JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
LOCAL WATER UTILITIES ADMINISTRATION
REPUBLIC OF THE PHILIPPINES

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR EMERGENCY REHABILITATION PROGRAM FOR TYPHOON-DAMAGED WATER SUPPLY SYSTEM IN LEYTE IN THE REPUBLIC OF THE PHILIPPINES

JUNE 1993

KYOWA ENGINEERING CONSULTANTS CO.,LTD.

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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a basic design study on the Project for Emergency Rehabilitation Program for Typhoon-Damaged Water Supply System in Leyte and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Masao Takai, Deputy Director of Planning Division, Grant Aid Project Management Department , JICA, from January 27 to March 5, 1993.

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. Then, a mission was sent to the Philippines in order to discuss a draft report 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 teams.

June, 1993

Kensuke Yanagiya
President
Japan International Cooperation Agency

June, 1993

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 Emergency Rehabilitation Program for Typhoon-Damaged Water Supply System in Leyte in the Republic of the Philippines.

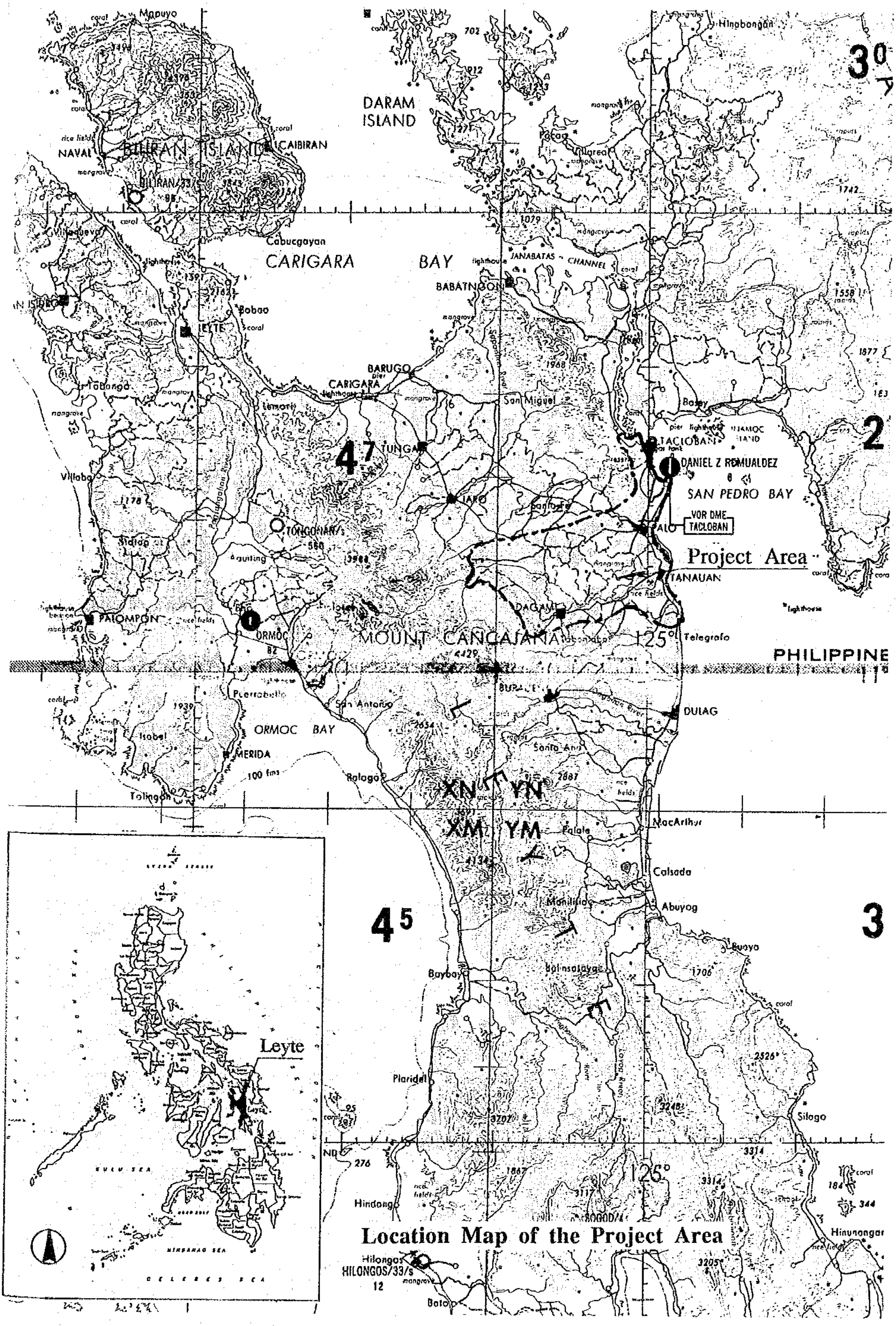
This study was conducted by Kyowa Engineering Consultants Co., Ltd., under a contract to JICA, during the period January 19, 1993 to June 25, 1993. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Philippines and formulate the most appropriate basic design for the project under Japan's grant aid scheme.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Health and Welfare. We would also like to express our gratitude to the officials concerned of the Local Water Utilities Administration, the JICA Philippines office, the Embassy of Japan in the Philippines for their cooperation and assistance throughout our field survey.

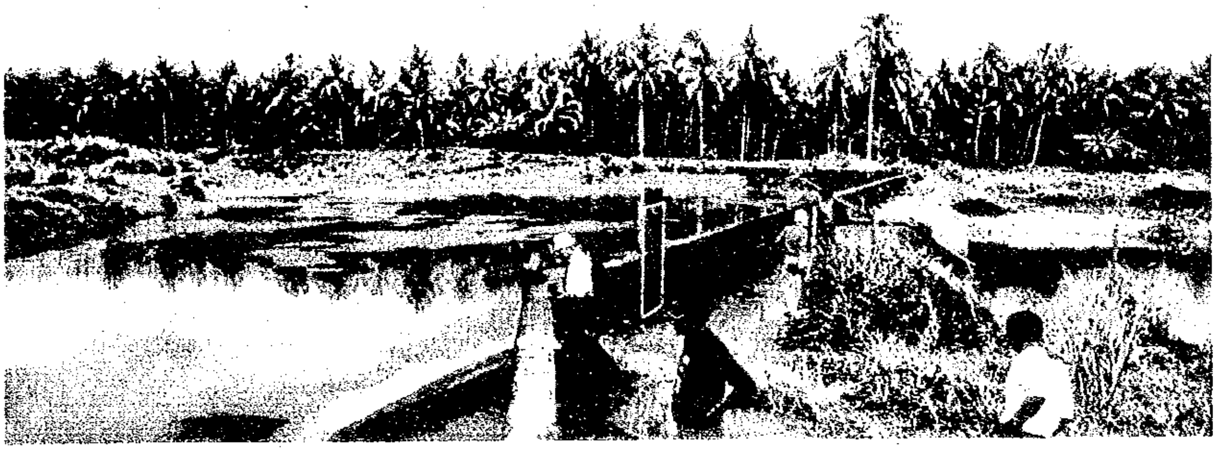
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Mashio Yamaha
Project manager,
Basic design study team on the Project for
Emergency Rehabilitation Program for
Typhoon-Damaged Water Supply System in Leyte,
Kyowa Engineering Consultants Co., Ltd.



Location Map of the Project Area



Entrance side of the existing filters of the Tingib treatment plant

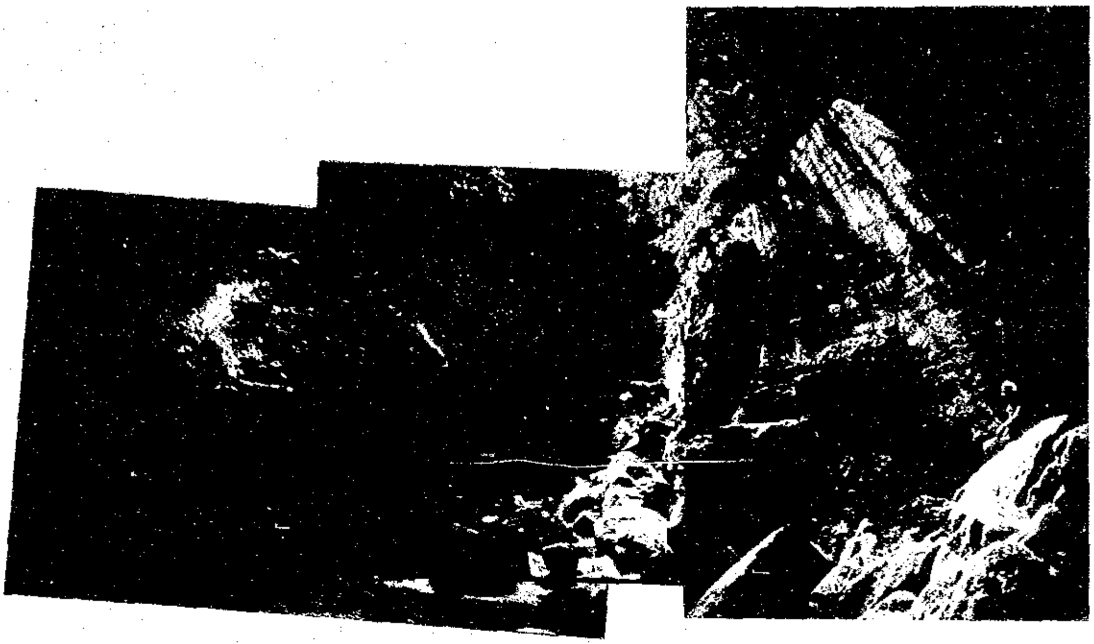
Existing slow sand filters of the Tingib treatment plant

Proposed intake site of the Tingib system

Binahaan River and
a catchment area in
the Central Mountains

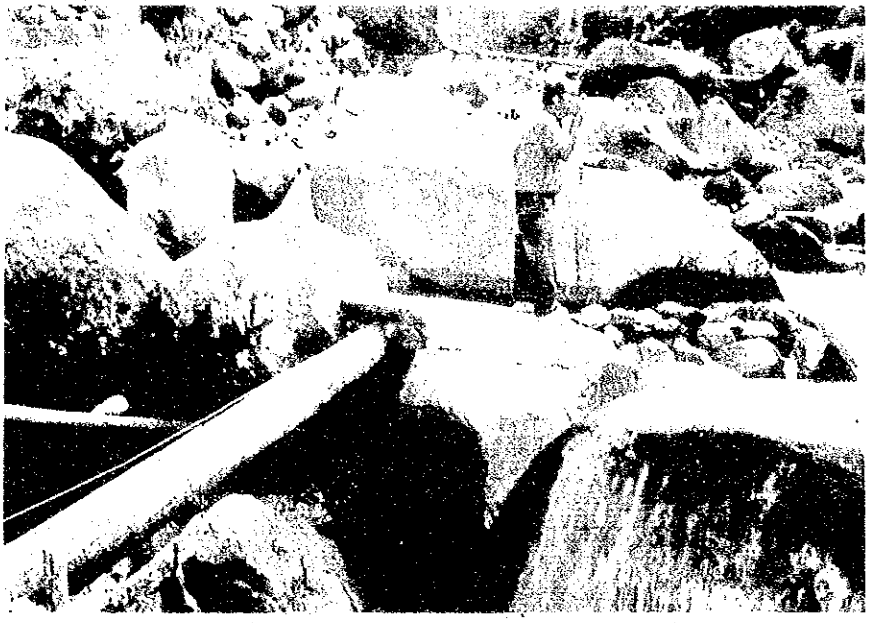
Manually dug settling ponds
constructed inside of the
earth dike of the Tingib
treatment plant

Irrigation canal crossing
of the transmission line
of the Tingib system



Hiabangan dam (in Dagami system), destroyed by Typhoon Uring
The center portion was collapsed and only the abutments of the both sides are remained.

