

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

No. 1

NATIONAL IRRIGATION ADMINISTRATION
THE REPUBLIC OF THE PHILIPPINES

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR MINIMIZING ASH-FALL DEPOSITION
ON THE WESTERN BARRIOS IMPOUNDING IRRIGATION SYSTEM
IN
THE REPUBLIC OF THE PHILIPPINES

JULY 1992

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NIPPON GIKEN INC.



国際協力事業団

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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a basic design study on the Project for Minimizing Ash-Fall Deposition on the Western Barrios Impounding Irrigation System and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Dr. Masami Yasunaka, Director, Laboratory of Structures Analysis, Department of Structural Engineering, National Research Institute of Agricultural Engineering, Ministry of Agriculture, Forestry and Fisheries, and constituted by members of Nippon Giken Inc., from April 9 to May 3, 1992.

The team held discussions with the officials concerned of the Government of the Philippines, and conducted a field study at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

July 1992



Kensuke Yanagiya

President

Japan International Cooperation Agency

July 1992

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

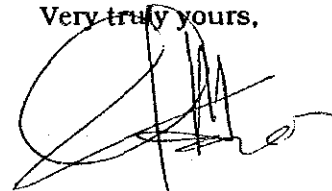
We are pleased to submit to you the basic design study report on the Project for Minimizing Ash-Fall Deposition on the Western Barrios Impounding Irrigation System in the Republic of the Philippines.

This study has been made by Nippon Giken Inc., based on a contract with JICA, from March 31, 1992 to July 31 1992. Throughout the study, we have taken into full consideration of the present situation in the Philippines, and have planned the most appropriate project in the scheme of Japan's grant aid.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, the Ministry of Agriculture, Forestry and Fisheries and Embassy of the Republic of the Philippines in Japan. We also wish to express our deep gratitude to the officials concerned of the National Irrigation Administration, JICA Philippine Office and Embassy of Japan in the Philippines for their close cooperation and assistance during our study.

At last, we hope that this report will be effectively used for the promotion of the project.

Very truly yours,



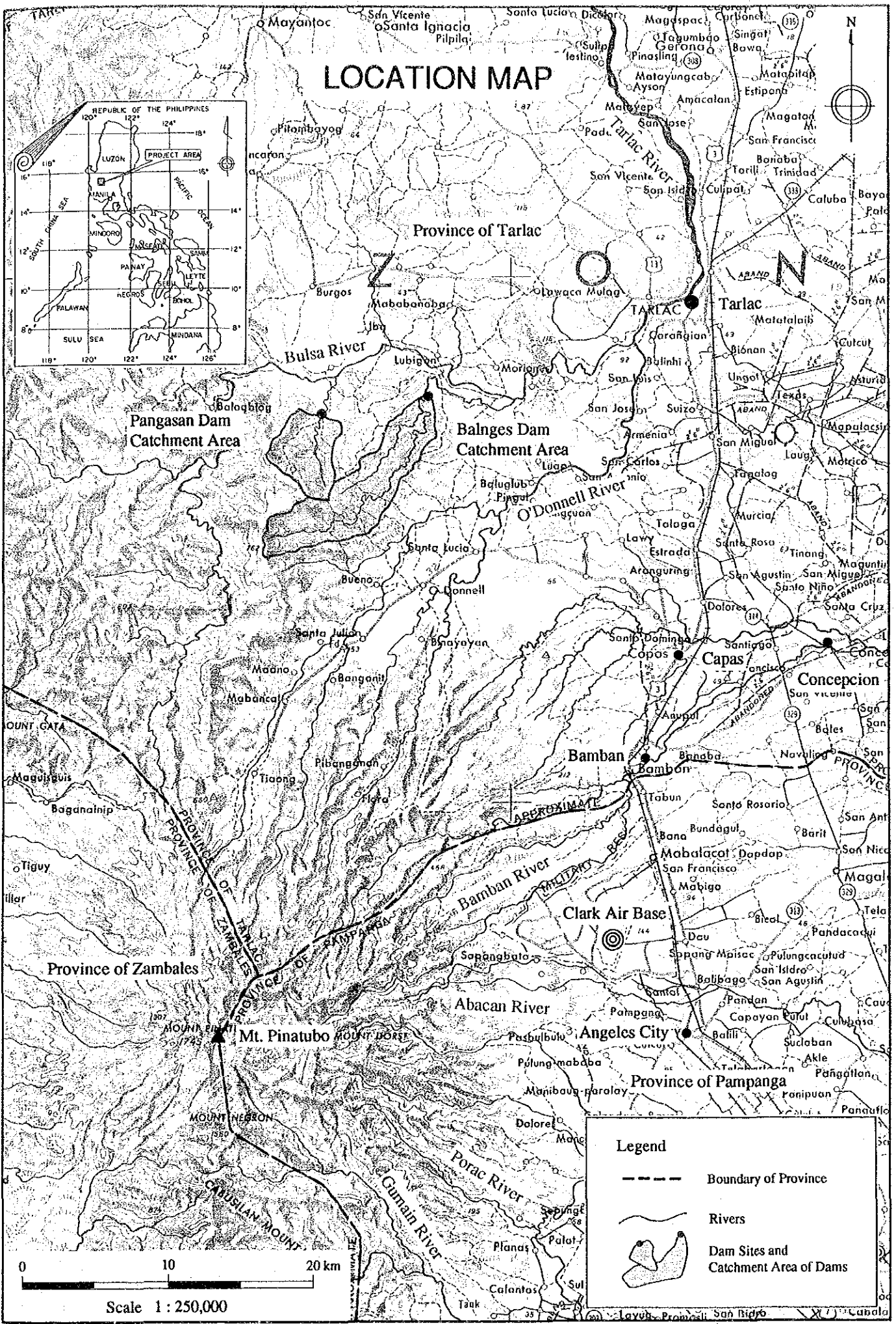
Yoshimitsu Yukawa

Team leader

Basic design study team

Nippon Giken Inc.

