CHAPTER 7 WATER SUPPLY MASTER PLAN

7.1 Conditions of Existing Water Supply Facilities

The Study Team surveyed the present condition and the situation of operation and maintenance of existing water supply facilities in the Study Area in 2000. The following matters were checked through the interview with operators for water supply facilities at sites. Method of managing, operation and maintenance of water supply facilities which contains pump and diesel engine generator, etc. and cases of accident in the past and current problems were surveyed. The Study Team executed the survey of the piping route and service area as much as possible in the Study period. The Table-7.1 below indicates the status of the existing water supply system of each Study Area.

Table-7.1 Situations of Existing Water Supply System in 2000

Area	Conditions of Existing Water Supply System	
Popondetta	Operation	24 hours water supplies. Problem on relocation of existing water intake facility and the water treatment plant.
Daru	Operation	18 hours water supplies. Problem of an environmental influence, alternative water source and an existing water source.
Bereina	Non Operation	System non operation since Feb. 2000 due to the breakdown of the existing well pump, generator and etc.
Kupiano	Non Operation	Currently water supply system is non-operation due to breakdown as water intake facilities and conveying pumps.
Kwikila	Non Operation	The water supply stopped since 1994 due to water intake facility's breakdown etc.
Finschhafen	Operation	Water is being supplied without any treatment and chlorination.
Mutzing	Operation	Interrupted supply due to fuel shortage, problem of generator, capacity of existing supply tank. Water supply 3 to 4 times in a day and 1 to 2 hours in one time.
Oro Bay	No Water Facilities	Water supply system is not constructed, yet. Rainwater collecting tank or shallow dug well is used for drinking water supply.

Both of the water supply systems in Popondetta and Daru have respective issues. Though the system has become old and strengthening and expansions of the services are necessary, the existing systems are working and continuously providing water supply services. On the other hand, the water supply systems at 4 District Towns namely Bereina, Kwikila, Kupiano and Mutzing stopped operation due to the trouble and/or damage of water source and/or intake facility in May 2000. Tables-7.2 to 7.9 indicate the status of existing water supply system at each Study Area.

Table-7.2 Conditions of Existing Water Supply Facilities in Popondetta

Existing Facilities		Conditions of Existing Water Supply
Water Source	Bangho River	The water intake facility, that was destroyed by flood in 1997, was temporary restored and is working well. Water intake pump operates for 18 hours in a day.
Power	ELCOM	Power is supplied by ELCOM and the standby generator is set up in preparation for power failure.
Treatment	Treatment Plant	Following facilities are available: Rapid filtration pond, rapid flocculation pond, chlorination (gas), and storage tank (490m^3) of storing water and booster pump (2), etc. Water is supplied 24 hours and treatment is conducted 15-18 hours.
Tank	Tank×2 (23m^3,H:12m)	Water is supplied directly with the booster pump, and existing elevated tank does not function as a water supply facility.
Pipeline	Total Length Approx.25km	The main pipe running from north to south in Town is ϕ150-100mm. The average water pressure in daytime is 2.5kg/cm^2. In the water pressure recorder of 24 hours set up in the water faucet in Town, it is 1.5kg/cm^2 at the morning peak, and 3-4kg/cm^2 at night.

Table-7.3 Conditions of Existing Water Supply Facilities in Daru

Existing Facilities		Conditions of Existing Water Supply
Water Source	Binaturi River	The water intake facilities are two sets of intake pumps and generators. The length of the water transmission pipeline to Daru island is about 16km, and the fuel is transported from Daru to Binaturi pumping station by ship.
Power	Diesel Generator	Power is supplied by public facility, and the standby generator is set up in the water treatment plant in preparation for power failure.
Treatment	Treatment Plant	The water treatment plant consists of the following facilities: Rapid filtration pond, Rapid flocculation pond, Chlorination (chlorinated lime), etc. The old reservoir tank (1620m^3) currently is not used though two storage tanks (1,800m^3, 1620m^3) are in the plant.
Tank	Tank (470m^3)	The water tank is set up on the northern part of Town. Water is supplied from water treatment plant's tank to this water tank by PVC ϕ200mm (about 2.4km), and water is supplied from this water tank to the Town.
Pipeline	Total Length Approx.24km	The main pipeline is ϕ25mm to 200mm. An old ϕ225mm supply line is partially deteriorated.

Table-7.4 Conditions of Existing Water Supply Facilities in Bereina

Existing Facilities		Conditions of Existing Water Supply
Water Source	Groundwater	The submersible motor pump breaks down due to pumping up of sand, and currently the water supply is stopped. Although boreholes constructed in the 60's-70's are existing, none are used due to contamination.
Power	Diesel Generator	The power supply is not reliable. The operation hour is limited due to shortage of fuel and the breakdown of the diesel engine, etc.
Treatment	—	There is no treatment facility and no chlorination.
Tank	Tank×2 ($45m^3$,H:15m)	The elevated tank was used until February 2000. Owing to the corrosion and damage on the deck of the elevated tank, daily maintenance work is difficult though signs of water leakage are not detected in the water tank. Water tank pedestal is corroded.
Pipeline	Total Length Approx. 6km	The main pipeline is ϕ 25mm to 100mm. GSP is mainly used for existing pipeline. The extension of pipeline for about 100-200m was done several times, and washout valves are set up in several places.

Table-7.5 Conditions of Existing Water Supply Facilities in Kupiano

Existing Facilities		Conditions of Existing Water Supply
Water Source	Lako River	Water source is located in the opposite bank of the Marshall lagoon. Water is pumped up by an engine drive pump, for 2km through a ϕ 150mm pipeline.
Power	Engine Driven Pump	Engine driven type similar to intake pump. There are some regions where the water can not be supplied due to the lack of pump head. The electric power supply is limited to certain hours due to the problem of shortage of fuel cost for the diesel engine generator, which a lumber company had handed over.
Treatment	Chlorination	There is no treatment facility, chlorination was used before.
Tank	Water Tank ×2	There are a lot of corroded parts, and water leaks from valves around pipe under the sidewall of water storage tank ($450m^3$). Originally water was supplied from a reservoir tank ($120m^3$) made of reinforced plastic located at the centre of the town, but the system is non-operation due to inadequate booster pump and illegal connections.
Pipeline	Total Length Approx. 8km	Many illegal connections were seen along supply main about 1.2km from the storage tank to the water supply tank in the town, and these illegal-connections create a situation where the water cannot reach the town. Due to undulation in the town, more air valves and washout valves are needed. During the survey, one air valve and 3 washout valves were broken and not used. Pipeline is connected from the town to the remote Gavuone Village located about 3.5km away, and there are six public faucets.

Table-7.6 Conditions of Existing Water Supply Facilities in Kwikila

Existing Facilities		Conditions of Existing Water Supply
Water Source	Kemp Welch River	Water intake pump and facility was removed due to breakdown.
Power	ELCOM	Power is supplied 24 hours by ELECOM. Transmission power line comes from Port Moresby.
Treatment	Treatment Plant	Water treatment plant consists of rapid filtration pond, rapid flocculation pond, chlorination (chlorinated lime), etc. This treatment plant including pump does not operate due to breakdown. The facilities were abandoned more than 7 years ago.
Tank	Water Tank ×5	There are two reservoirs ($114m^3$, $45m^3$) and an elevated tank ($23m^3$) on the hill in the northern part of the town. There were some corroded parts and it is necessary to repair them. Besides, there is a reservoir ($75m^3$) near the Vocational Centre, and another reservoir ($90m^3$) on the hill in the southern part of the town.
Pipeline	Total Length Approx. 4.5km	The water supply from 3 tanks in the northern part of the town goes through Kwikila high school and extends to the town. The high school also has its own water supply system using 2 boreholes. Water supply pipeline in the town that is connected to this school system is making the pipeline network more complicated.

Table-7.7 Conditions of Existing Water Supply Facilities in Finshhafen

Existing Facilities		Conditions of Existing Water Supply
Water Source	Buta Creek	During the dry season, the water supply is in shortage of water due to the decrease in the stream flow. Specifications of the intake pump are 415V, 8kw, 15A, and 287.5 Lit/min 30-50Hz.
Power	ELCOM	Power is supplied 24 hours by ELCOM power plant that is located in the northern part of the town.
Treatment	—	There is no treatment facility, and no chlorination.
Tank	Water Tank×2 ($194m^3$×2)	Water is supplied from two reservoir tanks to the town without treatment. The two tanks ($194m^3$) are set up on the hill besides the airport. The capacity of the existing tanks is sufficient to cover future water demands in spite of water leakage around valves and pipelines.
Pipeline	Total Length Approx.14km	The water pressure at the end of pipeline in the town was $0.3kg/cm^2$ in May 2000, and the 24hours water pressure was recorded showing $0.1\text{-}0.5kg/cm^2$. A PVC pipeline (ϕ 50mm) about 6km is extended from the town to Bugain in the south, and this pipeline connects to another water supply system (GFS).

Table-7.8 Conditions of Existing Water Supply Facilities in Mutzing

Existing Facilities		Conditions of Existing Water Supply
Water Source	Groundwater	The existing borehole is very shallow (5m) with a small discharge. Pumping hours are limited to1 to 2 hours for 3 to 4 times in a day.
Power	Diesel Generator	Existing generator is 165KVA, 415V, and 50Hz. ELCOM power supply started from July 2001.
Treatment	—	There is chlorination but no other treatment facility.
Tank	Water Tank×2	The elevated water tank ($28m^3$) becomes full in about three hours and empties immediately because of the large water demand and small pump capacity. On the other hand, power supply is limited due to shortage of operation cost. Although another water tank constructed in 1997 is available, it is not used effectively.
Pipeline	Total Length Approx. 2.5km	Almost all existing pipeline is GSP (less than ϕ 50mm) and PVC ϕ 40mm is used in some parts of the existing pipeline.

Table-7.9 Conditions of Existing Water Supply Facilities in Oro Bay

Existing Facilities		Conditions of Existing Water Supply
Water Source	Rain water Surface water	There are no existing water supply facilities. Rainwater is used for drinking water. Dug well is used only to wash clothes and to have a bath because the volume of water is insufficient and the salinity is high during the dry season. The river water from upstream is carried by boat for drinking water.
Power	—	Electric power is generated 24 hours for the harbour facilities. Public power is not served in the town. The fishery office generates power in the night time.

7.2 Present Population and Target Year

1) Present Populations of Study Area

Population of Popondetta is 14,556 persons, and population of Daru is 10,286 persons in year 2000. Table-7.10 shows the current population of study area in 2000. Populations of settlements, Villages, and compounds, which are scattered around the central part of the District Town, are floating and unreliable. Therefore, population and households for these areas were collected by District inquiries.

Table-7.10 Existing Populations in Study Area (2000)

Popondetta			Daru		
Ward	Family	Population	Area	Family	Population
Ward 1(north)	460	3,346	Laru	831	3,832
Ward 2(north-central)	295	3,670	Darawaro	322	1,839
Ward 3(central)	915	3,700	Tamate	377	1,807
Ward 4(south-central)	318	1,740	Karakara	554	2,808
Ward 5(south)	212	2,100			
Total	2,200	14,556	Total	2,084	10,286

Study Area	Residents	Schools.	Health Centre	Villages	Total
Bereina	760	–	70	(*1) 513	1,343
Kupiano	839	982	196	(*2) 5,792	7,809
Kwikila	1,180	1,396	170	(*3) 180	2,926
Finschhafen	900	(*4) 1,249	(*5) 920	(*6) 1,159	4,228
Mutzing	500	830	120	(*7) 650	2,100
Oro Bay	(*8) 231	(*9) 763	126	(*10) 3,105	4,225

(*1) includes Toreno No.1, No.2, Ponepone, Paikua, Kuroapaina, hihive No.1.No.2 and Baukeke
(*2) includes Gavuone and Wanigela
(*3) includes Vade compound, Mr. Braun Compound and Makan Compound
(*4) includes Cegerhaphen High School and Vocational Centre
(*5) Buraun Memorial Hospital
(*6) includes Godowa , Tamuc , Timbulim , Buta Compound, Gingala Village and Bugain Village
(*7) includes Sumpubagin Village, Mutzing Village and Intoap Village
(*8) includes Sub-District Administration and Ijividari District Administration
(*9) includes Eroro Primary/Elementary School and Embogo High School
(*10) includes Eroro, Busega, Kopure, Dombada, Embogo and Bema Village etc

2) Target Year

The target year of the water supply master plan is year 2015 based on the official discussions with PNGWB. This period was divided into three stages in this Study, i.e., up to the year 2005, up to 2010, and up to 2015. Daily water consumptions were proposed for each Stage, and based on these consumptions the total supply rates were calculated. Table-7.11 shows the Stages targeted in this master plan.

Table-7.11 Target Year of Master Plan to 2015

Target Year	2005	2010	2015
Stage	Stage-I	Stage-II	Stage-III

7.3 Design Criteria

The Papua New Guinea Waterboard (PNGWB) has its own Design Manual regarding water supply. The PNGWB was initially founded to improve the water supply and sewerage services in urban areas. Therefore, the design manual was also prepared according to the conditions of urban areas.

The manual has not been revised since its initial composition in the early 1980s, and it has been discussed long time within the PNGWB that it should be revised based on the current situations of Papua New Guinea. Because of the facts mentioned above, the design manual does not scenically suit the District Town water supply due to small population and living standard. The PNGWB requires new standards of water facility designs including the new criteria for water consumption.

In this master plan, the following criteria were set based on the discussions with PNGWB staffs and engineers regarding the water supply systems in District Towns and Provincial Towns.

1) Population Growth Rate

The census on a national level was carried out in September 2000. However, the result has not been published yet. Therefore, the population growth rates were analysed based on the census carried out in 1980 and 1990. The average population growth rate was 2.3% in Papua New Guinea, and the growth rates in each Province and District are shown in Table-7.12 below.

Table-7.12 Population Growth Rates in Target Provinces and Districts from 1980 to 1990

Province	PGR	District	PGR
Western	2.83 %	Daru	2.21 %
Central	1.93 %	Bereina	1.99 %
		Kupiano	1.99 %
		Kwikila	1.99 %
Morobe	2.15 %	Finschhafen	1.40 %
		Mutzing	2.15 %
Northern	2.24 %	Popondetta	2.46 %
		Oro Bay	2.46 %

Source: Census in 1990

2) Target Population

The target population of each Study Area was calculated by referring to the census of 1980 and 1990 based on the data of the social survey executed in this Study in 2000. Data on households and population of settlements, which are scattered around the District Town, villages, and compounds, were collected through the individual interviews and others.

Target population was calculated after consideration of water supply areas in each stage and the target year of 2005, 2010, and 2015 as shown in Table-7.13.

Table-7.13 Target Populations for Water Supply by Stages

Site	No. of household in 2000	Population in 2000	Target population for water supply		
			2005	2010	2015
Popondetta	2,080	14,556	16,434	18,559	20,961
Daru	1,470	10,286	11,469	12,796	14,277
Bereina	194	1,343	1,483	1,636	1,805
Kupiano	837	7,809	8,621	9,511	10,495
Kwikila	211	2,926	3,197	3,488	3,821
Finschhafen	297	4,228	4,532	4,858	5,209
Mutzing	163	2,100	2,335	2,598	2,888
Oro Bay	467	4,225	4,770	5,387	6,084
Total	5,719	47,473	52,841	58,833	65,540

3) Daily Water Consumption

In the PNGWB Design Manual, the daily water consumptions were designed as 70 to 225 litres/capita/day in residential areas in Towns, and 40 lit/cap/day in the surrounding settlements and the villages. The following Table-7.14 shows the daily water consumption of the Design Manual.

Table-7.14 *Daily Water Consumptions Designed by PNGWB*

Area	Standard Daily Water Consumption (lit/c/day)		
Residential Areas	High Covenant		225
	Low Covenant		160
	No Covenant		70
	Settlements		40
	Villages		40
Institutional Facilities	Schools	Teachers & Families	As for Residential
		Boarders	160
		Day Students	70
	Hospital	Staff & Families	As for Residential
		In-patients (Per Bed)	450
		Out-Patients & Guardians	40
	Corrective Institutions	Warders & Families	160
		Inmates	115
Commercial Areas	Hotels	(Per Room)	500
	Restaurants	(Per Table)	100
	Shops	(Per $15m^2$)	20
	Offices	(Per $15m^2$)	110
Industrial Facilities	General (Per Hectare)		10,000
	Water Intensive		Special Assessment

Source: PNGWB Design Manual

Based on the results of the social survey and study on the existing facilities a series of discussions was held with PNGWB during the Study in 2000 to conclude the most appropriate quantities of water supplies in the 6 District Towns. The designing was done in accordance with the 3 Stages of the development, Year of 2005, 2010 and 2015 considering present

insufficient water supply situation in the Study Area, and focusing on smooth transition of the operation and management system to a more efficient one.

Among the District Towns targeted in this master plan, the water sources and the existing water supply facilities are defective in some areas, whereas water has been supplied free of charge in some other areas. In this circumstance, it is assumed that applying the above mentioned design manual to the facility design of these areas may tend to lead to over-design and cause difficulties in sustainable operation.

a) A total of 5 levels were categorized in terms of the quantities of water supply: i) residents of Towns, ii)residents of settlements and villagers around the Towns, iii)hospitals, iv)boarding schools and v)offices.

b) The quantity of water supply for the residents of Towns was designed to increase up to 75 lit/c/day gradually until the year 2015 from 65 lit/c/day in 2005.

c) The water supply quantity for the residents of the settlements and the villages surrounding the Towns considering was designed at 45 lit/c/day, which is the necessary amount for drinking water in 2005 to 65 lit/c/day, which includes the use for bathing, in 2015.

d) The quantity of water for hospital patients who require more water was designed twice as much as the quantity for the residents of Towns.

e) The quantity of water for residents of boarding schools was designed between that for the residents of Towns and that for the residents of the settlements and the villages.

f) The quantity of water for the persons who use the water during daytime, such as officers, out-patients of the hospital, and school students, was designed half as much as that of the residents of Towns.