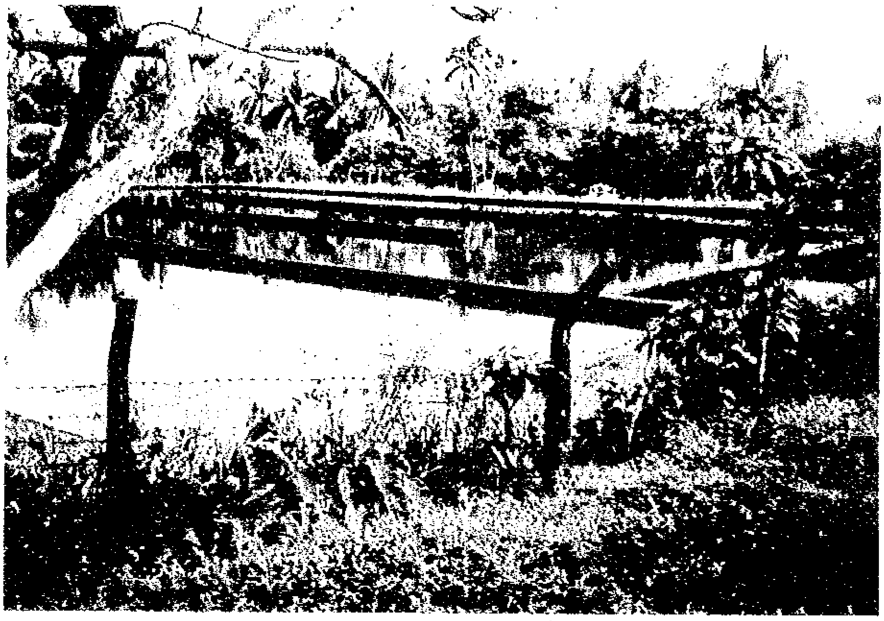
Hitognob dam (in the Dagami system)
Function was recovered as nearly same condition as before the Typhoon by removal of rocks and woods flown into the dam during the Typhoon



Intake installed in
the Hiabangan River
as a temporary measure

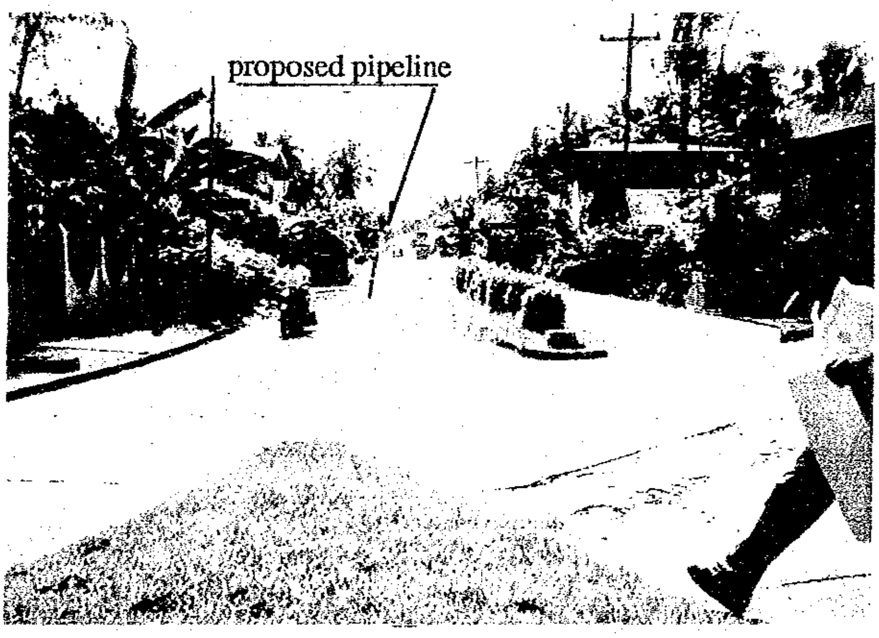
Rehabilitated raw water
conveyance pipeline
(PVC) of Hiabangan dam
as a temporary measure

Existing raw water
conveyance line (CCI)
of the Dagami system



The sedimentation tank
of Dagami treatment plant
which was free from damage
of the Typhoon Uring

Aqueduct of the existing
transmission pipeline
in the Dagami system
which was fallen into
the Quilot River
near Dagami town



Dagami - Tanauan road
where proposed transmission
pipeline is to be installed

SUMMARY

SUMMARY

Typhoon Uring that hit the central region of the Philippines on November 5, 1991 was accompanied by heavy rains recording 140.2 mm in three hours, and caused severe damages to Ormoc City and Tacloban City, two major cities of Leyte Province, and 13 municipalities. The toll of deaths and lost persons amounted to more than 8,000 and the total extent of damage to various infrastructure facilities affected in the area was estimated to be more than 1.02 billion Pesos. Then President, Mrs. Aquino, considering the extensive scale of damage in Leyte Province, specially declared it a disaster area and gave directions to the concerned authorities to plan and implement a rehabilitation program.

Water supply system of the Leyte Metro Water District (LMWD) which serves Tacloban City, the capital of Leyte Province, and the adjoining five municipalities; Pastrana, Dagami, Palo, Tanauan and Tolosa, was badly affected and its water supply capacity was greatly reduced. As a result, about 80,000 of the service population in these communities have been compelled to use water from shallow wells and surface sources etc., which is not satisfactory from the sanitary point of view. This has not only affected their daily life and paralyzed the industrial and economic activities but has also led to the increase of water-borne diseases. Under these circumstances, the LMWD, jointly with the Local Water Utilities Administration (LWUA), has made efforts in implementing some emergency measures to rehabilitate water supply facilities of the LMWD, for example, by construction of river embankments, repairs and rehabilitation works of intake facilities etc. However, the results of these efforts are far too small to put back the facilities to its previous capacity, leaving a situation for example, with the consumers forced to use muddy water from the taps. Therefore, a drastic rehabilitation program has become essential. The Republic of Philippines which is confronted with frequent occurrence of natural disasters such as earthquakes, volcanic eruptions etc., has a very stringent national budget for disaster rehabilitation activities. Therefore, the Government of the Philippines prepared a plan for the rehabilitation of the water supply facilities of the LMWD which needs urgent attention and requested the Government of Japan for Grant Aid cooperation to implement this plan. This request, as its contents shown in the Table S.1, was basically to restore the functions of the water supply facilities of the LMWD which were affected by the typhoon, but also include rehabilitation of some other existing facilities and construction of new facilities.

In response to this request, the Government of Japan decided to conduct a preliminary survey and accordingly the Japan International Cooperation Agency (JICA) dispatched a Preliminary Study mission in November 1992. The survey team while confirming the suitability of this project for consideration under the Japan's Grant Aid Program, also studied on the planning and

Table S.1 Contents of the Request

Facility/ies	Extent of Damage	Original Request
1. Hitognob Dam	The intake wall was totally covered with boulders, silt, forest materials. A portion of the raw water conveyance pipeline was washed away.	Rehabilitation of the raw water conveyance pipeline washed away.
2. Hiabangan Dam	The concrete dam structure was overturned due to high pressure from run-off water. Approximately 500 m of the raw water conveyance pipeline was washed away.	Reconstruction of the intake dam and a part of the raw water conveyance pipeline.
3. Tingib Treatment Plant	The treatment plant was overrun by a flash flood and was totally covered with heavy silt. Damage of the slow sand filter units.	Construction of the sedimentation tanks with a larger capacity. Introduction of coagulation and flocculation processes.
4. Dagami Treatment Plant	The plant is still capable of supplying water although the row water intake dams were damaged.	Introduction of coagulation and flocculation process to the sedimentation tanks.
5. Mini Hydropower System		Construction of mini hydropower system to use the available hydraulic head between Hitognob and Hiabangan intakes and Dagami Treatment Plant. The excess hydraulic head between the Dagami treatment plant and the highest service area of Dagami may be also useful to generate electric power.

organizational arrangements of the Philippine side for the implementation of the project, the scope, scale and effectiveness of cooperation and the scope of basic design study that may be followed, and submitted their findings in the Report on the Preliminary Study.

The Government of Japan, after studying the Report on the Preliminary Study, decided to conduct the basic design study for this project. Accordingly, JICA dispatched a Basic Design Study Team in January 1993. The study team in addition to having discussions with the LWUA, the executing agency responsible for the project, with regards to the contents of the request, carried out field surveys and collected relevant information and data with the cooperation of the LMWD which is responsible for water supply to the project area.

The Study Team, as part of the home study after returning to Japan, prepared a Draft Final Report presenting the team's findings after examining the justification of assistance to the project and the most appropriate scale and composition of water supply facilities. Later, in May 1993, the Study Team was dispatched again to the Philippines to explain the Draft Final Report.

The water supply facilities of the LMWD are comprised of two systems as shown in Fig. S.1, namely the Tingib System which uses Binahaan River as the water source and the Dagami System which uses Hitognob River and Hiabangan River as its water sources. The Tingib

System consists of the Tingib Treatment Plant, a transmission pipeline via Palo to Tacloban City which branches off at Palo to Tanauan and Tolosa. The Dagami System consists of the Dagami Treatment Plant and a transmission pipeline via Palo to Tacloban City. Using these facilities the treated water is distributed to Tacloban City and five municipalities which form the water service area of the LMWD.

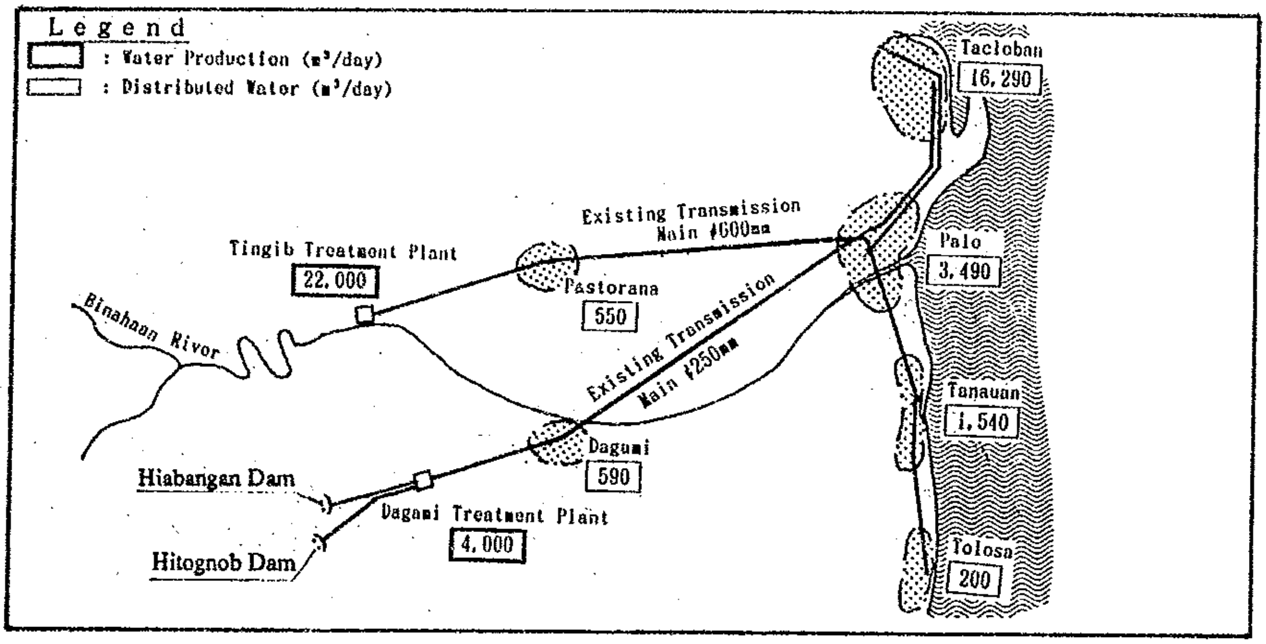


Fig. S.1 Water Supply Condition in the LMWD (before Typhoon in 1991)

Emergency rehabilitation works were implemented soon after the typhoon disaster and the Tingib Treatment Plant has been put back to operation, though inadequate in capacity, after completing the works such as the removal of mud and debris deposited in the sedimentation basin and filters and the construction of a manually dug sedimentation basin. On the other hand in the Dagami System, fortunately the treatment plant was not affected by the typhoon. Rehabilitation works of the Hitognob weir that was slightly damaged have been completed and a simple intake facility built of boulders has been installed downstream of the Hiabangan weir which was completely destroyed and therefore had to be abandoned. Moreover by installing a PVC pipeline in the place of the pipeline that was washed away, the intake capacity has been restored almost to the previous level before the typhoon. As a result of the field survey conducted under the present circumstances, the problems and the points for consideration that became clear with regards to the existing systems are as follows.

Tingib System

(1) The capacity of existing slow sand filter type treatment facilities cannot cope with the raw water drawn from the Binahaan River, which is the main water source of the LMWD, as the turbidity of the water reaches to high levels during rainy periods. Therefore, situations arise frequently when the plant has to be operated in an overloaded condition sacrificing the water quality or the water service has to be suspended thus causing severe inconveniences to daily life of the people and the economic activities in the area.

(2) Of the three filters, one is severely damaged and left without restoration up to now. To compensate for this filter, the thickness of the filter bed in the other two has been reduced and these filters are operated in an overloaded condition thus sacrificing the quality of treated water.

(3) The existing treatment plant is situated within the flood basin of the river and therefore vulnerable to recurring typhoon hazards.

(4) The existing transmission pipeline (Tingib ~ Palo) of this system is well maintained and there is no leakage nor pilferage of water although the functioning of air valves has significantly deteriorated.

Dagami System

(1) The raw water drawn for this system is very good in quality and does not require any specific chemical treatment or electric power thus facilitating an economical water supply. Moreover as the advantages are many in using these water sources, LMWD has a strong desire to continue use of this system even in the future. There are other potential water sources (streams) also available in the vicinity and future development of these resources is anticipated.

(2) Although the intakes of this system pose some instability against floods, as they are of a structure that can be easily maintained and repaired by the LMWD with its level of technical capabilities, there will be no problem about responding to them in the future.

(3) The existing pipeline (Dagami ~ Palo) of this system is laid through paddy fields and marshy lands, and therefore, proper maintenance is not possible and there are many problems of leakage and pilferage of water.

On taking the above into consideration, it became clear that simply the restoration alone of the facilities will not solve the problems of the project area nor will prevent recurrence of typhoon disasters. Therefore, in this project it is considered necessary to realize a water supply capacity, equivalent to what the existing facilities primarily should have, with improvements to the existing facilities and construction of new facilities. However, as this project is placed as an emergency disaster relief project against typhoon damages, the mini hydropower plant which has no relation to the typhoon was excluded from the project scope. The outline of the proposed facilities are as follows. The capacity of the proposed facilities is summarized in Table S.2. The condition of water distribution with the proposed facilities is illustrated in Fig. S.2.

Table S.2 Proposed Treatment Capacity of the Facilities

(i) Tingib System	:	22,000	m^3/day
(ii) Dagami System	:	4,000	m^3/day
Total	:	26,000	m^3/day

The Tingib System

A new treatment plant will be constructed close to the existing facilities at a higher location that will not be affected by floods. As the slow sand filter type facilities cannot cope up with the high turbidity of raw water from the Binahaan River, a rapid sand filter type treatment system will be adopted. The intake facilities will be constructed at a point about 2.6 km upstream of the existing treatment plant while a conveyance pipeline and a maintenance road will also be provided. To restore the functioning of the existing transmission pipeline, the superannuated air valves will be replaced.