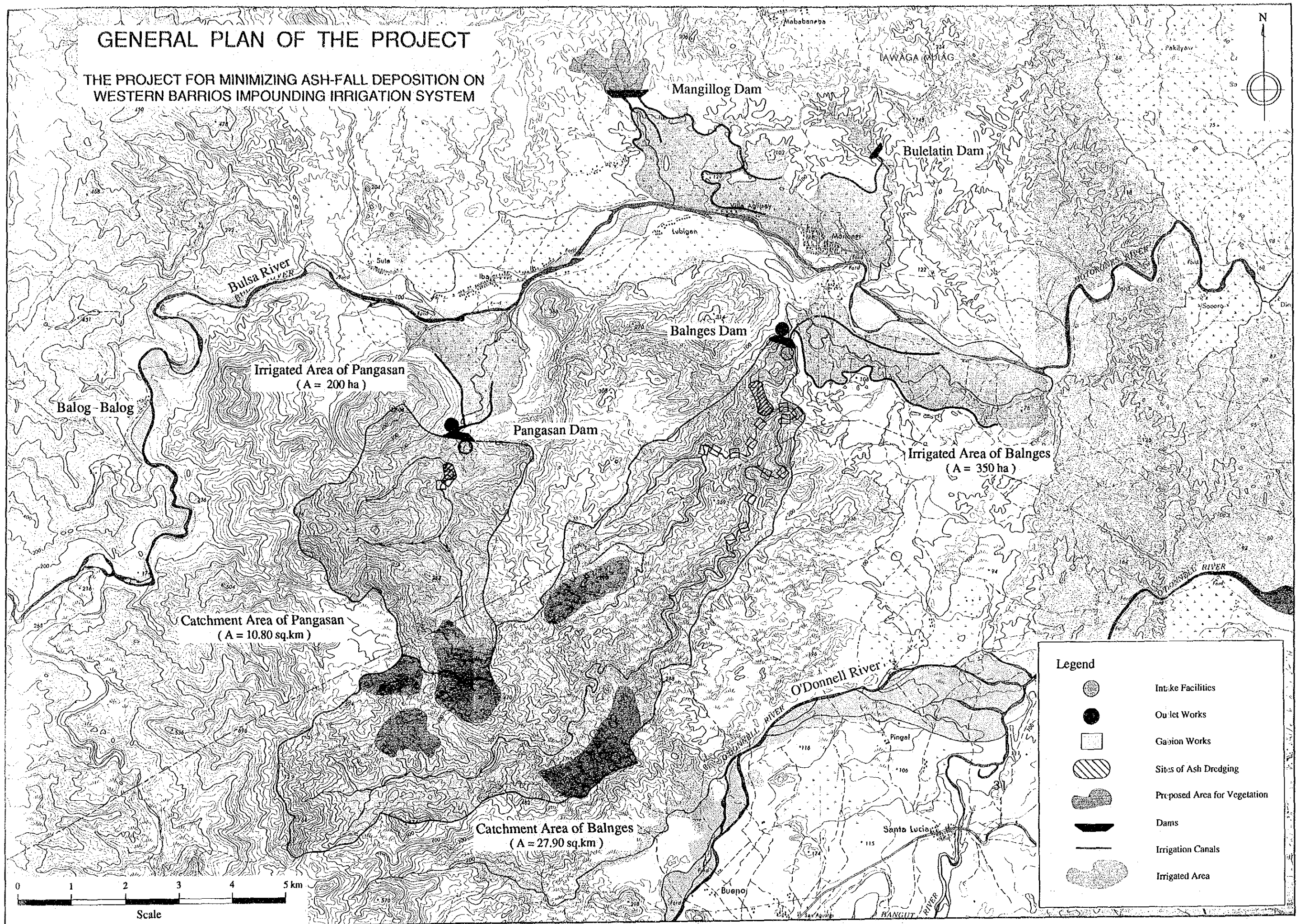
LOCATION MAP



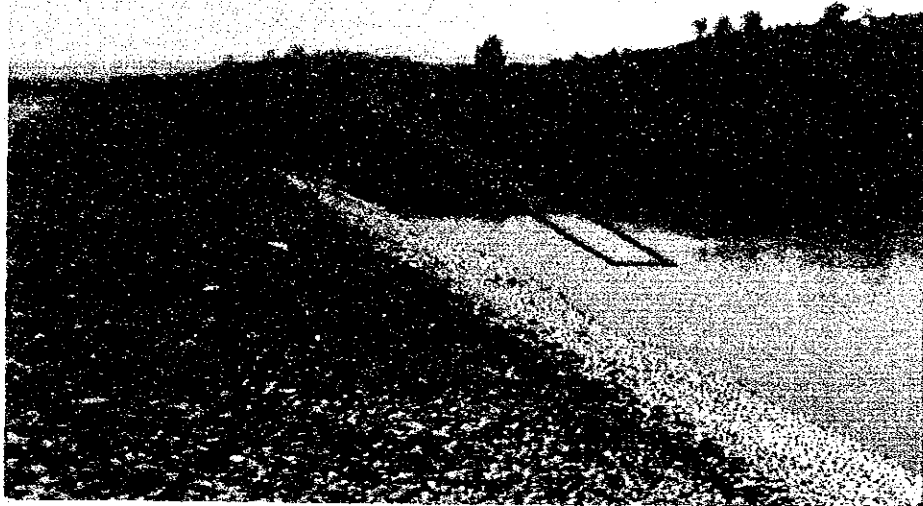
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GENERAL PLAN OF THE PROJECT

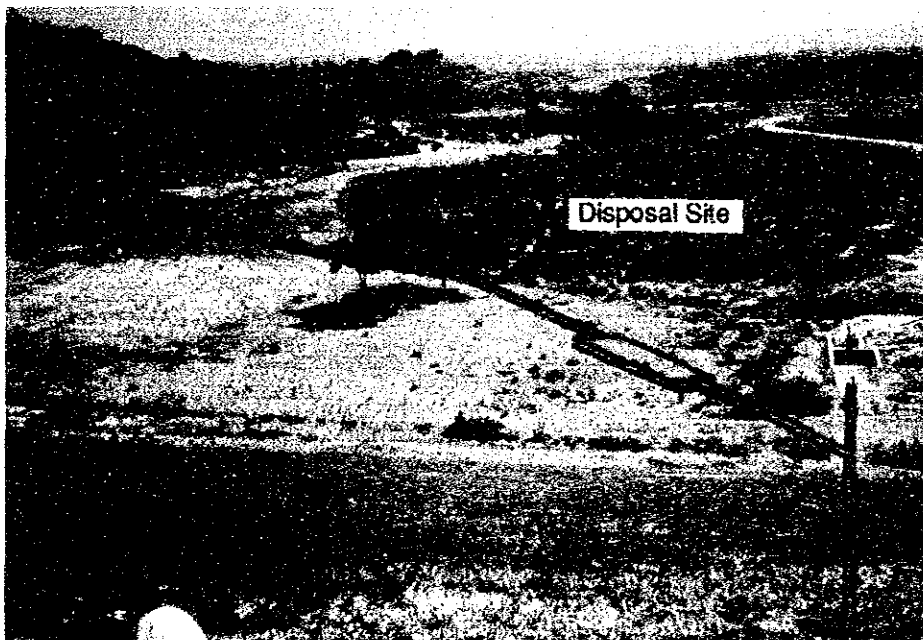
THE PROJECT FOR MINIMIZING ASH-FALL DEPOSITION ON WESTERN BARRIOS IMPOUNDING IRRIGATION SYSTEM



PHOTOGRAPH



Proposed site for inclined intake conduit for Pangasan dam



Proposed site for outlet works of Pangasan dam

Overview of proposed construction site of gabion works in Balnges watershed (STA. 0+600)



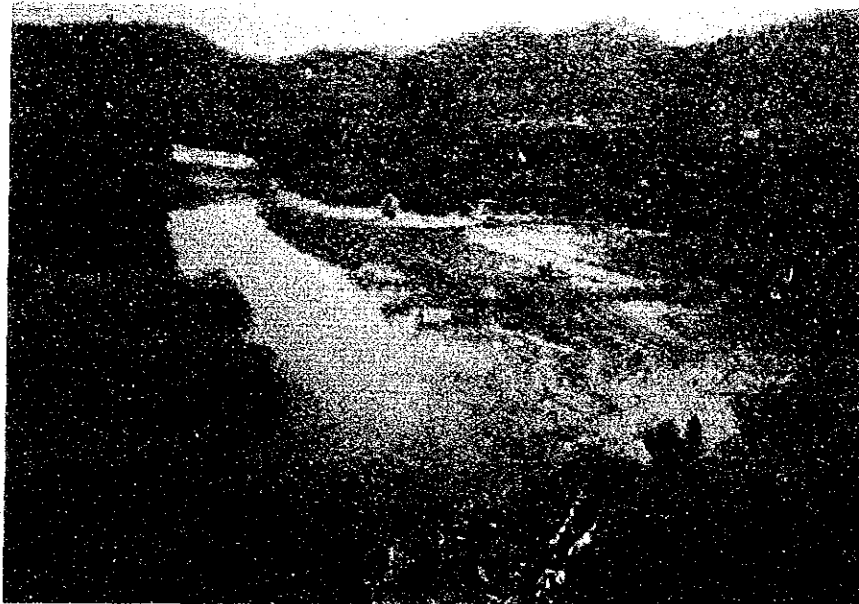
Proposed site of gabion works in Balnges watershed (STA. 0 + 500)



Proposed site of gabion works in Balnges watershed (STA. 3+400)



Proposed site for ash dredging
at the upstream of Balnges
dam storage area



Upstream of Balnges dam
storage area
(Depth of ash deposition is
4 to 5 meters)