Table-7.15 Level of Water Consumption

Levels	Targets	Remarks
Level-A	· Hospital Patient (bed)	The quantity of water supply is twice as much as Level B.
Level-B	· Formal Residents (Town) · Hospital Staffs & Families · High School Staffs & Families	The quantity of water supply is to be 75 lit/c/day until the target year 2015.
Level-C	· School (Boarders)	The quantity was designed between Level B and Level D.
Level-D	· Village · Settlement	The quantity was designed from 45 lit/c/day, necessary as drinking water, to 65 lit/c/day, the quantity including bathing, until the year 2015.
Level-E	· Office · Hospital Out-Patient · School (Day Students)	The quantity is half as much as Level B as it is used only during daytime.

The proposed quantities of water mentioned above are to be achieved in three stages of years

2005, 2010 and 2015.

Table-7.16 Daily Water Consumption (lit/c/day) – Recommended in This Study

Target Year	2005	2010	2015
Level－A	130	140	150
Level－B	65	70	75
Level－C	55	65	70
Level－D	45	55	65
Level－E	33	35	38

The allocations of the quantities of water mentioned above are aimed at sustainable operation systems for the PNGWB and the consumers in the Study Area.

The water supplies for commercial and industrial uses are also described in the PNGWB Design Manual. Nevertheless, they are not suitable to the water supplies in the rural areas including District Towns. Although there are some grocery shops in the 6 District Towns, it is assumed that these scales are rather small to pay special attentions. In addition, large-scale commercial and industrial water users are unlikely to occur in these areas in the near future. Therefore, in these District Towns, commercial and industrial users were not considered.

7.4 Water Demand

The water demand was calculated as follows. Initially, The Daily Flow (DF) was identified multiplying population by water supply per capita per day. The Average Daily Flow (ADF) was calculated multiplying the DF by a factor. The Peak Daily Flow (PDF) was calculated by multiplying a factor one more time. The factor was set out as below in accordance with the PNGWB Design Manual as follows.

- The average daily flow (ADF) is defined as the sum of the per capita, industrial and commercial demands multiplied by a factor of 1.2 to account for system losses.
- The peak daily flow (PDF) is defined as the ADF increased by a factor of between 1.2 and 1.4.
- The peak hourly flow (PHF) is defined as the PDF multiplied by factor of 1.8 – 2.5 ;the high rations which apply to smaller communities should be used unless otherwise directed.
- The capacity of Water Tank, Storage Reservoir is 50% of PDF.

Source: PNGWB Design Manual

In this master plan, the factor for ADF was set as 1.2, while that of PHF was set as1.5. The volume of a water storage tank was designed as a third of the PDF. The criteria for the water supply in District Towns were defined as follows, Table-7.17.

Table-7.17 Selected Criteria for Water Supply in District Town

Daily Flow	[DF]	= [TP] × [DWC]
Average Daily Flow	[ADF]	= [DF] × 1.2
Peak Daily Flow	[PDF]	= [ADF] × 1.2
Average Hourly Flow	[AHF]	= [ADF] ／ 24
Peak Hourly Flow	[PHF]	= ([PDF]／24) × 1.5
Tank Capacity	[TC]	= [PDF] × 1／3

Note : [TP] = Target Population, [DWC] = Daily Water Consumption

An effective rate of the amount of the water supply in the master plan was assumed to be 1.2, where 1.2 was adopted as ADF coefficient, and 1.5 was adopted in the PHF coefficient in this development investigation based on the Design Manual for the District Town water supply of the above-mentioned. 1/3 of the day amounts of the maximum water supply (for eight hours) were assumed as the capacity of the water tank in consideration of the District Town water supply. The projected water demand for the 6 District Towns are shown in Table-7.18 as below.

Table-7.18 Projected Water Demand for 6 District Towns (lit/day)

Study Area	Demand	2005	2010	2015
Bereina	DF	82,538	103,981	127,167
	ADF	99,046	124,777	152,600
	PDF	**118,855**	**149,732**	**183,120**
Kupiano	DF	109,624	310,127	674,407
	ADF	131,549	372,153	809,289,
	PDF	**157,858**	**446,583**	**971,146**
Kwikila	DF	177,147	205,883	247,184
	ADF	212,576	247,059	296,620
	PDF	**255,091**	**296,471**	**355,944**
Finschhafen	DF	264,417	319,824	376,638
	ADF	317,301	383,789	451,966
	PDF	**380,761**	**460,547**	**542,359**
Mutzing	DF	131,696	165,993	202,265
	ADF	158,036	199,192	242,718
	PDF	**189,643**	**239,030**	**291,262**
Oro Bay	DF	69,071	151,999	395,451
	ADF	82,885	243,614	474,542
	PDF	**99,462**	**292,337**	**569,450**

The tendency of the water consumption in Popondetta and Daru in 2000, which was calculated from sales record of the PNGWB, is shown in Table-7.19, below. The yearly water consumption in Popondetta is 446,800m^3 and Daru is 227,800m^3 in 2000. The industrial water consumption shares 10% of the total water consumption in Popondetta and 8% in Daru. The consumption of the

institutional users is 30% of the total water consumption in Popondetta and 10% in Daru.

Table-7.19 Water Consumption of Popondetta and Daru (2000)

Water User	Popondetta		Daru	
	m^3/year	%	m^3/year	%
1) Domestic	280,400	60%	186,200	82%
2) Industrial	44,200	10%	18,400	8%
3) Institutional	140,200	30%	23,200	10%
Total	464,800	100%	227,800	100%

(Sales Statistics of PNGWB)

The amount of the water demand in Popondetta and Daru calculated based on the above-mentioned data is shown in Table-7.20 below according to the master plan target years in consideration of the effective rate of 1.2% of the population increase and the water demand.

Table-7.20 Projected Water Demands in Popondetta and Daru, 2005-2015 (lit/day)

Study Area	Demand	2005	2010	2015
Popondetta	DF	2,014,420	3,087,393	4,404,553
	ADF	2,417,304	3,704,871	5,285,463
	PDF	**2,900,765**	**4,445,845**	**6,342,556**
Daru	DF	1,156,702	1,751,429	2,468,421
	ADF	1,388,042	2,101,715	2,962,106
	PDF	**1,665,651**	**2,522,058**	**3,554,527**

7.5 Groundwater Development Plan

7.5.1 Existing Water Supply Sources and Groundwater Development

Out of eight Study Area seven have existing water supply systems except Oro Bay that does not have any water supply facility. River water is the main water source of the water supply systems at five areas and groundwater at the other two areas. In Popondetta and Daru, the two Provincial Towns that are managed by PNGWB, river water is pumped at the intake point. Water is supplied to the town after treatment and chlorination. According to the operation record in the year of 2000, Popondetta treatment plant produced and supplied about 1,750 m^3/day of water and the volume of pumped water from river was about 1,800m^3/day. On the other hand, Daru treatment plant pumped river water about 1,250m^3/day at the intake point and about 1,000m^3/day was supplied to the town after treatment. Therefore, the production rate between supply and intake are 98%and 80%, respectively as shown in Table-7.21.

Presently groundwater is used in Bereina and Mutzing. In case of Bereina's water supply system

the submersible motor pump is pumping sand due to bad design of the borehole. Pumping groundwater for the water supply in Mutzing is carried out on an hourly basis because the water supply system does not have its own power source and relies on the diesel generating system of the town that is not a stable supply. In Bereina and Mutzing currently water is supplied without chlorination. Generally groundwater need not be treated, but chlorination is necessary. This is an advantage of groundwater over other sources of water supply and helps in minimizing the operation costs. Especially for the District Towns, this must be important and therefore, groundwater development is targeted under this Study that prepares the master plan for the target year of 2015. Groundwater potential has been examined through geophysical prospecting, hydrogeological study, test drilling and pump testing.

Table-7.21 Present Condition of Existing System in 2000 and Expected Groundwater Development in the Study Areas (2 Provincial Towns and 6 District towns)

Study Area	Status of Existing System	Existing Water Source	Water Intake in 2000 (m^3/day)	Water Supply in 2000 (m^3/day)	Water Supply Efficiency
1. Popondetta	Operation	River water	1,800	1,760	98%
2. Daru	Operation	River water	1,250	1,000	80%
3. Bereina	Stopping	Groundwater	Abandon	Abandon	-
4. Kupiano	Stopping	River water	Abandon	Abandon	-
5. Kwikila	Stopping	River water	Abandon	Abandon	-
6.Finschhafen	Operation	River water	380	380 (no treatment)	100%
7. Mutzing	Hourly operated	Groundwater	50	50	100%
8. Oro Bay	No system	Rain water	-	-	-

7.5.2 Groundwater Development Plan

Based on the groundwater potential per borehole in the Study Area, the master plan for groundwater development was prepared considering the water demand for the target year of 2015 as follows. At the same time, Table-7.22 and Fig.-7.1 (1), (2) and (3) illustrate the water demand and groundwater development plan from 2000 to 2015.

1) Popondetta

From geophysical prospecting and two test boreholes it was observed in Popondetta that there are high groundwater potential aquifers between 70m to 120m below ground level. Sustainable yield by continuous pumping was estimated to be about 850m^3/day/well. However, test boreholes completed with ϕ 6' PVC casing showed only 350m^3/day/well can be pumped from this borehole due to the limitation in actual submersible pump capacity. These two test boreholes can be added to the capacity of 700m^3/day as supplementary source for the existing water treatment plant that is supplying 1700m^3/day in 2000. Concerning groundwater development towards the target year 2015, new production borehole with ϕ 8' to ϕ 10' could supply more than

850m^3/day/well as shown in Table-7.22. As it is indicated in Fig.-7.1(1), for the water demand until 2005, two production wells need to be drilled due to the shortage of water demand. There is confirmed groundwater potential of 850 m^3/day/well, and based on this yield it is assumed that the water demand for the target year 2010 can be supplied by four boreholes with the diameter of more than ϕ 8'. Therefore two additional production wells should be requested. At the same time, it is essential to select a capable and experienced drilling contractor due to the problem of caving-in of boreholes during construction and monitor of water quality containing iron. Groundwater is recharged from surrounding volcanic mountains and groundwater potential is excellent during the dry season even in serious drought affected by El Niño.

2) Daru

Based on the results of test drilling, the yield of 3,250 m^3/day/well with 10m draw down is confirmed by the pump test. However groundwater that was seriously saline contained chloride 700 mg/l. Therefore, it is necessary to ensure and sustain the current capacity of water treatment plant at 1,500m^3/day. Because saline water intrusion is observed in Daru island due to its location surrounded by sea. On the other hand, from the results of geophysical survey, test drilling and hydrogeological interpretation, potential aquifers in shallower depths ranging from 10m to 30m, which could give fresh water. The problem of saltwater intrusion can come from the deeper aquifers because test borehole penetrated more than 30m to 80m depths. Follow up study described in Chapter 6, Table-6.7 indicated the existence of fresh water at the shallower depth of 30m without any disturbances. Therefore, fresh water can be pumped with small drawdown of 1m instead of 10m. The sustainable yield could be 325m^3/day/well with 1m drawdown within Daru island. Currently it is difficult to forecast on how fast the saline intrusion will affect the shallow aquifer. It is recommended to plan the groundwater development as a supplementary water source. The yield of 325 m^3/day/well is expected from the above evaluation. It is necessary to construct one additional borehole and use 2 JICA test wells to meet the water demand in 2010 as shown in Fig.-7.1(1). For the water demand in 2015, additional three boreholes will be required based on the yield at 325m^3/day/well. However, the water demand was studied based on the last 10 years trend of Daru Provincial Town of the Western Province and this could be an over estimate, and further groundwater development may cause saline intrusion. Therefore, raw water intake from Binaturi River is an essential water source in the long term, and appropriate rehabilitation and improvement of the raw water intake facility at U'ume Pumping Station, Binaturi River shall be examined.

3) Bereina

By geophysical prospecting and test drilling, the existence of potential aquifers 12 m below was observed. The sustainable yield of continuous pumping test was estimated at 751m^3/day with 10m drawdown. This test borehole could be used for the production well in Bereina. Adequate quantity of water to meet the water demand in 2015 can be supplied by a borehole as

shown in Fig.-7.1(1). Under the Pilot Project in 2001, pump was installed having capacity of 432m^3/day to cover the water demand up to 2015. When another borehole is planned in the future, it will be very important to select a well-experienced drilling contractor who has capacity to control required mud circulation for drilling technically because there are collapsible unconsolidated formations which are excellent potential aquifers.

4) Kupiano

The results of drilling carried out in Kupiano indicate that the yield of only 77m^3/day could be small and unsuccessful discharge comparing with hydrogeological potentials of 350m^3/day/well in the area. We request one borehole to cover the water demand up to 2010 and two more boreholes for the target year of 2015 will be required. The groundwater development study shall be followed up since high possibility of saline water intrusion exists. The possibility of utilising Iopara spring source to augment the water supply needs to be studied.

5) Kwikila

The groundwater potential (470m^3/day/well with 10m drawdown) in Kwikila was ascertained by the test drilling carried out. This test borehole could be used for the production well in Bereina. Under the Pilot Project in 2001, pump was installed having capacity of 288m^3/day to cover the water demand up to 2005 due to the limitation of pump capacity with ϕ6' PVC casing. Adequate quantity of water to meet the water demand in 2015 can be supplied by one additional borehole in the early stage of 2010 shown in Fig.-7.1(2).

6) Finschhafen

Existence of potential aquifer is ascertained by this Study. From the pumping test result, discharge of about 5,400 m^3/day/well with 10m drawdown is estimated. However, test boreholes of ϕ6' were completed with PVC casing, and showed that only 300m^3/day/well can be pumped due to the limitation of pump capacity. The total capacity of water supply including existing water sources (stream) at 380m^3/day and additional one borehole with yield of 300m^3/day are used, and the water supply capacity will meet the demand of target year of 2015. However, we recommend groundwater as a water source and to reduce the water from river as shown in Fig.-7.1(2). For the long-term plan to meet water demand after 2010, construction of one additional borehole (300m^3/day/well) is planned in the new inland area. The groundwater is high but monitoring of borehole condition is required considering the risk of saline water intrusion in this area.

7) Mutzing

The results of the study indicate rich potential of groundwater with excellent groundwater recharge from Markham river in Mutzing. Their occurrence was referred from geophysical prospecting and test drilling in this Study. There are confined aquifers under the depth of 12m

to 70m. Sustainable yield of the borehole is assumed at 8,640m^3/day or more with 10m drawdown from the pumping test. Therefore, the water demand in the target year of 2015 will be met by one borehole and the pump having capacity of 360m^3/day was installed under the Pilot Project in 2001. And water demand after the year of 2015 can be met with this JICA borehole in 2000 as shown in Fig.-7.1(3). It is observed that aquifer with high groundwater potential is located in the area of Mutzing. Also, it is necessary to get a technically qualified and experienced drilling contractor for drilling borehole in this area since there are unconsolidated Alluvial sediments consisting of gravel, pebble and bolder which may easily collapse while drilling.

8) Oro Bay

The groundwater development of Oro Bay is difficult due to hydrogeological, topographical conditions and saline water intrusion in the Study Area. Geophysical prospecting and test drilling indicate potential aquifers. Three test drillings were carried out in this Study Area but three of them were unsuccessful due to loose boulders with abundant groundwater. By pumping test, sustainable yield about 150m^3/day was estimated at the hilly area near Beama Village. On the other hand, the groundwater development in Kopure estimating potential yield at 700m^3/day/well was estimated by the study and will meet the water demand for target year, 2015 as shown in Fig.-7.1(3). Most of the available land in the area has risk of saltwater intrusion. Drilling in the surrounding inland area away from the Bay which may be customary land is a possibility. In such case, drilling at such area should get the concurrence of the Villages.

9) Considering the eight Study Areas of water demand for target year of 2015, the necessary number of production boreholes were programmed in Table-7.22 as follows. At the same time, test boreholes drilled by JICA during this Study in 2000 were evaluated for groundwater potential to be utilized in the groundwater development plan.

