CHAPTER 3 NATURAL ENVIRONMENT

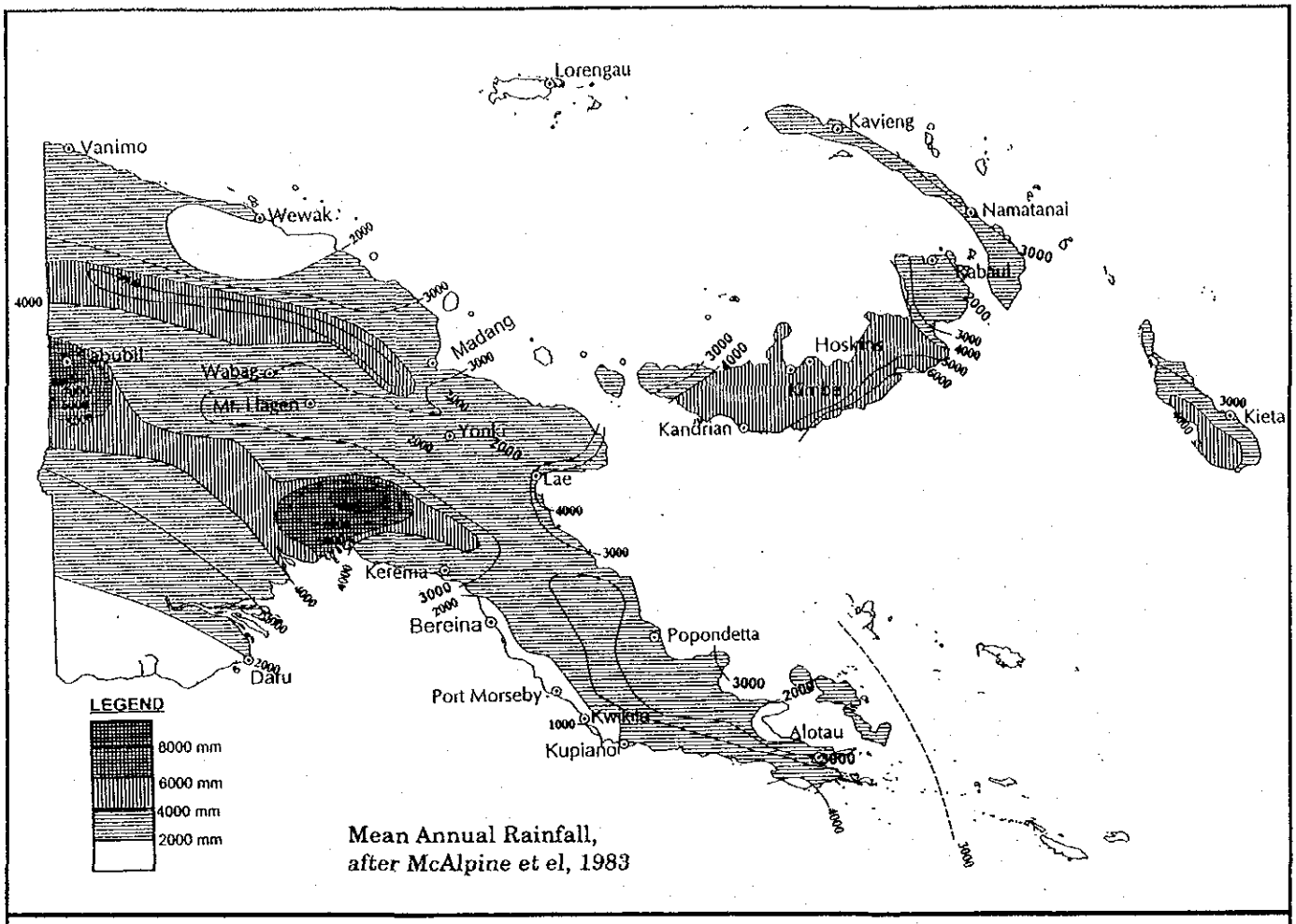
3.1 Climates and Hydrology

PNG is one of the wettest countries in world with a mean annual rainfall of 2,000 to 6,000 mm and significant areas have mean annual rainfall above 6,000 mm as shown in the study map of Fig.-3.1 (1) by McAlpine et al, 1982. The eight Study areas of the country experiences relatively high annual rainfall of 2,500 to 3,500 mm, with the maximum rainfall occurring during January to April (rainy season) and with a minimum during May to August (dry season). Mean monthly rainfall lies between 250 to 300mm in January, falling to around 100 to 150 mm in July.

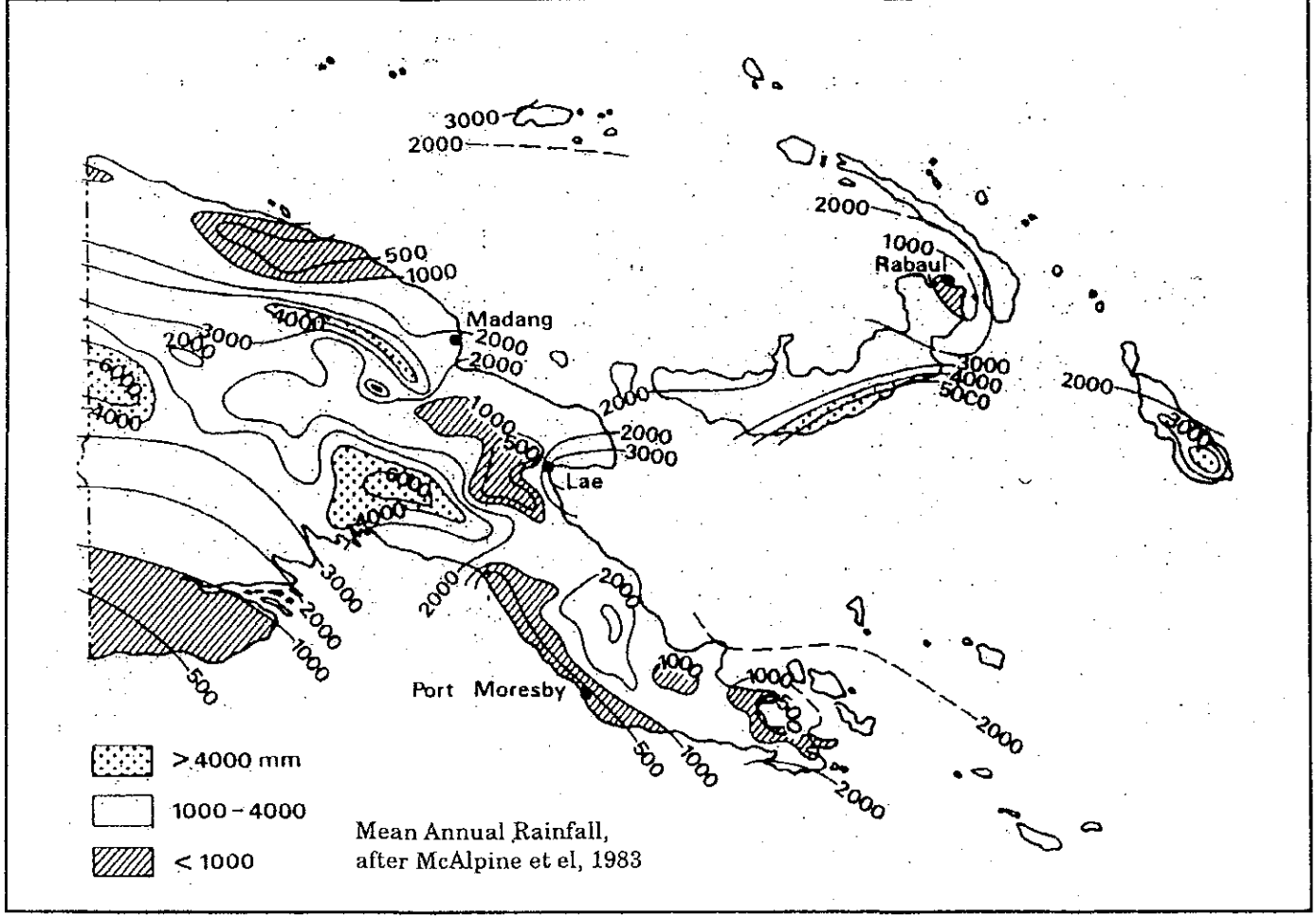
The major part of the precipitation stored within the area is held as soil moisture or in water bodies namely lakes, ponds, rivers and groundwater. Evaporation and plant transpiration are responsible for water losses to the atmosphere and surface run off and groundwater recharge in the area. This balance of inputs and outputs of water from catchments can be used to estimate unknown components of water budget and/or water balance. Runoff and stream flow are the end products of the climatologically processes. From the distribution and amount of rainfall over most of PNG, *runoff is generally high and exhibits weak to relatively strong differences in seasonal variation.* The overall pattern of mean annual precipitation and runoff for PNG to evaluate water resources potential is shown in Fig.-3.1 (2) of McAlpine et al, 1983.

Temperature regime shows little seasonal variations. Daily mean maximum temperatures on the coast are around 30 to 32°C with a minima around 23°C. The most marked characteristic of temperature drop is associated with increasing altitude. Between altitude 1500 m and 2000m the mean daily maxim are around 22 to 25°C. The combination of relatively high rainfall and temperature is associated with high humidity and cloudiness and moderate rates of evaporation, which range on the coast from 1,500 to 2,000 mm. (produced by Biorap project: CRES ANU, DECPNG, DWE CSIRO, CPBR, AGSO-1998)

A major drought and associated frost in the high altitudes affected much of PNG in 1997 and 1998. It was prolonged and widespread like the major droughts in 1914 and 1941, and probably more severe than those of 1956, 1964/1965, 1972 and 1987 droughts in the last century. In some locations the drought commenced in March 1997, with much of PNG affected by drought in May 1997.



Mean Annual Rainfall,
after McAlpine et el, 1983



Mean Annual Rainfall,
after McAlpine et el, 1983

Fig.-3.1 Mean Annual Rainfall and Runoff of PNG

However the effects were uneven between December 1996 and March 1997. First, across much of the country rainfall was significantly reduced from 'normal'. For example in one of the wettest places in the country, Tabubil, only 68mm of rainfall fell in July, compared to an average of 614 mm. In August, only 32 mm was received compared to the average of 870 mm. During the first two week of September there was no rainfall. The effect of El Niño associated drought in 1997 had a nation-wide impact on the food and water supply systems, rural life and the national economy. The drought had a major impact on the food gardens and availability of drinking water in the rural areas. 1.2 million people, some 40% of an estimated 3.15 million rural people were suffering from a severe food shortage. In many locations water supply facilities were reduced and by December it was reported some 400,000 people in the rural areas were drinking polluted water. Villagers needed to walk long distances to fetch water. This also resulted in large-scale migration of rural people to plantations and urban areas. The water supply situation was most severe in 1998 in parts of the southern Region, including coastal locations in Gulf provinces west of Ihu, parts of coastal Central province and some islands in Milne Bay Province. This had given rise to waterborne diseases.