Upstream of Balnges dam
storage area



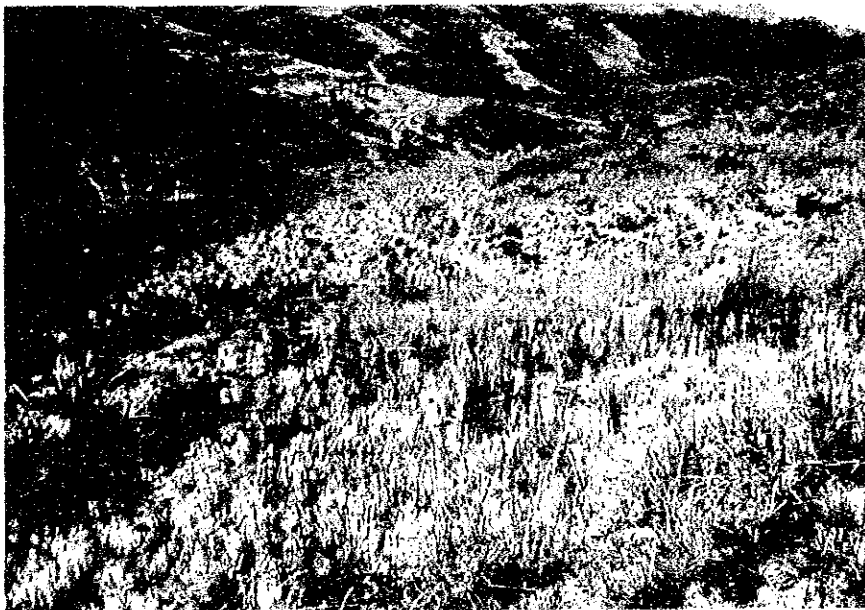
Overview of upstream of
Balnges dam watershed