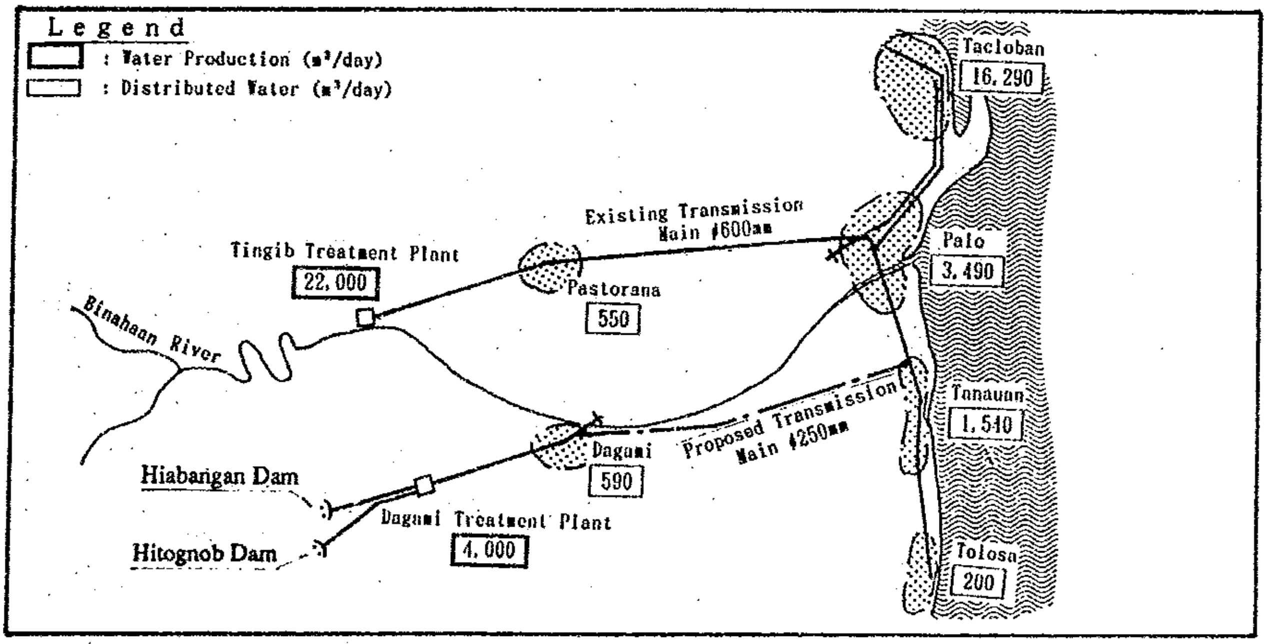


Fig. S.2. Condition of Water Distribution with the Proposed Facilities

Dagami System

The present intake is likely to be affected by a recurring typhoon in the future. However, considering the simplicity of its structure and the adequate technical capability locally available to cope with such an event, rehabilitation of the intake weir will not included under this project. Moreover, in order to maximize the effective utilization of the available high quality water source, the Dagami ~ Palo section of the transmission pipeline will be abandoned and instead a new transmission pipeline will be installed between Dagami and Tanauan.

Procurement of Equipment and Materials

The water quality testing equipment required for the operation of the new treatment plant, a maintenance vehicle required to communicate between the LMWD Office and the treatment plants and the intake facilities, and the PVC pipes required for replacing the deteriorated pipes in the conveyance pipeline of the Dagami System will be procured under this project. The list of facilities, equipment and materials provided in the project is given in Table S.3.

Table S.3. List of Facilities, Equipment and Materials

Facility and Equipment	Type/Specifications	Quantity	
1. Intake /Conveyance facilities			
Intake	Concrete fixed weir	1	unit
Settling tank	Reinforced concrete structure	2	basins
Conveyance line	Ductile cast iron pipe ø 500~ 600 mm	2.48	km
Maintenance road	3.5 m wide, gravel paved	2.60	km
2. Treatment facilities			
Flocculation basin	Reinforced concrete structure, detoured flow type	2	basins
Sedimentation tank	Reinforced concrete structure, lateral flow type	2	tanks
Rapid sand filter	Reinforced concrete structure, natural balancing self backwashing type	8	ponds
Clear water reservoir	Reinforced concrete structure	1	pond
Chemical feeding facility	Reinforced concrete structure, lime and alum mixing	1	set
Chlorination facility.	Wet chlorine doser	1	set
Transformer facilities	13.2/7.62 KV/220, 60Hz	1	set
Emergency power generator	Diesel engine, 100 KVA, 130 Ps	1	set
Buildings	Administrative building, Chemical feeding room, Chlorination room, Generator room	1	set
Connection to existing transmission pipeline	Ductile cast iron pipe T-3 type, 500 mm,	420	m
3. Transmission facilities			
Repairs to existing pipeline	Replacement of air valves	1	set
Installation of new pipeline	Ductile cast iron pipe T-3 type, 250 mm	14.2	km
4. Procurement of equipment and materials			
Water quality testing equipment	for routine tests	1	set
Maintenance vehicle	4 WD Vehicle pick-up type	1	unit
PVC pipes	PVC pipe ø 200~250 m,	1	set

The executing agency on the Philippine side responsible for this project is the LWUA, but the facilities will be transferred to the LMWD for operation after their completion.The new treatment plant is planned to be operated by a 16 member staff including the Plant Manager. It is desirable that the key technical staff be selected from among the present employees of the LMWD.

An estimated additional cost of about 4.3 million Pesos would be required annually for operating the new facilities, whereas an additional annual revenue of about 9.8 million Pesos is expected on account of the increased water supply. Therefore it is judged that future operational expenses could be secured without a problem.

When this project is implemented by Japan's Grant Aid, it is desirable to distribute the works in two phases. In Phase I which requires 12 months, raw water will be conveyed to the existing Tingib Treatment Plant by constructing the intake weir, the settling tank and the raw water conveyance pipeline. In Phase II, the entire project will be completed with the construction of the Tingib Treatment Plant along with the Dagami Transmission Pipeline and for this a construction period of another 12 months will be required. The contribution by the Philippine Government for implementation of this project is estimated at 4.99 million Pesos.

The facilities that are to be constructed under this project are located on safe high ground and will not be vulnerable to a recurring typhoon of the same order as the one of 1991. Moreover, they are of a type which can be operated even when the turbidity of raw water from the river is high. With the implementation of the project, the treatment capacity of the facilities will be restored to 26,000 m^3/day, the level before the typhoon with both Tingib and Dagami systems put together, from the present 21,600 m^3/day which is about 83% of the capacity before the typhoon.

Further, by realizing continuous operation not affected by the high turbidity of raw water from the Tingib River and by replacing the transmission pipeline of the Dagami System which has many problems with regards to leakage and pilferage of water, the billed water volume will increase to 17,200 m^3/day, 66% of the total treatment capacity, from the present 13,000 m^3/day, 50% of the total treatment capacity. As a result, it is expected that the population benefited by the water service will increase to 89,000 from the 77,800, the figure before the typhoon and the 58,700, the figure after the typhoon.

The implementation of the project will also help to reduce the burden on the LMWD which is undergoing difficulties in operations and to bring its financial situation to a sound condition. Moreover, a safe and stable water supply will be assured thus resolving the present situation where the people have to depend on unsafe water from shallow wells etc, as the water is supplied through the taps is often muddy and the water supply is suspended frequently.

Considering these, it is concluded that implementation of this project by Grant Aid of the Government of Japan is meaningful and appropriate. In order to further enhance the impact of the project, it is desirable that the Government of the Philippines will make endeavors to implement the following;

1. Administrative guidance to seek a balance between development activities and protection of the watershed of Binahaan River which is the main source of water.
2. Refraining from direct tapping of water from the transmission pipelines and development of distribution pipeline network inclusive of distribution reservoirs for each independent service area.
3. Rehabilitation of existing distribution facilities including pressure regulating devices of the transmission pipelines.
4. Implementation of proper maintenance work and strict measuring by meters in order to diminish leakage and pilferage and to increase the billed water ratio in the distribution networks.

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Abbreviation

ADB	:	Asian Development Bank
BPW	:	Bureau of Public Works
DAC	:	Development Assistance Committee
DCIP	:	Ductile Cast Iron Pipe
DENR	:	Department of Environment and Natural Resources
DOH	:	Department of Health
DPWH	:	Department of Public Works and Highways
EC	:	Electric Conductivity
EVTELCO	:	Eastern Visayas Telephone Company
FRPMP	:	Fiberglass Reinforced Plastic and Mortar Pipe
GNP	:	Gross National Product
ICC	:	Investment Coordinating Committee
JEM	:	Standard of the Japan Electrical Manufacture's Association
JIS	:	Japan Industrial Standard
JWWA	:	Japan Water Works Association
LEYECO	:	Leyte Electric Cooperative
LMWD	:	Leyte Metro Water District
LWUA	:	Local Water Utilities Administration
MAI	:	Multilateral Assistance Initiative
MWSS	:	Metropolitan Waterworks and Sewerage System
NEDA	:	National Economic and Development Authority
NIA	:	National Irrigation Administration
NPC	:	National Power Corporation
NWRB	:	National Water Resources Board
NWRC	:	National Water Resources Council
NWSA	:	National Water and Sewerage Authority
PAGASA	:	Philippine Atmospheric, Geophysical and Astronomical Service Administration
PNOC	:	Philippine National Oil Company
PVC	:	Polyvinyl Chloride
RIC	:	Regional Industrial Center
RWSA	:	Rural Waterworks and Sanitation
SP	:	Steel Pipe
UNDP	:	UN Development Program
UNHCR	:	Office of the United Nations High Commissioner for Refugees
USAID	:	United States Agency for International Development
WB	:	World Bank
WD	:	Water District

CHAPTER 1. INTRODUCTION

Water supply system of the Leyte Metro Water District (LMWD) which serves Tacloban City, the capital of Leyte Province, and the adjoining five municipalities of Pastrana, Dagami, Palo, Tanauan and Tolosa, was badly affected by typhoon Uring that struck in November 1991 and severe damage was caused mainly to the intake and treatment facilities paralyzing the water supply service. After the disaster although the LMWD in cooperation with the Local Water Utilities Administration (LWUA) implemented some emergency measures such as; construction of river dikes, repairs and rehabilitation works of intake and treatment facilities etc., the capacity of the facilities is still far below from the previous level and therefore a drastic rehabilitation program has become essential. Under these circumstances, the Government of Philippines prepared an emergency plan aimed at the rehabilitation of the LMWD's water supply system which needs urgent attention and the construction of relevant facilities, including a mini-hydropower plant, and requested for assistance for the implementation of this plan by the Grant Aid basis of the Government of Japan.

In response to this request, the Government of Japan decided to conduct a Preliminary Study and the Japan International Cooperation Agency (JICA) dispatched a study team, with Mr. Shigeru Okamoto, deputy director of the 1st Basic Design Study Division, Grant Aid Study and Design Department of JICA as the Team Leader, to the Philippines from 9th to 29th November 1992. The study team while confirming the appropriateness of this project for consideration under the grant aid program, also studied on the planning and organizational arrangements of the Philippine side for project implementation , the scope, scale and effectiveness of cooperation and the scope of basic design study that may be followed, and submitted its findings in the Report on the Preliminary Study.

The Government of Japan, after studying the Report on the Preliminary Study, decided to conduct the basic design study for this project. Accordingly, JICA dispatched a Basic Design Study Team led by Mr. Masao Takai, deputy director of the Grand Aid Project Management Department, JICA to the Philippines from 27th January to 5th March 1993. The survey team had deliberations with the LWUA, the executing agency responsible for the project, with regards to the contents of the request. Further, with the cooperation of the LMWD which is responsible for the water supply service to the project area, the team carried out field studies and surveys and collected relevant information and data with respect to; background of the project, grasping of the contents of the request, organizational arrangements of the executing agency, technical surveys, survey of natural and environmental conditions, survey of typhoon damages, survey of existing facilities, study of related plans, water quality tests, study of design criteria for the planning of project facilities, topographical and geological surveys of the proposed sites etc. Based on the basic findings derived from the above studies and surveys, a Technical Note was prepared presenting a basic concept of the project giving the outline and scale etc., of the facilities to be improved and this technical note was discussed with the LWUA and the LMWD.

The basic items that were agreed upon as a result of the discussions the team had with LWUA and LMWD were recorded as the Minutes of Discussions which was exchanged after signed by the representatives of both sides. Composition of the Study Team, schedule of the study, list of relevant authorities and persons in the Philippines, the Minutes of Discussions, Technical Notes, list of material collected etc., are presented in the Annex to this report.

The Study Team, after returning to Japan, analyzed the information and data gathered through discussions and field surveys, and after examining the justification of assistance to the project, carried out the basic design of water supply facilities for the most appropriate scale and composition. Later, the draft final report was explained to the concerned authorities in the Philippines by a mission that was dispatched from 27th May to 8th June 1993 with Mr. Masatoshi Okubo of the 1st Basic Design Study Division, Grant Aid Study and Design Department, JICA as the Team Leader, and further discussions were held between the two parties regarding the contents of the report.

The present report has been prepared following the steps mentioned above and it presents the details of the basic design.

CHAPTER 2. BACKGROUND OF THE PROJECT

2.1 Damage Caused by Typhoon Uring

2.1.1 Outline of the Damage

Typhoon Uring that struck Leyte Island on 5th November 1991, accompanied a recorded heavy rainfall of 140.2 mm in three hours and floods, and wrecked havoc in 270 Barangays in two major cities and 13 municipalities (shown in Fig.1) damaging 38,294 houses. The total number of people affected was 7,338 including 4,081 deaths and over 1,000 persons reported missing. The number of houses and buildings that were washed away rose to 4,446. Damage to agricultural crops and social infrastructure such as roads, telecommunication and water supply facilities was very high and the total loss has been estimated at 1.02 billion Pesos. Soon after the disaster, emergency disaster relief and restoration activities were commenced by a committee for disaster relief measures, NGOs and religious organizations, etc, and relief goods such as food, blankets, clothing and medicines were distributed with the assistance of the air force. Moreover, the roads were restored with the assistance of the army.

