave a value per hectare in 1995 of P12,650 which, after increasing by an estimated 15% increase in paddy prices since 1995, increases to P14,548/ha. The reason for the large difference in the two estimated prices is not known.

(b) Livestock

From the JBJ HH survey of 274 households[10], no data specific to types of livestock could be derived. However, an inspection revealed the following approximate valuation of livestock for responding households based on owner information. It was assumed that non-respondents have no livestock:

Approximate Valuation of Livestock

Municipality	Value per HH owning livestock (1,000 pesos)	Percentage of HH owning livestock (plus total HH in sample)	Average value of livestock per HH (1,000 pesos)
Botolan	8	63	5.0
Cabangan	35	85	29.8
Castillejos	30	88	26.4
San Antonio	15	70	10.5
San Felipe	20	35	7.0
San Marcelino	20	70	14.0
San Narciso	15	75	11.3
TOTAL		(274)	14.6

From this table, the average value of livestock for every household would be P14,600 per household.

3) Infrastructure

(a) Roads and Bridges

Unit values provided by DPWH for constructing national and local roads and bridges appear in the table below. In this case, the values from the East Pinatubo Study (adjusted for CP inflation) have been ignored as the DPWH values are between 1.5 and 4 times higher for similar new construction work[11].

[8] Sources of data were (1) Farm Prices Provincial Validation for Q1 2002, and (2) Farm Prices Survey Provincial Summary for April to June 2002; both documents issued by Bureau of Agricultural Statistics, Region 3.

[9] 2001 Philippine Statistical Yearbook

[10] 274 households in the 7 municipalities that are subject to inundation.

[11] This construction cost increase of up to 22% per annum seems at variance with the low annual WPI for construction materials in Metro Manila of approximately 2.6%

Average Unit Cost for Road & Bridge Construction (Pesos/meter)

Category/ Level of improvement	Year 2002	Year 2003
National Roads		
Rural Roads		
Concrete	9,500	10,000
Asphalt	6,400	6,700
Gravel	4,100	4,300
Urban Roads		
Concrete	11,600	12,200
Asphalt	8,700	9,200
Local Roads		
2-Lane Roads		
PCC	8,280	
Asphalt	5,980	
Gravel	3,640	
National Bridges		
Permanent Construction		
Steel	410,000	431,000
Pre-stressed concrete girder	330,000	348,000
Reinforced concrete deck girder		
Reinforced concrete box culvert		
Flyover		
Temporary Construction		
Bailey (with permanent structure)	170,000	180,300
Timber	150,000	160,400
Footbridge (suspended)	13,000	14,000
Local Bridges (2-Lane)		
RCDG	190,000	
PSCG	280,000	

Additional values are available for the improvement of national roads only.

In this study, the following unit values are applied referring to the East Pinatubo Study:

Road

National Road: P2,940 /l.m.

Other Roads: P2,353 /l.m

Bridge

National Road: P100,800 / l.m.

Other Roads: P84,000 / l.m.

(b) Irrigation Systems

As the study team did not access any separate data that of the East Pinatubo Study is given. The cost of irrigation canals, increased by the rate of CP inflation (53%) since 1995, is P979/meter.

(2) Indirect Damage

In this study, indirect damage refers to secondary damage resulting from flood and mudflow such as additional transport cost, loss of product (output) due to the interruption of economic activity caused by flood and mudflow, and the cost of evacuating people and cleaning buildings after the event. Indirect costs will be computed only in the feasibility study. At this moment, indirect damage was assumed at 100% of direct damage (usually the ratio of indirect damage to direct damage is 40% to 200%, depending on the characteristics of projects).

In some cases, the development benefits are considered, which takes into account the increase in unit value of buildings, products and infrastructure in the future. At this point in the study, however, the development benefits are not considered.

12.1.3 Project Benefit

The applied unit values of damages are shown in Table 12.1.6, which were explained in detail in Section 12.1.

The quantity of the probable damage is shown in Table 12.1.7, which was derived from the probable damage analysis given in Section 7.2.