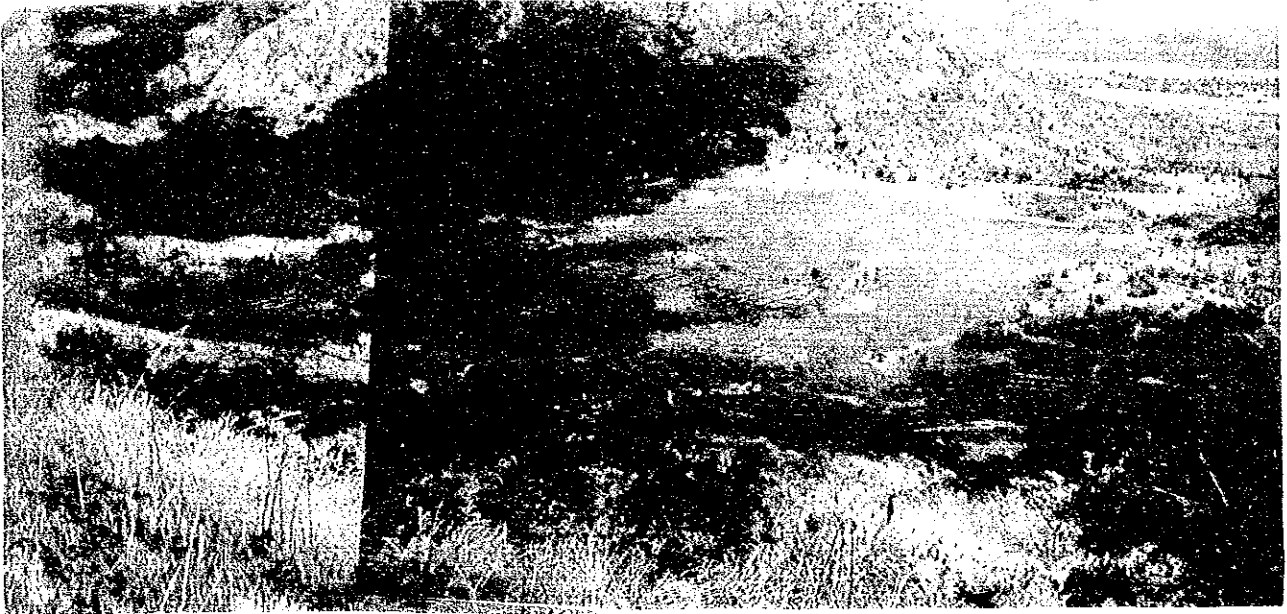


Overview of middle portion of
Balnges dam watershed



Ash deposition on hillside at
middle portion of Balnges dam
watershed





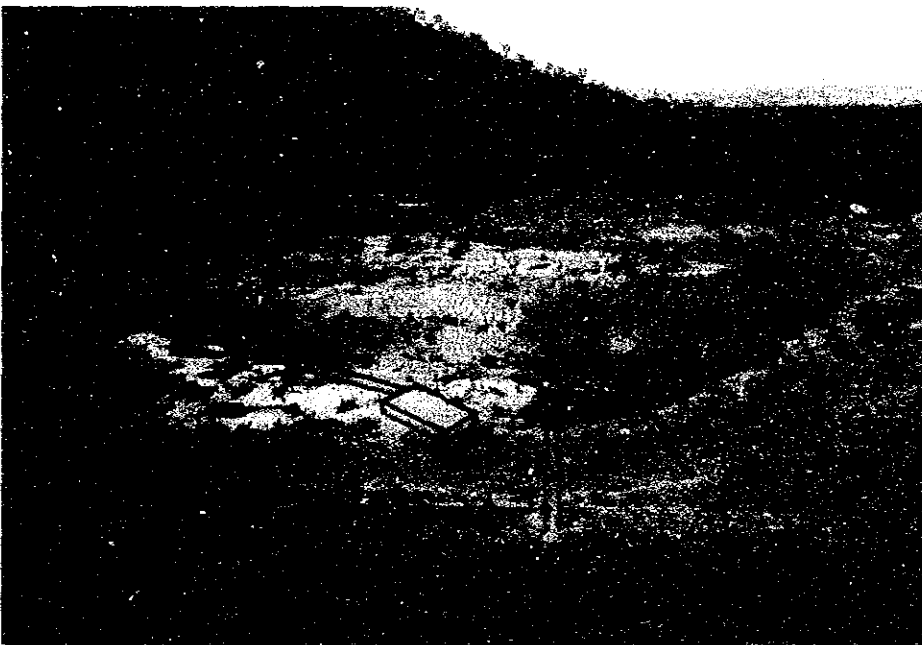
Overview of Pangasan dam & reservoir



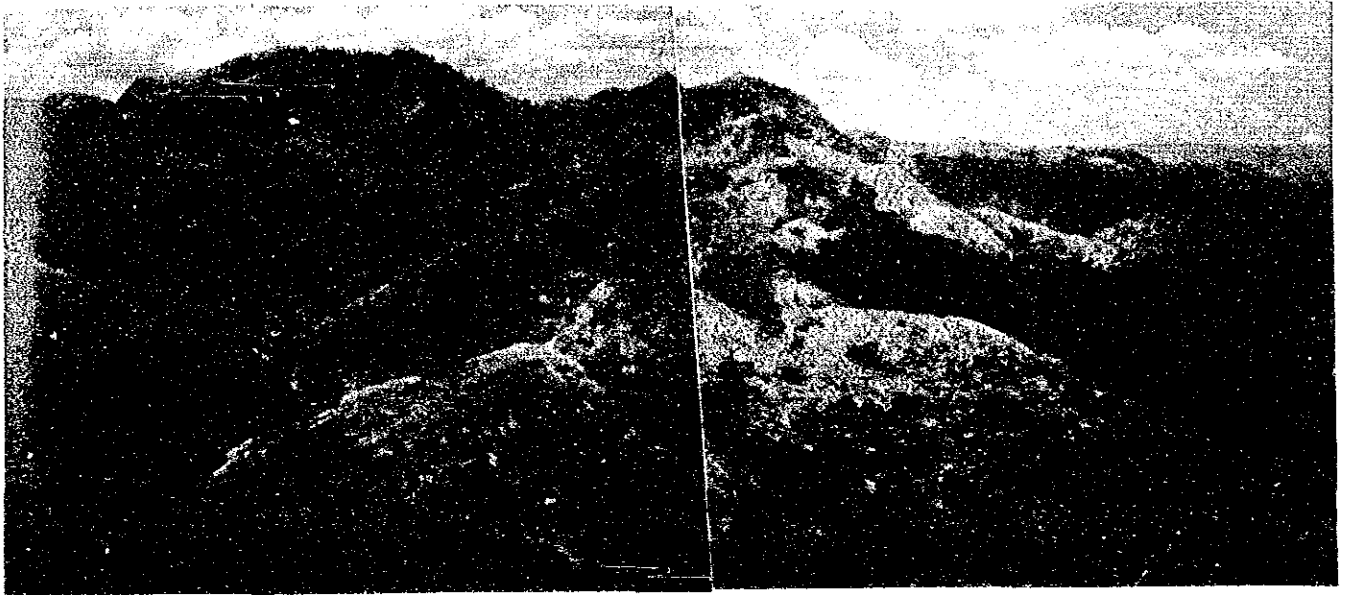
Proposed site of ash dredging and gabion works in Pangasan reservoir



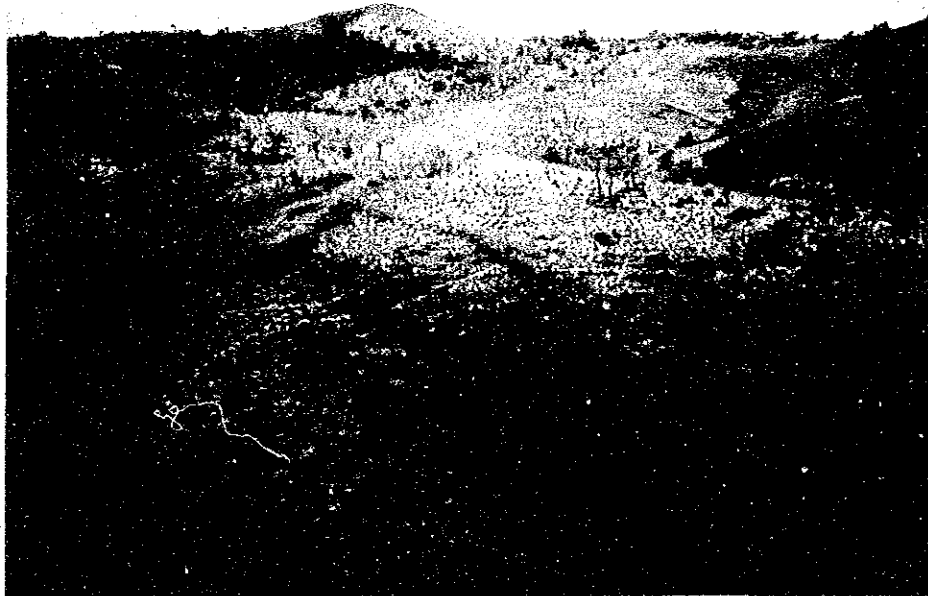
Proposed site for inclined intake conduit of Balnges dam



Proposed site for outlet works and ash disposal of Balnges dam



Overview of watershed of Pangasan reservoir
(Ash remaining on hillside is shown in white)



Ash remaining on hillside in watershed of Pangasan reservoir

Summary

The share of the agricultural sector in Gross Domestic Product (GDP) gradually decreased from 28 % in 1976 to 23 % in 1990 in the Philippines. Agricultural production increased steadily, and went as far as to export rice in 1987. However, the average farm size, measured at around 2.6 ha in 1980, remains small and the rural sector continues to suffer from poverty. The agricultural population occupies 45% of the active labor force. Approximately 70% of the agricultural population belongs to the poor. The rural-urban inequality of income has increased over time.

In the Medium-Term National Development Plan (1987-1992), the ultimate aim of the development has been to focus on (1) alleviation of poverty, (2) creation of employment opportunity, (3) promotion of equity and social justice, and (4) attainment of sustainable economic growth, with an emphasis on rural life's stability and the raising of living standards. The Government of the Philippines has preferred to promote the small-scale infrastructure projects and the labor-intensive development projects in line with the development strategy. Another aim of this plan is to reduce the incidence of poverty from 63.7% in 1985 to 48.1% in the rural areas.

The Western Barrios Impounding Irrigation System (the System) was constructed under Japan's grant aid program in Tarlac Province and completed in March 1991. The System aims at increasing the level of agricultural productivity and contributing towards the promotion and prosperity of the regional economy through the development of irrigation agriculture with reservoirs and canal systems in rainfed farming areas, in conformity to the aims in the Medium-Term National Development Plan. The System consists of four irrigation systems comprised of reservoirs and irrigation canals (Balnges, Pangasan, Mangillog and Bulelatin systems) and one bridge, and commands an irrigation area of 1,030 ha in total. Just before the operation of the System in the middle

of June 1991, Mt. Pinatubo, located in Central Luzon, started to erupt and emitted tons and tons of volcanic debris and ash, estimated at five billion cubic meters, which covered vast surrounding areas including the System.

In the Follow-up Study conducted by the Japan International Cooperation Agency (JICA) in December 1991, which investigated the System's damage due to the eruption, it was reported that the ashfall had piled up to two million cubic meters and 0.6 million cubic meters on the watersheds of the Balnges and the Pangasan reservoirs, respectively. The voluminous ashfalls re-mobilized by the following monsoon rains, silted up the rivers and reservoirs. The total storage capacity of the Balnges and the Pangasan reservoirs were respectively reduced by 11.0% and 10.5%, and it is foreseeable that in the future the deposited ash remaining on the hillsides and inside the river will flow into the reservoirs, and result in a further decrease of water storage capacities, and accordingly, the reduction of irrigable areas is unavoidable. It is estimated that 1.05 million cubic meters and 0.31 million cubic meters of ash will flow into the Balnges and Pangasan reservoirs in three to five years, which is equivalent to 58% and 31% of their total storage capacity, respectively. Consequently, if the whole quantity of the ash happens to flow into the reservoirs, the existing dam intake facilities will be buried completely by the ash and lose their functions, also result in such problems as the difficulty of controlling the water level of the reservoirs, which will bring about troubles of dam operation.

Considering above situations and based on the results of the Follow-up Study, the Government of the Philippines has formulated a plan, in order to acquire the intake functions and to prevent the flow of ash into the reservoirs, in what is considered as the most important areas of high potential to produce agricultural crops, and that of a preceding model project of the Small Water Impounding Management Project (SWIM). The Government of the Philippines requested the Government of Japan to grant financial cooperation on this plan in March 1992.

In response to the request, the Government of Japan decided to conduct the basic design study (the Study) on the Project for Minimizing Ash-fall Deposition on the Western Barrios Impounding Irrigation System (the Project). The JICA sent the study team (the Team) for 25 days from April 9, 1992 to May 3, 1992. The Team studied the project's viability, basic design of the proposed facilities, project cost, operation and maintenance plan on the basis of the field surveys, discussions and exchange of views with the Philippines officials concerned.

The content of the request from the Government of the Philippines is described hereunder. It concerns the two reservoirs of the Balnges and Pangasan reservoirs, which have particularly suffered from the deposition of volcanic ash. Accordingly, it is expected that the Project will result in the beneficial effects expected at the beginning from the irrigation project itself.

- i) Construction of structures for minimizing ash-fall deposition in the reservoirs,
- ii) Dredging of ash deposited in the reservoirs to maintain the storage capacity of the reservoirs, and
- iii) Installation of inclined type intake facilities and sand scouring valves to secure the dam intake function.