As far as the water supply facilities are concerned, Tingib Water Treatment Plant and the surroundings were completed inundated and buried by the mud flow carried down by Binahaan River which is the main water source of the LMWD water supply system and as a result of this devastating effect water supply was interrupted causing severe hindrance to the urban activities and daily activities of the people.

To find a way out of this difficulty, the LMWD engaged its entire staff in urgent restoration of the facilities with the support from LWUA. LMWD has managed to complete these emergency works for the time being by September 1992 and the capacity of the facilities are being gradually restored though not adequate. As the people of this region are compelled to depend mostly on unsanitary shallow wells for their water needs, risks of the incidence of diseases are also very high. The incidence of diseases in 1991 and in 1992 after the typhoon disaster are compared in Table 1. Increase in the incidence of dysentery in Tacloban City and incidence of typhoid in Palo etc., are remarkably evident from this table and there is a strong and urgent need for the rehabilitation of water supply facilities.

The extent of damage to the water supply facilities and the present situation of rehabilitation works so far implemented with the assistance of LWUA at a total cost of about 8 million Pesos are outlined below.

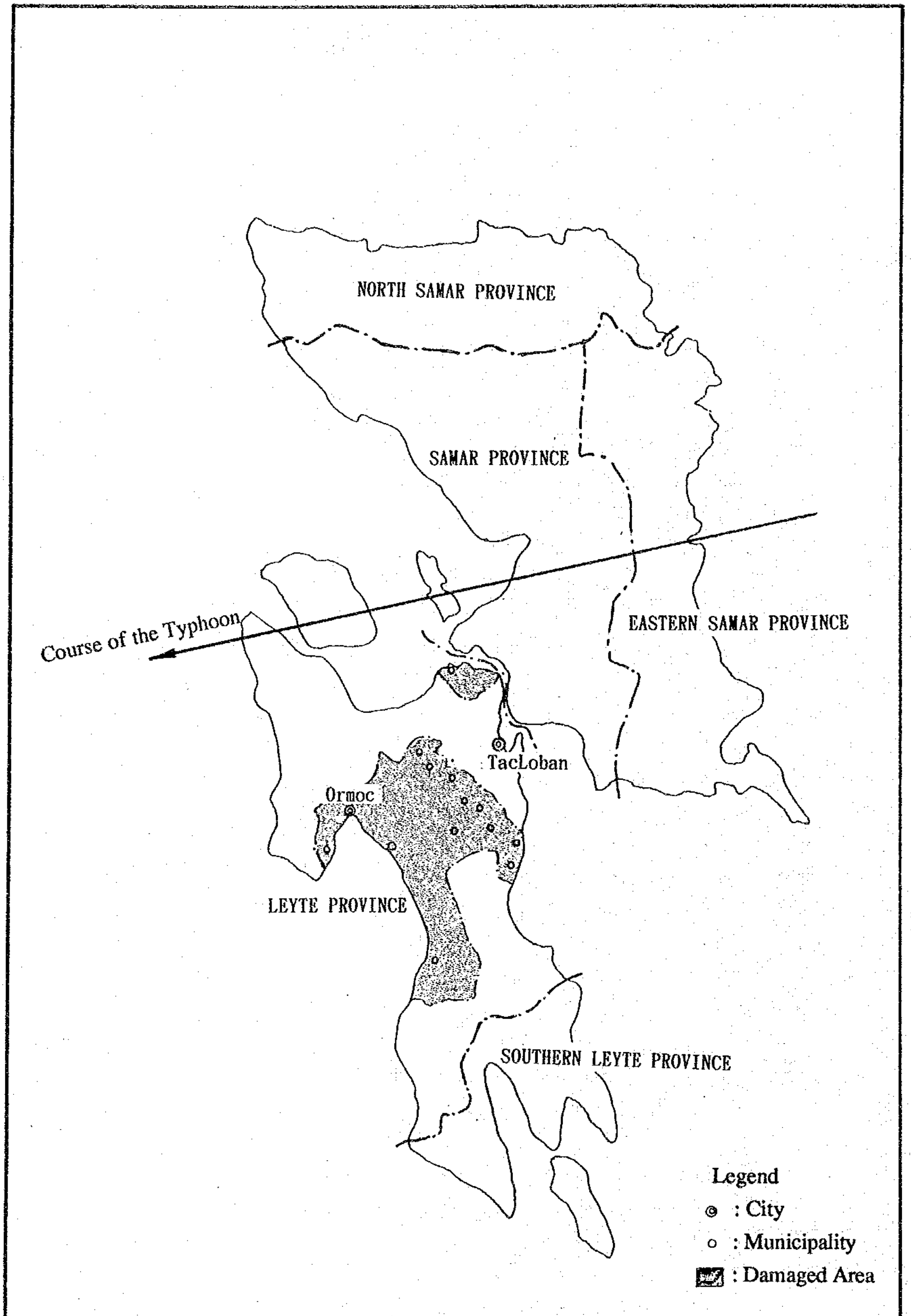


Fig. 1 Disaster Area of Typhoon URING

Table 1 Comparison of the Incidence of Diseases Before and After the Typhoon Disaster

Area	Disease	Incidence in Year 1991		Incidence in Year 1992	
		Total Number	/100,000 persons	Total Number	/100,00 persons
Tacloban City	Diarrhea	766	542	701	482
	Typhoid/ Salmonellosis	30	21	21	14
	Dysentery	31	22	105	72
Palo	Diarrhea	385	1,730	285	1,264
	Typhoid	0	0	20	89

Source: Department of Health, Leyte Province

2.1.2 Damage to Tingib System and Status of Rehabilitation

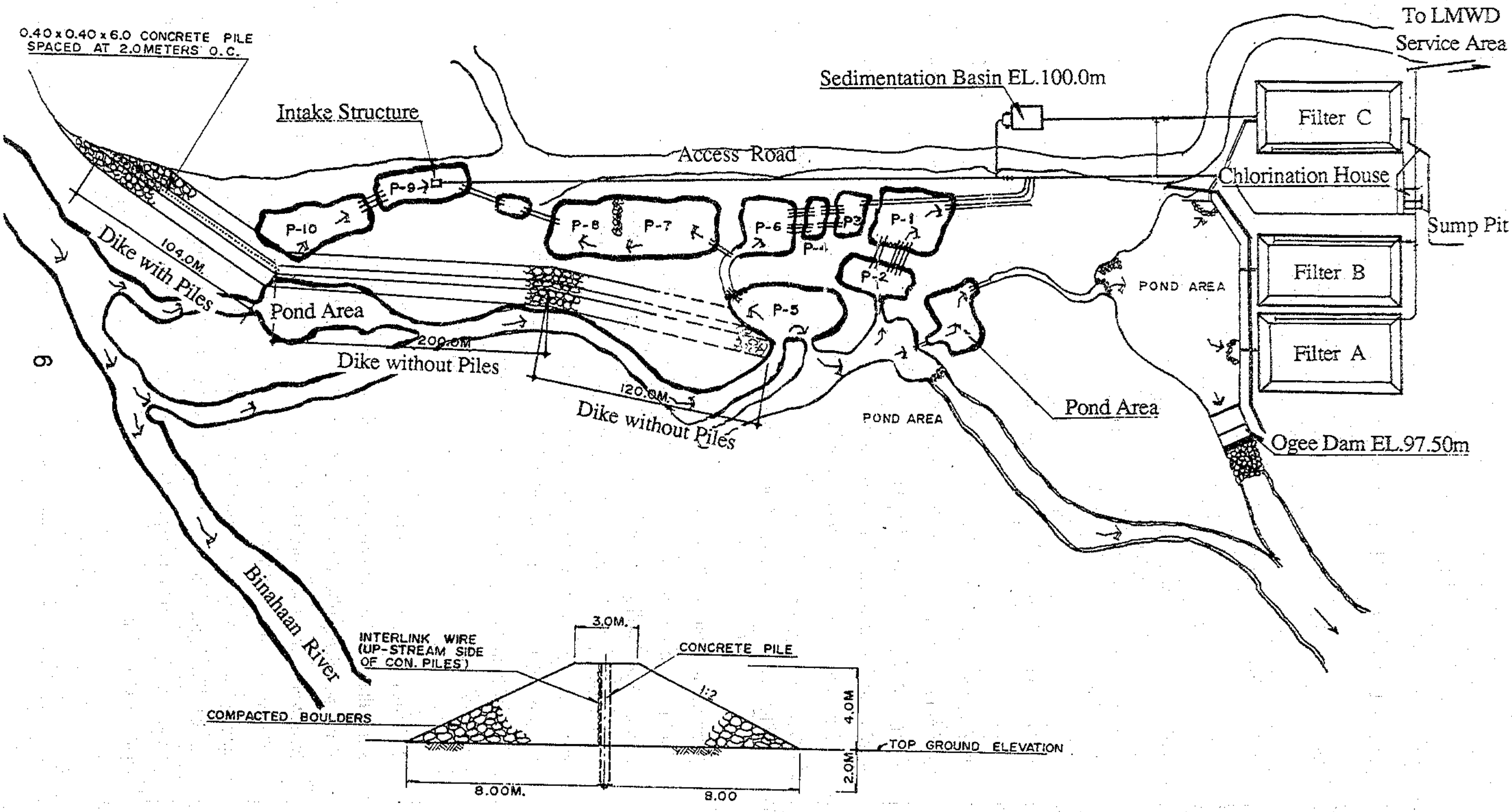
The whole area of the water treatment plant was completely buried with mud flow and driftwood. The earth dike that was constructed downstream of the intake was completely destroyed. The intake, settling tank and the three slow sand filters were buried with mud flow, rubble and drift wood. Due to sedimentation of sand and stones within Binahaan River itself, water routes of the river have shifted significantly. As a result, the entire system from intake to treatment became completely defunct. The emergency rehabilitation works undertaken after the disaster are summarized below. Outline of the rehabilitation plan is shown in Fig. 2.

1. Rehabilitation of the filters

The silt deposited in the three filter basins has been removed. Out of the three filter basins two basins (A and C) have been rehabilitated by replacing the filter material after cleaning, whereas the remaining basin (B) is left as it is because it has been considered that its rehabilitation is impossible as the collecting pipes installed at the bottom of the basin are damaged severely. Even in the two basins restored, the filter bed is very thin and the filters are overburdened in the operation as emphasis is given to the quantity of water filtered by sacrificing its quality to some extent.

2. Construction of earth dike

After the typhoon, construction of earth dike was commenced as the flow pattern of Binahaan River has changed and recurrence of flood was feared. Earth dike on the left bank, which has a trapezoidal cross section with a height of 4.0 m, a width of 3.0 m at the top and 16.0 m at the bottom, is reinforced over a stretch of 104 m from the upstream end with wires tied on to 8 m long 53 concrete piles driven at 2 m intervals along the dike. The adjacent downstream stretch of the dike, which is 250 m long, is constructed without piles and it protects the treatment plant. In the future, dike will be extended by another 70 m bringing the total length to 424 m.



Dike Crosssection

Fig. 2 Emergency Rehabilitation Plan for Tingib Treatment Plant

3. Construction of the manually dug settling pond.
LMWD has constructed 10 manually dug settling ponds and water is drawn into these ponds from the river through intake pipes buried at the bottom of the earth dike. Pipes, which connect these settling ponds one after another starting from the uppermost pond, are provided with nets mounted around the pipe inlet to minimize inflow of suspended matter. Although turbidity of the water is expected to be reduced by natural settlement within the pond, these settling ponds are not effective enough as the finer particles cannot be removed.

4. Rehabilitation of the sedimentation tank and intake
The existing sedimentation tank is a concrete structure and there was no big damage to it. The debris deposited has already been removed. The intake to the sedimentation tank, which is located in a settling pond mentioned above, has been repaired after clearing the deposited debris. Inflow of suspended matter is prevented by covering the inlet of the intake with a net. Although pipeline from the intake to the sedimentation tank has been rehabilitated, circumstances are such that the primary functions of the intake facilities cannot be achieved due to changes in the river flow caused by the earth dike construction.

5. Construction of intake on Maitom Creek
During the rainy season as the turbidity of the water in Binahaan River rises, it is not possible to treat the raw water in the slow sand filter. Therefore, an intake and a 2.2 km long pipeline are being constructed with the purpose of drawing water, even during the rainy periods, to the existing Tingib Treatment Plant from Maitom Creek which does not turn that much turbid. Cost of this construction work is borne by the special disaster funds allocated by the order of the president. Maitom Creek is a small waterway on the left bank of Binahaan River and its confluence with the river is about 1.6 km upstream of the treatment plant. The intake is located at a point approximately 0.6 km upstream of the confluence and a small weir will be constructed here. Maitom Creek which has a very small catchment area is an unstable water source as there is hardly any flow during the dry periods. Therefore these facilities will be used strictly as emergency intake facilities when the intake at existing treatment plant has to be stopped due to high turbidity in Binahaan River.

2.1.3 Damage to Dagami System and Status of Rehabilitation

Out of the two intake facilities located in the hills further west and about 6 km upstream of the Dagami Treatment Plant, Hiabangan weir is completely destroyed and the (ø 250 mm cast iron pipe) conveyance pipeline is broken over a stretch of about 1.5 km from the weir and has been carried away by a landslide. On the other hand at the Hitognob weir, intake was blocked by rolling stones accumulated on the upstream side of the weir, but fortunately there was no much damage to the weir itself. Further, about 30 m stretch of the conveyance pipeline (ø 200 mm cast iron pipe) at the intake end has been washed away.