The drought had a major impact on many institutions because of water supply problems. A number of High Schools and Health Centres were similarly threatened. Many primary and community schools were closed because children along with their parents were scattered looking for food and drinking water.

3.2 Geomorphology, Geology and Hydrogeology

PNG is located in the zone of interaction between the northward-moving Australian continental plate and the westward moving Pacific plate, since Cretaceous times. As the Australian plate is moving north and the Pacific plate is moving west, the area is structurally complex and strike slip movements and possible rotation of small plates are the results. The present contact between the two major plates is situated along the north coast of New Guinea and along the northern margin of Solomon Sea.

The geomorphologic history of PNG is linked with geological history that is dominated by young tectonic process, which has been responsible for their present day framework of landforms. The shape of the present landmass became apparent only by Pliocene. During much of Miocene the highlands were still covered by shallow seas and fluvial depositional plains. In the New Guinea mobile belt, active island arc volcanism accompanied the tectonic and igneous activity since the middle Miocene. During Plio-Pleistocene this land surface was uplifted. A number of drainage

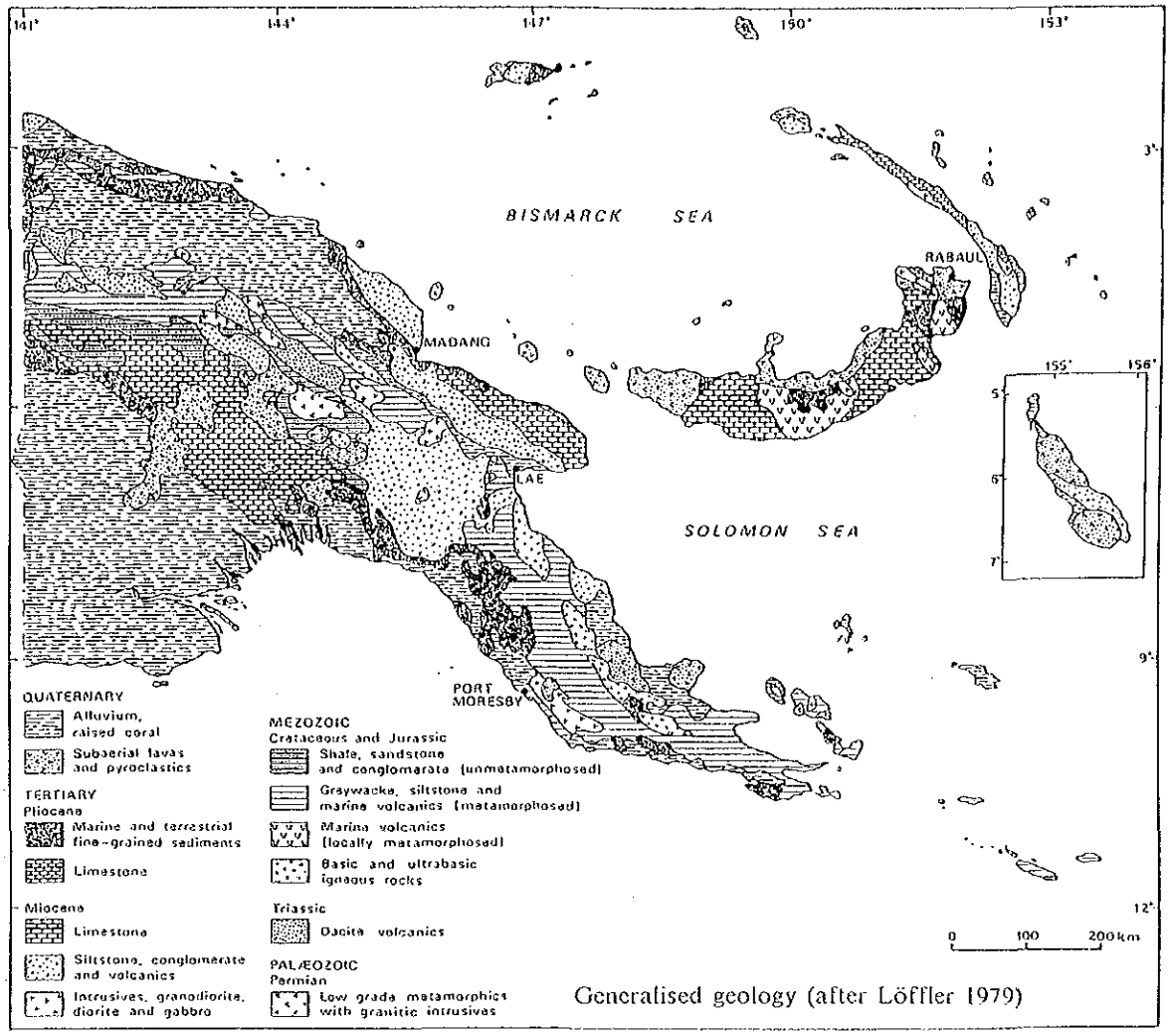
systems were interrupted by the volcanic activity leading to intramontanne basins. In the mountain forelands the rivers draining the mountains accumulated extensive alluvial deposits. Extensive fans were formed due to greater tectonic activity. Rivers with considerable steeper gradients such as Markham experienced increase of gradients. Groundwater contains these young sediments.

The geology of PNG is described in terms of twelve structural regions, which provide the framework for most of the physiographic regions showing maps of Loffler, 1979 shown in Fig.-3.2 (1), and Thompson et al, 1965 and Bain 1973 shown in Fig.-3.2 (2). The distributions of major structural regions are:

1) The Fly Platform
2) The Papuan Fold Belt
3) The Aure Trough
4) The Kubor Anticline
5) The New Guinea Mobile Belt
6) The East Papua Ultra basic Belt
7) The South-east Papua Volcanic Province
8) The Cape Vogel Basin
9) Sepik - Markham Depression
10) The Finisterre- New Britain Volcanic Arc
11) The Toricelli- Bewani Ranges and
12) The Bougainville- New Ireland Volcanic Arc.

The distributions of major structural regions in which the eight study areas are located are the following:

(1) The study area of Popondetta and Oro Bay is located in the Cape Vogel Basin, a region that extends from Morobe to Cape Vogel. It overlies the Papuan Ultra Basic Belt to the southwest. It consists of mid Miocene to Pliocene sedimentary rocks reaching up to a thickness of 4000 m and is overlain by Quaternary volcanics and alluvial sediments. Here there are two active volcanoes namely Mt. Lamington and Mt. Victory. Popondetta is located 17km north of Mt. Lamington, an active andesitic type volcano. The area is plain forming a part of the volcanic outwash fan, which form a part of Mt. Lamington volcanics, which consist of andesite agglomerates, tuff and lava. The fan is composed of a series of volcaniclastic formations with poorly sorted alluvial formations and deposits of volcanic origin. The outwash fans are drained by numerous streams resulting in formations with sandy clays intercalated with coarser pyroclastics in the form of silt, sand and gravel and boulders. Recent volcanic eruptions are noted in river cuttings. In the riverbeds and banks of Banghuo River gravelly deposits of alluvium with gravel and boulders are noticed along with boulder sized of



Generalised geology (after Löffler 1979)

Structural regions (after Thompson and Fisher 1965 and Bain 1973)

1. The Fly Platform
2. The Papuan Fold Belt
3. The Aure Trough
4. The Kubor Anticline
5. The New Guinea Mobile Belt
6. The East Papua Ultrabasic Belt
7. The South-east Papua Volcanic Province
8. The Cape Vogel Basin
9. The Sepik-Markham Depression
10. The Finisterre-New Britain Volcanic Arc
    a The Palaeogene volcanic arc
    b The Quaternary volcanic arc
11. The Toricelli-Bewani Ranges
12. The Bougainville-New Ireland Volcanic Arc
    a The Palaeogene volcanic arc
    b The Quaternary volcanic arc