Table-7.22 Groundwater Development Plan, 2000 to 2015

Study Area	Groundwater Potential	Pilot Project 2001	JICA	2005	2010	2015
1.Popondetta	850	-	-	2	2	2
2.Daru	3,250	-	325 x2	JICA	3	3
3.Bereina *	751	432	-	0	0	0
4.Kupiano	350	-	-	1	1	1
5.Kwikila *	470	288	-	1	0	0
6.Finschhafen	5,400	-	300	JICA	1	0
7.Mutzing *	8,640	360	-	0	0	0
8.Oro Bay	150-700	-	-	1	1	0

*) Pilot Project

(Groundwater Potential based on Test Drilling by JICA in 2000: m^3/day/well)

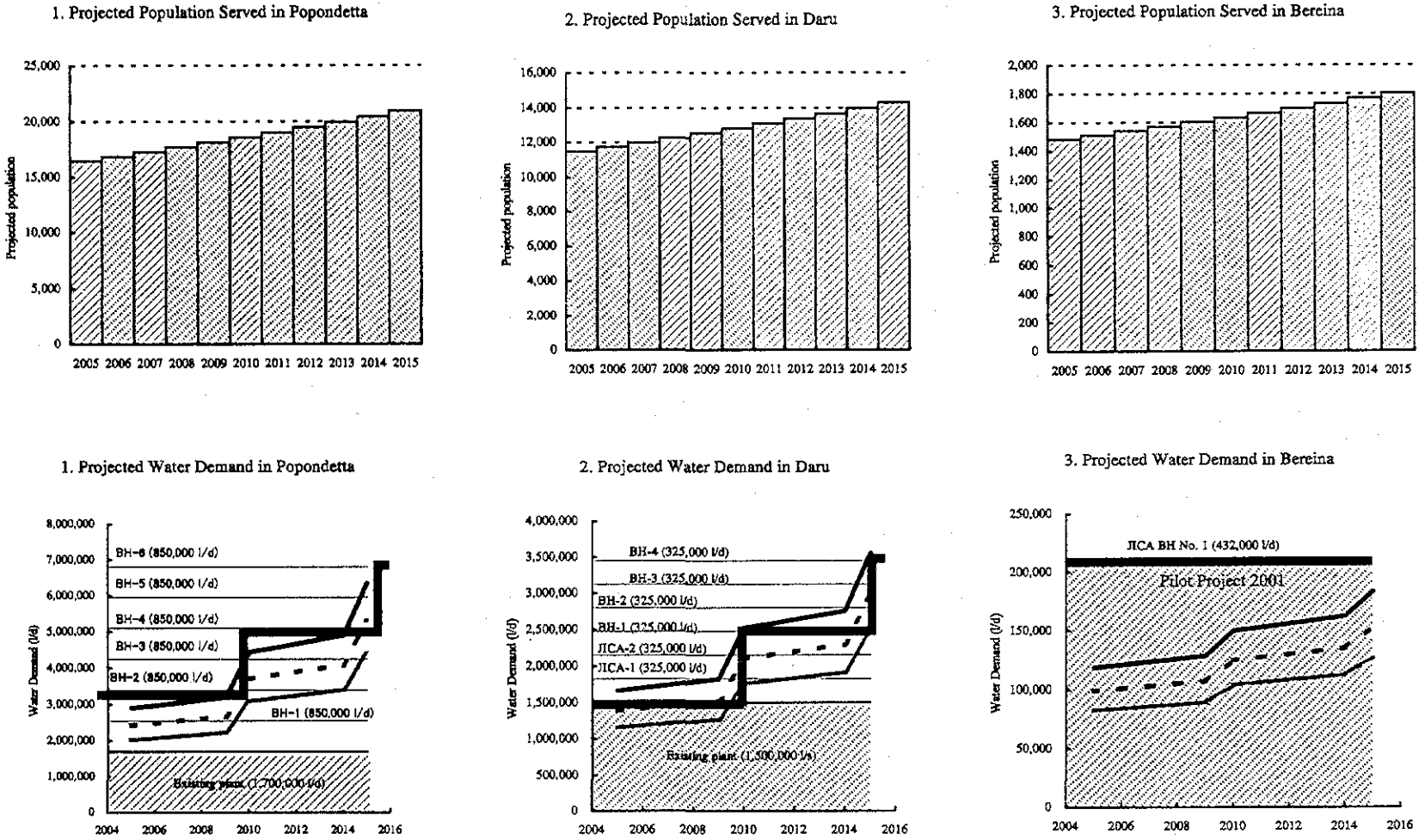


Fig.-7.1 (1) Water Demand and Groundwater Development 2000 - 2015

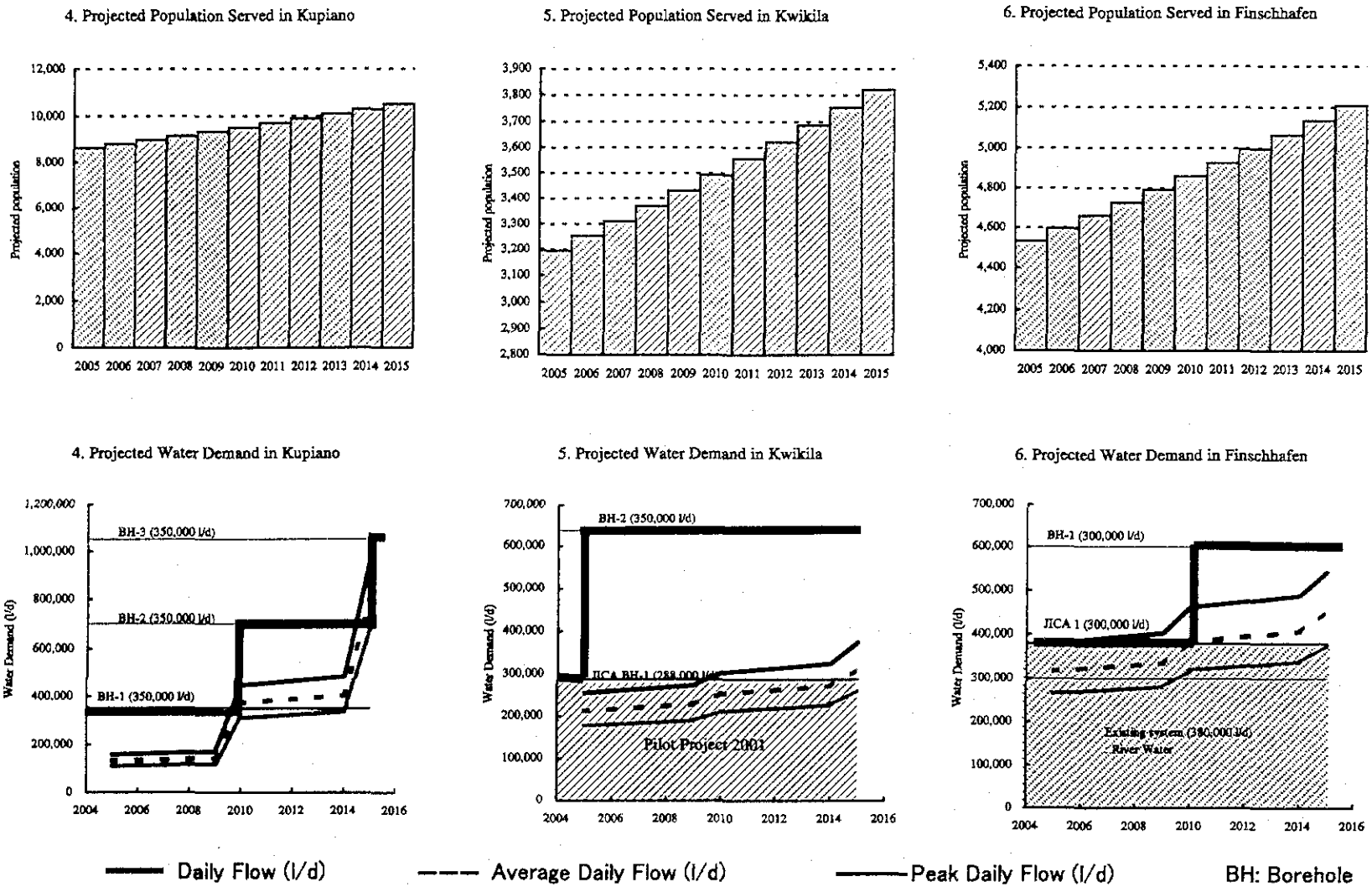


Fig.-7.1 (2) Water Demand and Groundwater Development 2000 - 2015

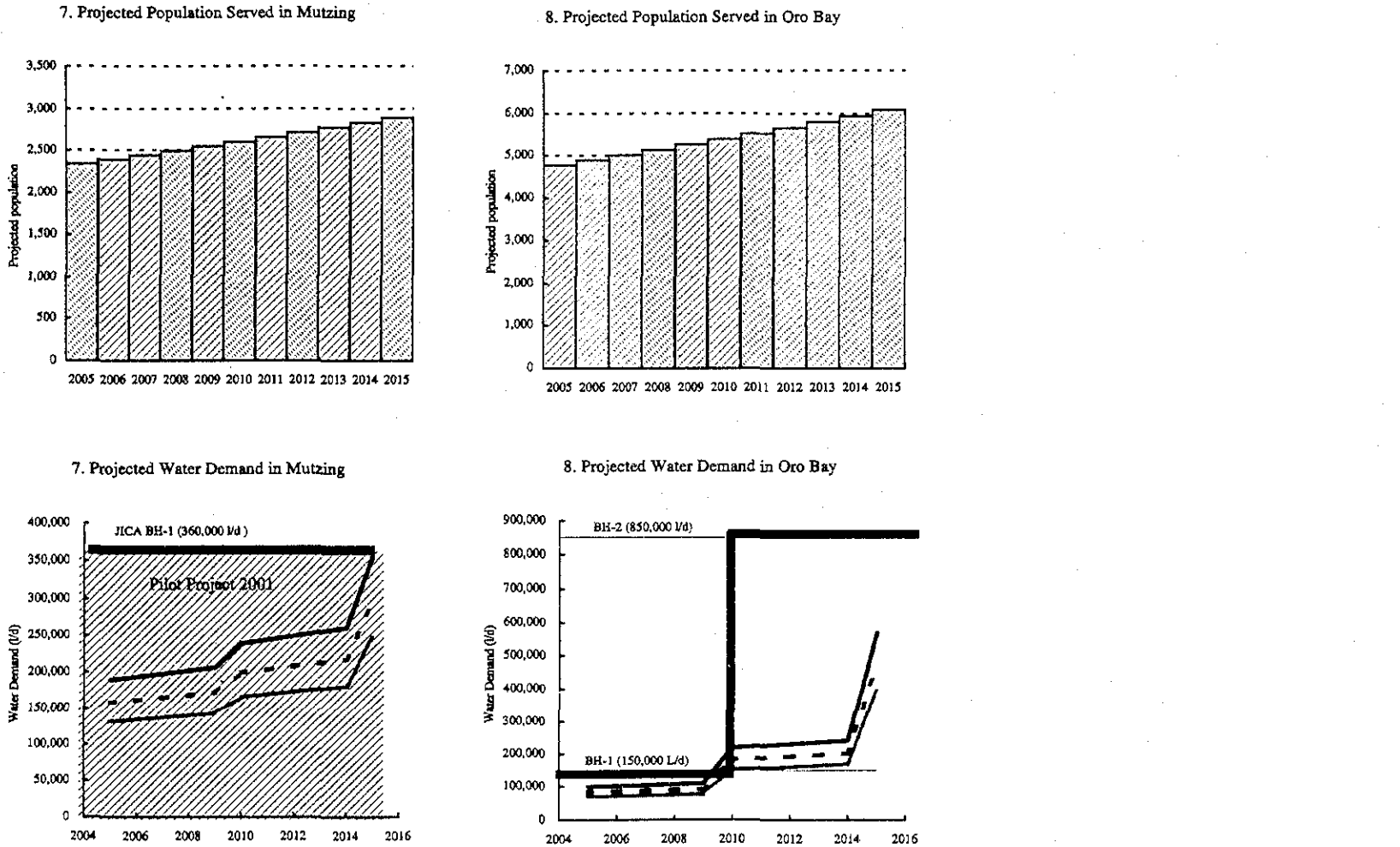


Fig.-7.1 (3) Water Demand and Groundwater Development 2000 - 2015

7.6 Building Codes & Material Standards

1) Building Codes & Standards

As standards of Papua New Guinea, there are the "Building Act", "Building Regulation" and "Papua New Guinea Standard (PNGS)" as following Tables-7.23.

Table-7.23 Building Standards in Papua New Guinea

Standard	Contents
Building Act	Application Formalities and Permission of Buildings, Administrative guidance, etc.
Building Regulation	General Provisions of Buildings
Papua New Guinea Standard (PNGS 1001~4)	Detailed Codes concerning design of Buildings

PNGS1001 to 1004 related to the building and the structure were published by the "National Standard Council (NSC)" in 1982. The NSC was established under "the National Standard Act 1978" and commenced operations in 1979. The outline of PNGS concerning the facility and the structure is as following Table-7.24.

Table-7.24 Outline of Papua New Guinea Standard

PNGS 1001 – 1982	Code of Practice for General Structural Design and design loadings for Buildings	
PNGS 1001 – 1982	Part 1	General Design Requirements
PNGS 1001 – 1982	Part 2	Dead and Live Loads
PNGS 1001 – 1982	Part 3	Wind Lards
PNGS 1001 – 1982	Part 4	Earthquake loadings
PNGS 1002 – 1982	Code of Practice for Reinforced Concrete Structures	
PNGS 1003 – 1982	Code of Practice for Steel Structures	
PNGS 1004 – 1982	Code of Practice for Reinforced Masonry Structures	
PNGS MP1 – 1982	Code of Practice for Design Manual	

At present, there are no original Papua New Guinea's standards concerning the electric installation. However, it is guided to design based on "S.A.A.Code" or "A.S.S.Specification" which were provided by the Standards Association of Australia.

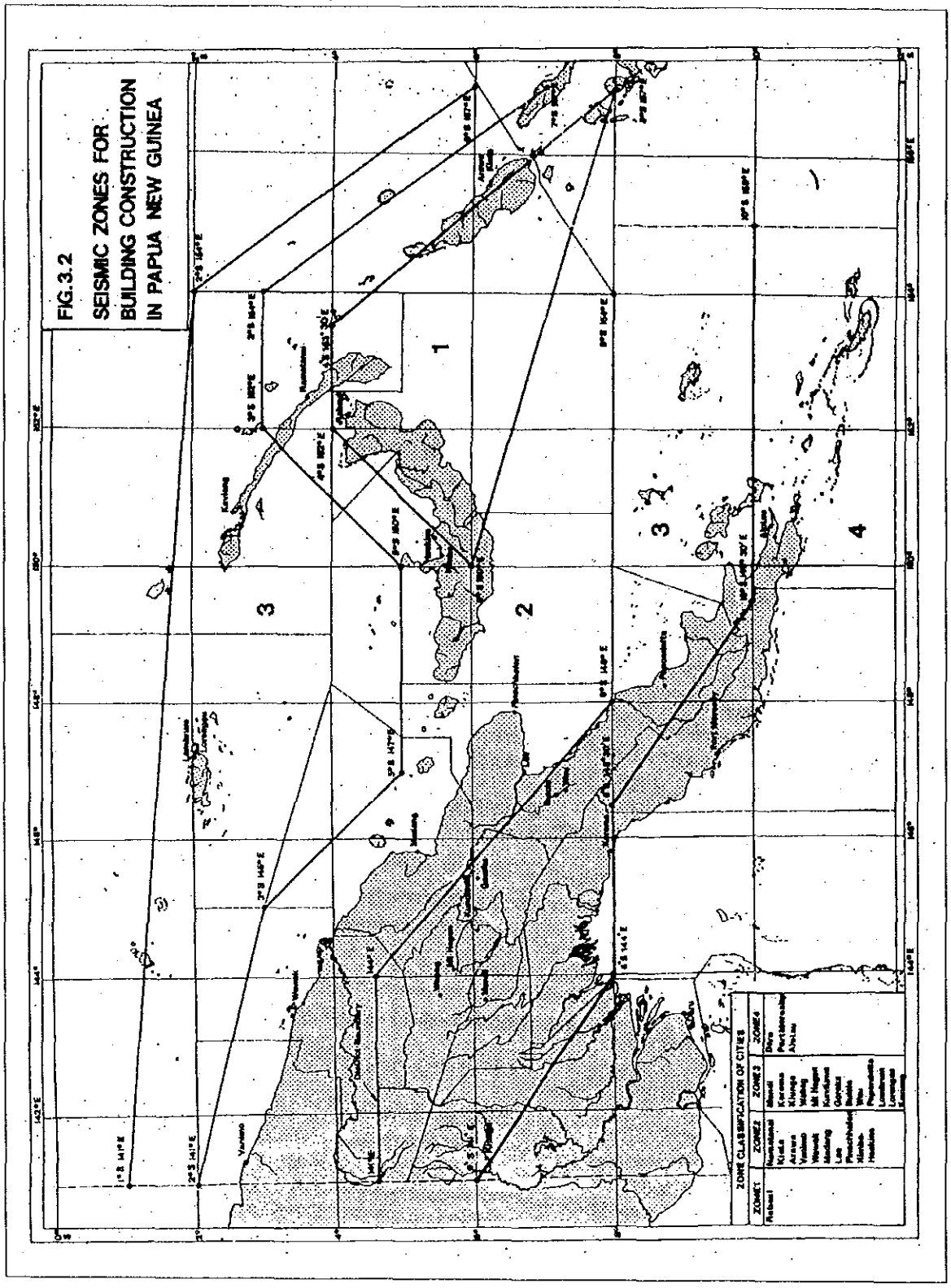
In designing buildings and facilities in Papua New Guinea, special attentions should be paid for their protections from earthquakes. Recently, quite a number of earthquakes occurred in New Britain Island and Bougainville Island, which are situated in Volcanic Arc Regions. The country has four categories in accordance with the Seismic Zones. The strengths of buildings are decided based on the Seismic Zones as shown in Table-7.25 and Fig.-7.2.