The entire area around the damaged Hiabangan weir is covered with stones and it is difficult to use the conveyance pipeline. Moreover, without any access roads and the topographical conditions being very bad, these facilities are left without repairs as there is no way to attend to them. However, as an emergency measure, a simple intake structure is constructed in a pit formed by boulders at a point about 1.5 km downstream of the destroyed weir and a PVC pipeline is drawn from this intake over a length of about 200 m to connect with the part of existing conveyance pipeline which is left without being washed away. With this arrangement the intake functions have being temporarily restored. As Hiabangan is a river in which the water routes are changed by the shifting of boulders during torrents, the possibilities are very high that this intake will be affected by floods once again. However, even in the event of such damage this intake could be easily repaired by the local staff because of the simplicity of its structure. On the other hand, the transmission pipeline of Hitognob weir is rehabilitated using PVC pipes and the intake functions have been restored almost to the previous capacity before typhoon disaster. All the ø 250 mm PVC pipes used in the repairs are exposed and deterioration has already begun in some of them under the severe natural environment.

The transmission pipeline which is laid with cast iron pipes is ø 300 mm from Dagami Treatment Plant to Dagami Town, and ø 250 mm from Dagami Town to Tacloban City through Palo. However, immediately after Dagami Town, an aqueduct has fallen and is left without repairs. Since the inside of the transmission pipeline is mortar lined, and as the mortar has peeled off with the fragments accumulated within the pipe as a result of the deformation of pipe caused by the falling of the aqueduct, it is assumed that the flow capacity of the pipeline is obstructed significantly.

2.2 Outline of Water Supply Sector

2.2.1 Water Supply Situation in the Philippines

Water supply service in the Philippines is broadly classified by the region served; Metro Manila Area, the other cities and municipalities and the rural areas. Further, the water supply systems in the regions other than the Metro Manila Area are categorized as follows according to the scale and the level of service;

Level I: With protected well or a developed spring as the source, this system serves about 100 persons within a radius of about 250 m. However there is no distribution system in particular.

Level II: In this system, about 100 households are served using common faucets. Each faucet serves about 4~6 households within a radius of 25 m.

Level III: A system with a source, a reservoir, a piped distribution network and household taps.

As of end of 1987, the coverage of water supply service by population was 86% in Metro Manila Area, whereas in the other areas served by the above systems it was 55% in urban areas and 62% in the rural areas, accounting to a national average of 63%. In the rural areas, where more than half the population live, people depend mostly on water supply direct from wells and springs (See Table 2).

Table 2 Drinking Water Service Coverage by Population (as of end of 1987)
(population in millions)

Classification	Total population	Population served					
		Wells & Springs		Piped system		Total	
		Population	%	Population	%	Population	%
Urban population							
Metro Manila Area	8.16*	0.17	2	6.84	84	7.01	86
Local Urban Area	15.37	2.70	18	5.68	37	8.38	55
Rural Area	33.83	15.38	46	5.40	16	20.78	62
Total	57.36	18.25	32	17.92	31	36.17	63

*Excluding the population of 303,443 in the town of Rizal

Source: Water Supply, Sewerage and Sanitation Master Plan of the Philippines 1988~2000

The existing water supply facilities in the Philippines as of end of 1987 is shown in Table 3. As seen from this table, leaving Metro Manila Area aside, the other urban areas have 214 waterworks systems of Level III, 1900 communal faucet systems of Level II and over 9000 point sources of Level I covering 55% of the population in those areas. In the rural areas, 46% of the population depend on shallow wells, deep wells and developed springs for their water, but they are often faced with sanitary problems. Further 16% of the rural population is served by more than 3000 piped systems of the Levels II or III.

2.2.2 Organization of Water Supply Administration

Water supply administration in the Philippines is implemented broadly by the three institutions mentioned below and several other related agencies.

(1) The Metropolitan Waterworks and Sewerage System

The Metropolitan Waterworks and Sewerage System (MWSS) was established in 1971 with the abolition of the National Water and Sewerage Authority (NWSA) which was

Table 3 Existing Water Supply Facilities (as of end of 1987)

Category/Area	Type of facility	Number	Population served	% of Population served
1. Metro Manila Area	Dams	4	7,008,000	86
	Tunnels	2		
	Aqueducts	7		
	Treatment plants	2		
	Balancing reservoirs	2		
	Pipelines	3,000		
	Pumping stations and reservoirs	9		
	Active deep wells	118		
	Fire hydrants	2,350		
	House service connections	534,900		
2. Other Urban Areas	Waterworks systems			
	Level III	214	3,970,000	26
	Level II	1,900	1,710,000	11
	Level I	9,000	2,700,000	18
	Sub total		8,380,000	55
3. Rural Areas	Waterworks systems			
	Level I	667,808	15,380,000	46
	Level II & Level III	3,232	5,400,000	16
	Sub total		20,780,000	62
Total water supply population			36,168,000	63

Source: Water Supply, Sewerage and Sanitation Master Plan of the Philippines 1988~2000

responsible for water supply in the entire Philippines. MWSS is responsible for water supply administration of the four cities (Caloocan, Manila, Pasay and Quezon) of the Metro Manila Area, Cavite City and 32 municipalities in and around Metro Manila. The total volume of water supplied daily is 2.40 million m^3 and the distribution pipeline network has a total length of about 2,000 km (ø 50 mm ~ 2,200 mm).

Water shortages are continuously experienced as a result of the increased water demand due to growing population and the superannuation of facilities, and therefore a project is now being implemented for rehabilitation and construction of the water supply facilities and distribution pipelines.

Under the Administrator of the MWSS there are seven Deputy Administrators and a staff of more than 8,800 (of which about 4,800 are permanent employees as of end 1991).

(2) The Local Water Utilities Administration

The Local Water Utilities Administration (LWUA), which is the agency responsible for the present project, was established in 1973 as a specialized institution for the purpose of providing financial, institutional and technical assistance to the Water Districts (WD). By the Circular of 1987, the functions of the LWUA were expanded to include assistance to the Rural Waterworks and Sanitation Associations for Level II type water supply systems. As of September 1992, LWUA has combined 618 municipalities in to 560 water districts and assists 390 of these WDs. Moreover, it has completed 327 systems belonging to Level II. The three major functions of the LWUA are as follows;

i) Financial Assistance

LWUA provides loans to WDs at concessionary terms. Therefore LWUA, as the borrowing agency, procures finance from both internal and external, public and private funds.

ii) Institutional Assistance

LWUA provides guidance and training to facilitate smooth institutional operations of the WDs for improvement of public health and benefits to the people.

iii) Technical Assistance

LWUA extends engineering advice for development of facilities.

a) Basic studies

b) Detailed design

c) Guidance on construction supervision, trial operation and operation & maintenance.

(3) The Department of Public Works and Highways

The Department of Public Works and Highways (DPWH), which was established in 1986 after restructuring of the Ministry of Public Works and Highways, is responsible in a broader scale for the implementation of public works and development of social infrastructures such as highways. In the water supply sector, DPWH implements the development of Level I type rural water supply systems, including drilling of wells and development of springs, through its Regional Director's Offices and District Engineers' Offices set up in various parts of the country.

(4) Others

In addition to the above three institutions, there are other agencies which are concerned with water supply administration as given below.

i) The Department of Health

The Department of Health (DOH) is responsible for promoting safe water supplies and exercising surveillance of water quality.

ii) The National Economic and Development Authority

Coordination with lending agencies etc., is done by the National Economic and Development Authority (NEDA) considering the various economic plans.

iii) The National Water Resources Board

The National Water Resources Board (NWRB), successor to the National Water Resources Council (NWRC) and restructured in 1987, is the agency responsible for policy planning of the development of water resources.

2.3 Water Supply Situation in the Project Area

2.3.1 Historical Background of Water Supply System

The original water supply system in the project area was built by the Bureau of Public Works (BPW) in 1936. This system, taking as its water source the surface waters of three rivers namely; Hitognob River and Hiabangan River in the Dagami System and Tigbao River that is located about 4 km west of Tacloban, covered Tacloban City and the three municipalities of Palo, Tanauan and Dagami. Main facilities include three intake weirs built on the three rivers, sedimentation tanks, transmission and distribution pipelines and two reservoir tanks of both the systems. Two years later in 1938, the facilities were transferred to the administration of the District Engineers Office of Leyte Provincial Government. When the National Water and Sewerage Authority (NWSA) was established in 1955, the administrative responsibilities were transferred formally to the NWSA, but the facilities were practically operated and maintained by the District Engineers Office even thereafter. After the LMWD was organized in May 1975, the responsibilities of these existing facilities were transferred to the LMWD. At the same time, Tolosa Water Supply System which had provided water to Tolosa Municipality from wells as the water source was added to the LMWD. Shortly after the transfer, a plan was formulated to review the facilities of the LMWD and respond to the increasing demand. Under this plan, construction of Tingib System, with Binahaan River as the water source was started in 1978 with the financial and technical assistance of the LWUA. The project was completed in 1979, and its operation and maintenance responsibilities were handed over to the LMWD. At that time, the facilities which used Tigbao River as the water source were abolished due to deterioration of water quality. In order to meet the increasing water demand and to respond to the high turbidity of raw water from Binahaan River, the LMWD in 1982 with it own funds constructed a new settling tank, intakes and a third slow sand filter at the Tingib Treatment Plant. At the same time it also implemented expansion works of the distribution pipeline network amounting to a total length of about 55 km. History of the water supply system is summarized in Table 4.

Table 4 History of the Water Supply System

Year 1936	
Administration:	Bureau of Public Works (BPW)
Service Area:	Tacloban City, Palo, Tanauan, Dagami
System:	Completion of the Dagami system - Two intakes on the Hitognob River and the Hiabangan River - One sedimentation tank (7,000 m3) Completion of the Tigbao system - One intake on the Tigbao River - One sedimentation tank (950 m3) Transmission pipeline- 42.9 km Distribution pipeline- 29.5 km Two reservoir tanks at Utap Hill (1,900 m3) and Ambao Hill (450 m3)
Year 1975	
Administration:	Formulation of the Leyte Metro Water District (LMWD)
Service Area:	Tacloban City, Palo, Tanauan, Tolosa, Dagami
System:	Incorporation of Tolosa System into the LMWD
Year 1979	
Administration:	LMWD
Service Area:	Tacloban City, Palo, Tanauan, Tolosa, Dagami, Pastrana
System:	Completion of the Tingib System - Intake on Binahaan River - Two slow sand filters (1,525 m2/filter) - Transmission pipeline (600 mm - 200mm) 47.7 km - Upgrading of the Reservoirs Utap Hill (8,300 m3), Ambao Hill (2,270 m3) - Distribution pipe line 35 km Abolition of the Tigbao System due to deterioration of water quality
Year 1982	
Administration:	LMWD
Service Area:	Tacloban City, Palo, Tanauan, Tolosa, Dagami, Pastrana
System:	Expansion of Tingib system - Intake on Binahaan River - One settling tank (225 m3) - One slow sand filter (1,525 m2/filter) - Distribution pipeline 55 km

Source: Information supplied by LMWD

2.3.2 Water Supply System

(1) Service area

Currently the LMWD provides water to Tacloban City and five municipalities, namely, Palo, Tanauan, Tolosa, Dagami, and Pastrana. In response to the increasing demand for a water supply system in the three municipalities of Santa Fe, Alangalang and Tabontabon which are located adjacent to the existing water service areas, the LMWD has formulated an expansion program of the existing system to include the above three municipalities.

The current water service area is limited to the highly populated urban areas and basically to the dwellings within the range of 100 m on either side along the water transmission pipelines. LMWD has planned to expand the distribution pipeline network to meet the demand of the neighboring areas, but the expansion works have scarcely been executed since 1980 due to lack of budgetary measures. In the area along the transmission pipelines where construction work is somewhat easy, water supply has been gradually provided by connecting branch pipes directly to the main pipelines. Present water service area is shown in the Fig. 3.

(2) Supply Volume and Population Served

1) Condition before the Typhoon

a. Supply Volume

The volume of water consumed monthly (i.e. volume of water billed monthly) from January 1989 to January 1992 is given in Table 5. It indicates how the volume of water supply, which had been constantly increasing until October 1989, has suddenly decreased after November 1991 when the water supply system was damaged by the typhoon.