In accordance with the request from the Government of the Philippines, the Team carried out the field survey on items such as the present condition of related dam facilities, the conditions of volcanic ashfalls piling on the watersheds, the deposition volumes in the reservoirs, and the estimation of the future possible flow of ash into the reservoirs, etc. As for the components of the Project, their required functions and their appropriate specifications were studied and determined through the analyses of the collected data in Japan.

The project components consist of the improvement works of dam intake and outlet facilities to discharge ash which will flow into the reservoirs and bury present dam intake facilities, gabion dam works and vegetation works to minimize ash deposition in the reservoirs to ensure storage capacities, and dredging of ash already deposited in the reservoirs. The features of these components are as follows:

Proposed Facilities	Balnges dam	Pangasan dam
a) For maintaining functional order of dam intake facilities		
Inclined intake conduit		
Intake gate installation	ø600mm: 1 gate ø400mm: 2 gates	ø600mm: 1 gate ø400mm: 1 gate
Outlet facilities		
Outlet valve installation and energy dissipator	ø500mm: 2 valves	ø500mm: 2 valves
b) For minimizing ash deposition in the reservoir and ensuring storage capacity		
Gabion dam	13 nos.	2 nos.
(Ash volume accumulated)	(640,000 m ³)	(120,000 m ³)
Dredging of ash	80,000 m ³	50,000 m ³
Vegetation	150 ha.	50 ha.

The executing agency of the Project is the National Irrigation Administration (NIA). The NIA is the administrative organization which implements irrigation projects in the Philippines and has a good level of experience and capability both in technology and management. It can be said that the NIA has ample capability to execute the Project. The Irrigators' Associations (IAs) composed of the project beneficiaries were already established in the project area. The NIA and the IAs have responsibility for the operation

and maintenance of the proposed facilities. The IAs have capabilities for the maintenance of the irrigation canals, collection of the irrigation fee and whole management of the irrigation systems. As for the project implementation, necessary procedures including budget provision for land acquisition of ash disposal sites and land compensation for temporary roads shall be undertaken by the Government of the Philippines. The total cost for the above items is estimated at around 1.75 million pesos.

The Project will be completed within a total of eleven months, three months for detailed design and eight months for construction.

With the implementation of the Project, a stable irrigation farming will become possible, however, if no measure is taken, agriculture will be obliged to return to the rainfed farming because of a shortage of the dam storage capacity, malfunction of the intake facilities related to the irrigation water supply. By the construction of the proposed facilities, the aforementioned damages induced by the ash deposition in the reservoirs and also the difficulty of dam water level control which have an important function to secure the stability of dam embankment and reservoir can be prevented from occurring. The beneficial farm area of the Project is 550 ha in total (Balnges : 350 ha, Pangasan : 200 ha), and the number of beneficiaries is 1,640 persons (Balnges : 1,150 persons , Pangasan : 490 persons). In addition to this, a great number of farmers will have a employment opportunity at the construction works of the Project. This will be of financial benefit to the approximately 8,400 farmers employed.

The economic effects of the Project can be seen in the fact that agricultural production losses will be saved by preventing volcanic ash from flowing into the reservoirs. The annual saved production losses are estimated at 1,155 tons of paddy and 2,200 tons of corn, which are valued at 6,024 thousand pesos per annum in total. The effects of the income on the typical farm household are studied on the small tenant farmers (farm size 1.0 ha) as a model, whose lands are located in the irrigation areas of

the dams. Without project conditions, the annual net farm income is estimated at about 7,900 pesos. On the other hand, with project conditions, it will increase to about 13,800 pesos, or 1.75 times of the income in without project conditions. As for the annual disposable income, it is expected to increase by about 5,500 pesos. This incremental disposable income will contribute towards upgrading the living standards of the beneficial farmers and creating the employment opportunities in the rural area through active agricultural productivity.

As described above, the Project is expected to create direct and indirect effects. Meanwhile, the nationwide SWIM Project whose implementation has been rapidly promoted since 1991 by the Government of the Philippines, aims to attain 1) acceleration of economic growth in less developed regions and enhancement of living standards of farmers in these regions, 2) creation of employment opportunity for rural people through construction activities as well as operation and maintenance of the projects, 3) promotion of effective development and utilization of land and water resources, and so on. Whereas, the System will contribute by extending its valuable demonstrative effects over the country in serving as a pilot model project prior to the SWIM Project. In this connection, it is recommended that the Project will be executed under a grant aid program by the Government of Japan to minimize the damages of the ash deposition and to take urgent countermeasures to secure the reservoirs functions. In order to ensure smooth implementation, operation and maintenance of the Project, it is recommended that the following shall be undertaken by the Government of the Philippines.

-- to secure the land for construction and temporary roads.

-- to hold explanatory meeting in advance for the farmers. The aim would be to confirm the planting periods and to escape from the problems caused by the construction works on their irrigation and farming activities.

Furthermore, realization of effective operation after construction will depend considerably upon the self-help efforts of farmers as well as the efforts of the Philippine officials and the NIA. It is therefore recommended that the concerned Philippine personnel conduct their activities with due attention to the following points.

- to designate specialized engineers to manage the operation and maintenance related to the dam facilities and water distribution, and to carry out cleaning of ash deposited in the irrigation canals. In addition to this, the engineers shall conduct periodical monitoring of ash development in the reservoir and appropriately operate the outlet valves to scour ash on the bottom of the reservoirs when necessary.
- to enhance cooperative relations between the NIA and IAs. The NIA is responsible for the establishment of legislation and undertaking for operation and maintenance of reservoirs and irrigation canals, and the collection of irrigation fees.

Furthermore, the resettlement and the reclamation by the landless farmers evacuated from the Mt. Pinatubo eruption are taking place in the watersheds of the Balnges and Pangasan reservoirs. It is expected that the outflow of remaining ash and erosion of soil resulting from rainfalls will be accelerated owing to their excessive reclamation, as well as felling trees. The survey shows that the outflow of ash remaining in the watersheds and soil erosion are refrained by herbaceous plants naturally growing in these watersheds. For this reason, it is necessary to promote "vegetation work" on a wide area as a measure not only for the protection from ash flowing and soil erosion, but for the comprehensive soil conservation in the watershed of the reservoirs. If a guidance concerning vegetation work is organized by the Department of Agriculture and other relevant agencies for the resettling farmers, the Project can be expected to have more sustainable effects.

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Technical Report

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ABBREVIATIONS

BBMP	: Balog-Balog Multipurpose Project
CARP	: Comprehensive Agrarian Reform Program
CIS	: Communal Irrigation System
DA	: Department of Agriculture
DPWH	: Department of Public Works and Highways
IAs	: Irrigators' Associations
JICA	: Japan International Cooperation Agency
NEDA	: National Economic and Development Authority
NIA	: National Irrigation Administration
NPC	: National Power Corporation
SWIM	: Small Water Impounding Management Project
WBIIP	: Western Barrios Impounding Irrigation Project

cavan	: 50 kg paddy
cm	: centimeter
cm ²	: square centimeter
EL	: elevation above mean sea level
ha	: hectare
kg	: kilogram
km	: kilometer
km ²	: square kilometer
l	: liter
m	: meter
MCM	: million cubic meter
mm	: millimeter
m ²	: square meter
m ³	: cubic meter
sec	: second
ton	: metric ton

Chapter 1 Introduction

The Western Barrios Impounding Irrigation System (the System) was constructed under the Japan's grant aid program in Tarlac Province and completed on March 1991. The System aims at increasing the level of agricultural productivity and contributing towards the promotion and prosperity of regional economy through the development of irrigation agriculture comprising with reservoirs and canal system in existing rainfed farming areas. The System consists of four irrigation systems comprised of reservoirs and irrigation canals (Balnges, Pangasan, Mangilloog and Bulelatin irrigation systems) and one bridge. Just before the operation of the System in the middle of June 1991, Mt. Pinatubo, located in the Central Luzon area, started to erupt and emitted voluminous volcanic materials and ash, estimated at five billion cubic meters, which covered vast surrounding areas including the System.