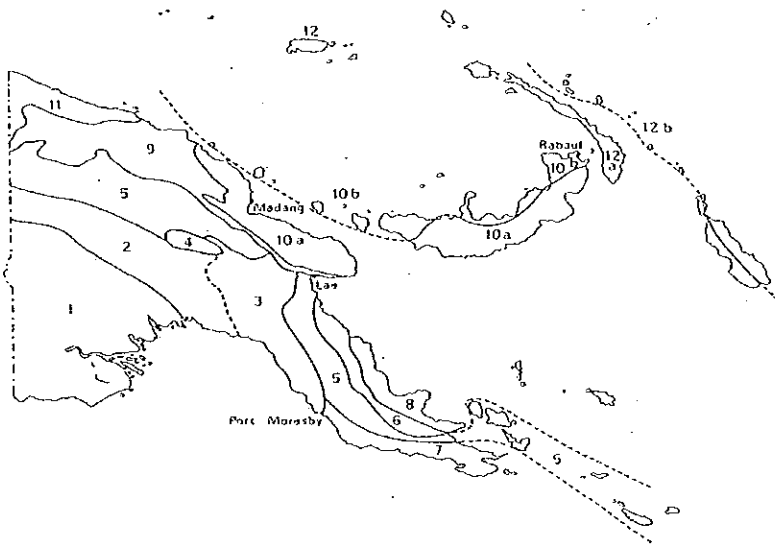


Fig. 3.2 Generalised Geology and Structural Regions of PNG

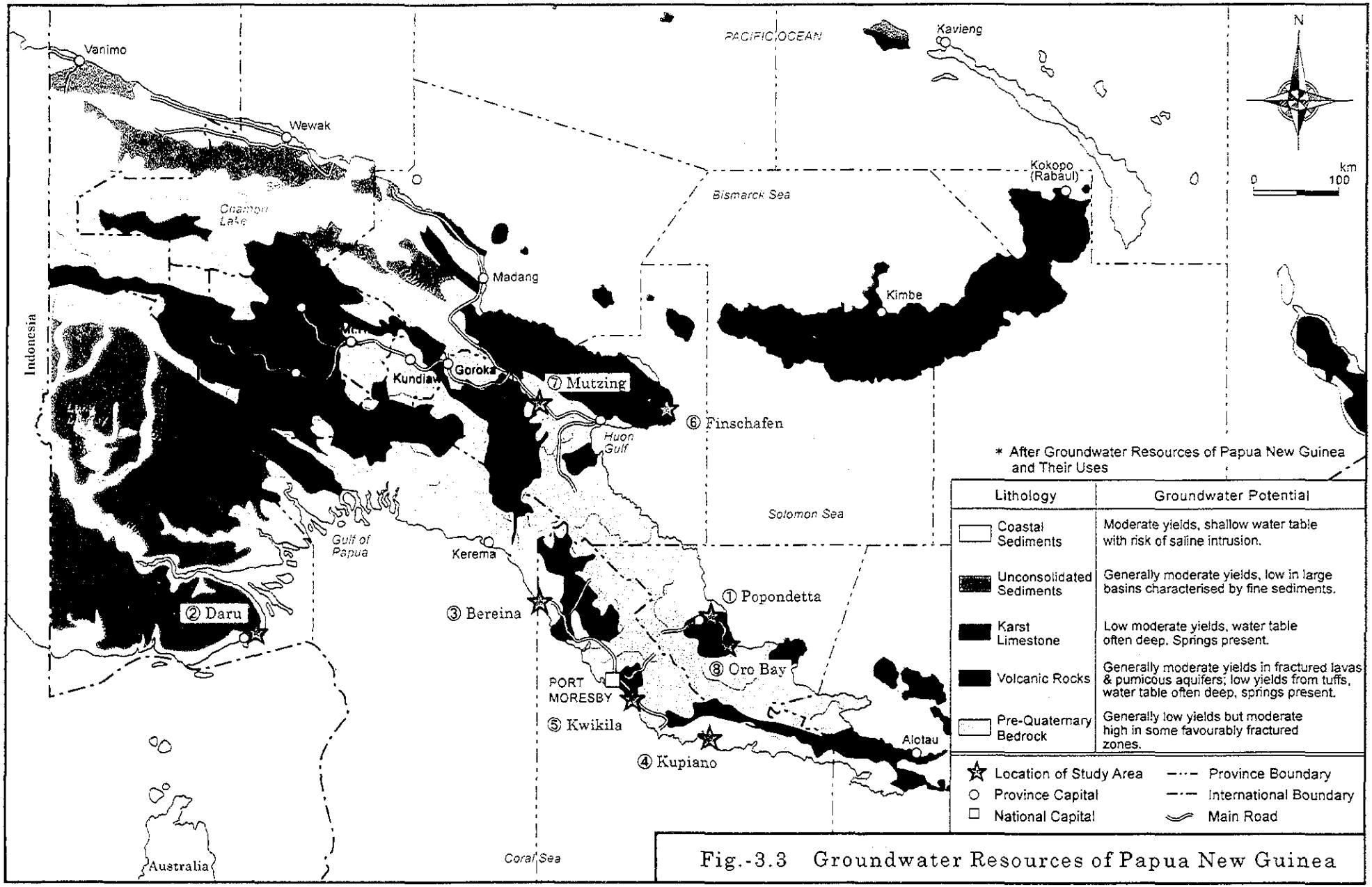


Fig.-3.3 Groundwater Resources of Papua New Guinea

andesite. In the Riverbed of Komburo Creek, sandy material associated with silt and boulders are noticed. The volcanic sediments contain groundwater, however groundwater development is hard due to difficulties to drill into these volcanic boulders.

(2) Study area of Daru is located in the Fly Platform. This is an extensive stable shelf comprising of the vast plains and low lands associated with the Fly and Strickland Rivers. Daru Island is made up of volcanic rocks and coral limestone. Relatively young swampy alluvial deposits fringe Daru Island formed by basic volcanic activity during the Pleistocene. The principal rock types include basaltic lavas, tuffs and coralline limestone. Due to the porous coralline limestone, saline water occurrs in the area.

(3) Study area of Bereina is located in the Aure Trough. This is a trough with a great thickness of 15,000m sediments. Most of the sediments are relatively coarse-grained greywacke sandstones derived from volcanic rocks fringing the basin to the west. The deposition and subsidence in the trough was during Miocene and Pliocene followed by intense orogeny. Groundwater contains young sediments of sands and silt.

(4) Study area of Kwikila and Kupiano is located in the Southeast Papua Volcanic Province. This region lies south of the Owen Stanley Range and extends from Port Moresby eastward to Milne Bay at the tail end of the mainland. It consists mainly of submarine basaltic lavas flanked to the south by highly deformed early Tertiary sedimentary rocks including sandstone, siltstone, shale, conglomerate, limestone and chert. The upper Eocene to middle Oligocene gabbro, basalt and dolerites predominantly underlies the area. Upper Miocene to Holocene fluvial sediments that are made up of sand, silt and gravels overlies them. There is a marked unconformity over which the unconsolidated sediments had been overlain. Groundwater contains these young sediments of sands and gravels.

(5) Study area of Mutzing is located in Sepik – Markham Depression. This depression is one of the major structural elements of New Guinea, extending through the entire island from Geelvink Bay in Irian Jaya to the Huoan Gulf in PNG, where it continues as a submarine depression leading into the New Britain Trench. The depression has been a zone of relative subsidence since late Tertiary and steep fault scarps locally mark its margins. The trough is filled with terrestrial clastic sediments forming extensive alluvial plains and fans. The study area is located in the Ramu-Markham valley, which is a northwest-south easterly trending valley, 150 km long and 30km wide. This is a tectonic valley forming the part of the downthrown side of a block faulted area as a Graben. This wide flat-floored valley is flanked on both sides by high mountain ranges and is drained by Markham river

flowing southeast. The valley floor consists of flood plain deposits, alluvial fans deposited by tributary rivers draining from the mountain ranges. Therefore, groundwater is abundant in sands and gravels of flooded river plain.

(6) Study area of Finchaffen is located in the Finisterre-New Britain Palaeogene Volcanic Arc. This structural unit includes New Britain, the Finisterre and Saruwaged Ranges of the New Guinea mainland and the chain of volcanic islands off the north coast. And it has the distinctive features of an Island Arc and continues westward into the Ramu - Markham Graben. The area is made up of volcanics, sandstone and coral limestone. The coralline limestone contains abundant groundwater, however saline water intrusion is occurred near the coast.

3.3 Existing Water Sources in the Study Area

The situation of the water usage in the eight Study areas was investigated. It was found that tap water is currently supplied at 4 study areas: Popondetta, Daru, Finschhafen and Mutzing. Among these areas, the systems are managed by PNGWB in Popondetta and Daru, while these systems are managed by the Local Government in the other two. In Bereina, Kupiano, Kwikila, the existing systems are not working. There is no existing water supply system in Oro Bay. The investigation revealed that there are six types of water sources for drinking and other domestic uses namely rainwater, river water, shallow wells, boreholes, spring and piped water. Since the country has relatively high annual precipitation of more than 2,000 mm, households and public facilities generally use rain water collected by water tanks. However, rain water can be used only seven months in a year, and therefore, they need safe drinking water in the dry season.

3.3.1 Hydrologic Measurement

1) General

As a part of the inventory of the existing water sources that are being utilised in the Study area, hydrologic investigations were carried out. Four Study areas from where water is being pumped and one spring source that could possibly augment the present supply were visited. The investigations involved the profiling of the river sections and making stream gauge measurements. Hydrologic measurements were carried out at the following five areas in the Study area during the period May-June, 2000:

i) Daru water supply, Binaturi River Intake

ii) Kupiano water supply, Lako River Intake

iii) Popondetta, Bangoho River Intake

iv) Finschhafen, Buta Creek and Buta Weing Creek,

v) Iapora Spring/Stream Flow outside Kupiano Town.

2) Methodology:

Binaturi River intake for Daru water supply and Lako river intake for Kupinao were approached travelling upstream of Binaturi and Lako Rivers by boats fitted with out-board motors. Stream flow measurements were made using San-Ei Current Meter manufactured by San-Ei Sokuryoki Co.Ltd, Japan. This is a Price's Current Meter – vertical axis type. The rating equation of this particular instrument is v = 0.161 N + 0.004. Measurements were made across rivers and streams at suitable locations, moving by boat or by wading. The mean velocity flow was determined by making velocity measurements across the stream at suitable intervals ranging between 0.5 m to 5 m horizontally depending on the width of the river or stream. Vertical measurements were made every 50 cms starting from the bottom of the river or stream. The readings were taken using Digital Meters mostly and by using 'Fractionalize Buzzer'. Computations were carried out using 'Two Points Method' applying the following formula: Vm = (v 0.2 + v 0.8). The area of cross sectional flow was determined by plotting the profile.

3) Hydrological Observations

i) Daru Water Supply, Binaturi River Intake

Binaturi River flows in the Western Province, along the southern coast of the South Fly District, West-Northwest of Daru Island. The Binaturi catchment area spreads for 842 sq. km. There is a pumping station at U'Ume on Binaturi River, approximately 15km West North West of Daru, which supplies Daru with water. The pumping station was visited during 6th June 2000. It was reported that approximately 1,250 m^3 of river water is pumped for the use of Daru town every day. Stream flow measurements were carried out near the intake point. Here the river is 35 m wide and 5 m deep at the deepest point. The flow was worked out as 37.8 m^3/sec (136,080 m^3/h = 3,266,920 m^3/d). Therefore, about 0.04% of the river discharge was pumped to Daru in June 2000. This was during the rainy season and so it is felt that there is more detailed study to be taken during dry season. Earlier study by Unisearch, team of University of Papua New Guinea, conducted in 24th January 1994 measured 30 m downstream and 500m upstream of the river intake using flotation method. Cross sectional volume 500 upstream was worked out as 17.5 m^3/sec (63,000 m^3/h), while cross sectional volume 30m down-stream was worked out as 12.5 m^3/sec (45,000 m^3/h). Therefore, about

0.08% of river discharge was pumped to Daru in January 1994.

ii) Lako River Intake, Kupiano Water Supply

Lako River flows southernly in the southern coast of Abau District west north west of Marshall Lagoon. Kupiano Town is located at the entrance of Marshall lagoon. Kupiano is supplied by an intake at Lako River about 2.5 km north of the Town, located about 1.5 km upstream from the confluence of the river. This point was approached by sailing in a boat fitted with an out-board motor up to about 500 m of the intake and then wading in the river to the intake. It was reported that the intake could be approached when the tide is in. Lako River drains into Marshall Lagoon, which is tidal. Tidal fluctuations have a bearing on the stream flow and the tidal influence is felt in lower reaches of Lako River. During the time of measurement on 27th June 2000 afternoon, the tide was falling and the ebb current was setting in. The river is 50 m wide and at the deepest point was 75 cm deep. This depth varies when the tide rises and the current tide moves in. The cross sectional area of the flow during the time of measurement was 28.03 m^2 and the river was flowing with a velocity of 2.08 m/sec. The stream flow was noted to be 58.3 m^3/s (209,880 m^3/h). This figure is felt to be slightly higher due to the seasonal increase after a rainy spell. As such this may not be quite representative of the average flow of the river. However stream flow measurements were carried out. But the need to measure during the dry season is being emphasised.