Table-7.25 Seismic Zones & Study Areas

Seismic Zone		Seismic Coefficient	Max. Height	Study Areas
Zone –1	The triangle zone which extends over the eastern part of New Britain Island, southern part of New Ireland, and the western part of Bougainville Island. The influence of earthquake to this area is the largest in PNG. Rabaul corresponds to Zone 1.	0.09～0.25	15 m	—
Zone –2	Northeast part of New Guinea Island, the west of New Britain Island, and the central part of New, Ireland, etc. Vanimo, Madang, Lae, and Kinbe, etc. correspond to Zone 2.	0.07～0.20	20 m	Mutzing Finschhafen
Zone –3	This zone extends from Highland of New Guinea Island over Oro Province. Manus island and the western part of New Ireland also belong to this zone. Kiunga, Goroka, and Popondetta Lorengau, etc. correspond to Zone 3.	0.05～0.16	25 m	Popondetta Oro Bay
Zone –4	A southern part of the Western Province and the Southwest of the Central Province belong to this Zone. Daru, Port Moresby, and Alotau, etc. belong to this Zone.	0.02～0.10	25 m	Daru Bereina Kwikila Kupiano

The detailed codes about the anti-earthquake designs are instructed in "PNGS1001-1982 Part4". In this master plan, the attentions should be paid to construct the buildings and the facilities, especially elevated water tanks, in accordance with the Papua New Guinea's standards. Seismic Zone Map is shown in Fig.-7.2.

Fig.-7.2 Seismic Zone Map (PNGS 1001-1982: Part4)



2) Material Standard

In general, most of the materials for water supplies are imported from Australia and following the Australian Standards. For the water pipes, High Density Polyethylene Pipe (HDPE) and Polyvinyl Chloride Pipes (PVC) are manufactured in Papua New Guinea, while elbows and joints are imported. Valves and pumps are also imported mainly from Australia. Considering the above situation, the following International Standards are applied for the materials.

Table-7.26 Material Standard of The Project

[AS]	Australian Standards	Standards Association of Australia, Standard House
[BS]	British Standards	British Standards Institution, British Standards House
[ASTM]	American Society for Testing and Materials	American Society for Testing and Materials

Among the standards above, the AS, which is especially important in the construction works in PNG, is shown in Table-7.27 below.

Table-7.27 Australian Standards (AS) for Construction Works

AS 1012	Methods of Testing Concrete
AS 1141	Methods for Sampling and Testing aggregates
AS 1302	Steel Reinforcing Bar for Concrete
AS 1315	Portland Cement
AS 1475	ASS Block work Code Part 1 –Unreinforced Block work
AS 1500	Concrete Building Blocks
AS 1509	SAA Formwork Code
AS 1510	Code of Practice for Control of Concrete Surfaces
AS 1254	Polyvinyl Chloride Pipe (PVC)
AS 1074	Galvanized Steel Pipe (GSP)
AS 1159	Polyethylene Pipe (PE)
AS 2280	Ductile Iron Pipe (DI)
AS 1432	Copper Pipe
AS 2032	Code of Practice for Installation of PVC Pipe Systems
AS 1628	Valves Gate Bronze
AS 2638	Cast Iron Sluice Valves
AS 2129	Flanges for Pipes, Valves and Fittings

7.7 Water Supply Plan

1) Design Concept

The water supply facilities were designed considering the factors below.

1) To establish water supply systems that the responsible agency, the PNGWB, can operate, maintain and manage independently.
2) To intend the maximum use of the existing facilities and minimize the time and the costs for the construction.
3) To design the water supply systems, which suit the areas where water supply systems, such as rain water collection systems, already exist.

The master plan consists of Stage-I, II and III in terms of the years for the implementation. In Stage-I, the core facilities such as intake facilities, pump stations and water tanks are installed. While the extensions of the distribution pipelines, the installation of the public faucets, and the renovation of the existing facilities are planned in Stage-II and III.

Table-7.28 Water Supply Master Plan by Stages

Stage and Year		Water Supply Master Plan by Stages
Stage-I	2005	- Construction of intake facilities and pump stations - Construction of water storage tanks - Installation of transmission and distribution lines - Construction of public faucets
Stage-II	2010	- Construction of additional water tanks - Renovation and extension of old lines
Stage-III	2015	- Extension of distribution lines - Extension and renovation of existing lines - Construction of additional public faucets

2) Outline of the Water Supply System

The basic components of water supply systems consist of water source, intake facilities, transmission facilities, distribution facilities and supply facilities. The water supply facilities were designed according to the concept in master plan. The successful test boreholes constructed in Phase I in 2000 under this Study are utilized as the water sources.

Table-7.29 Components of the Water Supply System

NO	Water Facility	Components		
1	Water Source	Pump Station	Borehole	
2	Intake Facility		Submersible Pump and Pump Pit	
			Power Source	① Power Line (ELCOM)
				② Diesel Engine Generator
				③ Solar Generating System
			Pump House	Pump Control Room
				Chlorination Chamber
			Fence & Gate	① Concrete Block Fence
				② Crimped Wire Fence
3	Transmission Facility	Rising Main Pipe		
		Road Crossing & River Crossing		
4	Distribution Facility	Water Storage Tank		① Ground Water Tank
				② Elevated Water Tank
		Distribution Pipe		
		Road Crossing & River Crossing		
		Rehabilitation of Existing Pipe		
5	Supply Facility	Public Faucet		
		House Connection		

The water supply system of each Study Area is composed of (A) the pump station, (B) the rising main pipe, (C) water storage tank, and (D) the public faucet. And the pump station is divided into (a) borehole and pump pit, (b) pump house and c) power source. When the sunlight is used as a power source, the PV array is set up in the pump station.

The chlorination chamber is established next to the pump control room, and the dosage pump and the chlorination tank are set up in this chamber. Moreover, the use of crimped wire fence of 2.3m in height is the basic choice as a fence for the pump station, and when the solar generating system is adopted for the power source, the block fence of 3.25m in height is adopted in consideration of crime prevention. A basic composition of the water supply facilities in this master plan is shown in Fig.-7.3.

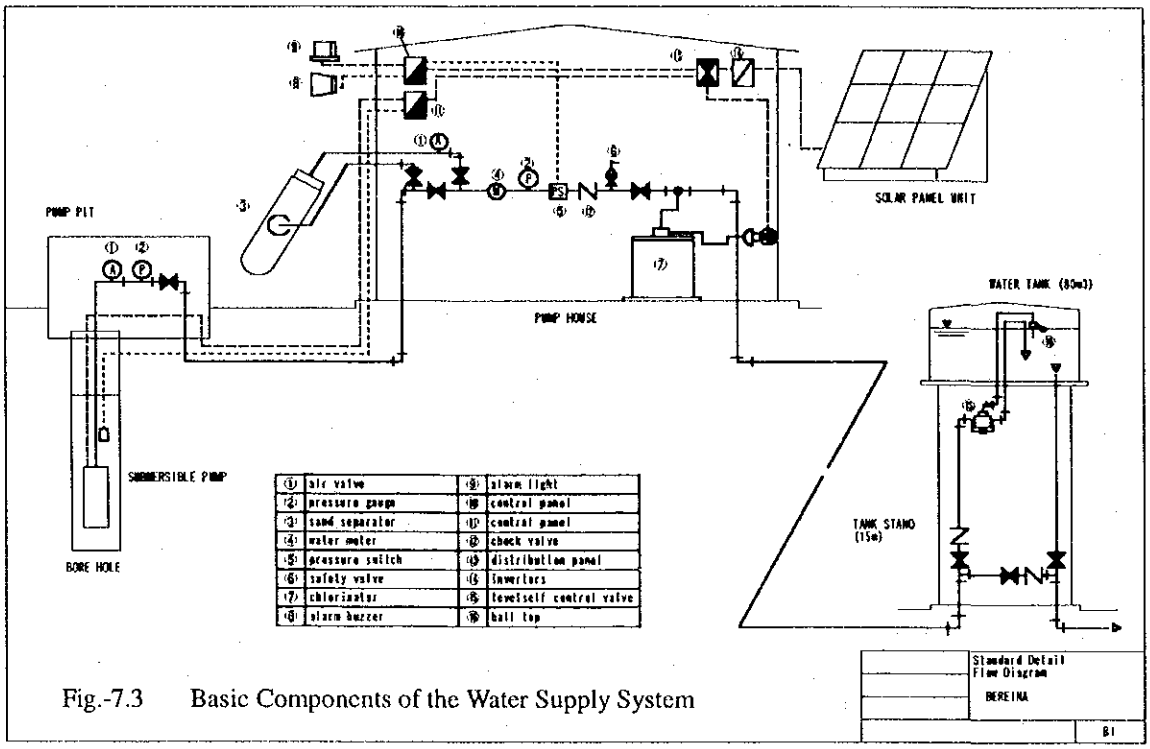


Fig.-7.3 Basic Components of the Water Supply System

3) Power Source of Water Supply System

There are several types of power sources of the water supply facilities such as ① a public electric power, ② diesel engine generator, and ③ renewable energy are enumerated as an alternatives. Considering operation, maintenance and management for the power source of facilities in the Areas the public electric power and/or ELCOM is the most preferable. The diesel generator is used in general where the service of a public electric power is not complete so far.

However, there are a lot of problems where the budget of operation and the maintenance expense is not enough. In such a case, the water supply hours is limited due to the lack of the fuel cost, and in such a case, the superannuating of the diesel engine generator is assumed to be a cause and the water supply stops intermitting.

The solar pump system was introduced as a renewable energy in the master plan of this project in consideration of the restriction of the power source and the electric power circumstances by such the locale though the use of the force of the wind was also considered.

4) Solar Generating System

In 6 District Towns, there are no stable power supply services from ELCOM except Kwikila and Mutzing to obtain the electric power with transmission line from Port Moresby and Lae, respectively. The diesel engine generator is assumed to be a power source in Bereina and the non-full time water supply is forced from the lack of fuel cost for the power expense. In this master plan, the solar generating system is introduced in consideration of the restriction of the local electric power circumstances.

To introduce the solar generating power for pump, the amount of insolation of 4.1kw/m^2/day or more is needed in general. It is important to set up the duration of pumping hours, which is restricted to sunshine hours. In this Study, 6 hours (from 9 to15 o'clock) as the operation hour is assumed under the consideration of the Design Flow and the capacity of the water storage tank in the sites. Table-7.30 and 7.31, and Fig.-7.4 show the amount of the average insolation of Port Moresby and Lae.

In this table, the amount of the insolation in Lae in August is 3.8 kw/ m^2/day. However, it is assumed that August is the rainy season, and the amount of insolation is below the average of the required insolation of 4.1kw/ m^2/day during this time. Therefore since this is raining period, rainwater collection can be used, to compensate for this shortage.

Table-7.30 Average Daily Insolation in Port Moresby (kw/m^2/day)

Month	1	2	3	4	5	6	7	8	9	10	11	12
Recipi.	169.0	221.0	191.0	167.0	51.0	40.0	20.0	34.0	40.0	40.0	69.0	156/0
Inso.	**5.4**	**5.3**	**5.2**	**5.1**	**4.8**	**4.5**	**4.5**	**4.9**	**5.2**	**5.8**	**6.1**	**5.6**
Langley	466.0	457.0	448.0	439.0	409.0	387.0	383.0	419.0	443.0	497.0	526.0	483.0

Precipi. : Precipitation, Inso.:Insolation

Table-7.31 Average Daily Insolation in Lae (kw/ m^2/day)

Month	1	2	3	4	5	6	7	8	9	10	11	12
Recipi.	267.0	231.0	324.0	403.0	424.0	414.0	501.0	517.0	473.0	386.0	346/0	332.0
Inso.	**5.2**	**5.4**	**5.0**	**4.9**	**4.4**	**4.0**	**3.8**	**4.4**	**4.9**	**5.6**	**4.8**	**5.3**
Langley	448.0	464.0	434.0	423.0	381.0	342.0	311.0	376.0	422.0	479.0	416.0	460.0

Precipi. : Precipitation, Inso.:Insolation

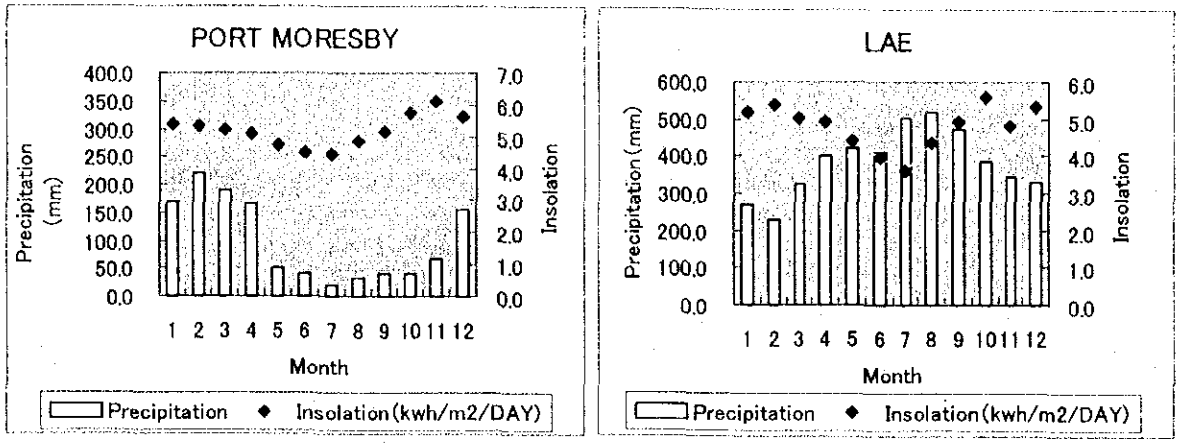


Fig.-7.4 Average Daily Insolation in Port Moresby and Lae

Moreover, in case a large pump output of 6.0kw or more is needed, it becomes disadvantageous to use a solar pump system. A community with a population of 1,000 to 2,000 is ideally suited for the introduction of the solar generating pump system. Therefore, the solar generating pump system of rated output 3.7 or 5.5kw is ideally suited for setting up water supply system in Stages.

Fig.-7.5(1) Concept Chart of Solar System

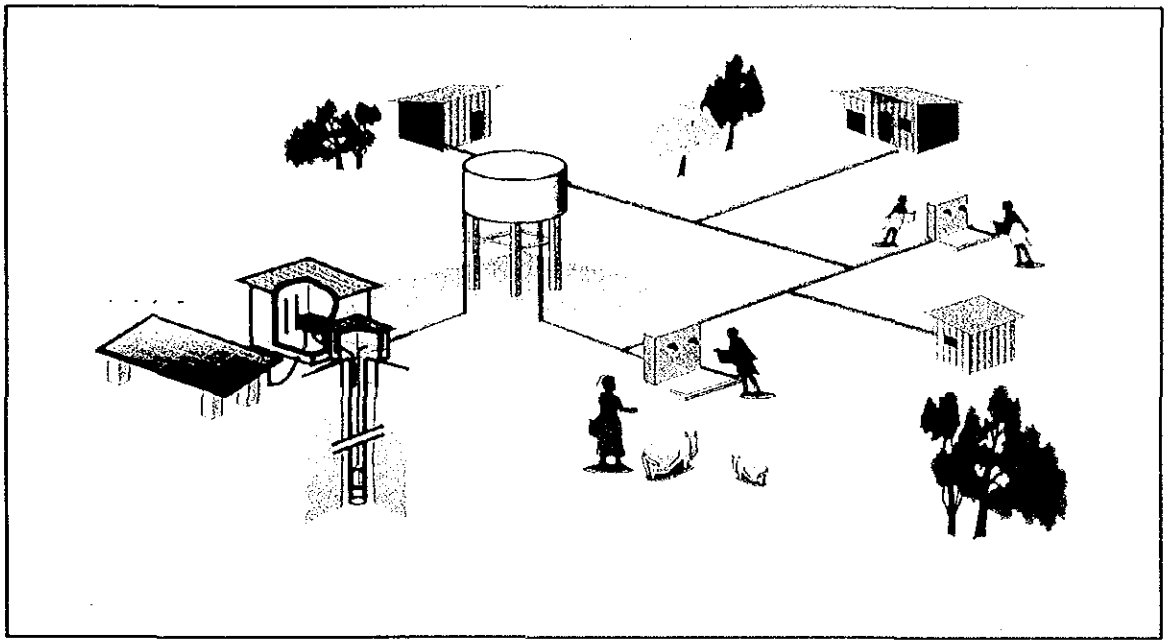
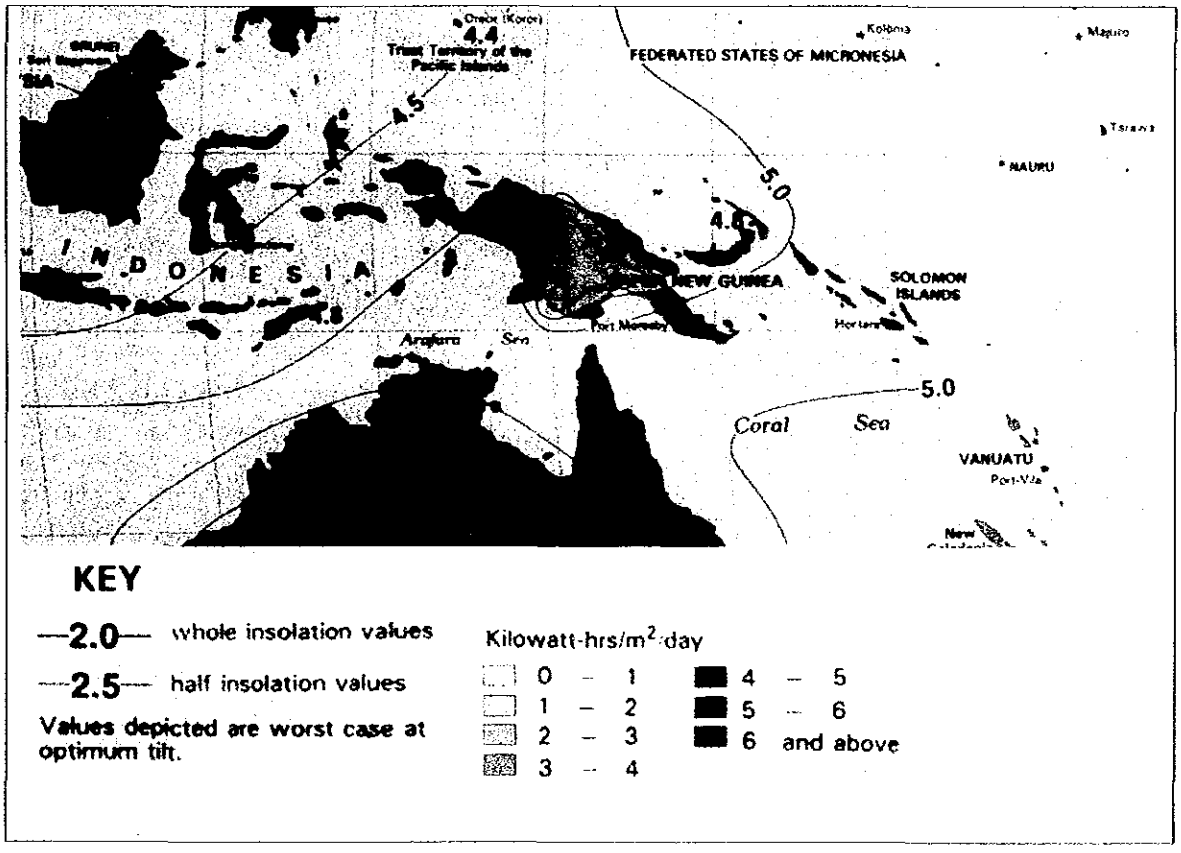


Fig.-7.5(2) Insolation Map in Papua New Guinea



7.8 Water Supply Systems

1) Water Supply Systems in 6 District Town

The water supply system at 6 District Town is composed of the (A) pump station, (B) the water storage tank, and (C) the public faucet. There are existing water supply facilities neither of five Study Area other than Oro Bay. In the master plan, the water supply system including effective use for existing facilities in a possible range was examined. The outline of the water supply systems and the proposed facilities according to each Stage at 6 District Town is shown as follows.