In the Follow-up Study conducted by the Japan International Cooperation Agency (the JICA) in December 1991, which investigated the System's damages caused by the eruption, it was reported that the Balnges and the Pangasan dams and reservoirs will be filled up by the ash in three to five years.

The Project for Minimizing Ash-fall Deposition on the Western Barrios Impounding Irrigation System (the Project) aims to recover agricultural productivity, as was originally planned in the beginning of the irrigation project, taking proper countermeasures to prevent functional disorder of dam intake facilities and reduction of dam storage capacities caused by ash accumulation in the Balnges and Pangasan reservoirs.

The Government of the Republic of the Philippines (the GOP) confirmed the Project as a high priority and also in urgent need for its implementation. The GOP requested the Government of Japan (the GOJ) to grant financial cooperation for the Project in March 1992. In response to the request, the GOJ decided to conduct the basic design study (the Study) on the Project.

The JICA sent the basic design study team (the Team) headed by Dr. Masami YASUNAKA, Director of Laboratory of Structures Analysis, Department of Structural Engineering, National Research Institute of Agricultural Engineering, Ministry of Agriculture, Forestry and Fisheries, and constituted by the members of Nippon Giken Inc. to justify the Project for Japan's grant aid program, for 25 days from April 9 to May 3, 1992.

The Team studied the project viability, basic design of the proposed facilities, project cost and operation and maintenance plans on the basis of the field surveys, discussions and exchanging views with the Philippines officials concerned. After the study in the project site and further studies in Japan were completed, the basic design study report on the Project was prepared.

The Team member list, survey schedule, list of persons concerned, and Minutes of Discussions are attached in the Appendix.

Chapter 2 Background of the Project

2.1 Background of the Project

The share of the agricultural sector in Gross Domestic Product (GDP) gradually decreased from 28 % in 1976 to 23 % in 1990. The production of rice grew steadily, and 593,095 tons of rice equivalent to about \$1.2 million was exported in 1990. The agricultural population occupies 45 % (about 10.2 million persons) of the total active labor force (about 22.5 million persons). Average farm size has in fact fallen from 3.5 ha in 1960 to 2.6 ha in 1980 because of population growth.

The rural sector continues to suffer from poverty. It has a higher incidence of poverty (about 70 %) compared to the urban sector (about 60 %). The major problems of the agricultural sector are: (a) low productivity, (b) insufficient support services for agricultural activities, (c) lack of post harvest facilities, and (d) weak farmers' organizations.

Farm land area in the Philippines was 7.51 million ha (25.1 % of the country's land area) in total as of 1987, of which 1.54 million ha (about 50 % of total irrigable area in the country) is under the command of irrigation systems/projects. Recently, 1.45 million ha of paddy fields, out of the total 3.17 million ha of paddy fields in the country, are irrigated by the various irrigation systems under the administration of the National Irrigation Administration (the NIA). In the said irrigated paddy field, the National Irrigation Systems (the NIS) serve in about 0.627 million ha (42 %), the Communal Irrigation Systems (the CIS) serve in about 0.709 million ha (48 %), and the remaining 0.152 million ha (10 %) are irrigated by pump irrigation systems. The NIS are being well-operated and maintained directly by the NIA and produce comparatively high yields. However, the CIS mostly have problems with operation and maintenance due to inadequate facilities, lack of water resources and a budget shortage for proper operation and maintenance so that unstable farming activities are consequently being performed.

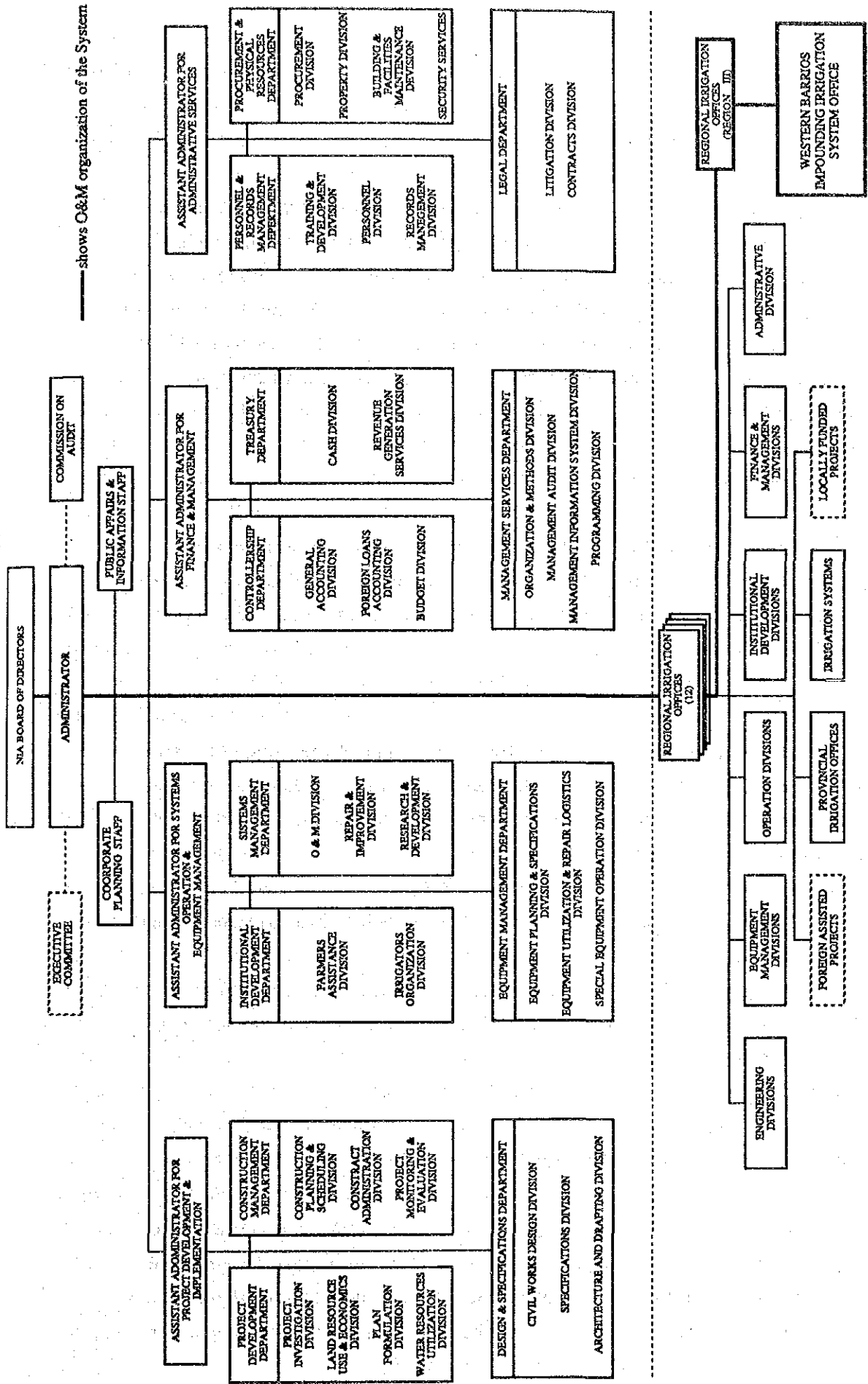
The Western Barrios Impounding Irrigation System (the System), having an irrigation area of 1,030 ha located in the Province of Tarlac, was completed under a grant aid program of Japan and was turned over to the NIA on March 1991. The System aims at raising the present low level of agricultural productivity and contributing to promotion and prosperity of regional economy. As for its

components, four dams and reservoirs (Balnges, Pangasan, Mangillo and Bulelatin reservoirs having total storage capacity of 6.9 million m³ in total), irrigation canals (23.86 km length in total) and one bridge (175 m length) were constructed. Just before the operation of the System in the middle of June 1991, Mt. Pinatubo suddenly awoke from its long slumber and erupted in a succession of explosions, thus called "the eruption of the century". Mt. Pinatubo's eruption spewed out an enormous amount of volcanic debris, estimated at five billion m³, that covered the area for more than a radius of 50 km around the volcano. The lahars or mudflows, that cascaded from Mt. Pinatubo as a result of the wet-season rains, caused many rivers to swell and overflow into paddy fields, and the cost of their damages to properties have run into the billions of pesos.