Note on tidal influence on the flow of the above two rivers: The lower reaches of Binaturi and Lako Rivers are Alluvial Flood Plains subject to tidal influence. Tidal fluctuations have a bearing on the stream flow. The rising tides sets in motion the tidal currents. When the tide begins to fall, ebb current sets in and as the tide begins to rise, flood current begins to flow landward. River discharge generally augments the ebb current but opposes the flood current; thus the ebb current attains a higher speed than flood current. During high tides in the peak of dry season, maximum incursion of seawater occurs. The extent of the influence inland depends on the nature of tides and the base flow. And these parameters vary seasonally. Stream gauging need to be carried out during different seasons especially during dry seasons, both during low and high tides. However this was not possible during the Study period. And unfortunately, the existing Kupiano water suppry system is not working due to the lack of management and broken facilities.

iii) Popondetta, Banguho Creek Intake:

Banguho Creek takes rise in Mt. Lamington and is a 20 km long creek, draining about 60 km^2 of the slopes of the mountain and forms a tributary of Girua River. Representative stream measurements were done closer to PNGWB Intake point near Popondetta Town. At this point the creek is 7 m wide and at the deepest point 0.6 m deep. The discharge was noted to be 1.6 m^3/sec (5,760 m^3/h) in May 2000. It was reported that approximately 1,700

m^3 of river water is pumped for the use of Popondetta Town every day. Therefore, about 1.2 % of the river discharge was pumped to Popondetta Water Supply in May 2000.

iv) Finschhafen, Buta Creek:

Buta Creek is the water source of the existing Finschafen Town water supply. River discharge measurements were made slightly downstream of the intake. The flow of the stream during the time (23rd May 2000) of inspection was noticed to be 16.5 l/sec (59.4 m^3/h). It was reported that approximately 150 m^3 of river water is pumped for the use of Finschhafen Town every day. Therefore, about 10.5 % of the river discharge was pumped to Finschhafen Water Supply in May 2000. However when the stream was visited in late June 2000 the flow was noticed to be over double the flow. On the other hand, in the nearby Butaweing Creek that was not a source of existing water supply now due to it being more than 5 km away from the Town, the flow was noticed to be approximately 50 l/sec (180 m^3/h).

v) Iopora Spring/Stream Flow Outside Kupiano Town.

Iopora is a stream originating from a spring in Olupara hillock located about 2 km northeast of the existing treatment plant that is not working now. The stream is reported to be perennial. The stream flow was measured to be 1.25 l/sec (4.5 m^3/h). The possibility of utilising this stream, by probably capping the spring source to augment the water supply, needs to be studied in the future due to the reduction of discharge in dry season

Conclusion: The above Stream Flow Measurement of five areas was summarized in Table-3.1. And the above observations were made during the rainy season and as such cannot be taken as representing the flow measurements of all seasons, except the spring flow at Iopara, Kupiano. There is a need to carry out stream flow measurements during the dry season to assess the actual situation. The rivers like Binaturi and Lako need to be measured during high and low tides since their flows are affected by tidal influence.

3.4 Existing Water Sources and Water Quality Analyses

In this Study, the existing water sources and the groundwater potentials were investigated, and the possibility of the development was considered. Regarding the water quality analysis of the water sources and the pollution caused by human activities, 2 to 6 sampling points were selected in each site covering the above mentioned water sources except for rainwater. The water samples were analysed by National Agricultural Research Institute (NARI) in Port Moresby from the viewpoints of the PNG water standard and characteristics.

Table-3.1 Stream Flow Measurement

Binaturi River Intake (measured on 6 June 2000)

	1.0	6.0	11.0	16.0	21.0	26.0	31.0	35.0
Depth (m)	2.30	3.00	4.00	4.80	5.85	4.70	1.60	1.50
Average velocity (m/s)	0.032	.0.165	0.290	0.395	0.344	0.362	0.159	0.032
Discharge in the strip (m3/s)	0.074	2.468	5.800	9.468	10.062	8.507	1.272	0.192
Total Flow (m3/s)	**37.8**							

KUPIANO

Lako R. Intake (measured on 27 June 2000)

Distance from one end of water surface (m)	1.0	5.0	10.0	20.0	30.0	40.0	49.0
Depth (m)	0.26	0.30	0.76	0.53	0.51	0.76	0.53
Average velocity (m/s)	0.232	1.555	1.677	2.3335	2.2125	2.494	1.542
Discharge in the strip (m3/s)	0.060	1.866	6.373	12.368	11.284	18.954	7.355
Total Flow (m3/s)	**58.3**						

POPONDETTA

Banguho R. Intake (measured on 20 May 2000)

Distance from one end of water surface (m)	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Depth (m)	0.21	0.27	0.35	0.42	0.56	0.61	0.71	0.60
Average velocity (m/s)	0.519	0.799	0.815	0.785	1.002	0.9275	0.674	0.356
Discharge in the strip (m3/s)	0.163	0.108	0.143	0.165	0.281	0.283	0.239	0.107

Distance from one end of water surface (m)	5.5	6.0	6.5	7.0
Depth (m)	0.36	0.24	0.30	0.20
Average velocity (m/s)	0.318	0.2555	0.169	0.41
Discharge in the strip (m3/s)	0.057	0.031	0.025	0.041
Total Flow (m3/s)	**1.6**			

FINSCHHAFEN

Buta Creek (measured on 23 May 2000)

The stream flow was measured to be **16.5 L/s (0.0165 m3/s).**

1) Analyses of the General Characteristics of the Water Sources

The six parameters namely temperature, pH, electric conductivity (EC), Turbidity and colour and odours and tastes were analysed as general characteristics. The weather and the air temperature were also recorded on the sampling day as well.

2) Sampling and Storage of the Samples

Five 600 ml bottles of water (3l in total) were sampled at each site. Nitric acid was added to one sample so that it contains about 1% of NHO_3 in order to stabilise metallic ions. The other samples were kept cool at a temperature of about 0℃ in a cooler box during their transfer to NARI for the analyses.

3) Water Quality Analysis in NARI

The parameters analysed are mainly divided into two groups: one consisting of the parameters relating to the drinking standards; and the other consisting of parameters which are important for the water characteristics, although they are not described in the drinking water standards. The analysed parameters include both elements and compound groups. The Inductively Coupled Plasma (ICP) analyser was used to analyse the metallic elements, and the High-Performance Liquid Chromatography (HPLC) method was used for the non-metallic elements and compounds. In addition, other parameters like nitrogen groups were analysed by spectrometry and titration.

The analyses of the parameters relating to the PNG water standard is shown in Table-3.2 (1), and Table3.2 (2) shows that for parameters relating to the water characteristics. The PNG water standards are the same as those recommended by the WHO guidelines. The items for water standards include general items, elements, compounds, bacteria groups and residual chlorine as shown in Table-3.2 (1). In 23 sites out of a total 35 sites (66%), water from the sources is used for drinking. Turbidity, odour and taste satisfy the standard in all of the sites. For colour, the sample from Oro Bay (8c) does not meet the standard. Concerning pH, the value at the water treatment plant in Daru (2b) is relatively low (pH:5.4) due to the influence of aluminium sulphate used as coagulant. This might cause corrosion in the distribution pipes, and thus, the pH value needs to be strictly controlled.

As far as the 19 elements which are described in the PNG water standards are concerned, in all of the samples, the water standards are satisfied except for iron. The concentrations of iron do not meet the standard value (0.3 mg/L) in two sites: Daru (2e), 0.8 mg/L; and Kwikila (5d), 0.4

mg/L. For other compounds, the value of total acidity, total alkalinity, total hardness, total dissolved solids (TDS), and Langelier's index (LI) meet the standards. In Popondetta and Daru, the tap water is chlorinated, and the waters in these two towns satisfy the standards in terms of total coliform groups. No total coliform group was detected from the sample from the borehole in Kwikila (5c). On the other hand, it was found that the samples from the other 20 sites (87%) were contaminated by total coliforms, although the people are using this source for drinking water. These contaminated water sources include 3 high schools and 2 hospitals. According to the standard, the maximum value of residual chlorine is 5 mg/L, and the desirable minimum value is 0.1 mg/L. Treated tap waters in Popondetta and Daru have 1.0 mg/L and 0.2 mg/L of residual chlorine respectively.

The results of characteristics of water in the study areas are also shown in tri-linear diagrams and hexa-diagrams as shown in Figure-3.4 and 3.5 (1), (2).

Table-3.2(1) Analysis of Existing Water Sources from Eight Sites in the Study Area (parameters relating to the PNG water standard)