The probable amount of damage was calculated as shown in Table 12.1.8, which was given based on Table 12.1.6 for the unit value, and Table 12.1.7 for the damage quantity.

Calculation of the annual damage amount is given in Table 12.1.9, which was estimated based on the amount of damage over the respective probable inundation and the probability of the inundation occurrence.

12.2 Structural Measures

(1) Flood / Mudflow Control Works including Bridge Re-construction

The proposed structural measures will be implemented to prevent flooding and mudflow spreading to the flood/mudflow prone areas and also to improve the safety conditions along National Highway No.7. All the bridges across the three rivers need to be re-constructed, together with the proposed dike heightening or river widening. Accordingly, the cost of re-construction of the three bridges was included in the cost of structural measures for flood and mudflow control.

The results of the economic evaluation are given as follows and shown in Table 12.2.1:

Summary of the Results of the Economic Evaluation for the Structural Measures

River / Alt No.	Structural Measure	Project Cost (Million Pesos)	EIRR
Bucao			
Alt-1	Dike Heightening	981 (Equivalent to US$ 19.4 million)	15.2%
Alt-2	Dike Heightening & Malomboy Consolidation Dam	1,710 (Equivalent to US$ 33.9 million)	6.7%
Alt-3	Dike Heightening, Malomboy Consolidation dam, and Sand Pockets	3,301 (Equivalent to US$ 65.4 million)	-
Maloma			
	Channel Work & Dike Construction	1,298 (Equivalent to US$ 25.7 million)	-
Sto.Tomas			
Alt-1	Dike Heightening & Strengthening	1,505 (Equivalent to US$ 29.8 million)	48.2%
Alt-2	Dike Heightening /Strengthening and Marella Channel Training Works	5,473 (Equivalent to US$ 108.4 million)	17.1%
Alt-3	Dike Heightening /Strengthening and Marella Sand Pockets	3,556 (Equivalent to US$ 70.4 million)	25.5%

The construction period was assumed to be 4 years and the project life is considered to be 30 years, which will be reviewed and re-assessed during the feasibility study stage.

For the Bucao River, it is evaluated that Alternative-1, dike heightening is the most feasible in terms of the economic aspect. However, consolidation work to protect against secondary erosion of the unstable lahar deposits, and construction of sand pockets to minimize lahar flow to the downstream reaches may not be feasible. The river width at the river crossing structure downstream is more than 2 km and deep sheet-pile driving will be required to protect the structure against failure due to scouring of the downstream portion. Accordingly, the cost of the river crossing structures will be fairly expensive, which is the main reason why Alternatives 2 and 3 are not feasible.

For the Maloma River, it is evaluated that the proposed flood control measure is not economically feasible because the flood prone area is relatively limited and only about 100 households would be affected by flood and mudflow.

For the Sto. Tomas River, all proposed alternatives are expected to be feasible from an economic viewpoint. The damage prone area was reasonably wide and more than 5,000 households could be protected from flood and mudflow damage. In particular, Alternative-1, dike heightening and strengthening, received an extremely high grade with an EIRR of 48.2%. This is owing to the sunk cost of the existing dike, which was not counted in the cash flow.

12.3 Non Structural Measures and Community Disaster Prevention Plans

The results of the economic evaluation of the proposed non-structural measures and community disaster prevention plans are summarized as follows:

Economic Evaluation for Non-Structural Measures and Community Disaster Prevention Plans

Proposed Projects	Project Cost (Million Pesos)	EIRR
Telemeter / Warning System through Cellphone Network and Improvement / Additional Evacuation Centers (construction of new elementary school)	115 (Equivalent to US$2.3 million)	15.1%
Community Infrastructure Development at Tektek Resettlement Center	35 (Equivalent to US$0.69 million)	14.6%
Extension of Community-Based Forest Management Project (40 Areas)	80 (Equivalent to US$1.6 million)	60.8%
Pilot Project for Lahar-Agriculture Development as Livelihood Development	30 (Equivalent to US$0.59 million)	12.3%
Community Development on Mapanuepe Lake Basin (Study & Pilot Scheme under ODA)	70 (Equivelent to US$1.4 million)	N.A.
Community Road Rehabilitation	326 (Equivalent to US$6.5 million)	1.5%
Establishment of Aeta Assistance Station (AETAS) (Study & Pilot Scheme under NGO)	15 (Equivalent to US$0.3 million)	N.A.