2) Water Supply System in Bereina

The water supply has stopped intermittently because of the shortages of the fuel cost and breakdowns of the diesel engine generator of the town operated by District office. Although there are eight villages around Station, pipeline is not extended to these eight villages. Dug wells or the rainwater tanks have been used by villagers because the water supply service dose not reach these villages.

Table-7.32 The Master Plan of Bereina

BEREINA		Area	Facilities
STAGE-I	2005	Station Toreno No.1, No.2 Ponepone Paikwa, Baukeke Karoapaina Hihive No.1, No.2	・Borehole & Pumping House No.1 ・Solar Generating System ・Water Storage Tank (80m^3, H:15m) ・Distribution Pipeline (2.8km) ・Public Faucet (9)
STAGE-II	2010	Station	・Water Storage Tank Rehabilitation (45m^3, H:15m)×2 ・Distribution Pipeline (1.3km)
STAGE-III	2015	Station	・Distribution Pipeline (2.2km)

Therefore, the plan of the pump station where the solar power generating system is adopted as power source for the water supply was considered in Stage-I and the distribution pipeline for eight villages and the installations of public faucets were planned. The pump station is composed of a pump operation room, an elevated water tank etc. of facilities related to solar generating system.

The construction of raising main pipeline from the pump station should be planned in Stage-II. New construction and the rehabilitation of distribution pipeline which runs from east to west in Bereina Station are considered in Stage-II. In Stage-III, new construction and rehabilitation of branch pipeline from main distribution pipeline are also considered. The master plan of water supply system in Bereina is shown in Fig.-7.6.

3) Water Supply System in Kupiano

Kupiano is located in the center of Abau District in Central Province and the population is about 2,000 people. However, total population together with Gavuone (about 2,500 people) in the downstream of the Marshall lagoon and Wanigala (about 3,300 people) in the upstream of the Marshall lagoon became 7,800 people. The target population of the year 2015 will be more than 10,000 people in the Study Area. There was no appropriate existing water source in Waigani and Gavoune as well as Kupiano, and the water supply master plan was included in those areas of Kupiano. Moreover, the solar power generating system was adopted because there was no appropriate electric power service in Kupiano for the power source of water facilities.

Table-7.33 The Master Plan of Kupiano

Stage		Area	Facilities
STAGE-I	2005	Kupiano	· Borehole & Pumping House · Solar Generating System · Water Storage Tank Rehabilitation (180m^3) · Water Storage Tank (30m^3 ×2) · Rising Main Pipeline (5.0m) · Distribution Pipeline (2.1km)
STAGE-II	*2010*	*Gavuone*	· Borehole & Pumping House · Solar Generating System · Water Storage Tank (200m^3) · Rising Main Pipeline (2.2km) · Distribution Pipeline (3.4km) · Public Faucet (6)
STAGE-III	2015	Wanigela	· Borehole & Pumping House (in Kupiano) · Solar Generating System · Water Storage Tank (200m^3) · Rising Main Pipeline (7.0km) · Distribution Pipeline (0.7km) · Public Faucet (5)

The pump station was planned at a place where is 3km away from the Kupiano Town due to the

groundwater potential site, and the construction of the distribution pipeline and the ground water tank ($180m^3$) was planned in Stage-I. Moreover, rising main pipeline for the pump station and two school (Korela Mission School and Iopara School) located in the middle of Kupiano town are arranged. The total pipelines extension of rising main pipeline and distribution pipeline becomes about 7.1km in total.

Gavuone will be one of the water supply areas in Stage-II. The second pump station is planned in a place where is about 1.3km away from the pump station of Kupiano constructed in Stage-I, and it is assumed to be connected with the rising main pipeline to the first pump station by rising main pipeline. Elevated water tank ($200m^3$) for the water supply to Gavuone is arranged on the east side of Kupiano town. Rising main pipeline will be constructed from this elevated water tank to Gavoune in the distance of about 2.5km. Six public faucets are arranged. The total extension of pipeline becomes about 5.6km.

The water supply system of Wanigala of Stage-III also assumes the composition same as Gavoune. Therefore, the third pump station, elevated water tank ($200m^3$), and five public faucets are arranged. The total extension of pipeline becomes 7.7km. The master plan of water supply system in Kupiano is shown in Fig.-7.7

4) Water Supply System in Kwikila

The water supply area of Kwikila is divided into three of ① Station, ② Kwikila High School, and ③ Vocational Training School. There are two boreholes originally in Kwikila High school, and the water supply is done although it is insufficient in the volume of water. Because the public water supply had stopped for a long term around Station and the Vocational Training School area, there was lot of water leaks in each place, and it was judged that effective use for existing piping was not easy. Existing pipeline is gradually substituted in each Stage of the master plan.

In each water supply area, there is an existing water tank that has sufficient capacity in comparison with the water demand in the area. Existing water tanks in Kwikila High School and Vocational Centre can be effectively used in the plan for the future. Because superannuation is remarkable, two existing water tanks that supply water to the Station should be newly constructed.

Therefore, the new establishment of the pump station and the construction of rising main

pipeline to each water supply area and the new establishment of ground water tank ($60m^3 \times 2$) were planned in Stage-I. Moreover, the installation of a public faucet is planned in order to supply the water for the Compound in east side of the Station.

Table-7.34 The Master Plan of Kwikila

Stage		Area	Facilities
STAGE-I	2005	Station High School Vada Compound Mr.Broun Compound Makan Compound Vocational Centre Community School	· Borehole & Pumping House No.1 · Water Storage Tank ($60m^3 \times 2$) · Rising Main Pipeline (2.6km) · Distribution Pipeline (2.0km) · Public Faucet (1)
STAGE-II	2010	Central High school Vada Compound Mr.Broun Compound Makan Compound	· Borehole & Pumping house No.2 · Rising main Pipeline (0.5km) · Water Storage Tank Rehabilitation ($45m^3 \times 2$)
STAGE-III	2015		· Distribution Pipeline (3.2km)

In Stage-II, new borehole and to the second pump station composed of the pump pit and the pump operation room, etc. are planned in order to deal with the water demand until 2015 which is the target year of 2015, and a rising main pipeline from the pump station will be connected with the rising main pipeline prepared in Stage-I. The rehabilitation concerning the water tank of the Kwikila High School should be done in Stage-II. And the existing distribution pipeline is planned to substitute almost completely in Stage-III. The total extension of pipeline for substitution becomes about 4.3km. The master plan of water supply system in Kwikila is shown in Fig.-7.8

5) Water Supply System in Finshhafen

In Finschhafen, as for the water supply area is divided into three areas ① from Station (Gagidu) to Gingala to Gingala, ② from Gingala to Bugain through the Dregerhafen High School, ③ from Buroun Hospital to Station (Gagidu), along the road which runs in the coastline of Langemark Bay. The total extension of pipeline of the master plan reaches about 15km along the road and the target population in 2015 that becomes about 4,700 people.

Although the existing water supply facilities of Finschhafen are operating, the water source came from surface water of Buta Creek. However, because the amount of discharge from the river is less than the amount of the water demand, and water supply without chlorination, the

pump station is constructed in the Station of Finschhafen (Gagidu), and existing pipline about 7.4km is substituted for Gingala located in the south of Gagidu in Stage-I. Moreover, the distribution pipeline is planned in Buta Compound, DCA, and Gingala, etc. , and a public faucet are planned to set up.

Table-7.35 The Master Plan of Finschhafen

Stage		Area	Facilities
STAGE-I	2005	Station (Gagidu) Buta Compound DCA Gingala Village	· Borehole & Pumping House No.2 · Water Storage Tank ($60m^3 \times 2$) · Rising Main Pipeline (0.2km) · Distribution Pipeline (7.4km) · Public Faucet (3)
STAGE-II	2010	Bugain Village High School	· Distribution Pipeline (4.8km) · Public Faucet (2)
STAGE-III	2015	Vocational Centre Broun Hospital Godowa Village Tomuc Village *Timblim Settlement*	· Borehole & Pumping House No.1 · Rising Main Pipeline (0.1km) · Water Storage Tank ($60m^3$, H:15m) · Distribution Pipeline (9.9km) · Public Faucet (2)

The distribution pipeline should be renewed from Gingala to further Bugain Village at the position of about 4.8km in the south in Stage-II, and a public faucets will be arranged in Buki Village and Dreger High School located on the way. The second pump station should be in the Butaweng Creek upstream, and water storage tank ($50m^3$) are planned to construct in Stage-III. The distribution pipeline about 9.9km is planned from this tank through Buraun Memorial Hospital even as for Station (Gagidu). The installation of branch pipeline for Godowa Village and Tomuc Village located along to the distribution pipeline also considered and public faucets in these villages are planned in Stage-III. The master plan of water supply system in Finschhafen is shown in Fig.-7.9

6) Water Supply System in Mutzing

The power line of ELCOM was extended from Lae to Mutzing in June, 2001. Now it is available to get 24-hour power supply in Mutzing. Because the existing pipeline is limited only inside of Station the water supply area in Mutzing has been expanded into three areas ① Station internal, ② Mutzing Village, Sampubangin Village in the east side of the Station, and ③ Markham Valley High School on the west side of the Station.

Water pressure from existing taps where locate in the surrounding area away from the Station is insufficient. Because, the height of an existing elevated water tank is not high. And, the diameters of existing pipeline are small. Therefore, an elevated water tank 15m in height and the update of existing pipeline are necessary.

The pump station composed of a pump operation room and an elevated water tank, etc. is planned in Stage-I. The amount of the water demand in 2015 which is the final target year is covered by the amount of water supply from this pump station in Mutzing. Moreover, the rising main pipeline and the distribution pipeline to the villages namely Mutzing Village and Sampubagin Village, and Markham Valley High School that are new water supply areas are considered. In addition, the update of existing pipeline in Intoap Model village is planned in order to improve the shortage of the water pressure from existing taps.

Table-7.36 The Master Plan of Mutzing

Stage		Area	Facilities
STAGE-I	2005	Station Sampubagin Village Mutzing Village Intop Village Markham valley High School	· Borehole & Pumping House No.1 · Rising Main Pipeline (0.6km) · Water Storage Tank ($80m^3$) × 15m · Distribution Pipeline (2.4km) · Public Faucet (1)
STAGE-II	2010	Station	· Water Storage Tank Rehabilitation ($30m^3$) · Rehabilitation of Existing Pipeline

The present Mutzing is Sub district town of Kaiapit District in Morobe Province. Mutzing is a relay point on Highlands Highway to face directions of Madang and Goroka. Therefore, the development of Mutzing is expected as a heartland of the surrounding area. In Stage-II, rehabilitation or new construction works of existing water tanks and existing pipeline are planned in preparation for the increase of the water demand in the target year of 2015. The master plan of water supply system in Mutzing is shown in Fig.-7.10

7) Water Supply System in Oro Bay

As for the water supply area of Oro Bay is divided, even Eroro Mission and Kopure Village are divided three areas such as ①from Wharf to Fisheries office, ②from north side of Fisheries office to Kopure Village through Ijivitari District Administration, ③from north side of Eroro Mission Embogo High School. And these water supply areas are in a wide about 17km along

the trunk main pipeline along the road from Oro bay to Kopure Village.

The target population in 2015 becomes 5,800 people. All the water supply facilities in the master plan are planned as new construction of water facilities because there are no existing water supply systems in Oro Bay. The solar generating system is introduced as a power source of the water supply facilities because there is no public power service from ELCOM.

Table-7.37 The Master Plan of Oro Bay

Stage		Area	Facilities
STAGE-I	2005	Sub-Dist. Administration Health Centre Marine Compound Beama Village Mobil Oil Depot CCEA & Wharf	· Borehole & Pumping House No.1 · Solar Generating System · Water Storage Tank ($80m^3$) · Distribution Pipeline (5.2km) · Public Faucet (4)
STAGE-II	2010	Ijividari Dist. Administration Kopure Village Eroro Village Eroro Mission Basego Village Ijivitali Dist Office	· Borehole & Pumping House No.2 · Solar Generating System · Water Storage Tank ($80m^3$) · Distribution Pipeline (7.2km) · Public Faucet (4)
STAGE-III	2015	Embogo Village Embogo High School Dombada Village	· Distribution Pipeline (7.0km) · Public Faucet (3)

In Stage-I, the pump station and water storage tank are planned at a position away from Bama Village about 1km inland side, and rising main pipeline about 1.5km from this water tank to the coastline are planned. Moreover, the distribution pipeline about 2.1km, which encloses Oro Bay from Wharf to Fisheries office, is planned. Total three public faucets are arranged in Wharf, Health Centre, and Fisheries office. The total extension pipeline of Stage-I becomes about 5.7km.