On the watersheds of the Balnges and the Pangasan reservoirs, which are located close to the volcano, ashfalls reached 5 to 10 cm thick, and these ashfalls were transported into rivers and reservoirs by the rains. As the remaining ash on the hillsides of the watersheds flows out in the future, the problems such as the filling up of reservoirs by ash deposition, disorder of dam intake function, reduction of irrigable area corresponding to decreased dam storage capacity, difficulties in dam management especially for emergency release of dam storage water, etc. are expected.

In quick response to these situations, the NIA has formulated a plan to restore the Balnges and the Pangasan dams and reservoirs in order to solve the problems aforementioned. The Government of the Philippines made a request for the Government of Japan to grant financial cooperation on the Project.

The NIA is responsible for the administration and implementation of the Project. The NIA is the administrative organization to implement irrigation projects in the Philippines, and is competent to conduct the whole stages of the project cycle- planning, designing, supervision, operation and maintenance, monitoring and project evaluation. The organization chart of the NIA is shown in Fig. 2.1.



shows O&M organization of the System

Fig. 2.1 Organization Chart of National Irrigation Administration (NIA)

2.2 Outline of the Request

(1) Circumstances of the request

As the System is a pilot model project of reservoir irrigation system prior to the Small Water Impounding Management Project (SWIM) which is going on all over the country, the NIA has promptly established an immediate restoration plan on both of the Balnges and the Pangasan reservoirs. In line with this, the Government of the Philippines requested the Government of Japan to grant financial cooperation for this Project in March 1992.

(2) Objectives of the request

The objectives of the Project are to take proper countermeasures to prevent functional disorder of dam intake facilities and reduction of dam storage capacity caused by ash deposition in the reservoirs.

(3) Items requested

The items of the request from the Government of the Philippines are described below. The dams and irrigation facilities of the Balnges and the Pangasan dams including their watersheds were requested as the subject of study and project implementation.

- i) Construction of structures for minimizing ash-fall deposition in the reservoirs,
- ii) Dredging of ash deposits in selected areas of the reservoirs, and
- iii) Installation of inclined type intake facilities and sand scouring valves.

2.3 Outline of the Eruption and Damages

Mt. Pinatubo located at the boundary of the Provinces Zambales, Tarlac and Pampanga, first showed signs of restiveness in April 1991, and started a series of the big eruptions with tons and tons of volcanic materials and ash, estimated at five billion cubic meters or over, on June 12, 1991. The numerous numbers of the houses

and buildings collapsed from the weight of volcanic debris accumulated during ashfalls. Fig. 2.2 shows the locations of Mt. Pinatubo and Provinces in Region III affected by the eruptions.

As shown in Fig. 2.3, the mudflows that cascaded from Mt. Pinatubo as a result of the heavy rainfalls spawned by the storms destroyed houses, bridges and dikes of the rivers. Several towns and barangays, and also agricultural lands were buried in the mudflows. The amount of the damages by the ashfalls and mudflows as of March 1992 was estimated at around 9.4 billion pesos as listed in table (2) in Appendix 5. The total affected area of the agricultural land was estimated around 101,000 ha and the amount of the damages was about 523 million pesos. Total affected area of paddy field in Region III was estimated at 78,884 ha and the 57,000 farmers were affected. The affected area by mudflows was reported around 23,063 ha in September 1991.

The extent of the damages of the irrigation system in the Provinces of Bataan, Pampanga, Tarlac and Zambales is summarized in Table 2.1. The affected irrigated area of 45,700 ha was comprised of the National Irrigation Systems 25,000 ha, the Communal Irrigation Systems 20,700 ha. Fig. 2.4, 2.5 are location maps of the National and Communal Irrigation Systems in the aforesaid Provinces.

The project area is located from 35 to 40 km northeast of the crater of Mt. Pinatubo. The catchment areas (the watersheds) of the Balnges and Pangasan reservoirs along the right bank of the Bulsa river vary from 25 to 35 km, and beneficial areas of both reservoirs vary from 35 to 40 km from the crater. The ash had a thickness of 5 to 10 cm at the catchment areas and around 2 cm at the beneficial areas as shown in Fig. 2.6. Several rivers located close to the project area, such as the O'Donnell river and the Tarlac river, already swollen with volcanic debris and mudflows that cascaded from Mt. Pinatubo. The mudflows collapsed the river dikes and buried more houses and agricultural lands. In comparison with the damages occurred in the agricultural lands along the O'Donnell river and the Tarlac river, that damages in the project areas including both of the reservoir catchment areas were minimized because of the limited thickness of the ashfalls. The catchment areas of the Bulsa river and its tributaries, where the two dams of the Balnges and Pangasan dams were constructed, are at far distance from the hillside of Mt. Pinatubo, that the inflow of pyroclastic materials into the irrigation systems is less expected. As described above, the damages by the Mt. Pinatubo eruption were limited and the occurrence of the mudflow is less expected in the project areas.

Table 2.1 Irrigation Systems Affected by Mt. Pinatubo Eruption

Province and Type of System	Affected Systems		Restoration Requirements (Amount in P'000)		
	No. of System	Coverage Area(ha)	Level-I	Level-II	Total
A. Bataan					
National	1	1,417	2,940	4,180	7,120
Communal	20	1,555	6,182	5,327	11,509
(Sub-total)	21	2,972	9,122	9,507	18,629
B. Pampanga					
National	1	4,486	4,291	8,699	12,990
Communal	79	12,340	26,780	38,511	65,291
(Sub-total)	80	16,826	31,071	47,210	78,281
C. Tarlac					
National*/	1	13,976	5,654	15,435	21,089
Communal	14	2,504	6,165	6,476	12,641
(Sub-total)	15	16,480	11,819	21,911	33,730
D. Zambales					
National	2	5,155	11,176	13,841	25,017
Communal	50	4,308	16,763	16,762	33,525
(Sub-total)	52	9,463	27,939	30,603	58,542
Total	168	45,741	79,951	109,231	189,182
National	5	25,034	24,061	42,155	66,216
Communal	163	20,707	55,890	67,076	122,966

Source: "Summary of Extent of Damage to Irrigation Systems due to the Mt. Pinatubo Eruptions", NIA, 16 June 1991.

a. National - NIA managed systems, Communal - Farmer irrigator's association managed systems.

b. Level-I: Immediate Restoration,
Level-II: Long term rehabilitation.