Study Area	Location	Source	Date of year 2000	Weather	Atm. Temp. ℃	General Quality: Temp. ℃	pH	EC mS/m	Turb.	Color	Odour Taste	Elements: Cd mg/l	Hg mg/l	Se mg/l	Pb mg/l	As mg/l	Cr mg/l	F mg/l	Ba mg/l	Zn mg/l	Fe mg/l	Cu mg/l	Na mg/l	Mn mg/l	Cl mg/l	Ni mg/l	Sb mg/l	B mg/l	Mo mg/l	Al mg/l	Compounds & Others: CN mg/l	NO2-N mg/l	NO3-N mg/l	SO4 mg/l	TOC mg/l	TDS mg/l	Bacteria: Total /100ml	SPC	Residual Cl mg/l
1.Popondetta	a. Agr.College	Borehole	24.May	Fine	29.0	28.0	7.2	25.9	0	6	Nil	ND	ND	ND	ND	ND	ND	0.70	ND	ND	0.2	ND	7.5	0.38	10	ND	ND	0.1	0.01	0.1	ND	ND	0.6	54.9	1	160	13	77	
	b. Village	Spring	25.May	Rain	26.5	25.8	6.3	14.8	0	2	Nil	ND	ND	ND	ND	0.002	ND	0.64	ND	ND	0.1	ND	7.2	0.09	9	ND	ND	ND	0.01	ND	ND	ND	0.5	8.5	1	118	69	200>	
	c. W. B. Intake	River	25.May	Cloudy	25.8	27.3	7.8	24.2	1	6	Algae	ND	ND	ND	ND	0.006	ND	0.59	ND	ND	0.1	ND	13.6	0.02	12	ND	ND	0.1	0.01	0.1	ND	ND	0.9	80.7	1	152	200>	200>	
	d. Town	Tap	25.May	Cloudy	24.7	26.8	7.5	24.1	0	6	Chlorine	ND	ND	ND	ND	0.006	ND	0.56	ND	ND	ND	ND	13.6	0.01	13	ND	ND	0.1	0.01	0.2	ND	ND	0.6	82.2	1	154	0	1	1
2.Daru	a. Uume Intake	River	5.June	Rain	26.5	25.0	6.3	5.1	0.5	75	Nil	ND	ND	ND	ND	0.003	ND	0.14	ND	ND	0.5	ND	2.4	0.01	11	ND	ND	ND	0.01	0.2	ND	ND	0.5	3.9	3	160	61	73	
	b. Treatment Plant	Tap	6.June	Cloudy	27.3	26.6	5.4	9.1	0.5	5	Nil	ND	ND	ND	ND	0.002	ND	0.05	ND	0.3	0.1	ND	7.0	0.01	11	ND	ND	ND	ND	ND	ND	ND	1.2	51.3	1	34	0	6	0.2
	c. Town A	S. Well	6.June	Rain	27.3	27.9	7.2	92.9	0	0	Nil	ND	ND	ND	ND	0.002	0.002	0.56	ND	0.1	ND	ND	20.0	ND	100	ND	ND	ND	ND	ND	ND	ND	0.6	55.5	3	524	30	200>	
	d. Town B	S. Well	7.June	Cloudy	27.1	26.4	7.0	14.0	50	100	Soil	ND	ND	ND	ND	ND	ND	0.21	ND	0.2	ND	ND	5.5	0.49	11	0.01	0.002	ND	0.01	0.2	ND	ND	0.4	2.2	1	72	21	200>	
	e. Town C	S. Well	7.June	Cloudy	27.3	27.2	6.3	21.1	0.5	0	Sulfide	ND	ND	ND	ND	0.003	ND	0.25	ND	ND	0.8	ND	20.0	0.04	50	0.01	ND	ND	0.03	ND	ND	ND	0.5	19.1	1	98	200>	200>	
	f. Town D	S. Well	7.June	Cloudy	28.4	26.9	7.2	184.3	15	20	Scented	ND	ND	ND	0.002	0.005	0.005	0.49	0.1	ND	0.3	ND	157.0	0.16	350	ND	ND	ND	0.02	0.1	ND	ND	0.6	163.6	1	1030	200>	200>	
3.Bereina	b. Training C.	Borehole	23.June	Clear	28.3	25.7	7.8	53.2	0	0	Nil	ND	ND	ND	ND	ND	ND	0.43	ND	ND	ND	ND	95.1	0.03	110	ND	ND	0.1	0.01	ND	ND	ND	0.6	4.0	1	39	5	52	
	c. P.S #1	S. Well	23.June	Clear	27.2	27.7	7.6	175.3	5	6	Nil	ND	ND	ND	ND	ND	ND	0.43	ND	ND	ND	ND	172.0	0.08	341	ND	ND	0.1	0.01	ND	ND	ND	0.7	52.3	1	1022	47	113	
	d. Maniohene Intake	River	23.June	Fine	29.3	24.7	8.0	12.4	150>	100>	Nil	ND	ND	ND	0.003	ND	0.019	0.23	ND	0.1	0.2	ND	4.0	0.08	9	0.02	ND	0.1	0.02	0.1	ND	ND	0.6	4.9	1	104	200>	200>	
	e. High School	Borehole	23.June	Fine	29.3	27.4	8.2	117.1	0	2	Nil	ND	ND	ND	ND	0.003	ND	0.77	ND	ND	0.1	ND	206.0	0.05	19	ND	ND	0.2	0.02	ND	ND	ND	0.5	8.8	1	726	8	7	
	f. Angabang	River	23.June	Clear	28.0	24.8	7.9	12.6	150>	100>	Nil	ND	ND	ND	0.008	0.004	0.023	0.33	0.1	0.1	1.4	ND	4.2	0.03	8	0.02	0.002	0.1	0.01	0.1	ND	ND	0.4	6.1	1	116	200>	200>	
4.Kupiano	a. Lako R. intake	River	27.June	Fine	27.7	28.3	7.7	16.4	2	0	Nil	ND	ND	ND	ND	0.003	ND	0.28	ND	ND	0.3	ND	4.2	0.02	1	ND	ND	ND	ND	0.2	ND	ND	0.6	4.6	1	13	32	81	
	c. Iopora	Spring	27.June	Fine	27.0	27.5	8.0	8.5	0	0	Nil	ND	ND	ND	ND	ND	ND	0.19	ND	ND	0.2	ND	21.4	0.02	4	ND	ND	0.1	ND	ND	ND	ND	0.6	17.6	1	32	4	5	
5.Kwikila	a. High School	Borehole	18.May	Fine	30.6	27.9	7.3	73.6	0	0	Nil	ND	ND	ND	ND	ND	ND	0.65	ND	ND	0.1	ND	47.6	0.02	54	ND	ND	ND	0.01	ND	ND	ND	1.0	3.1	1	404	200>	59	
	b. Hospital	Borehole	18.May	Fine	29.5	27.2	7.3	84.3	0	0	Nil	ND	ND	ND	ND	ND	ND	0.70	0.1	0.1	0.2	ND	46.4	ND	46	0.01	ND	ND	ND	ND	ND	ND	1.2	9.1	1	444	11	70	
	c.SalvationArmy A	Borehole	18.May	Fine	30.0	28.7	6.9	79.7	0	2	Nil	ND	ND	ND	ND	ND	ND	0.49	ND	ND	0.1	ND	51.2	ND	50	ND	ND	ND	0.01	ND	ND	ND	0.8	4.0	1	478	0	0	
	d.SalvationArmy B	Borehole	18.May	Fine	30.0	28.5	7.0	86.7	0	0	Nil	ND	ND	ND	ND	ND	ND	0.47	ND	0.2	0.4	ND	54.1	0.01	50	ND	ND	ND	0.01	ND	ND	ND	1.8	7.9	1	490	72	0	
	e. Kemp Welch R.	River	19.May	Fine	29.6	24.5	7.6	13.4	20	50	Nil	ND	ND	ND	ND	ND	ND	0.30	0.1	ND	0.2	ND	4.2	ND	35	ND	ND	ND	0.01	0.2	ND	ND	1.1	3.2	1	28	200>	200>	
6.Finschhafen	a. Intake	River	30.May	Fine	27.1	25.1	8.0	40.1	0	0	Nil	ND	ND	0.003	ND	ND	ND	0.71	ND	ND	ND	ND	5.7	ND	10	ND	ND	ND	ND	ND	ND	ND	0.7	9.5	1	250	92	58	
	b. Hospital	River	30.May	Cloudy	28.8	25.1	8.2	31.3	0.5	0	Nil	ND	ND	ND	ND	ND	ND	0.80	0.2	ND	ND	ND	1.8	ND	9	ND	ND	ND	0.01	ND	ND	ND	0.6	3.6	1	194	82	103	
	c. Village Intake	River	30.May	Cloudy	28.3	25.7	8.2	29.5	3	4	Nil	ND	ND	0.004	ND	ND	ND	0.56	ND	ND	0.1	ND	1.1	0.02	8	ND	ND	ND	0.01	ND	ND	ND	0.5	2.1	1	182	112	84	
	d. Seminary	Spring	30.May	Cloudy	28.0	25.7	7.8	29.9	0	0	Nil	ND	ND	0.006	ND	ND	ND	0.41	ND	ND	ND	ND	1.0	ND	11	ND	ND	ND	ND	ND	ND	ND	1.5	2.4	1	166	200>	200>	
	e. Town	Tap	30.May	Clear	31.0	26.3	8.1	38.1	0	0	Nil	ND	ND	ND	ND	0.003	ND	0.43	ND	ND	ND	ND	5.6	0.01	7	ND	ND	ND	0.01	ND	ND	ND	0.5	9.3	1	248	200>	200>	
7.Mutzing	a. Manging R.	River	28.May	Fine	31.2	32.3	8.5	28.8	150>	100>	Soil	ND	ND	ND	ND	ND	ND	0.41	0.1	0.1	0.1	0.1	40.8	0.02	10	ND	ND	0.2	ND	ND	ND	ND	0.5	10.2	1	158	200>	200>	
	b. Supply Source-2	Borehole	28.May	Fine	31.2	27.6	7.3	53.4	0	0	Nil	ND	ND	ND	ND	0.003	ND	0.56	ND	ND	ND	ND	35.9	ND	9	ND	ND	0.2	0.01	ND	ND	ND	0.5	18.2	4	326	109	200>	
	c. Village	S. Well	28.May	Clear	31.2	27.9	7.3	52.7	0	1	Soil	ND	ND	0.002	ND	0.002	ND	0.82	ND	ND	0.1	ND	35.3	0.03	15	ND	ND	0.1	ND	ND	ND	ND	0.6	18.9	2	310	19	71	
	d. High School	Borehole	28.May	Clear	32.3	28.0	7.6	45.2	0	0	Nil	ND	ND	ND	ND	ND	ND	0.60	ND	ND	ND	ND	29.3	ND	7	ND	ND	0.1	ND	ND	ND	ND	0.5	14.5	1	344	36	200>	
8.Oro Bay	a. Kosisi R.	River	25.May	Fine	32.9	26.3	7.4	5.4	6	30	Nil	ND	ND	ND	ND	0.002	ND	0.24	ND	ND	0.3	ND	3.6	0.01	10	ND	ND	ND	ND	0.1	ND	ND	0.7	0.3	4	46	173	74	
	b. Beana R.	River	25.May	Fine	34.0	28.6	7.9	8.0	1	6	Nil	ND	ND	ND	ND	0.002	ND	0.22	ND	0.1	0.1	ND	5.3	0.01	8	ND	ND	ND	ND	0.2	ND	ND	0.6	0.2	4	60	200>	200>	
	c. Hospital	River	25.May	Fine	29.0	25.8	7.2	6.0	1	20	Nil	ND	ND	ND	ND	0.002	ND	0.17	ND	ND	0.3	ND	4.2	0.02	9	ND	ND	ND	ND	0.1	ND	ND	0.6	0.3	1	35	146	200>	
	d. Fishery	S. Well	25.May	Fine	29.5	26.5	7.5	75.3	5	20	Nil	ND	ND	ND	ND	ND	ND	0.58	ND	ND	0.9	ND	35.3	0.11	80	ND	ND	0.1	ND	ND	ND	ND	0.7	3.6	1	426	23	37	
Analysis Limit												0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.1	0.1	0.1	0.1	0.1	0.01	1	0.01	0.001	0.1	0.01	0.1	0.01	0.1	0.1	0.1	1	1	1	1	0.05
Drinking Water Standard																																						
PNG(WHO-1993)					-	-	-	5	15	Acceptable	0.003	0.001	0.01	0.01	0.01	0.05	1.5	0.7	3	0.3	2	200	0.5	250	0.02	0.005	0.3	0.07	0.2	0.07	3	50	250	-	1000	0	-	5
Japan					-	5.8-8.6	-	2	5	Acceptable	0.01	0.0005	0.01	0.05	0.01	0.05	0.8	-	1	0.3	1	200	0.05	200	0.01	0.002	0.2	0.07	0.2	0.01	10		-	*	500	0	100	1