The construction of the second pump station and water tank was planned to Kopure in Stage-II. Moreover, distribution pipeline about 7.7km is arranged from Kopure to north side of Fisheries office and public faucets in 4 places namely Kopure Village, Eroro Mission, Basego Village and Ijivitari District Administration are arranged. The range from north side of Eroro Mission to Embogo High School becomes a water supply area in Stage-III. The extension of pipeline becomes about 7.0km including the distribution branch pipeline. Four public faucets are arranged in Embogo Village, Dombada Village, Eroro Village, and Embogo High School. The master plan of water supply system in Oro Bay is shown in Fig.-7.11

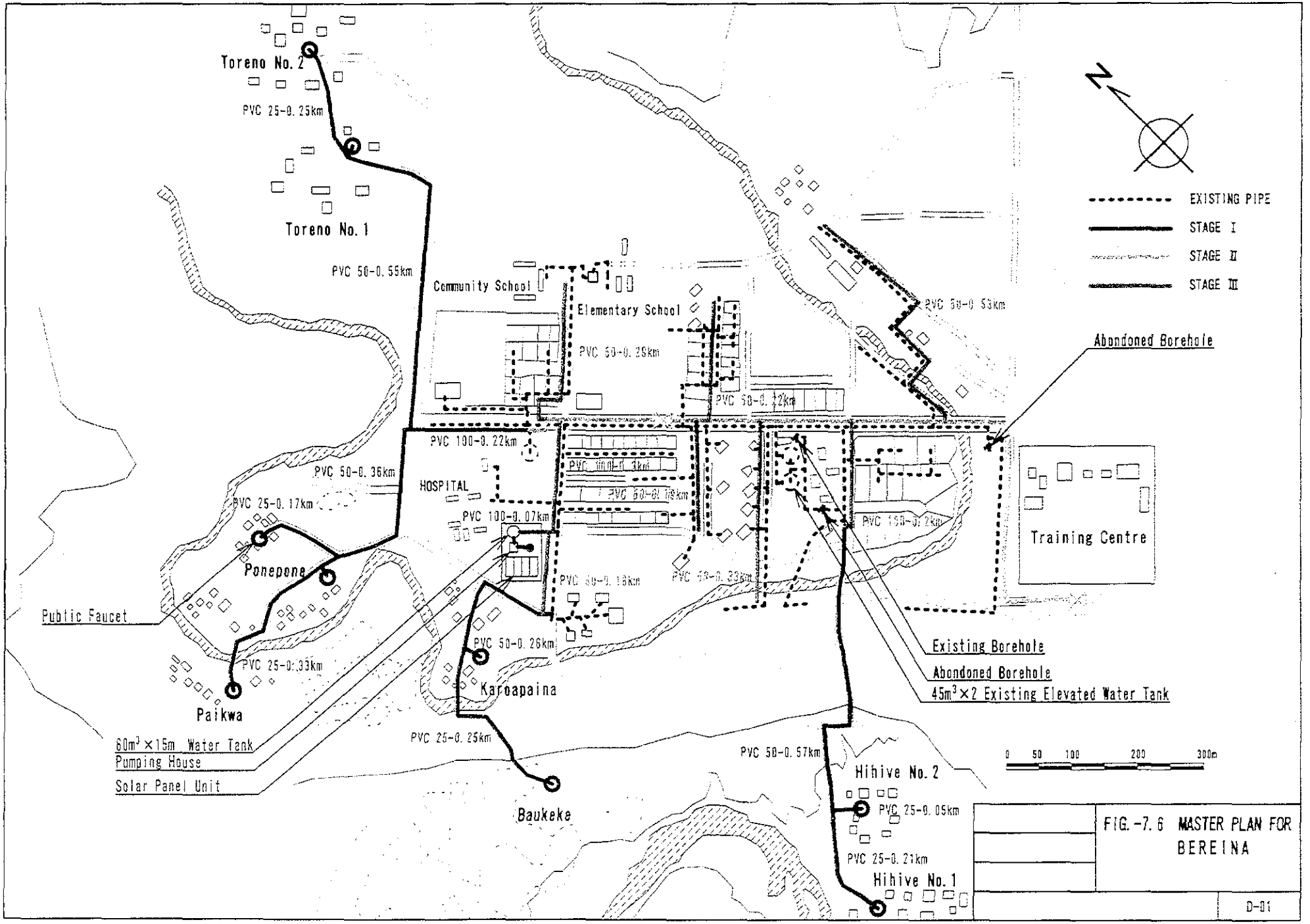
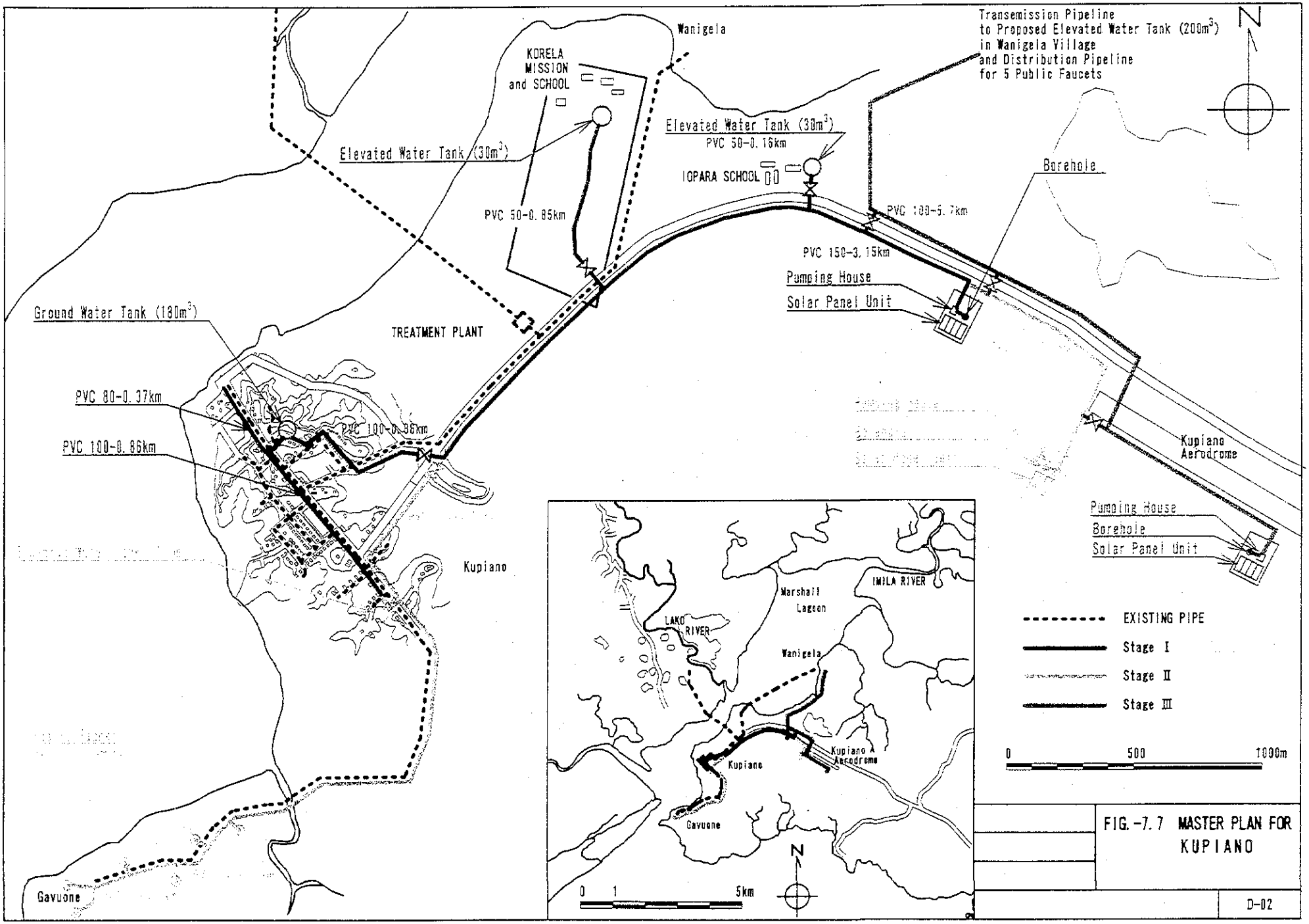


FIG.-7.6 MASTER PLAN FOR BEREINA

D-01


Wanigela
KORELA MISSION and SCHOOL
Elevated Water Tank (30m³)
PVC 50-0.85km
Elevated Water Tank (30m³)
PVC 50-0.16km
IOPARA SCHOOL
Transemission Pipeline to Proposed Elevated Water Tank (200m³) in Wanigela Village and Distribution Pipeline for 5 Public Faucets
N
Borehole
PVC 100-5.7km
PVC 150-3.15km
Pumping House
Solar Panel Unit
Ground Water Tank (180m³)
TREATMENT PLANT
PVC 80-0.37km
PVC 100-0.36km
PVC 100-0.86km
Kupiano
Kupiano Aerodrome
Pumping House
Borehole
Solar Panel Unit
Gavuone
Marshall Lagoon
IMILA RIVER
LAKO RIVER
Wanigela
Kupiano
Kupiano Aerodrome
Gavuone
0 1 5km
N
EXISTING PIPE
Stage I
Stage II
Stage III
0 500 1000m
FIG.-7.7 MASTER PLAN FOR KUPIANO
D-02

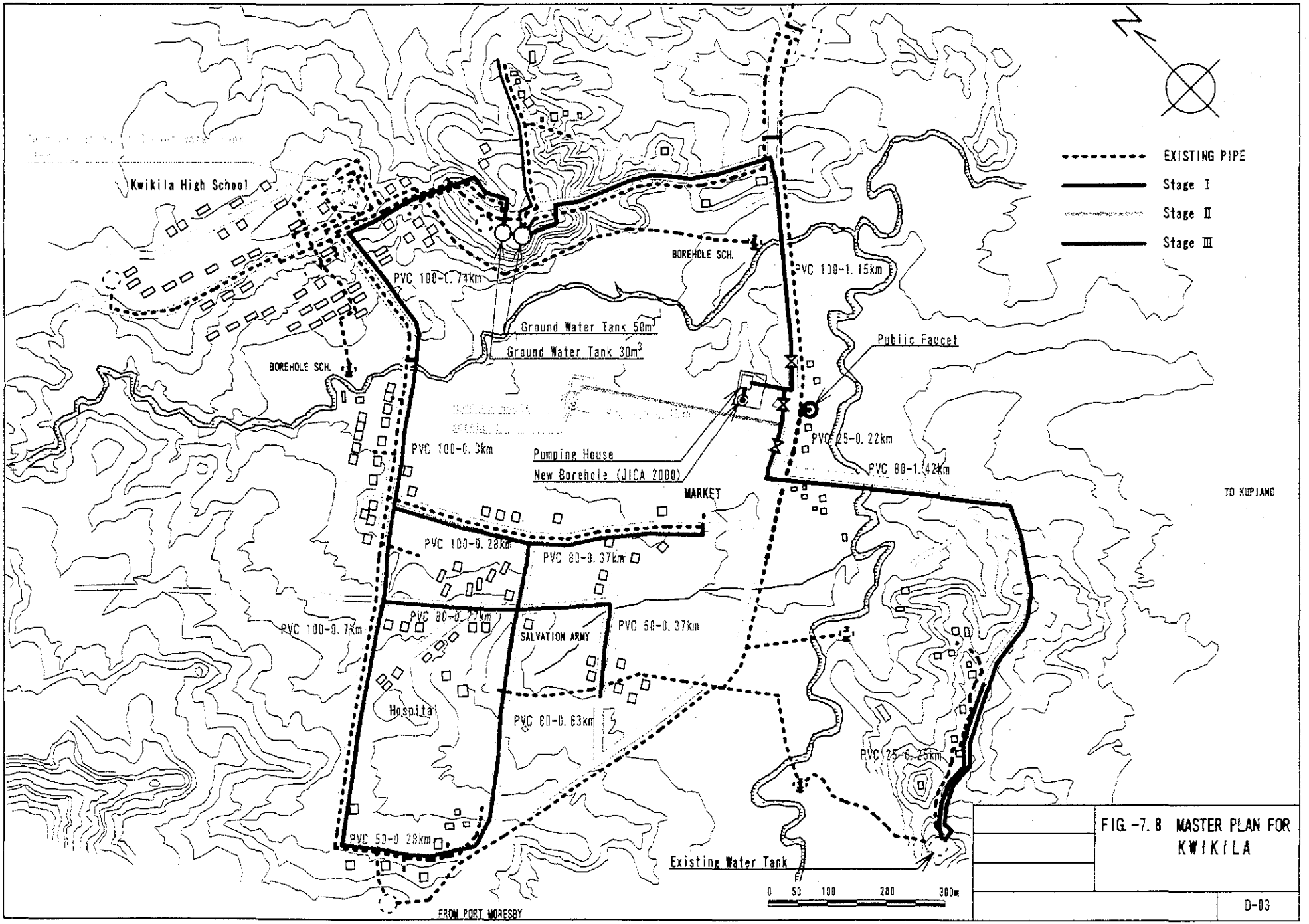


FIG.-7.8 MASTER PLAN FOR KWIKILA

D-03

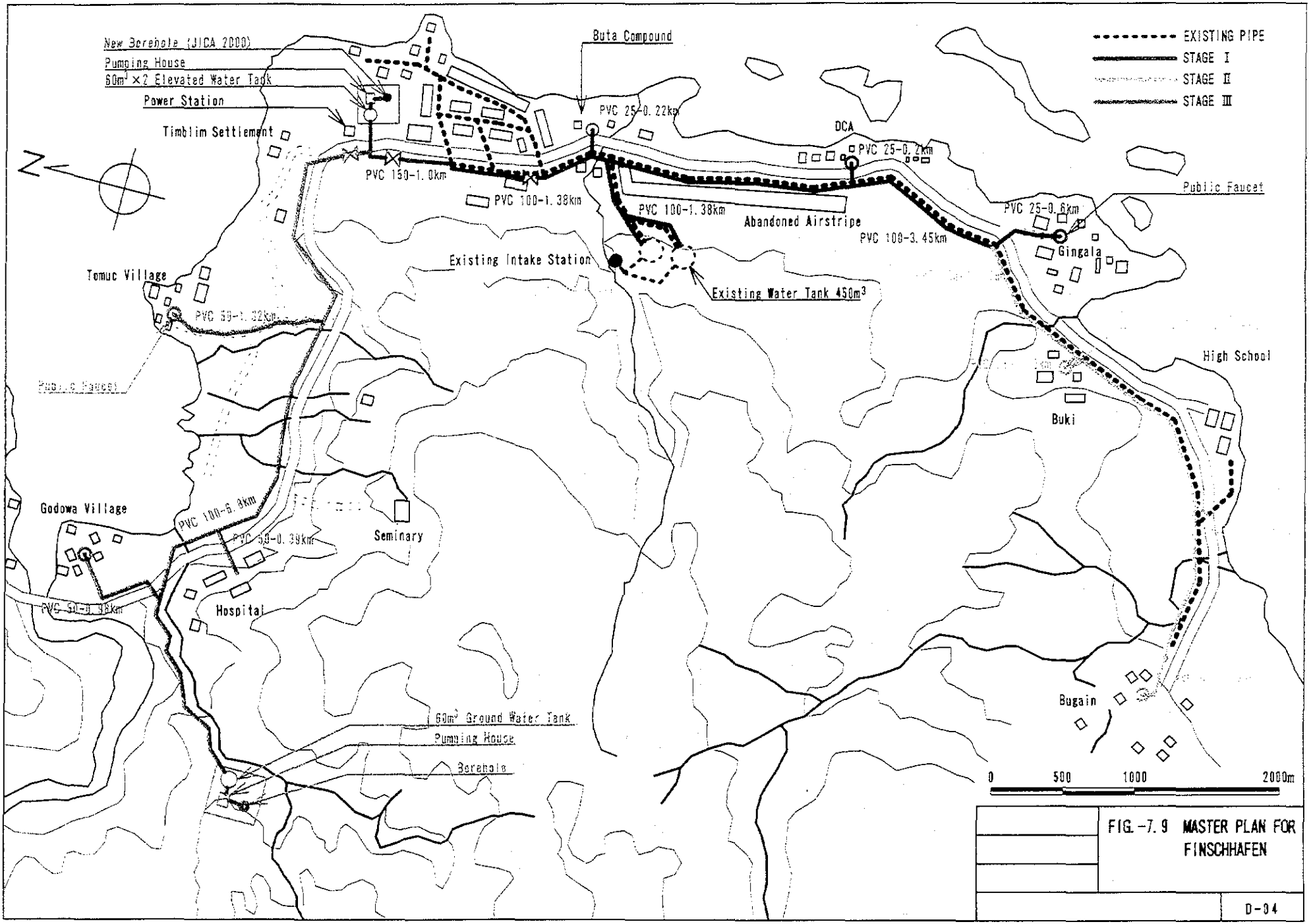
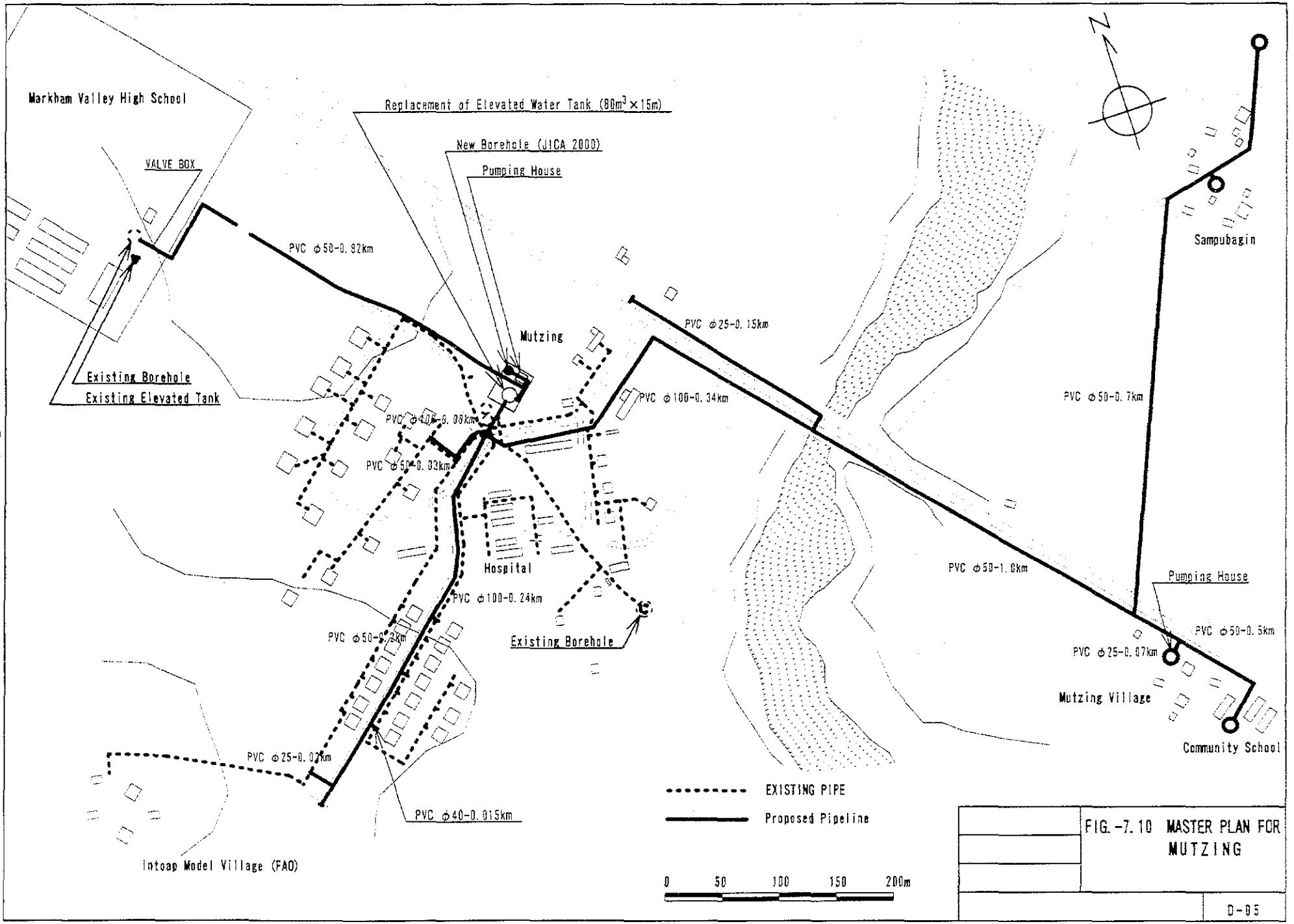
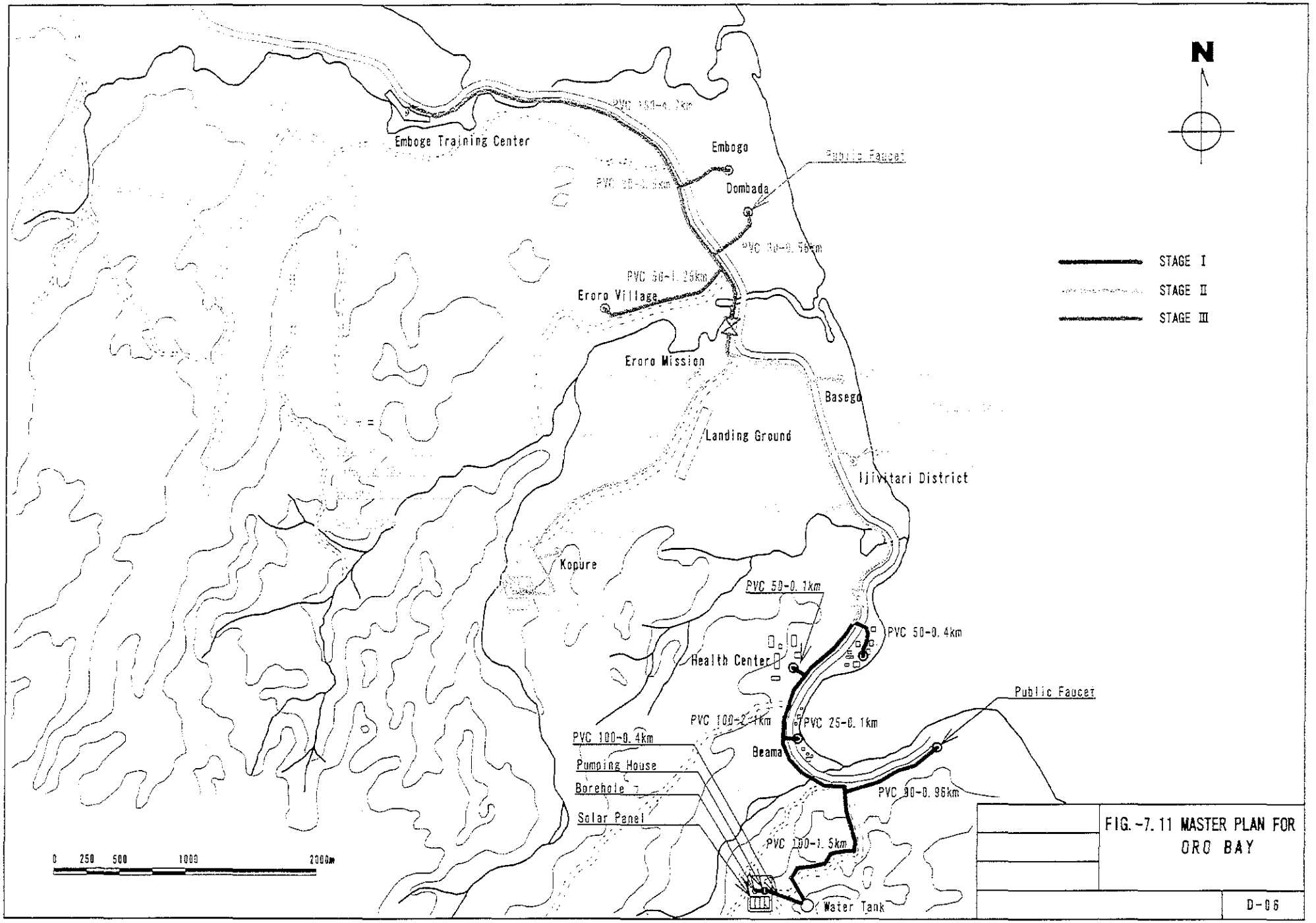