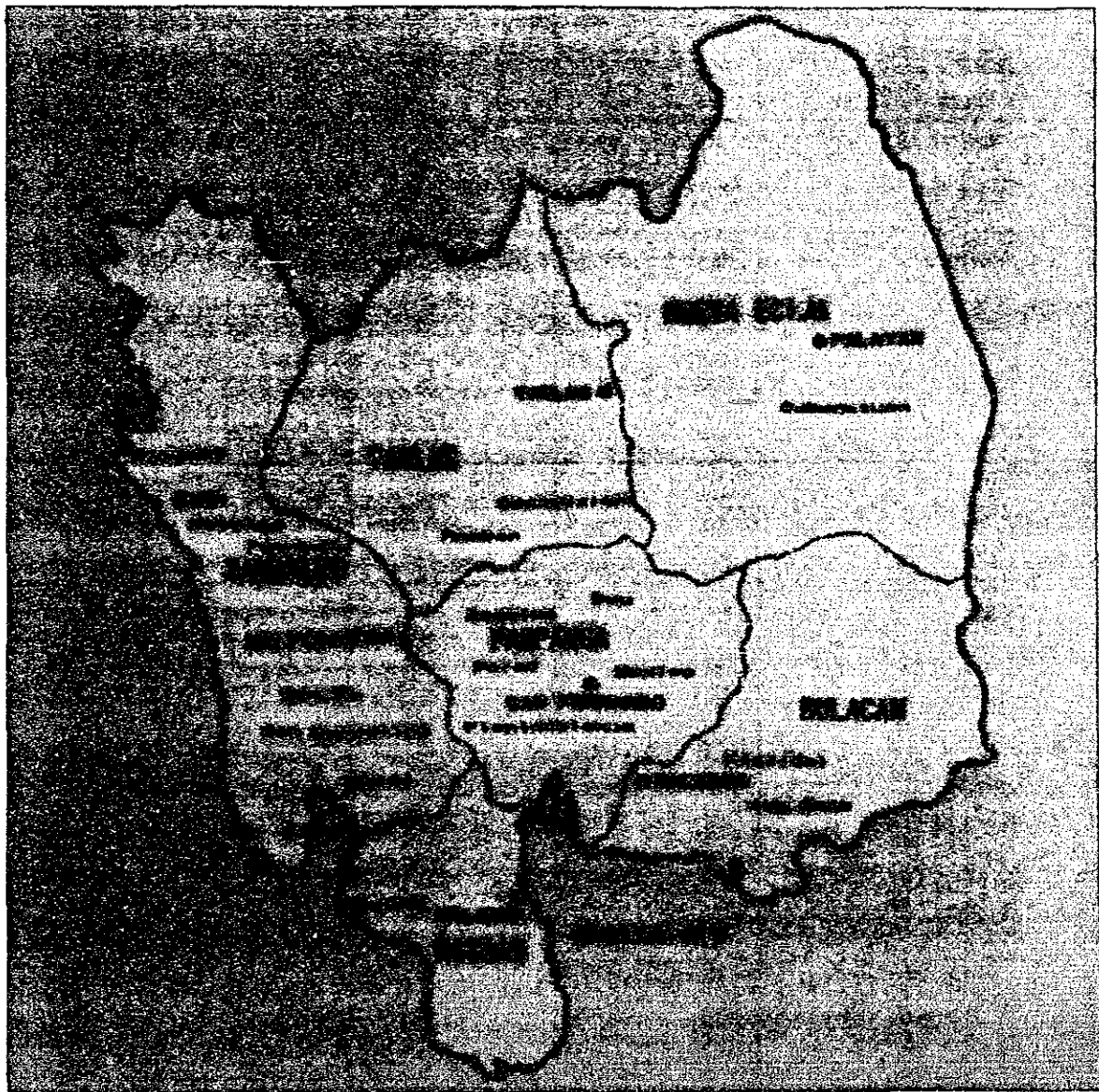
*/ Additionally including BBMP (Balog-Balog Multi-Purpose Project) in Level-II only.

Note/ Work items of restoration are as follows:

NATIONAL	COMMUNAL
(Level-I)	(Level-I)
Removal of Debris	Removal of Debris
Channelization	Channelization
Desilting Work	Desilting Work
Un-clogging	Un-clogging
Silt Disposal	
(Level-II)	(Level-II)
Repair of Diversion	Repair of Diversion
Repair of Gates	Repair of Gates
Desilting Work	Desilting Work
Silt Disposal	
Building Rehab.	
Watershed Rehab.	

Fig. 2. 2

Location Map of Mt. Pinatubo and Provinces in Region III



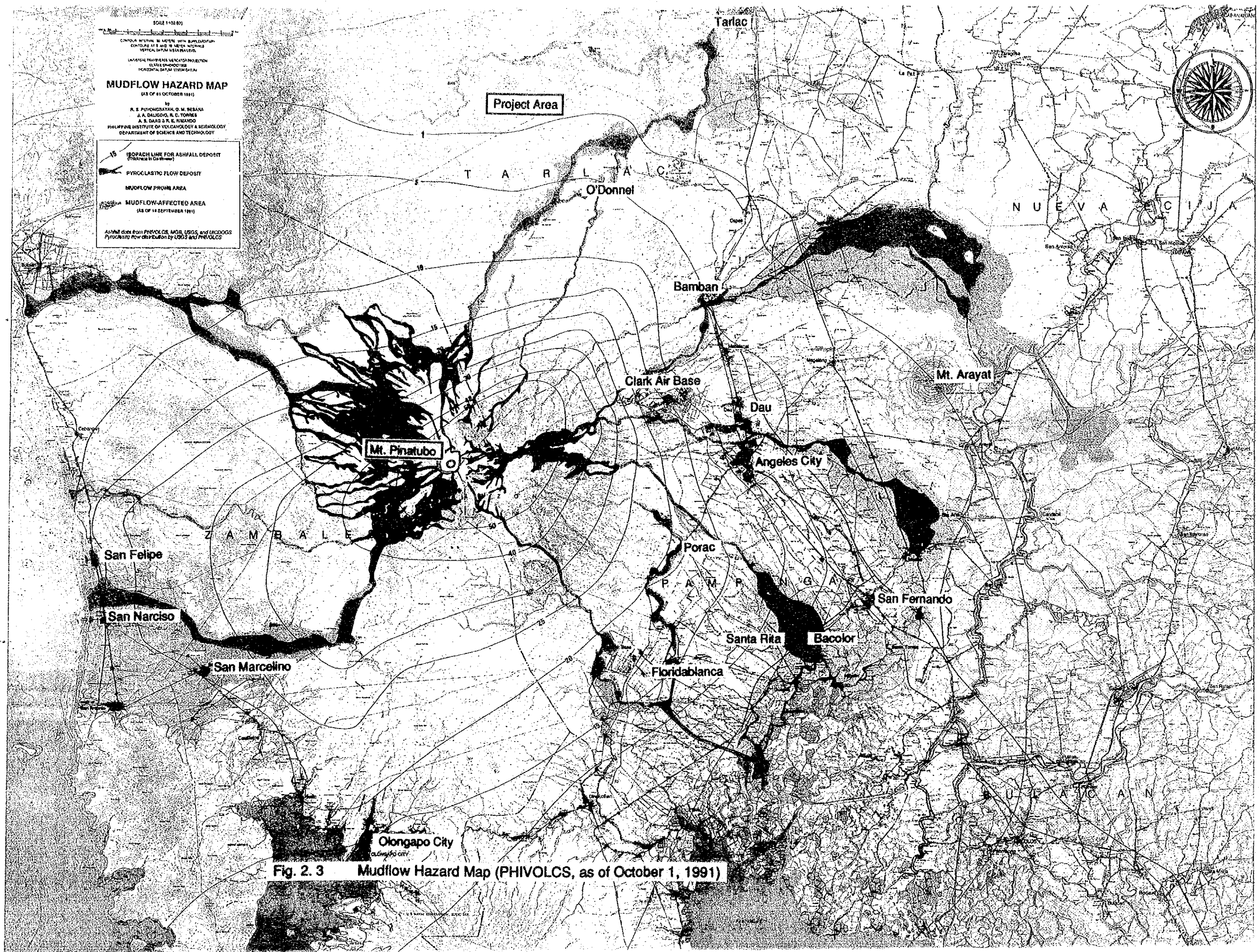


Fig. 2.3 Mudflow Hazard Map (PHIVOLCS, as of October 1, 1991)