Table 5 Water Consumption before Typhoon (as billed)

(units: m^3/day)

Month		Domestic	Government	Commercial	Industrial	Wholesale	Total
Jan.	1989	7,914	1,231	1,868	984	28	12,024
Feb.	1989	8,894	1,934	2,199	712	22	13,760
Mar.	1989	8,530	1,310	1,781	390	29	12,039
Apr.	1989	9,425	1,720	2,150	908	48	14,250
May.	1989	9,232	1,870	2,064	1,000	56	14,223
Jun.	1989	9,737	1,947	2,113	963	47	14,807
Jul.	1989	9,671	1,800	2,160	933	41	14,604
Aug.	1989	9,681	1,817	2,247	909	34	14,689
Sept.	1989	10,850	2,006	2,487	857	35	16,235
Oct.	1989	9,695	1,740	2,202	919	36	14,591
Nov.	1989	10,117	1,890	2,329	745	49	15,129
Dec.	1989	9,116	1,741	2,175	660	21	13,713
Jun.	1991	10,555	1,744	2,135	785	70	15,289
Jul.	1991	10,457	1,704	2,343	741	51	15,296
Aug.	1991	11,296	1,787	2,466	806	70	16,425
Sept.	1991	10,817	1,687	2,421	843	58	15,826
Oct.	1991	10,035	1,674	2,355	767	60	14,891
Nov.	1991	7,750	1,194	1,985	216	94	11,239
Dec.	1991	1,818	154	216	2	215	2,405
Jun.	1992	3,629	313	466	290	137	4,834

Source: Information supplied by LMWD

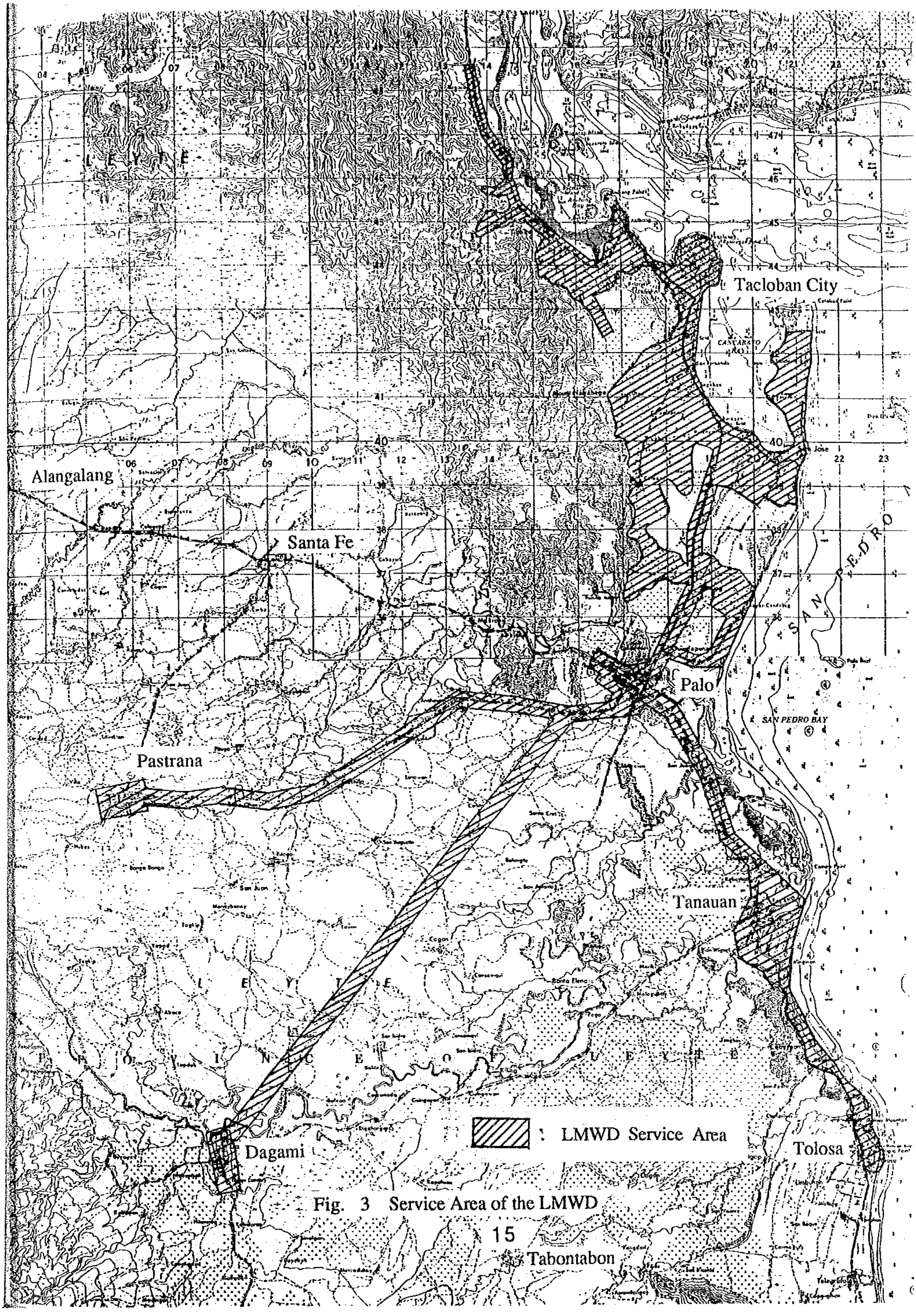


Fig. 3 Service Area of the LMWD

Table 6 shows the monthly average of the volume of water supplied during the five months from June to October 1991 before the typhoon, and the number of service connections at the end of October 1991. The average volume of water supplied daily is 15,545 m^3 and 69 % of this cover domestic consumption. Besides, water is supplied to government and public facilities, commercial and industrial facilities and, though small in volume, to the ships calling at Tacloban Port. Moreover, water is also supplied to 54 public faucets and residents along the main transmission pipelines, though this volume is not metered. The average daily water consumption (as billed) in each district is shown in Table 7. The volume consumed in Tacloban City accounts for 76 % of the whole.

Table 6. Average Daily Water Consumption based on the Billed Records (June 1991 - October 1991)

Sector	Domestic	Government	Commercial	Industry	Wholesale	Total
Consumption (m3/day)	10,632	1,719	2,344	788	62	15,545
Connections (nos)	13,376	270	1,063	24	2	14,734
Unit Consump. (l/day)	795	6,367	2,205	32,833	31,000	1,055

Source: Information supplied by LMWD

Table 7. Daily Water Consumption by Municipality (June 1991 - October 1991)
(unit : m3/day)

Sector	Domestic	Government	Commercial	Industrial	Wholesale	Total	(%)
Tacloban City	8,071	1,136	2,118	436	62	11,822	76
Palo	1,396	485	207	2	0	2,091	13
Tanauan	740	60	17	349	0	1,161	7
Tolosa	94	4	2	0	0	101	1
Dagami	236	10	0	0	0	247	2
Pastrana	95	23	1	1	0	119	1
Total	10,632	1,719	2,344	788	62	15,545	100

Source: Information supplied by LMWD

b. Service Population and Unit Supply Volume

As of October 1991, a total of 13,376 households are registered as consumers of the water supply service in the LMWD. The population in the registered households estimated by multiplying the number of the households by the average number of family members in each area based on the census of 1990 is 72,726 as shown in Table 8. In addition, there are 54 public faucets in the LMWD which are not metered and the estimated population served by these faucets is 5,400 persons (100 persons per faucet). Therefore, the total water service population is about 77,800 including the population served by public faucets. On the other hand, the total volume of water consumed by the households is 10,632 m^3/day as shown in Table 7, and the consumption from the public faucets is estimated at 140 m^3/day (assuming 26 lpcd). Therefore the estimated total consumption is 10,772 m^3/day, and by dividing this by the water service population of 77,800, the unit consumption is estimated to be 138 lpcd. The total population within the District in 1991 is estimated at 270,800 based on the population of 264,500 in 1990 Census and the growth rate of population. This means that 28.7 % of the total population in the District is covered by the water supply service.

Table 8 Population Served with Water Supply as of October 1991

City/Municipality	Number of connections	Average household size (persons)	Water service population		
			in registered households (persons)	using public faucets (persons)	Total (persons)
Tacloban City	9,904	5.5	54,472	1,400	55,872
Palo	1,845	5.3	9,779	2,300	12,029
Tanauan	1,020	4.9	4,998	300	5,298
Tolosa	130	5.2	676	0	676
Dagami	297	5.1	1,515	400	1,915
Pastrana	180	5.2	936	1,000	1,936
Total	13,376	--	72,376	5,400	77,726

Source: Information supplied by LMWD

2) Condition after the Typhoon

a. Supply Volume

Although the supply volume has gradually improved after rehabilitation works were completed in mid 1992 for the time being, only a daily average of 13,000 m^3 of water, 84% of volume before typhoon, has been supplied during year 1992 as shown in Table 9.

Table 9 Water Consumption after Typhoon (as billed)

Month		Monthly (m^3/month)	Daily (m^3/day)
Jan.	1992	149,847	4,834
Feb.	1992	310,630	10,771
Mar.	1992	410,402	13,239
Apr.	1992	462,487	15,416
May.	1992	488,411	15,755
Jun.	1992	454,086	15,136
Jul.	1992	429,712	13,862
Aug.	1992	386,097	12,455
Sept.	1992	444,343	14,811
Oct.	1992	485,839	15,672
Nov.	1992	357,991	11,933
Dec.	1992	398,536	12,856
Average		398,198	13,056

Source: Information supplied by LMWD

b. Service Population

The total water service population after typhoon can be estimated by dividing the domestic water consumption by the unit consumption of 138 lpcd. The domestic water consumption is estimated at 8,100 m^3/day by deducting 4,900 m^3/day of water supplied for other than domestic uses from the total consumption of 13,000 m^3/day shown in Table 9. Therefore, the total water service population is estimated at 58,700. This means that only 75 % of service population before typhoon can be covered by the water supply service.

(3) Outline of the Existing Facilities

The entire water supply facilities in LMWD are comprised in two systems, namely the Tingib System and the Dagami System, as illustrated in Fig. 4. The Tingib System consists of the Tingib Treatment Plant which draws raw water from Binahaan River and a transmission pipeline (ø600 mm - ø500 mm steel pipe) via Palo to Tacloban City. The Dagami System consists of two intakes, the Dagami Treatment Plant, a transmission pipeline (ø300 mm - ø250 mm cast iron pipe) via Dagami and Palo to Tacloban City. The distribution system, consists of four reservoirs (including two elevated tanks) and distribution pipeline network in the service area. The water is supplied to the villages along the transmission pipeline using branch pipes connected to the pipeline which in fact serves also as a distribution main. The outline of the existing facilities is summarized below.

1. Treatment Facilities

The main features of the treatment facilities of the two systems are summarized in Table 10.

Table 10 Features of the Treatment Facilities

Items		Tingib System	Dagami System	
a. Intake				
Water source		Binahaan River	Hitognob River	Hiabangan River
River discharge	(l/sec)	2,545	12	42
Intake discharge	(l/sec)	245	12	34.7
Altitude	(m)	100	752	668
b. Treatment plant				
Facilities		One sedimentation tank (225 m^3) Three slow sand filters (1,525 m^2/filter)	One sedimentation tank (7,000 m^3) ----	
Location		Tingib, Pastrana	Dagami	
Altitude	(m)	97.5	150	
Capacity		22,000 m^3/day	7,000 m^3 (tank)	
Retention time	(hrs)	-----	40	
Sterilization		Chlorine gas (36 kg/day)	Chlorine gas (6.82 kg/day)	

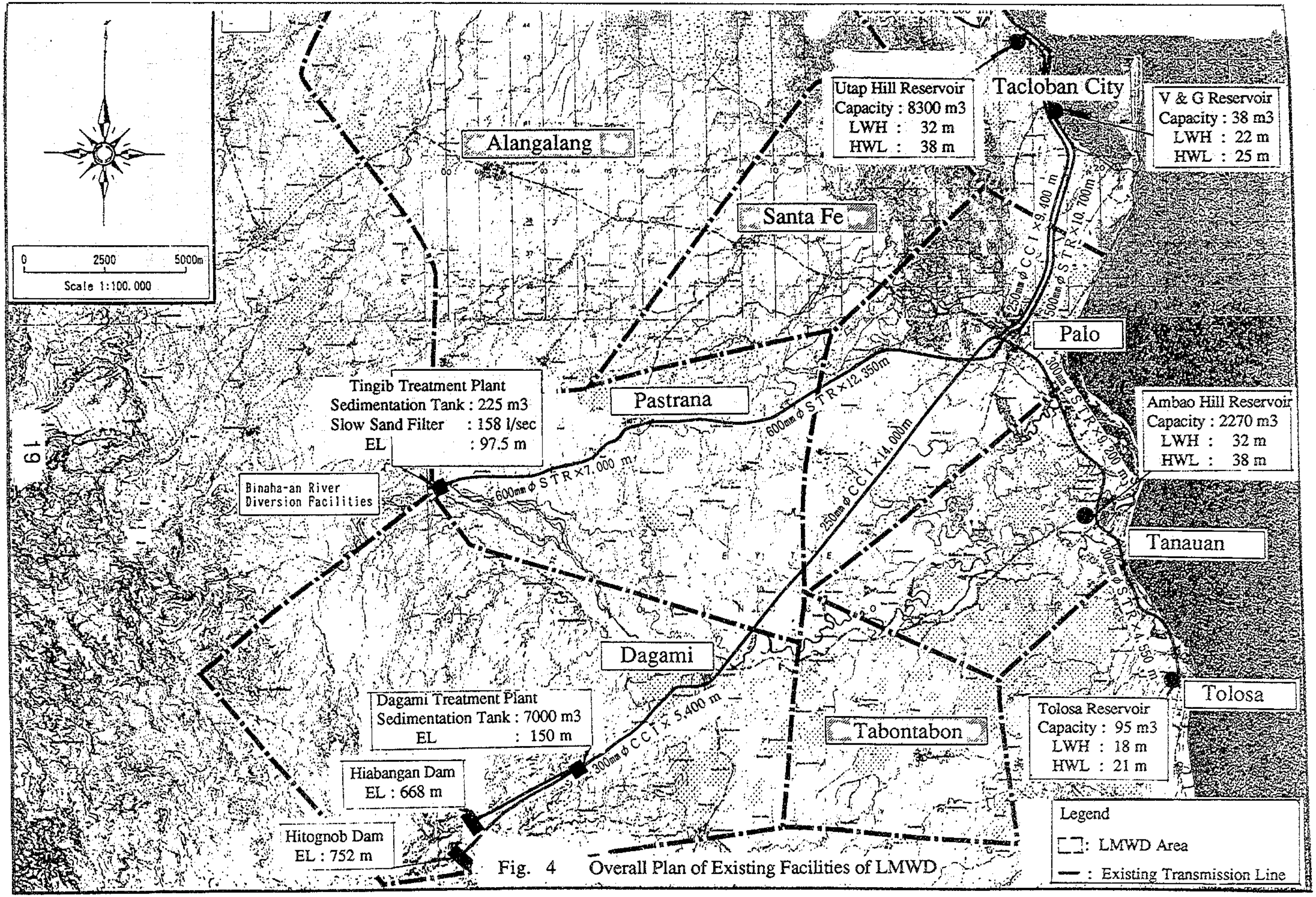


Fig. 4 Overall Plan of Existing Facilities of LMWD

i) Tingib System

The existing Tingib Treatment Plant started its operation in 1979 after the two slow sand filters were constructed. At the initial stages of its operation, the quality of water in Binahaan River was good and it was possible to draw the raw water directly into the slow sand filters without the necessity of pretreatment by sedimentation. In the early 1980s, geothermal power development activities were started in the upstream catchment of Binahaan River and as a result, the turbidity of raw water began to increase. Therefore, a third slow sand filter was added in 1982, and at the same time, a sedimentation tank was newly constructed for pretreatment along with an intake about 400 m upstream.