NOTE : The above analyses is relevant to drinking water standard

Atm. Temp.: Atmospheric Temperature
W. Temp.: Water Temperature
SPC : Standard Plate Count
Turb.: Turbidity
ND : Not Detected
S. Well: Shallow Well
- : Not Mentioned
* : COD 10mg/L

Table-3.2(2) Analysis of Existing Water Sources from Eight Sites in the Study Area (parameters relating to water characteristics)

Study Area	Location	Source	Date of year 2000	Weather	Atm. Temp. ℃	General Quality W.Temp ℃	pH	EC mS/m	Turb.	Parameters Represented Graphically Na mg/l	K mg/l	Ca mg/l	Cl mg/l	Mg mg/l	HCO3 mg/l	CO3 mg/l	SO4 mg/l	Hardness & Others T-Acid mg/l	T-Alka. mg/l	T-Hard mg/l	TDS mg/l	L I mg/l	Non-metals NH4-N mg/l	T-P mg/l
1.Popondetta	a. Agr.College	Borehole	24,May	Fine	29.0	28.0	7.2	25.9	0	7.5	5.22	24.4	10	13.1	75.6	0.6	54.9	12.0	76	114	180	-0.81	ND	0.24
	b. Village	Spring	25,May	Rain	28.5	25.8	6.3	14.8	0	7.2	4.59	12.2	9	6.0	69.1	0.5	6.5	34.5	69	55	118	-2.09	0.2	0.22
	c. W. B. Intake	River	25,May	Cloudy	25.8	27.3	7.8	24.2	1	13.6	5.86	20.7	12	7.6	38.5	0.3	80.7	8.3	39	82	152	-0.58	ND	0.15
	d. Town	Tap	25,May	Cloudy	24.7	26.8	7.5	24.1	0	13.6	5.74	20.4	13	7.6	32.9	0.3	82.2	7.8	33	81	154	-0.97	ND	0.09
2.Daru	a. U'ume Intake	River	5,June	Rain	26.6	25.0	6.3	5.1	0.5	2.4	0.55	3.1	11	1.4	7.1	0.1	3.9	0.0	7	14	160	-3.69	ND	ND
	b. Treatment Plant	Tap	6,June	Cloudy	27.3	26.6	5.4	9.1	0.5	7.0	0.54	3.7	11	1.3	36.1	0.3	51.3	0.0	36	14	34	-3.77	ND	ND
	c. Town A	S. Well	6,June	Rain	27.3	27.9	7.2	82.9	0	20.0	0.88	95.4	100	33.6	123.0	1.0	55.5	0.5	124	371	524	-0.01	ND	0.03
	d. Town B	S. Well	7,June	Cloudy	27.1	26.4	7	14	50	5.5	0.20	6.7	11	4.8	29.9	0.2	2.2	0.1	30	36	72	-2.00	ND	ND
	e. Town C	S. Well	7,June	Cloudy	27.3	27.2	6.3	21.1	0.5	20.0	1.43	4.6	50	5.2	21.0	0.2	19.1	0.1	21	33	98	-3.01	ND	0.16
	f. Town D	S. Well	7,June	Cloudy	28.4	26.9	7.2	184.3	15	157.0	4.62	94.5	350	62.0	27.0	0.2	163.8	1.0	27	488	1030	-0.69	ND	0.04
3.*Bereina*	*b. Training C.*	*Borehole*	*23,June*	*Clear*	28.3	26.7	7.8	53.2	0	95.1	4.47	4.4	110	4.0	208.0	1.6	4.0	8.0	208	28	39	-0.54	ND	0.48
	c. P.S #1	S. Well	23,June	Clear	27.2	27.7	7.6	175.3	5	172.0	5.51	111.0	341	40.2	76.1	0.6	52.3	10.5	77	435	1020	0.25	ND	0.14
	d. Manichana In.	River	23,June	Fine	29.3	24.7	8	12.4	150>	4.0	4.30	21.2	9	9.7	122.0	1.0	4.9	7.0	123	92	104	0.09	ND	0.32
	e. High School	Borehole	23,June	Fine	29.3	27.4	8.2	117.1	0	206.0	8.24	8.0	18	7.9	432.0	3.4	8.8	11.3	441	52	726	0.46	ND	0.45
	f. Angabang	River	23,June	Clear	28.0	24.8	7.9	12.6	150>	4.2	2.57	23.1	8	11.2	142.0	1.1	6.1	4.0	143	103	116	0.09	ND	0.40
4.Kupiano	a. Lako R. intake	River	27,June	Fine	27.7	28.3	7.7	16.4	2	4.2	0.33	18.5	1	7.0	89.7	0.8	4.6	4.9	90	75	13	-0.35	ND	0.02
	c. Icpora	Spring	27,June	Fine	27.0	27.5	8	6.5	0	21.4	0.59	92.3	4	18.4	369.9	0.1	17.6	11.5	371	306	32	1.25	ND	0.03
5.Kwikila	a. High School	Borehole	18,May	Fine	30.6	27.9	7.3	73.6	0	47.6	1.44	70.8	54	28.5	342.0	2.7	3.1	22.0	342	294	404	0.40	ND	ND
	b. Hospital	Borehole	18,May	Fine	29.5	27.2	7.3	84.3	0	46.4	0.94	98.5	46	33.1	427.0	3.3	9.1	22.0	428	382	444	0.63	0.7	ND
	c.SalvationAmy A	Borehole	18,May	Fine	30.0	28.7	8.9	79.7	0	51.2	0.78	87.2	50	26.9	398.0	3.1	4.0	43.0	399	329	478	0.17	0.7	ND
	d.SalvationArmy B	Borehole	18,May	Fine	30.0	28.6	7	88.7	0	54.1	0.84	97.2	50	29.8	323.0	2.5	7.9	37.5	323	252	490	0.23	ND	ND
	e. Kemp Welch R.	River	19,May	Fine	29.6	24.5	7.6	13.4	20	4.2	1.43	17.1	35	5.2	63.0	0.5	3.2	4.5	33	50	28	-0.98	ND	0.05
6.Finschhafen	a. Intake	River	30,May	Fine	27.1	25.1	8	40.1	0	5.7	6.13	71.9	10	5.9	189.0	1.5	9.5	6.8	190	201	250	0.81	ND	0.04
	b. Hospital	River	30,May	Cloudy	28.8	25.1	8.2	31.3	0.5	1.8	0.93	69.1	9	2.0	151.0	1.2	3.8	5.5	153	178	194	0.90	ND	ND
	c. Village Intake	River	30,May	Cloudy	28.3	25.7	8.2	29.5	3	1.1	0.30	67.1	6	1.4	149.0	1.2	2.1	5.0	151	170	182	0.89	ND	0.03
	d. Seminary	*Spring*	*30,May*	*Cloudy*	28.0	25.7	7.9	29.9	0	1.0	0.15	67.2	11	0.9	134.0	1.0	2.4	9.5	135	169	166	0.44	ND	0.03
	e. Town	Tap	30,May	Clear	31.0	26.3	8.1	38.1	0	5.6	8.06	71.0	7	5.5	187.0	1.5	9.3	7.0	190	197	248	0.93	ND	0.04
7.Mutzing	a. Manging R.	River	28,May	Fine	31.2	32.3	8.5	28.8	150>	40.8	2.12	81.2	10	27.5	560.0	4.4	10.2	5.3	571	315	158	1.95	ND	1.02
	b. Supply Source-2	Borehole	28,May	Fine	31.2	27.6	7.3	53.4	0	35.9	0.76	73.1	9	9.5	293.0	2.3	18.2	12.3	295	219	328	0.35	ND	ND
	c. Village	S. Well	28,May	Clear	31.2	27.9	7.3	52.7	0	35.3	0.51	72.7	15	8.4	281.0	2.2	18.9	19.5	282	214	310	0.33	ND	0.02
	d. High School	Borehole	28,May	Clear	32.3	28.0	7.6	45.2	0	29.3	0.64	62.4	7	6.9	244.0	1.9	14.5	10.5	246	181	344	0.51	ND	ND
8.Oro Bay	a. Kosisi R.	River	25,May	Fine	32.9	26.3	7.4	5.4	6	3.6	1.28	3.1	10	2.4	9.0	0.1	0.3	8.3	9	18	46	-2.46	ND	0.04
	b. Beana R.	River	25,May	Fine	34.0	28.6	7.9	8	1	5.3	1.39	4.5	8	3.8	29.0	0.2	0.2	5.8	29	27	60	-1.25	ND	0.05
	c. Hospital	River	25,May	Fine	29.0	26.8	7.2	6	1	4.2	1.73	3.6	9	2.5	16.0	0.1	0.3	7.8	16	19	36	-2.34	ND	0.04
	d. Fishery	S. Well	25,May	Fine	29.5	26.5	7.5	75.3	5	35.3	7.91	94.8	80	19.5	248.0	1.9	3.6	18.5	249	310	426	0.57	ND	0.07

Atm. Temp.: Atmospheric Temperature W. Temp.: Water Temperature Turb.: Turbidity S. Well: Shallow Well

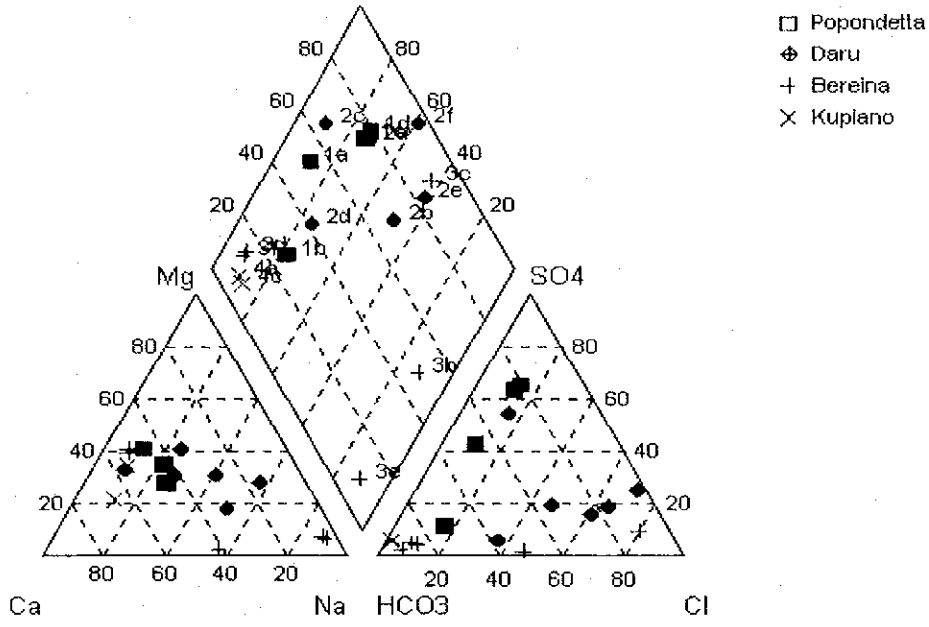


Fig.-3.4(1) Characteristics of water samples in 4 towns, Popondetta, Daru, Bereina and Kupiano