FIG.-7.9 MASTER PLAN FOR FINSCHHAFEN

D-04


Markham Valley High School
VALVE BOX
Replacement of Elevated Water Tank (80m³×15m)
New Borehole (JICA 2000)
Pumping House
PVC φ50-0.92km
Existing Borehole
Existing Elevated Tank
Mutzing
PVC φ25-0.15km
PVC φ100-0.34km
PVC φ40-0.08km
PVC φ50-0.03km
PVC φ50-0.7km
Sampubagin
Hospital
PVC φ50-1.8km
Pumping House
PVC φ100-0.24km
PVC φ50-0.5km
PVC φ50-0.2km
Existing Borehole
PVC φ25-0.87km
Mutzing Village
Community School
PVC φ25-0.02km
PVC φ40-0.015km
Intoap Model Village (FAO)
EXISTING PIPE
Proposed Pipeline
0 50 100 150 200m
FIG.-7.10 MASTER PLAN FOR MUTZING
D-05


N
STAGE I
STAGE II
STAGE III
Emboge Training Center
Embogo
Public Faucet
Dombada
PVC 50-0.55km
PVC 50-1.25km
Eroro Village
Eroro Mission
Basego
Landing Ground
Ijivitari District
Kopure
PVC 50-0.1km
PVC 50-0.4km
Health Center
Public Faucet
PVC 100-2.1km
PVC 25-0.1km
PVC 100-0.4km
Beama
Pumping House
Borehole
Solar Panel
PVC 90-0.96km
PVC 100-1.5km
Water Tank
0 250 500 1000 2000m
FIG.-7.11 MASTER PLAN FOR ORO BAY
D-06

CHAPTER 8 ORGANIZATION & INSTITUTION FOR OPERATION, MANAGEMENT AND MAINTENANCE

8.1 Current Situation of Organization & Institution for Operation, Management and Maintenance (O, M & M) of Water Supply Sector

Among the Study Areas of 8 Towns, the water supply systems at two Provincial Towns of Daru and Popondetta are already included in the PNGWB's management and it will be all right in principle if the present organization & institution for operation, management and maintenance (O, M & M) are sustained. However, the cost exceeds the revenue and making losses for both cases of Daru and Popondetta. Salary of the staff is the biggest item among the expenditure items. Especially the operators in Daru are too many and review of the organization is required. As it is described later, the Customer Services Division, the division in charge of the O, M & M in the PNGWB, is urging renovation of organization and institution that must be effective for improvement of the service and business efficiency. It is assumed that rationalization of the organization and institution such as cutting the number of staff will be done in the two Provincial Town water supplies that are not making profit. In fact in case of Daru, it is scheduled to introduce a new scheme where the water district will be under management of the Southern Region Office, and so no District Manager will be appointed and the Regional Manager will have direct control. This is expected to give a cost reduction.

On the other hand, in case of water supply services in 6 District Towns of the Study Area, District Administration is in charge of operation and maintenance of water supply systems under the Provincial Government. Although problems are found in the facilities, the fact that adequate improvement of the facilities and the sustainable operation were not done is indicating difficulties in management under the present scheme. Therefore, these water supply systems at District Towns require a new scheme of O, M & M. Among the District Towns of the Study Area, Oro Bay is the only area where the water supply facility does not exist and planning for O, M & M in the future shall be considered on a "zero" basis.

8.2 PNGWB's Organizational Reform

PNGWB is proceeding its reorganization and reformation apart from this Study. As part of this reorganization/reformation, its Customer Services Division, which is the centre for O, M & M, has introduced a new structure recently (please refer to the attached organization chart of the Customer Services Division). New structure divides the entire work zone of PNGWB into three regions and each region is managed by respective Regional Office. It is expected that this will contribute to realize more efficient management of each water district, especially in small Water Districts. The entire country was divided into Northern Region, Highlands Region, Southern Region, and the regional offices are established at Lae, Mt. Hagen, and Port Moresby, respectively. The following table shows the coverage of each Regional Office.

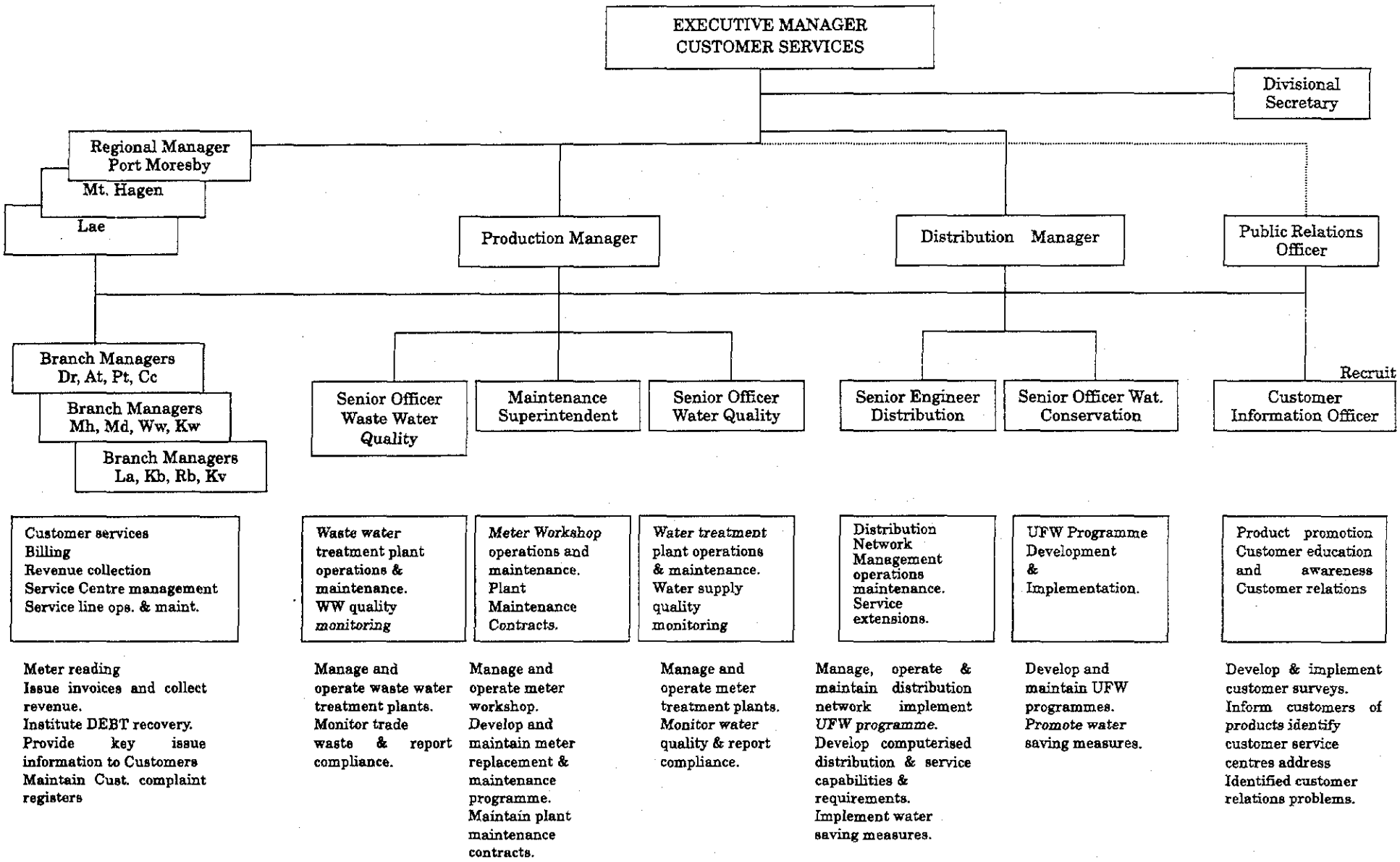


Fig.-8.1 Organization Structure of PNG WATERBOARD Customer Services Division

Table-8.1 PNGWB New Organization of Regional Office

Region	Regional Office	Water District (WD) to be managed *WD in bracket (): projection stage	Current Situation
Northern	Lae	Lae, Kimbe, Rabaul, Kavieng, (Lorengau)	Office: Established in early June, 2001 Manager: Appointed.
Highland	Mt.Hagen	Mt.Hagen, Madang, Wewak, Kundiawa, (Mendi, Wabag)	Office: Established in early June, 2001 Manager: Appointed.
Southern	Port Moresby	Daru, Alotau, Popondetta, (Central City, Kerema)	Office: Established in early June 2001 Manager: To be appointed soon.

*Central City is a Provincial Town of Central Province under construction.

These three Regional Office have been established and the managers for Northern Region and for Highland Region were appointed while one for Southern Region is in the process of recruitment. It is expected that the regionally decentralized management system utilizing Regional Offices improves the efficiency of operation. At the same time, as a result of this reformation of Customer Services Division, positions of Production Manager (stationed at Madang) and Distribution Manager (stationed at Lae) are set up and these managers have been appointed. The Production Manager is responsible for water production in the entire country and the Distribution Manager is responsible for entire distribution. Their grades in the PNGWB are the same as that for Regional Managers (Grade 14). It is presumed that if managerial staff is reduced at the water districts like Daru where constant deficit is made, Regional Office may directly manage and contribute to reduce the shortfall. This concept can be adopted also to the management of water supply services at District Centres.

Another reformation under consideration is attachment of Public Relations Officer under Executive Manager Customer Services from Corporate Relations Division. This concept should be urged because this attachment of Public Relations Officer to the Customer Services may contribute to activate communications with the water users while such communications are lacking currently. It is observed that the engineering viewpoint has been dominant in the organization as it is important when Technical Services Division promotes new construction and upgrading of the facilities, and Customer Services Division operates and maintains the facilities.

However, for the actual improvement of water supply services, communications with the water users are also indispensable to encourage proper use of water supply facility, to achieve satisfaction of the users and to let the users pay smoothly. Especially for District Centre water supply, this aspect of communication with the users must be essential and it is recommended that PNGWB strengthen this function. Further, more training programs on communications and customer relations should be included in the existent training programs to the staff of PNGWB that currently cover mainly technical knowledge and skills only.

8.3 Analysis on Organizations & Institution for Operation, Management and Maintenance

It is considered that sustainable provision of water supply services in 6 District Towns under the current organization and institution for operation, management and maintenance (O, M& M) is difficult, and in principle it is assumed that the O, M & M by the PNGWB as their Water District would be most appropriate.

On the other hand, it is obvious that the sizes of population of these 6 District Towns are small and the Water Districts would not be able to earn enough revenue for proper O, M & M, and it is essential to set up the framework of financial support to the Water Districts of the PNGWB. In case of the 3 District Towns of Bereina, Kwikila and Mutzing where the Pilot Project was implemented, the declaration of new Water Districts was done by the minister, and the O, M & M is under the PNGWB. In order to minimize the O, M & M cost only a water operator and the assistant are stationed in the Water District and the management of the Water Districts is done by the Regional Managers of Southern Regional Office for Bereina and Kwikila and of Northern Regional Office for Mutzing. Therefore, when improvement of water supply systems in the other District Towns, i.e. Finschhafen, Oro Bay and Kupiano are realized, Finschhafen will be managed by the Northern Regional Office at Lae, Kupiano by the Southern Regional Office. In case of Oro Bay the management by the Branch Office at Popondetta will be realistic.

Concerning the District Towns where the pilot project was implemented, the minutes of understanding on implementation of the Pilot Project (MOU) and the minutes of agreement on the O, M & M of the water supply systems (MOA) were made between the PNGWB and the respective Provincial Government and the Local-level Government. The functions of both parties agreed in the MOA are described as below.

a) Function of PNGWB

PNGWB is the owner of the water supply systems in the Water District and in charge of the O, M & M. When the NWSS Act was enforced the water supply systems of the Provincial Towns were transferred from the DoW to the PNGWB, and the Water Districts were declared by the minister. At the same time the ownership of the facility was handed to the PNGWB, and the O, M & M has been done by the PNGWB. On the other hand, in case of the District Towns the ownership shall be transferred to the PNGWB from DoW or the Provincial Government when the Water District is declared. Similarly, the entire process of the comprehensive O, M & M of the water supply services including operation of the facilities, water fee collection, inspection and repair. shall be the responsibility of the PNGWB after the transfer. Moreover, when the facilities require renovation and/or extension, funds for the capital investment shall be secured also by the PNGWB. In case of the facilities renovated by the pilot project, installation of water meters for individual connections is necessary and the PNGWB is doing this.

b) Function of Provincial Government & Local-level Government

Function of Provincial Government and Local-level Government regarding water supply services of District Towns is to support the PNGWB's routine activities in the Water District and a Consultation Meeting with the PNGWB shall be held at a minimum of once a year to discuss the issues and to find the solution. The most important point is that Provincial Government and Local-Level Government are in a position to compensate to the PNGWB by providing the subsidy when the deficit is made in the operation of these Water Districts. Amount of the subsidy shall be decided in the above-mentioned Consultation Meeting. This function of Provincial Government and Local-Level Government is proposed in order to facilitate the PNGWB's extension of their services into the District Towns where the deficit in the operation is anticipated, and this kind of function is not required in case of the water supply services in the Provincial Towns.