Generally, the benefits from flood forecasting and warning projects are estimated at 5% of direct flood damage. This has also been applied in the Philippines for evaluation of the existing flood forecasting and warning system in PAGASA. In the study area, some warning systems exist and people take evasive action when they feel it necessary. Although the existing system is not functioning properly, some effects should be considered for the new projects. Considering the above, the benefit of the proposed telemeter/warning/evacuation system is defined as 2.5% of the direct damage amount and it is assumed that another 2.5% of the benefit is for the existing evacuation system. Based on the above, the EIRR for the telemeter/ warning /evacuation system is estimated at 15.1%.

For the community infrastructure development of the Tektek Resettlement Center, the differences in land value are considered to be the benefit. Without basic infrastructure such as electricity, water supply, an access road and elementary school, the area is not considered as residential land but just farm land. The average land value of residential areas is P120/m^2 and the farm land is P20/m^2 in the municipality of San Felipe. It is considered that the land value can be assessed as residential area if the proposed project is realized. Accordingly, the benefit of the project is defined as P100/m^2 (P120 - P20/m^2). The EIRR is then estimated at 14.6%.

For the CBFM project, the reduction of sediment yield from forest management is considered to be the project benefit. Based on the Japanese authorized textbook for forest management, the sediment yield in a forest mountain is assumed to be only 1% of a bare mountain. In this study, however, 10% is applied instead of 1% to be on the conservative side. The alternative cost to reduce sediment yield is assumed to be P100/m^3 as mentioned in the evaluation of the countermeasures for the Maraunot Notch. Based on the said assumptions, the EIRR for a community-based forest management project is estimated at 60.8%, the highest value among all proposed projects.

For the lahar agricultural development as a livelihood program, the same approach as that used for the Tektek Resettlement Center was applied. The land value of lahar is defined as only P3.0/m^2, and the sandy farm land is P18/m^2. The difference, P15/m^2 is taken into account as the benefit of the proposed project. In addition, the expected products are also considered as the benefit as the proposed project is to create livelihood / job opportunities for the jobless people. The difference of land value is not considered the benefit of creation of job opportunities for jobless / affected people. The benefit of creation of job opportunities is considered as 50% of products (cassava) from the developed lahar agriculture land, which is P32,000/ha. Taking into account both the values of land and products, the EIRR is estimated at 12.3%.

For community development on Mapanuepe Lake basin, the cost for further study has been considered as the scheme is still premature and further studies, such as a potential study on tourism development, an environmental study particularly for the water quality for the Mapanuepe Lake for tourism, irrigation and aqua-culture development, are required. The economic evaluation for this project is, therefore, not proceeded in this stage.

For community road development, time saving for traveling is considered as the benefit. In the Upper Bucao River Basin, the estimated population is about 11,000 people, which is considered as to receiving the direct benefit. The average time saving from community road development is assumed to be 5 hours, as they have so far no access road and they usually travel by carabao cart or by foot along the lahar buried river channel. In this case, 12 trips/person/year are considered for estimation of travel time saving for the people to travel for marketing, schooling, working and so on. The accumulated time saving is then estimated at:

11,000 persons x 5 hours x 12 trips x 2 = 1,320,000 hours / year

The hourly rate of time saving is assumed based on the GRDP per capita of Region III at P30,784/year. The daily GRDP is therefore estimated at 84 Pesos, and the hourly GRDP, which is considered as 8 hours productive hours per day, is P10.5/hour. The annual benefit for travel time saving is therefore estimated at P13.86 million/year. Based on the above assumption, the economic internal rate of return is estimated at only 1.5%, which is much lower than the NEDA's criteria for investment. Although the economic return for community road rehabilitation is quite low, the project is definitely expected to solve various issues encountered in the remote communities in the mountain area, and that can provide access to poverty reduction in the mountain area. From the viewpoint of strengthening the access for economic development as well as the improvement of social services, it is still recommended that this be implemented.