The operation of the slow sand filters is discontinued to avoid clogging when the turbidity of raw water exceeds 30 degrees. According to the past data the operation had been suspended on six days per month on the average, and in the month October 1992 operation had been stopped for a recorded maximum of 21 days. Even during the field survey for the present basic design study, operation of the treatment plant was stopped for about two weeks due to continuous rains. As the suspension of water supply for long periods can severely affect the civil life, sometimes water is supplied forcibly even if the turbidity is somewhat high. In the water quality tests conducted with tap water during the field survey, the turbidity of the water was found to be more than 10 degrees in some cases. The layout of the existing treatment plant and the structural concept of the facilities are shown in Fig. 5 and Fig. 6.

ii) Dagami System

The Dagami System was constructed in 1936 with the aid from U.S.A. The intake points are located at the two dams built on Hitognob River and Hiabangan River. The Hitognob Dam is located at an elevation of 752 m above sea level, and the Hiabangan Dam is located at elevation 668 m above sea level. Although the intake functions at Hitognob Dam were hindered by mud flow and rolling stones when the typhoon struck in 1991, damage to the dam itself was fortunately very small, and the intake is now restored almost to its previous condition. On the other hand, the Hiabangan Dam was completely destroyed by the typhoon and the conveyance pipeline from the dam was disconnected and washed away in most of its upstream parts laid along the river. At present, water is drawn from a simple intake, made by raising the sides of a pool formed by the rolling stones with concrete and connecting it with steel pipes, located at an elevation of about 500 m above sea level and about 1.5 km downstream of the original intake. As the pipeline beyond about 200 m downstream of the intake had been laid on highground on the right bank away from the river, the stretch of about 4 km up to the treatment plant of the original pipeline remains in good condition without damage. Between this simple intake, which was provided as an emergency measure, and up to the unaffected part of the original pipeline is now connected with a PVC pipeline which is anchored with wires to the trees on the river bank. The base flow of

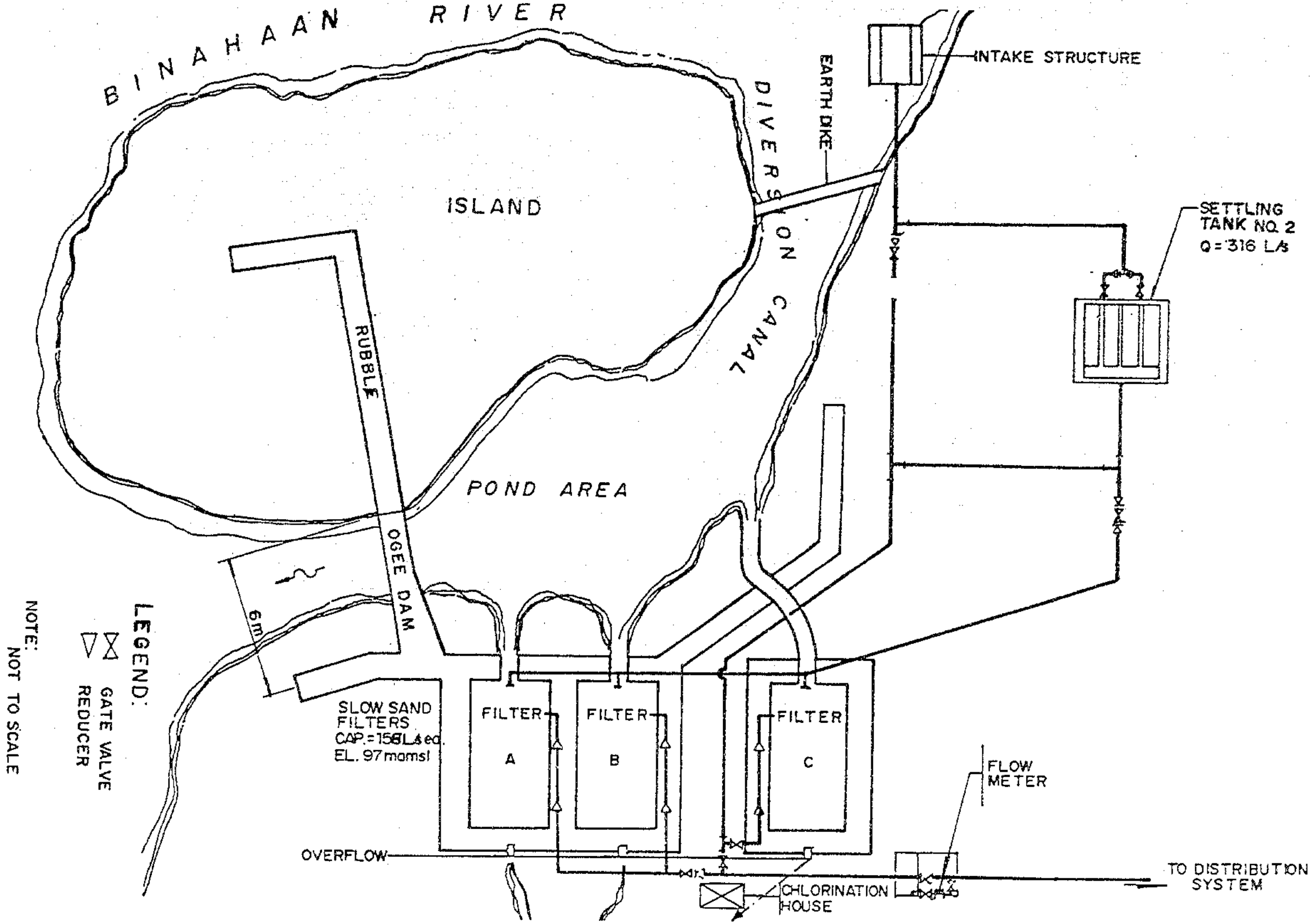


Fig. 5 Layout Plan of Existing Tingib Treatment Plant

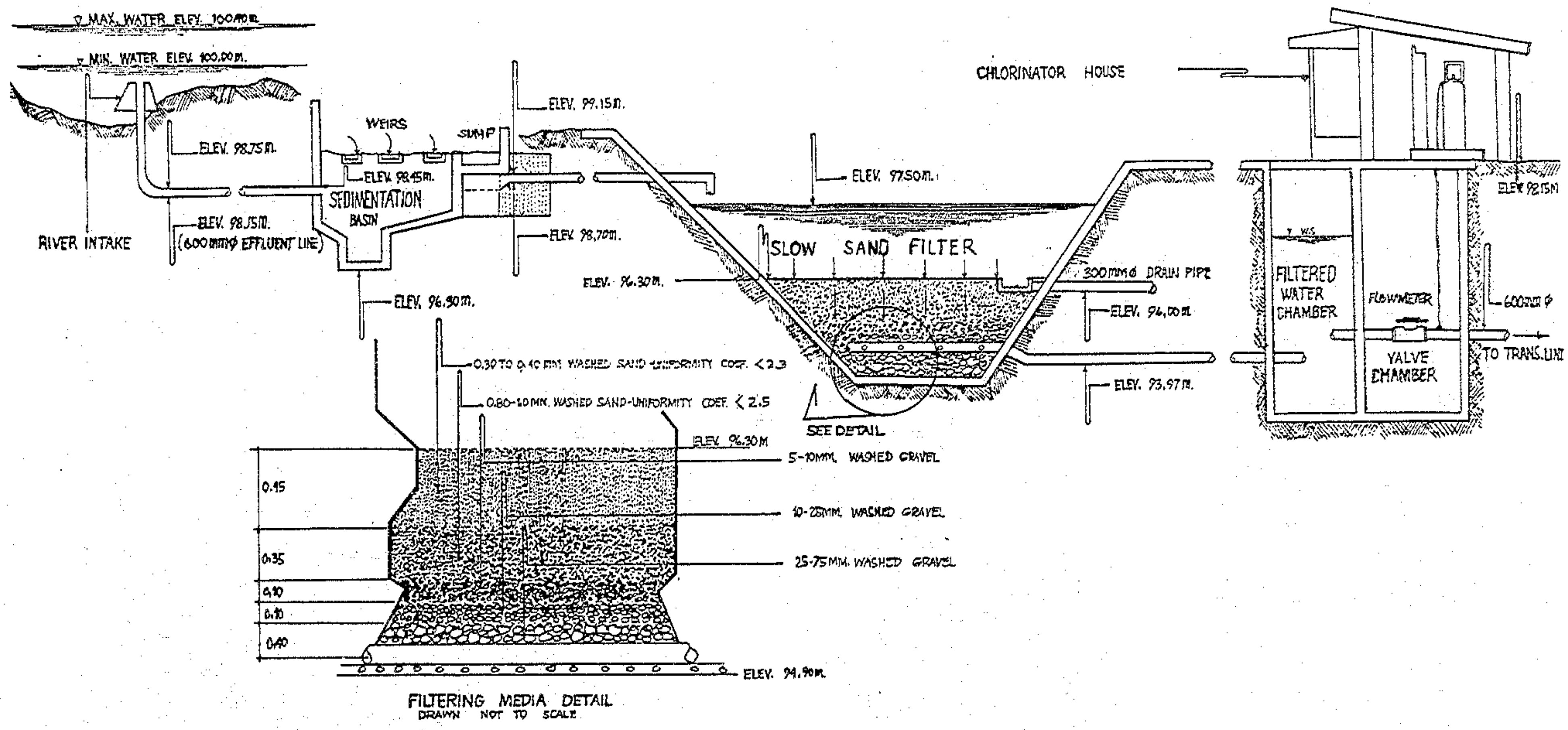


Fig. 6 Structural Concept of Facilities of Existing Tingib Treatment Plant

Hitognob River and Hiabangan River is estimated as 12 l/s, and 42 l/s respectively. The raw water drawn from the two intakes is conveyed by gravity flow to the treatment plant which is located at an elevation of 150 m above sea level. The quality of the raw water is so good that no filtration is required, and the treatment plant is equipped with only a natural settling type sedimentation tank which has a capacity of 7,000 m^3 and a retention period of about 2 days. In the sedimentation tank, water quality is normally maintained at a transparency level of more than 1 m and a turbidity level below 2 degrees. After natural sedimentation, chlorine is injected and the water is then transmitted. The structure of the existing sedimentation tank is illustrated in Fig. 7.

2. Transmission Pipelines

The main features of the transmission facilities of the two systems are summarized in Table 11.

Table 11 Features of Transmission Facilities

Items	Tingib System	Dagami System
Route	Plant - Pastrana - Palo - Tacloban	Plant - Dagami - Palo - Tacloban
Length (km)	7.0 + 12.3 + 10.7 = 30.0	5.4 + 14.0 + 9.4 =28.8
Diameter (mm)	ø600 ø600 ø500	ø300 ø250 ø250
Material	mortar lined steel pipes	cast iron pipes
Year constructed	1979	1936

i) Tingib Transmission Pipeline

The treated water from the Tingib Treatment Plant is transmitted in a ø 600 mm steel pipeline, over a length of about 20 km and the water is served to the villages on the way through Pastrana to Palo. At Palo, the transmission pipeline is bifurcated into ø 500 mm and ø 300 mm steel pipes. The ø 500 mm steel pipeline passes through Tacloban and transmits the water to the Utap Hill Reservoir located in the west end of Tacloban City. On the other hand, the ø 300 mm steel pipeline transmits water to Tanauan and Tolosa areas. The longitudinal profile of the Tingib Transmission Pipeline is shown in Fig. 8.