8.4 Operation, Management & Maintenance Scheme

1) Establishment of O, M & M Scheme for Water Supply Services in the Study Area

a) Management by PG & LLGs and Their Constraints

PNGWB has been trying to extend its water supply and sanitation service in Provincial Towns entirely under current situations as mentioned above. The Study Area includes two Provincial Towns that PNGWB has been managing and 6 District Towns that are the target for the future.

District Administration is in charge of management of water supply service at 6 District Towns

of the Study Area except Oro Bay that does not have any facilities. There are District Towns such as Finschhafen and Mutzing that are supplying water though it is insufficient. On the other hand, there are District Towns where the water supply has stopped for a long period as it is in Kwikila, Kupiano, and Bereina.

"Water Supply Service" had been provided free of cost to the people by the Government before NWSS Act was enacted. Operation & management of water supply service of District Town were transferred from Dept. of Works (DOW) to PG & LLG. Originally, the water supply facility of District Town was constructed for only "Station" which was the base of the administrative service of Provincial Government (PG) at the district level. In majority of the Stations, water supply are provided while the minimum level of the additional investment and repairs which are required for operation of the facility built during the DOW period. However, because the fee collection for the water supply service is not practised at all, the cost is mainly borne by PG & LLG.

In case of Kwikila and Kupiano after the breakdown of the facility and the equipment the water supply service stopped, and the systems remain unused while the budget preparation for repair/replacement of the equipment was not done by the Provincial Administration. Although there must be efforts of PG & LLGs to improve the situation, their financial, human and organizational resources required for water supply improvement are insufficient, and the water supply stops continuously. Moreover, the existing facility often include incompleteness and defective construction. These show the necessity of the provision of the service by the organization that is well versed in the water supply service.

In Finschhafen and Mutzing, the enhancing construction and the maintenance and management. have been done by using the budget of the PG & LLGs. Therefore, the water supply is maintained more or less constantly. However, because the facility is becoming old, stable water supply service is vulnerable. The operator who belongs to DOW is allocated for operation of the water supply system of District Town. However, their roles are limited to doing the operation of existing facilities and minimum maintenance due to budget shortage. The fee collection is not done. Anything is hardly performed for basic management. It is curious that dissatisfaction of the residents do not confront the authority even if the water supply has stopped. It is thought that the reason for this is that most of residents can use the water of the rain water collected as an alternative source.

"Commitment", "High Motivation", and "Resources" are necessary to do a consistent water supply service management as the implementing organization. All of these are insufficient for PG & LLGs concerning current District Town water supply service. The workshop was held in Port Moresby for the staff of PNGWB on the 19th and 21st of August 2000. Moreover, the representatives of relevant organizations on the national and local levels and in the water supply sector participated in the workshop which was held in Kwikila on the 23rd and August 24th, 2000. Similar problems as mentioned-above were pointed out in these workshops. Therefore, it is assumed that it is difficult for PG & LLGs to achieve the management of water supply service.

b) Consideration for Low Income Group and Promotion for Water Supply Coverage in Village

i) Water Supply to Low Income Group in The Urban Area

In two Provincial Towns of the Study Area, Popondetta and Daru, settlements for low income groups among the residential areas exist. Especially, it is obvious in Daru. The water supply is available even in the area where low income group lives and many of the residents in such areas have water connection. However, many of these residents fail to pay for water charge in time. When they do not pay for three months these customers are disconnected by PNGWB. The unpaid bill amount and reconnection fee must be paid to restore water supply. There are many residents who gave up to reconnect because they could not pay. Since they could not get water supply service they use water from the shallow well where most shallow wells have the problem of water quality, volume and seasonal instability. Such a situation is common and seen in most Provincial Towns. PNGWB has been trying to mitigate the problem that questions on how to balance promotion for water supply coverage and cost recovery. Although trial and error such as introduction of flat rate for the users of the public faucet, etc. have been done by PNGWB, but a concrete evaluation has not been practically done yet.

It is proposed in this Study to try the water vendor method as follows that have been introduced under similar environments in other countries.

- PNGWB sets up the public faucet for this trial in the target area.
- PNGWB contracts Water Vendors and appoints them as "Water Distribution Agents" and. In that case, certain amount of money is deposited by "Water Distribution Agents" to PNGWB.
- The Water Distribution Agent sells water to users by certain unit of water such as bucket or tank at the above-mentioned public faucet. In this case, the water price by Water Distribution Agent shall be within the range that PNGWB admits.
- The residents pays water charge to the Water Distribution Agent whenever water is drawn

from the public faucet, and the Water Distribution Agent pays PNGWB the water charge by measuring the meter installed at the public faucet.

It seems that a similar experiment was not carried out in PNG. Therefore, it is proposed to have this experimental introduction of the system to confirm its adaptability in PNG, and especially as the Pilot Project of which implementation during the "Study in PNG 2" is recommended. If the adaptability is confirmed, this method can be applied to other towns. Eda Ranu that is in charge of water supply in NCD has a large area where fee collection is not made and it is a considerable issue for them. Eda Ranu also has a plan as follows for the Pilot Project in a part of the settlement in Port Moresby from December 2000.

- Communal tap shared by about four households is set up by Eda Ranu.
- The residents establish water committee. This water committee makes a contract with Eda Ranu, and the charges are collected from the residents.
- Water committee pays Eda Ranu water charge (flat rate) for communal tap.

ii) Water Supply to Village Residents

There are some cases where the water sources for water supply service of Provincial Towns and District Town are not available within the Town boundary, and the proposed water source point is located in the customary-land which is traditionally owned by village residents. In such a case, the village residents very often are also facing shortage of drinking water and willing to receive the water supply service. Provision of water supply service to the village residents may be one of the key issues to get the consent from them concerning use of water source.

In case of the water intake for Daru water supply at Binaturi River, this water source is very essential for the water supply in Daru. There are several villages along the river and the residents do not have water supply facility and there is drinking water shortage. Among them some demand large amount of money as compensation from PG & LLG and PNGWB for the water intake, and sometimes obstruct the operation of water-intake. Such residents are frustrated because no improvement was made for their water supply and hoping to have water supply facility. The demand for water supply service may be one motivation of their behaviour other than economic reasons. Therefore, it is necessary to examine the demand and feasibility of water supply to these village residents related to the water source use during the water supply plan stage. In case of the villages along Binaturi River, independent and simple water supply facilities such as rain water tank and shallow well are appropriate since the villages are located far from the water supply system and the population is not large.

On the other hand, it is common that residents of the villages that locate adjacent to the District Town hope to receive the water supply service. This is also an issue to be considered and the village residents shall be covered by the water supply service when the conditions such as enough capacity of water source, appropriate distance of pipeline to the village, the villagers' preparedness for cost bearing are satisfactory.

When most of the District Towns are covered with appropriate water supply system in the future, the water supply improvement of the villages that are outside of the District Towns will become another task to be tackled by PNGWB. The construction and/or improvement of the facilities and sustainable O, M & M for these areas will be more difficult than the case of District Towns. However, there is no organization that is in a position to solve this problem other than PNGWB as CSA under NWSS Act. The Study Team made a presentation concerning the proposed participation of PNGWB in District Town water supply service to the executives (Water Executive Team: WET) of PNGWB on September 1, 2000. WET of PNGWB showed their interest and understanding to the concept explained by the Study Team, and explanation by WET to the Board on this issue is scheduled. Moreover, although it is still at the level of idea, setting up a specialized division or separate organization such as Non-Profit Organization apart from the basic framework of PNGWB for the particular task to work on District Town and rural water supply services which are not on commercial basis at the moment is under consideration at the management level of PNGWB.

2) Support for O, M & M Scheme (Possibility of Subsidy Provision)

Institution and management of water supply system for the District Towns and concrete measures of support are considered as follows.

If it is assumed that District Town water supply service continuously make a large amount of deficit and such a loss has to be absorbed by PNGWB, PNGWB cannot undertake the O, M & M. Therefore, it is necessary to take measures that make PNGWB free from such financial burden. The possible approaches are: i) to increase the revenue, ii) to get financial support of the government, iii) to reduce expenses. These concrete measures are proposed as follows.

a) Establishment of Trust Fund by Grant from Rural Development Fund

Rural Development Fund is a fund to appropriate the government capital directly to the investment of development in rural areas. The population of the rural area is counted approximately 85% of the entire population of the country and economic and social

infrastructures in the rural areas are still at very limited level. The improvement of the living standard in the rural areas is strongly requested by the residents. However, the administrative system, where PG&LLG are commanded by the central government and its financial flow from the central to the rural area goes through bureaucratic steps, has not been able to achieve high performance for the improvement of the living conditions of the people in rural areas. In that sense, Rural Development Fund is an alternative flow of the government budget for this particular purpose. The budget is allocated in District Development Program (DDP) through Office of Rural Development (ORD). In 2000 fiscal year the budget of K143.5 million in total is allocated and divided into the following several kinds of grant as shown in Table-8.2.

The proposed measure to utilize the Rural Development Fund is part of the Social and Rural Development Grant (S & RDG) allocated to establish a trust fund to support the management capital of District Town water supply service in the concerned districts. The amount of deficit caused as the balance between income and expenditure will be funded from the trust fund as the supplementary funding. Among the various types of the grant of the Rural Development Fund, S & RDG is assumed as an appropriate grant for the purpose. Although S & RDG is mainly allotted for capital investment, this trust fund is to mortgage the management of District Town Water Supply Service that is an important infrastructure investment. Therefore, allocation of this grant for the establishment of the trust fund is considered eligible. It is indispensable that the plan of establishment and management of the trust fund shall be contained in the District Development Plan with the endorsement of Joint development Planning & Budget Prioritisation Committee (JDP & BPC). Therefore, it is necessary to confer sufficiently with the related organizations.

Table-8.2 Trust Fund by Grant from Rural Development Fund, 2000

Type Of Grant	District Support Grant (DSG)		Provincial Support Grant (PSG)		Social and Rural Development Grant (S&RDG)
Recipient Of Grant	89 Open members of the national parliament (Member)		Provincial member of The national parliament (Member)		89 Districts
Amount of Grant	K50 million per Member		K50 million Per Member		K1 million per District
Sub-Type Of Grant	Discretionary	Non Discretionary	Discretionary	Non Discretionary	N. A.
Amount of Grant	K25 million	K25 million	K25 million	K25 million	N. A.
Decision -Maker on Utilization	Member	JDP&BPC	Member	JDP&BPC	JDP&BPC For endorsement

*JDP&BPC: Joint Development Planning & Budget Prioritisation Committee

b) Supplementary Funding from Budget of PG&LLG

There is a budget which PG & LLG has expended for the existing system for water supply service. The equivalent budget can be offered as supplementary funding to absorb the deficit of O, M & M for district water supply service, and PG & LLG will agree to allocate the budget for this funding if the partnership agreement is made between PG & LLG and PNGWB. On the other hand, however, PG & LLG are not recognizing accurately the actual financial position of water supply services in District Towns. It is essential that PNGWB secures the transparency of the financial positions of each District Town water supply service, and must be ready for the accountability. The anxiety of this approach is unstable cash flow of the national government that disburses the fund to PG & LLG. In recent years this delay of disbursement of the budget has been affecting the work of PG & LLG considerably. When the disbursement delays excessively or becomes unexecuted, this approach will not contribute to support PNGWB.

c) Establishment of Maintenance Support Base

In O, M & M of water supply system, there are technical aspects such as operation and maintenance of the facility and equipment, and managerial aspects such as billing, fee collections and administrative matters. Certain resources for O, M & M such as staff, facilities, equipment, are not used everyday but required regardless of the scale of the water supply system. Such required resources may become a heavy burden for District Town water supply. If District Towns can share such resources as much as possible, the load can be reduced. The maintenance support base is that common O, M & M resources are available and can be used by two or more District Town water supply services. As a result, reduction of the total expenditure for this kind of resources in these District Town water supply services may be achieved.

It is realistic that the maintenance support base is set up within the existing Water District Office of PNGWB. The maintenance support base shall secure the required capacity of human resources to support District Town water supply services with easily accessible geographical conditions as well as the facility and the equipment for repair, inspection, training, accounting, etc. *Especially, in case of district centres which are located in the area where the existing Water* District Office does not exist, the set-up of this kind of maintenance support base is strongly recommended. For setting up this kind of facility funding by the government and/or the foreign aid shall be considered to reduce the load of PNGWB.

3) O, M & M Plan

The following measures for solution of the problems are considered. The water supply in District Town is not well managed due to problems in "Facility", "Institutional framework (including human resources)", and "Financial Affairs". The following solutions are discussed.

i) The facility: The most appropriate plan, design and construction should be implemented.

ii) The institutional framework: The institutional framework which has the capability to respond to the issues on both technical aspect and managerial aspect should be established.

iii) Financial affairs: It is necessary to establish the fee collection as the cost sharing by users and the independent accounting of water supply service. Subsidy allocation from the Governmental budget to compensate the loss caused by insufficient revenue should be possible.

The human resources competent in the technical aspect and the managerial aspect, and the institutional framework which can offer them enough knowledge and experiences are required to manage water supply service of District Town. The following Table-8.3 shows the comparison of evaluation of readiness of respective organization as a candidate for the management.

Tbale-8.3 The Comparison of Evaluation of Readiness of Respective Organization

Name of Organization Evaluated	Technical Aspect (Human Resources/ Knowledge & Experiences)	Managerial Aspect (Human Resources/ Knowledge & Experiences)	Feasibility to be a Responsible Organization for the Management
Provincial Government	Difficult	Difficult	Low
District Administration	Difficult	Difficult	Low
Local Level Government	Difficult	Difficult	Low
Dept. of Works	Available	Difficult	Low
PNG Waterboard (PNGWB)	Available	Available	High
Private enterprise	Available	Available	Low

During this Study, hearings, discussions, and information and data collection from the relevant organizations such as PNGWB, central governmental agencies, and PG & LLGs were made. Only PNGWB and private enterprises have capacity to provide the human resources and knowledge on technology and management. However, private enterprises cannot provide services due to the limited commercial viability of water supply service in District Town while PNGWB's case has feasibility.

The following two methods are possible when PNGWB's participation to the water supply service in District Town is discussed. One method is direct operation & management by PNGWB, and another one is called "External Services" in which PNGWB provides the technical service to PG&LLG who is in charge for the management of the water supply service. These are explained as follows.

a) Direct operation & management by PNGWB and declaration of new Water District

Direct operation & management by PNGWB is an alternative in which PNGWB takes charge of operation, maintenance & management (O, M & M) of the water supply service directly as same as is of Provincial Towns where currently O, M & M is done by PNGWB. For this method a new water district for each District Town under NWSS Act shall be set up so that PNGWB will become solely responsible for the O, M & M of District Town water supply service. Meantime the support by PG & LLG to PNGWB for the O, M & M shall be there. The following processes are necessary for this.

Setting up (declaration) of a new Water District:

- PNGWB confers and agrees with the relevant PG&LLG concerning the partnership agreement.
- The Board of PNGWB recommends the minister the declaration of a new Water District.
- The Minister (currently Minister for Privatisation and Corporatisation) declares the Water District under NWSS Act.

When the new Water District is set up for water supply service of the District Town, the management system for the new Water District basically follows the one applied for Provincial Town currently. This shall be an integrated management of different (smaller) business scale, and include the following essential items:

- Operation of water supply service meeting the standard in water quality, volume of water, hydraulic pressure, etc.
- Maintenance, service, repair, expansion
- Billing, fee collection, procurement, public relations, and other management issues

In comparison to the number of customers among 11 Provincial Towns under PNGWB, Kundiawa having approximately 600 customers is the smallest. Daru which shows the biggest loss among 11 Provincial Towns has 1,100 customers. Most of 6 District Towns under the Study can expect customers less than 200. Therefore, the following conditions are required for this kind of small-scale water supply system.

i) Design and construction of low-cost and efficient facility

ii) Low-cost management system

However, the income of the District Town water supply with 200 customers is assumed to be absolutely insufficient. Therefore, a mechanism that PG & LLG bridge over the financial gap is assumed indispensable.

b) External Service by PNGWB

External Service is a method in which PNGWB provides only the technical services (operation and maintenance, regular service, etc.) to PG & LLG. In this case, the management of water supply service is conducted continuously under PG & LLG. PNGWB is providing this external service currently in Lihir, New Ireland Province, to respond to the request of the mining company (Angoram) by the request of the East Sepik state, and Kokopo for the public utilities such as high school. located outside of Rabaul Water District in Eastern New Britain Province. The condition and the charge for the external service is concluded in the agreement between PNGWB and the respective PG & LLG. For example, in case of Angoram, East Sepik Province, PNGWB and the Provincial Government are arranging either of each Operator and the assistant.

The managerial aspect such as fee collections in these water supply service shall be taken care by PG & LLG. Therefore, PNGWB does not know the actual position of balance between the fee collected and the cost. It is assumed that there are cases in which the PG & LLG are not collecting water fee for the water service in spite of the national water policy "USER PAY POLICY", and other cases where large amount of financial deficit is generated. In fact there are cases where PG & LLG fails to pay the external services fee to PNGWB. Therefore, it is assumed that only in case of the water supply service of which cost of O,M&M is low and/or certain level of revenue is expected, the external service method is applicable for District Water supply. However, the number of such District Town must be very limited.