For establishment of an Aeta Assistance Station, the cost for further study and a pilot scheme has been considered. No economic return has been considered so far as the project aims to preserve the tradition and culture of the Aeta People, originated in the Mount Pinatubo area.

Among the above community disaster prevention plans, community infrastructure development at Tektek resettlement center and community development on Mapanuepe Lake basin were found to be not feasible as the results of the feasibility study. Future review and studies are, hence, recommended for these programs.

CHAPTER 13 IMPLEMENTATION SCHEDULE FOR MASTER PLAN

13.1 Project Implementation Schedule

Figure 13.1.1 shows the proposed implementation schedule for the master plan.

The proposed implementation period for the master plan was set at 20 years, which is generally applied in the basin-wide master plan formulation. The 20-year period was divided into three development stages, as follows:

1) Short Term Development: 6 Years (2003 - 2008)
2) Middle Term Development: 8 Years (2009 - 2016)
3) Long Term Development: 6 Years (2017 - 2022)

The duration of the respective development terms was determined based on the required construction/implementation period of each component of the master plan.

The schedule of each component was thoroughly assessed in terms of economic viability, the main priorities of the people in the area, and urgency in terms of physical vulnerability, and sustainability of development activities.

Most of the projects scheduled within the short term development period were included in the feasibility studies in this study, and the results are described in the following chapters.

13.2 Project Implementation Structure

This section presents recommendations in the following areas:

- River basin management: legislation and organization,
- Project organization, management and relationships with Government institutions,
- Capacity building measures,
- The community, NGOs and private enterprises, and their relations with the project.

13.2.1 River Basin Management: Legislation and Organization

Following the issues identified in Subsection 3.11.3, certain revisions to the Water Code and its IRR are urgently required and should be implemented for the study area well before the implementation of the proposed project in order to avoid problems that would otherwise be encountered. Some of these could be implemented by the GOP as part of the instruction in EO 123 to amend the Water Code IRR to include the following.

1) River Areas, Flood Control Areas and Land Use Regulation

River areas and flood control areas should be clearly designated and enforced. The designation of flood plain land should be based on the hazard map created in this master plan. These areas should be announced to the public as soon as possible and preferably before project implementation.

The use of the above river areas for settlement and cultivation should be controlled according to the law, and arrangements should be made to accommodate those inhabitants who have traditionally lived in and cultivated these locations. Other illegal users of these areas should be resettled.

2) River Basins: Definition and Management

A system should be agreed for (i) categorizing the major river basins and (ii) the agency responsible for managing these and the remaining rivers. It is suggested that the cross-boundary concept is a useful first, and possibly only, indicator. Any river which crosses provincial boundaries would be designated as a major river and automatically managed at the national level; those crossing municipal boundaries would be managed by the province; all others would be managed by the municipality concerned.

According to this definition, all rivers in the study area would be managed by the province, even though approximately 80 km^2 in the north-east of the study area is in the Tarlac and Capas Provinces (Region 2).

River (basin) management should encompass the six main functional areas as set out in subsection 3.11.2(2)[1]. This should apply to all rivers whether managed nationally or by LGUs, as defined above. Under this concept (already practiced in some other countries) overall policy making responsibility for river management would be with a national department (previously DPWH, now the office of the President and in the future, very probably DENR) and executed nationally and regionally by a dependable agency with considerable powers. The NWRB is well placed to take on such executive responsibility and this would provide the framework for a unified river (basin) management approach, which is currently required. Considerable organizational changes would be needed, however.

3) Relocation / Resettlement

Any relocation or resettlement of people required by the project or by implementation of the defined river and flood control areas should be undertaken by LGUs, but with financial and possibly technical assistance from the National Government. If not already available, standard criteria and procedures should be prepared for the relocation of (i) people with title to land and therefore entitled to compensation, and (ii) squatters. This should be done together with a careful review of the relevant legislation.