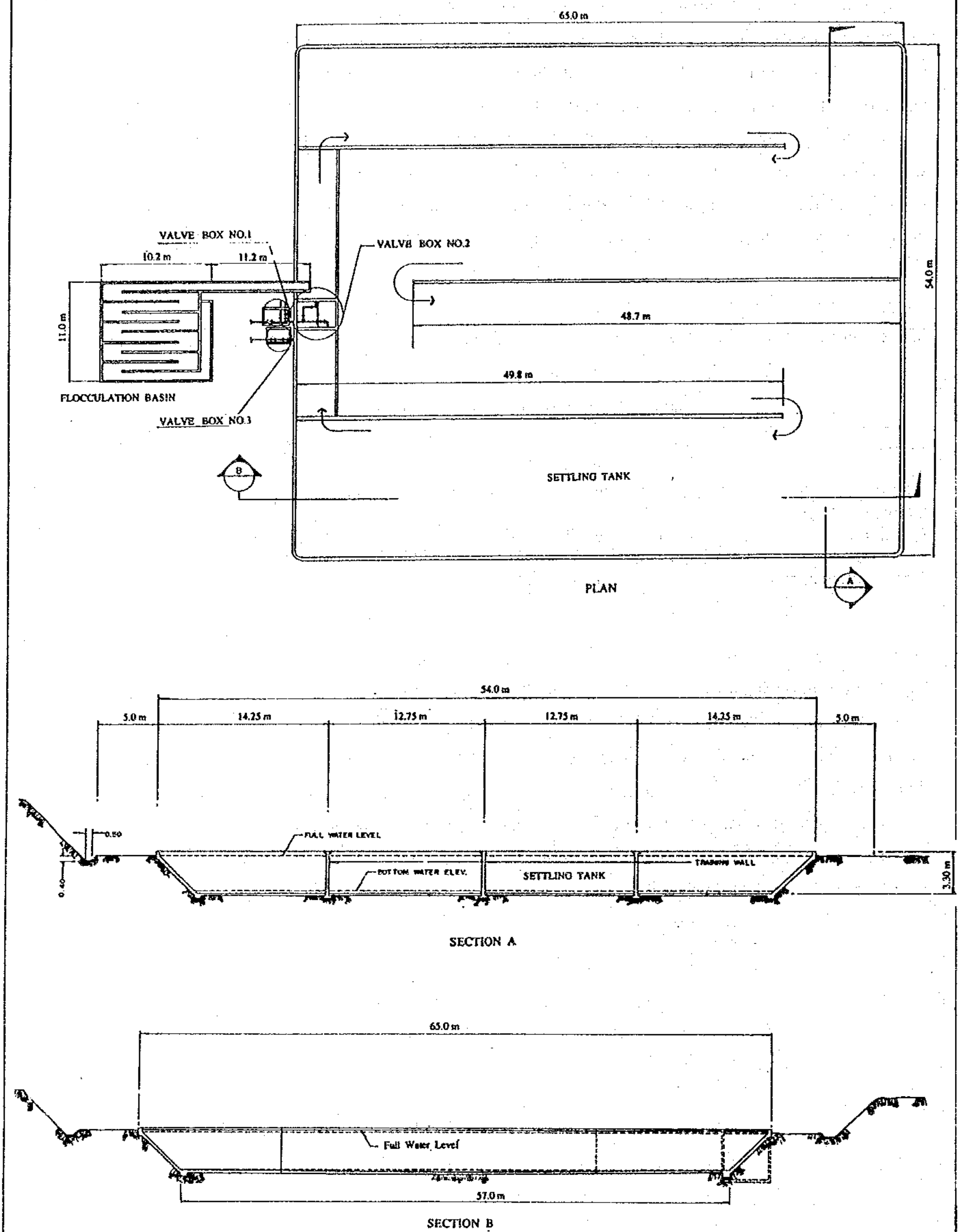


Fig. 7 Existing Dagami Sedimentation Tank

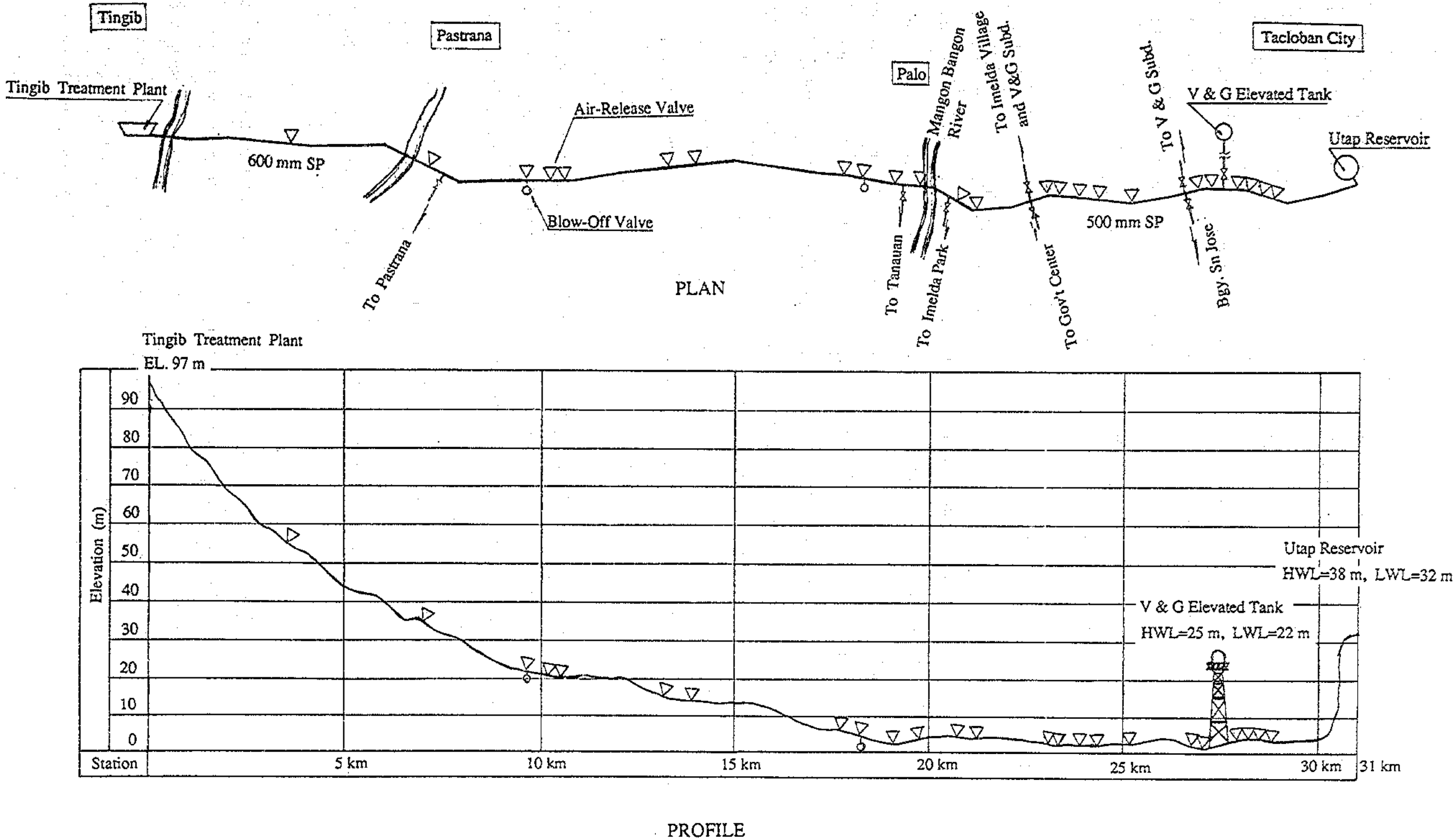


Fig. 8 Longitudinal Profile of Existing Tingib Transmission Pipeline

It is feared that suspension of water transmission during the times of high turbidity in raw water will develop negative pressure temporarily in the transmission pipelines thus causing entry of groundwater or drainage into the pipes. Further, after the transmission is suspended, it takes 18-24 hours until the air entrapped in the transmission pipeline escapes and the normal distribution function is restored. This is because air valves have been installed only at 22 locations within the entire length of 30 km long pipeline from the Tingib to Tacloban, and besides the ventilation performance of these air valves has deteriorated. The pipes in the transmission pipeline are free from damage and are in relatively good condition. The field survey confirmed that there is no leakage nor pilferage of water from the transmission pipeline.

ii) Dagami Transmission Pipeline

The treated water is transmitted from the Dagami Treatment Plant through a ø 300 mm cast iron pipes to Dagami which is located about 5 km downstream, and supplied to the Dagami Municipality. At Dagami, the pipeline narrows down to ø 250 mm and the water is transmitted through the swamps and rice fields to Palo situated about 14 km north-east. Just after passing Dagami, an aqueduct of the transmission pipeline across Quilot River has fallen down thus hindering the transmission capacity. In the stretch of swamps and paddy fields before Palo, proper maintenance of the pipeline is not possible because it is not clear where the transmission pipe is laid, and moreover there are no roads for maintenance. Besides, the LMWD staff cannot approach this area because it is infested with Schistosomiasis. As a result, leakage is high along the transmission pipeline, and moreover, water is often stolen by the inhabitants for irrigation and other purposes thus posing a serious problem.

Dagami Transmission Pipeline and Tingib Transmission Pipeline are inter-connected after crossing the Purisima Bridge over Palo River which flows through Palo City, and it is possible to interchange the transmission by the operation of valves. The longitudinal profile of Dagami Transmission Pipeline is shown in Fig. 9.

3. Distribution Facilities

The distribution facilities include four distribution reservoirs (including two elevated tanks) and the pipeline network.

i) Distribution Reservoirs

At present there are four reservoirs in the LMWD system as shown in Table 12, but none of them functions satisfactorily. In addition to the drop in water pressure within the pipes caused by the tapping of water in the villages along the pipeline, a drop in both volume and pressure is caused by the discontinuation of operation at the treatment plant. As a result, no water is conveyed at all to the Utap Hill Reservoir while even the Ambao Hill Reservoir gets only half filled and this situation is continuing. The V&G Tank that is installed in a residential area developed about 3 km

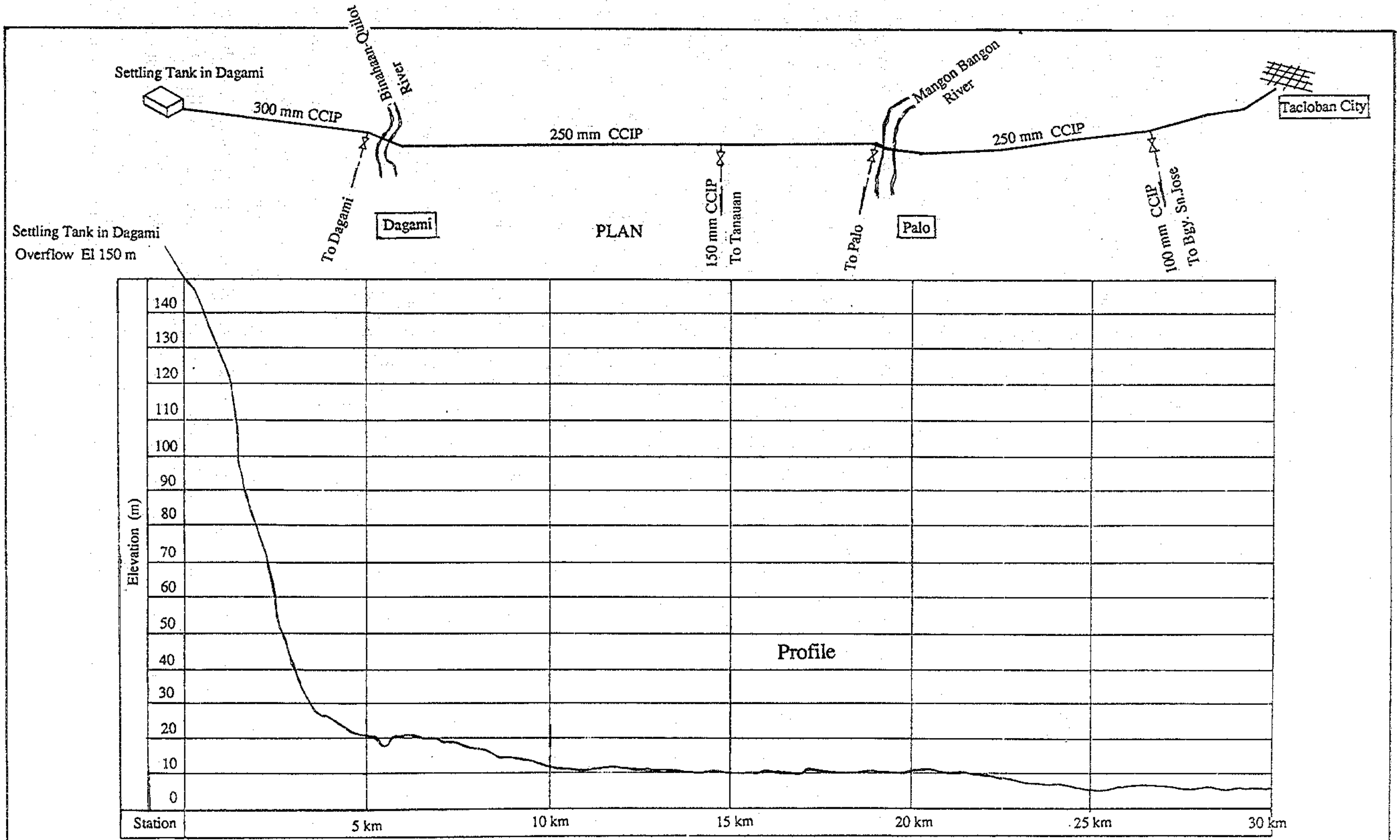


Fig. 9 Longitudinal Profile of Existing Dagami Transmission Pipeline

south of Tacloban City is not used now because the inner surface of this tank has corroded. V&G Tank and Tolosa Tank are small in capacity and their effectiveness as reservoirs is also very small.

Table 12 Features of the Reservoirs

Name	Utap Hill	Ambao Hill	V &G	Tolosa
Location	Tacloban City	Tanauan	Tacloban City	Tolosa
Type	RC, ground	RC, ground	steel, elevated	RC, elevated
Year constructed	1978	1978	1974	1963
Capacity (m^3)	8,300	2,270	38	95
LWL (m)	32	32	22	18
HWL (m)	38	38	25	21

ii) Pipeline Network

The total length of the pipeline network which is installed mainly in the urban areas of Tacloban, Palo, Tanauan,Tolosa, Pastrana, and Dagami is 128.4 km. The main features of the distribution pipeline network is shown in Table 13. The Tingib and Dagami treatment plants are located at higher elevations that the hydrostatic pressure within the distribution pipes in Tacloban city and the coastal area is as high as 90~150 m. Moreover, in this distribution system, the water is transmitted while being supplied to the areas on the way directly from the transmission pipelines. This makes planned distribution of the water difficult, and moreover, hinders the effective utilization of the water in the whole service area. Furthermore, due to the frequent discontinuations of operation of the treatment plants, lack of water pressure and volume is experienced often. Apparently, in some households water is pumped up forcibly by installing a pump directly to the supply pipeline, causing many problems also from the sanitary aspects.

Table 13 Features of Distribution Pipeline Network

Total length of pipelines (ø 50 ~ 300 mm)	128.4 km
Type of pipes	Steel , Asbestos cement, Cast iron, PVC
Year of construction	1938 - 1990
Fire hydrants	138 units
Valves	674 nos.

iii) Wells

Even within Tacloban City and the five municipalities under the administration of the LMWD, people living outside the service area have to depend upon wells for drinking water. As shown in Table 14, according to the census of 1990, it is estimated that there were 15,964 wells in this area most of which are privately owned shallow wells.

According to the inventory of the existing wells, 141 wells are registered in this area including the