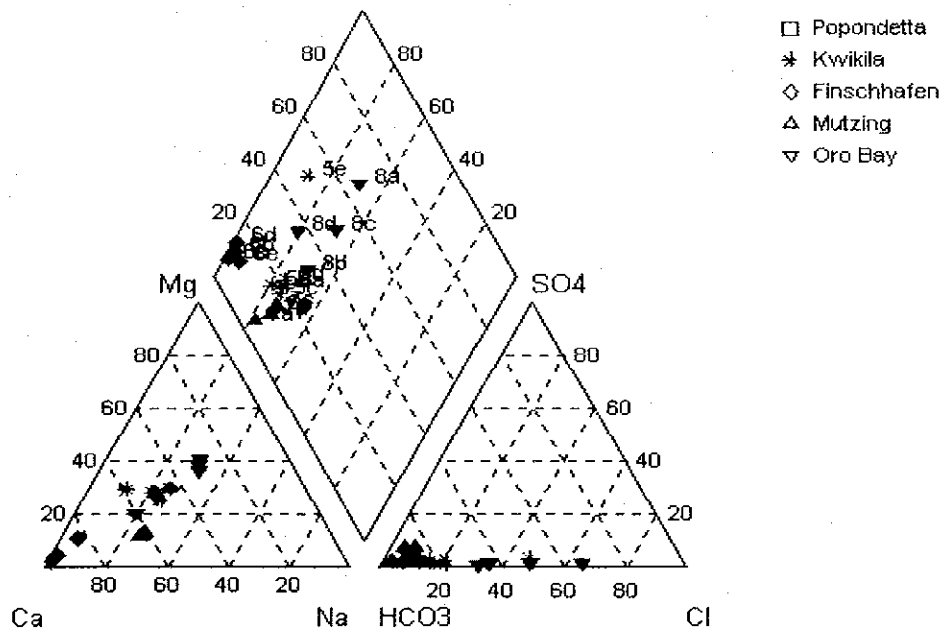


Fig.-3.4(2) Characteristics of water samples in 4 towns, Kwilila, Finschhafen, Mutzing and Oro Bay

Fig.-3.5(1) Hexadiagrams of Chemical Components of Water Samples Collected in Study Areas (Popondetta, Daru, Bereina and Kupiano)

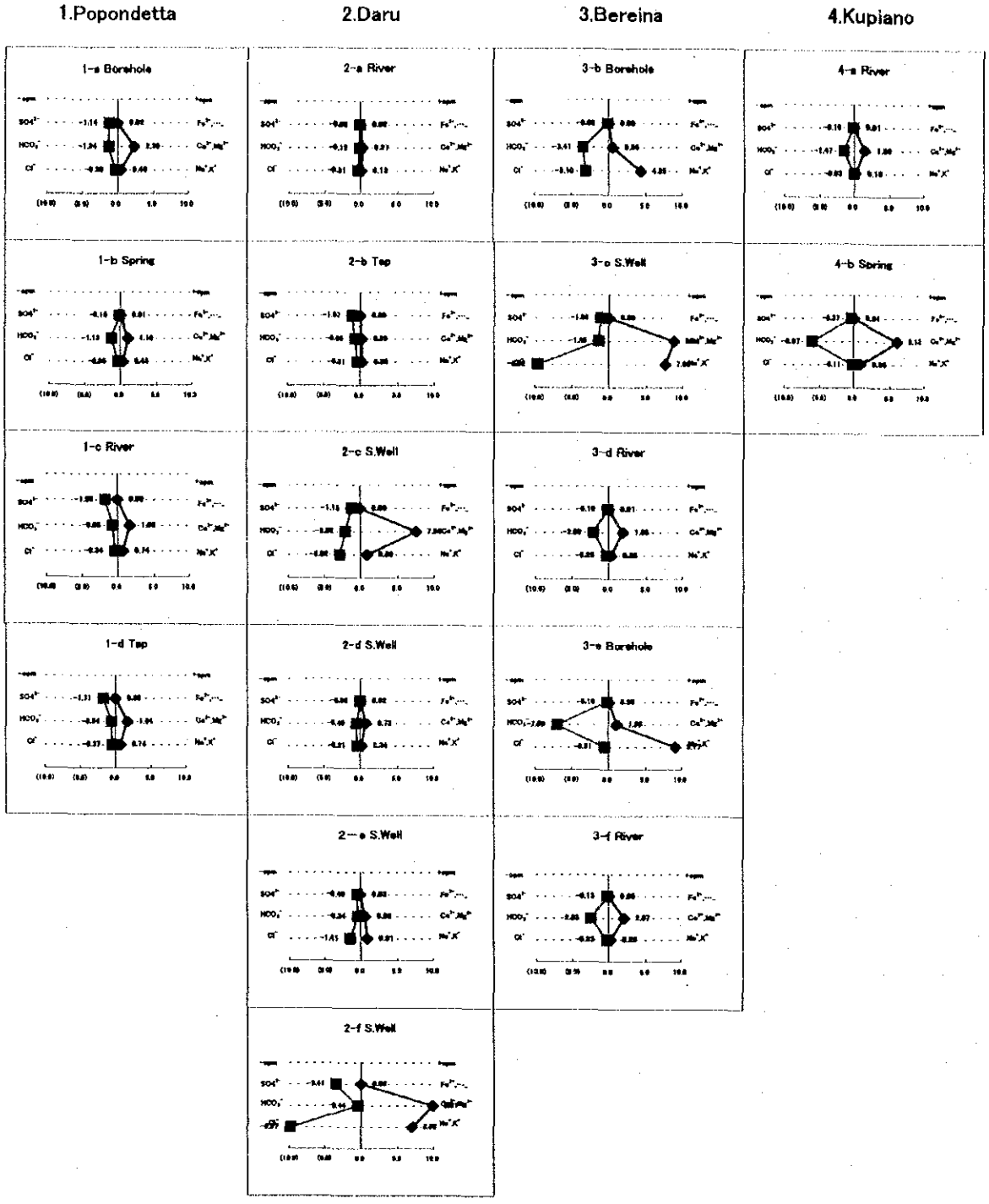
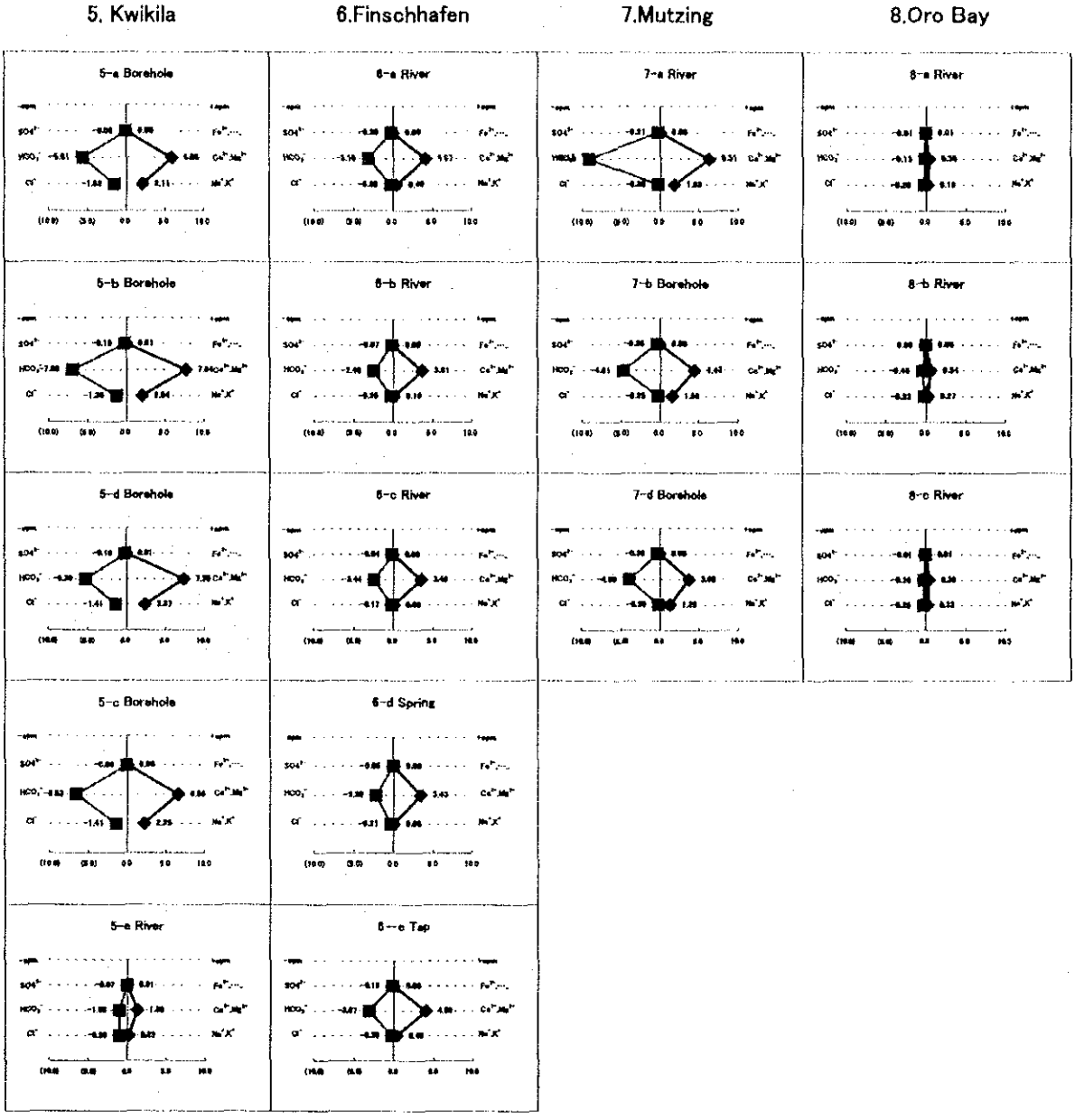


Fig.-3.5(2) Hexadiagrams of Chemical Components of Water Samples Collected in Study Areas (Kwikila, Finschhafen, Mutzing and Oro Bay)



CHAPTER 4 SOCIAL ENVIRONMENT

4.1 Population and Socio-Economic Situation

PNG had its independence in 1975 from Australia and is a member of the British Commonwealth. PNG covers an area of 460 thousand km^2, and has an estimated population of about 5 million in 2000. Australia is the top donor supplying 50% of official development assistance for PNG. It is about 25 billion yen (about US$210 million). Japan is the second largest donor following Australia with good friendship. PNG is also a member of APEC since 1993, and economic activities of Chinese capitals coming from Malaysia, Singapore and Indonesia are recently very common. An estimated per capita GNP in 1996 was US$1,150 and US$890 in 1998 (World Development Indicators). Agriculture remains the major sector of the economy, employing over 80% of the labour force living in the rural area. Economic re-structuring was held in 1990 and 1995 with recommendation from World Bank and IMF, and introduction of value added tax (VAT) increased incomes for the PNG Government. At the same time privatisation of government-owned commercial entities (Air Niugini, PNG Banking Group, other Commercial Statutory Agencies in public services including PNGWB) was recommended and the PNG Government is seeking the implementation.