4) Local Government Code and LGU Capacity Building

As reported earlier, the purpose of the Local Government Code is to promote the role and autonomy of LGUs. In river management, and more specifically flood control, LGUs will require additional capacity in terms of personnel, expertise and funds so that they can undertake flood control projects and their subsequent maintenance. To promote this increased decentralization, LGUs should be involved in the project implementation and should contribute an initially small share of the cost. In this way, they would be building capacity and at the same time helping to defray project cost.

13.2.2 Project Organization and Management

This master plan project is multi-sectoral. The project components and the proposed agencies responsible (lead agency is given first in each case) are:

(1) Structural measures which comprise:

- Bucao River:
    - Dike heightening / revetment (cost P0.981 billion): DPWH
    - Bridge reconstruction (cost included above): DPWH

[1] 1) Watershed management (river basin conservation); 2) Water resources management (development, licensing, allocation, distribution of water resources, billing and receiving payment for water supplied); 3) Flood control (development of infrastructure, flood forecasting); 4) River water quality management (water quality monitoring, pollution control); 5) River environment management (river corridor maintenance, river environment land use management); 6) Water resources infrastructure maintenance (preventive, corrective, emergency maintenance).

- o Maloma River:
  - ▪ Channel work and dike construction (cost P1.298 billion): DPWH (review was recommended)
  - ▪ Bridge reconstruction (cost included above): DPWH (review was recommended)
- o Sto. Tomas River (DPWH):
  - ▪ Alternative-1: Dike heightening / revetment (cost P1.505 billion): DPWH

(2) Non-structural measures, comprising:

- o Improvements to provincial / municipal level flood monitoring / warning and evacuation systems (cost P115 million): PAGASA, P/M/BDCC, PHIVOLCS, DPWH, DSWD, LGUs, NGOs
- o Monitoring of riverbed movement (cost P3 million): DPWH, PHIVOLCS
- o Monitoring of water quality of Mapanuepe Lake (cost P3 million): LGUs, DENR, NIA

(3) Community disaster prevention plans (CDPP), comprising:

- o Agricultural development on lahar high water channel areas (cost P30 million): DA, DENR, NWRB, LGUs, DPWH, DSWD, NIA
- o Community-based forest management (cost P80 million): DENR, LGUs
- o Improvements to resettlement centers (cost P35 million): LGUs, DPWH/DPWH R3, DSWD, NGOs (future discussion and review were recommended in the feasibility study.)
- o Community road rehabilitation (cost P326 million): DPWH, LGUs, DENR, DILG
- o Aeta Assistance Station (cost P15 million): NGOs, NCIP, DENR, DA, LGUs, DILG
- o Community development for Mapanuepe Lake basin (cost P70 million): DENR, LGUs (future monitoring and review were recommended in the feasibility study.)

As mentioned previously, because of the relatively large size of the project components, national government agencies would undertake implementation of each component assisted by foreign consultants, except where indicated above. However, in line with the intentions of the Local Government Code, LGUs should be involved as much as possible, and if funds permit should contribute a modest amount to the cost. They should participate particularly in the resettlement centers, lahar agricultural development and forest management projects. They should also undertake land acquisition for right of way (ROW) purposes where this is needed.

The project should be managed by a Project Coordination Committee (PCC), an arrangement that can accommodate sub-projects in different sectors, with different funding sources and implementation periods. This arrangement is widely used in the Philippines. (The formation of a commission or an authority is more appropriate for major, complex, long-term projects needing much interaction between the components).

Members of the PCC would consist of senior representatives of the main agencies concerned – in this case DPWH, DENR, NWRB, PAGASA, DSWD, DA, DENR and the relevant LGUs. Disaster Coordinating Councils should also be represented. DPWH would have overall responsibility for the project, the PCC reporting to the Assistant Secretary (Planning, MIS and Operation in CAR, Regions 1, 2 & 3) in Manila.

A Project Management Office reporting to the PCC would be established for both structural and non-structural projects, and consultants would be retained as advisors to the PCC and PMO. The PMO would report functionally to either MPR or MPE (responsible for the whole of Mount Pinatubo rehabilitation) which would monitor the functional performance of the PMO in managing the project.

Figure 13.2.1 outlines a project management structure based on the above concept. However, the proposed institutional arrangement for a multi-sector approach is so far not realistic considering the existing budget flow and the structure of government institutions. Project implementation is the responsibility of line agencies in a single sector at present. Accordingly, a multi-sector project approach will require drastic change of the government system, which would take time. The proposed institutional structure is considered as the future vision.

In the feasibility study, therefore, the organization for project implementation will be assessed based on the existing system of line agencies with maximum coordination of various agencies related to the project components.

CHAPTER 14 SELECTION OF PRIORITY PROJECTS

14.1 Criteria for Selection

The priority projects, to be examined in the feasibility studies, were selected from the projects identified in the master plan based on the following selection criteria:

1) The priority projects need to be technically feasible.
2) The priority projects should have an economic internal rate of return (EIRR) of greater than or equal to 15%, a minimum requirement that NEDA use to select projects for implementation.
3) The priority projects should be urgently required by the local people residing in the project areas in view of minimizing disasters and upgrading their living standards.
4) The priority projects should have positive impacts, or a lesser degree of negative impacts, on the natural and social environments.
5) The priority projects may contribute to accelerate economic activities and development in the study area.
6) The priority projects consist of structural measures, non-structural measures and community disaster prevention plans.

14.2 Selected Structural Measures

The structural measures selected as priority projects are as follows:

Structural Measures Selected as Priority Projects

No	Priority Projects	Project Cost (Million Pesos)	EIRR (%)
1	The Bucao River dike heightening including re-construction of the Bucao Bridge.	981 (Equivalent to US$19.4 million)	15.2
2	The Sto.Tomas River dike heightening & strengthening.	1,505 (Equivalent to US$29.8 million)	48.2

It is concluded that the structural countermeasures on the Maraunot Notch are, so far, not required as almost all the un-consolidated material at the notch portion was washed out by the flood in July 2002. Instead of provision of structural measures, however, it is recommended that a monitoring system for the lake water level, rainfall and ground water level at the Pinatubo Crater Lake be established.

14.3 Selected Non-Structural Measures

The non-structural measures selected as priority projects are as follows:

Non-Structural Measures Selected as Priority Projects

No	Priority Projects	Project Cost (Million Pesos)	EIRR (%)
1	Provincial / Municipal level flood / mudflow monitoring, early warning and evacuation systems.	115 (Equivalent to US$2.3 million)	15.1

14.4 Selected Community Disaster Prevention Plans

The community disaster prevention plans selected as priority projects are as follows:

Community Disaster Prevention Plans Selected as Priority Projects

No	Priority Projects	Project Cost (Million Pesos)	EIRR (%)
1	Community infrastructure development of the Tektek resettlement center.	35 (Equivalent to US$0.69 million)	14.6
2	Extension of on-going community-based forest management projects (40 areas).	80 (Equivalent to US$1.6 million)	60.8
3	Pilot project for agricultural development on the lahar high water channel.	30 (Equivalent to US$0.59 million)	12.3
4	Community Development of Mapanuepe Lake Basin (Study & Pilot Scheme under ODA).	70 (Equivalent to US$1.4 million)	N.A.
5	Community Road Rehabilitation	326 (Equivalent to US$6.5 million)	1.5%
6	Establishment of Aeta Assistance Station (AETAS) (Study & Pilot Scheme under NGO).	15 (Equivalent to US$0.3 million)	N.A.

Although some projects of the CDPP show an EIRR of less than 15%, these projects are recommended for selection as priority projects due to the importance of the social development in the study area.

Among the above community disaster prevention plans, community infrastructure development of the Tektek resettlement center and community development of Mapanuepe Lake basin were found to be not feasible as a result of the feasibility study. Future discussion, monitoring, review and studies are, hence, recommended for these programs.