4.2 Organization for Administration in Water Sector

The following organizations are relevant to the administration of water sector in PNG. It is difficult to express that the administration on water sector is really unified.

a) PNGWB as a counterpart agency of this Study, in charge of water supply and sewerage services on a national level especially for Provincial Towns, District Towns and other rural areas.
b) Water Resources Management Division, Dept. of Environment and Conservation, Water Resources Management Division in charge of water resources management.
c) Eda Ranu in charge of water supply and sewerage in National Capital District (NCD). This is a 100% government owned company to distribute water in the service area, while bulk water supply is done by PNG Water that is a joint venture with foreign capitals.
d) Dept. of Health (DOH), Health Improvement Division mainly in charge of promotion of water supply and sanitation improvement as an organization in health.
e) Local Level Government (LLG) is in charge of existing water supply and sewerage facilities. Especially LLG is authorized to be in charge of water supply in the area under the Organic Law, and there are many small-scale water supply systems under the management of LLG. Concerning development and conservation of water resources, under the Water Resources Act Water Resources Management Division (WRMD) has the function of a regulatory body. The authority regarding water resources development and utilization is also stipulated in the NWSS Act that is the basis for PNGWB. It is not very clear concerning the demarcation of the authority between WRMD and PNGWB on this point. However, there is no inconvenience practically so far because of this unclear demarcation. Therefore, it seems that the clarification has not been tried yet.

4.3 Water Supply Services

Among the above-described organizations working in the water sector, PNGWB and Eda Ranu are in charge of provision of water supply and sewerage services in the urban areas. The PNGWB was established to cover water supply and sewerage services in all the Provincial Towns in the country, and currently covers 11 Provincial Towns. The Eda Ranu was set up exclusively to service water supply and sewerage in National Capital District (NCD) and working accordingly. On the other hand, in case of rural communities, promotions of water supply and sanitation have been done by Dept. of Health, Health Improvement Division. However, the number of the villages receiving water supply is still very limited. None of these organizations are able to provide exact information and data on actual situation of rural water supply and water use. Although the District Towns have their importance in the position next to the Provincial Towns, no organization has achieved realizing water supply improvement at the District Towns. When water supply service in PNG is considered improvement in the rural area is essential and District Towns, as the gateway for the rural upgrading, have high priority.

1) Water Supply Service at the Provincial Towns in the Country

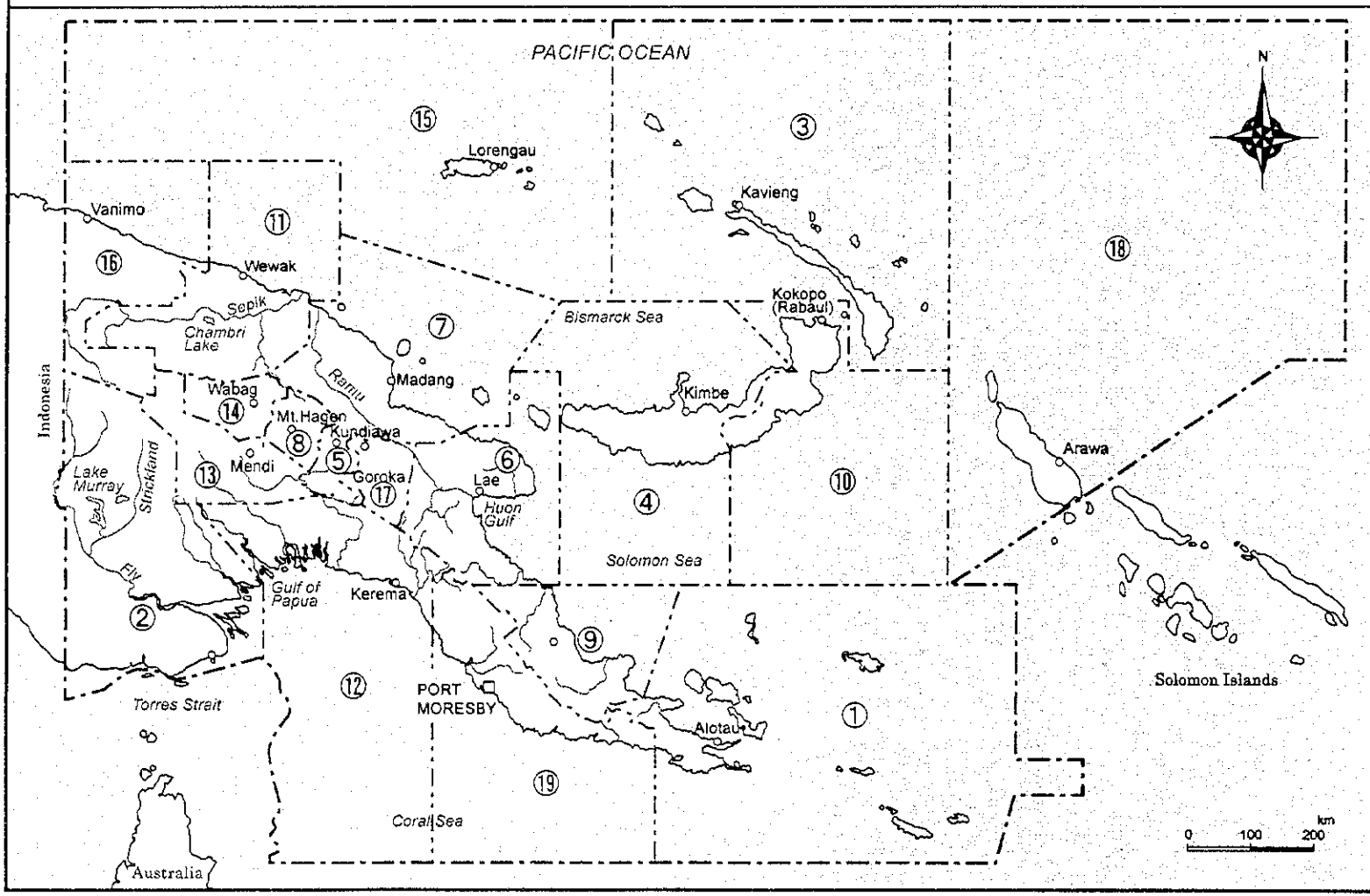
There are 19 Provinces with their Provincial Towns and the NCD. The PNGWB is currently providing services at 11 Provincial Towns.

Table-4.1 Provincial Towns and Organization Providing Water Supply Services in PNG

Provincial Town	Province	Organization Providing Water Supply Services
Alotau	Milne Bay	PNGWB
Daru	Western	PNGWB
Kavieng	New Ireland	PNGWB
Kimbe	West New Britain	PNGWB
Kundiawa	Simbu	PNGWB
Lae	Morobe	PNGWB
Madang	Madang	PNGWB
Mount Hagen	Western Highlands	PNGWB
Popondetta	Oro	PNGWB
Rabaul	East New Britain	PNGWB
Wewak	East Sepik	PNGWB
Kerema	Gulf	LLG
Mendi	Southern Highlands	LLG
Wabag	Enga	LLG
Lorengau	Manus	LLG
Vanimo	Sandaun	No water supply system
Goroka	Eastern Highlands	LLG
Arawa	North Solomon	PNGWB (operation suspended)
Port Moresby	NCD and Central	Eda Ranu/PNG Water

* Port Moresby is the National Capital and formulates the NCD, and simultaneously it is the Provincial town of Central Province. Therefore, there are only 19 provincial towns while 20 Provinces (including NCD) exist.

Fig-4.1 Provincial Towns and Water Supply Services by PNGWB



Province	Town
Water Supply by PNGWB	
①Milne Bay	Alotau
②Western	Daru
③New Ireland	Kavieng
④West New Britain	Kimbe
⑤Simbu	Kundiawa
⑥Morobe	Lae
⑦Madang	Madang
⑧Western Highlands	Mount Hagen
⑨Oro	Popondetta
⑩East New Britain	Rabaul/Kokopo
⑪East Sepik	Wewak
⑫Gulf	Kerema
⑬Southern Highlands	Mendi
⑭Enga	Wabag
⑮Manus	Lorengau
⑯Sandaun	Vanimo
⑰Eastern Highlands	Goroka
⑱North Solomon	Arawa
⑲NCD and Central	Port Moresby

○ Provincial Town
□ National Capital
---- Boundary of Province
—·— Boundary of State

Water supply services in the Provincial Towns listed below are currently managed by either Local Level Governments or Provincial Administrations and it is planned that the services will be handed over to PNGWB after the facilities are rehabilitated and/or extended which require funding by foreign aids.

Table-4.2 Foreign Aid Agency for Funding on Water Supply Services

Provincial Town	Province	Foreign Aid Agency for Funding
Kerema	Gulf	ADB
Mendi	Southern Highlands	ADB
Wabag	Enga	ADB
Lorengau	Manus	JICA
Vanimo	Sandaun	AusAID

The service in NCD is done by Eda Ranu while the bulk water supply for NCD is provided by the PNG Water, a joint venture with foreign capitals that are in charge of construction of the facilities and the management under the BOT contract with the PNG Government. Meantime in Eastern Highlands Province Goroka Township, LLG has been sustaining the service. In case of water supply at Arawa (North Solomon Province), it used to be managed by PNGWB. However, due to the emergency situation in Bougainville, the operation has been suspended. When the above- described plans are implemented in the near future, the water supply services at all the Provincial Towns in the country except these three Towns will be managed by PNGWB.

2) NWSS Act and Organic Law

The PNGWB was established based on the NWSS Act the enacted in 1986. As a Commercial Statutory Authority (CSA) it is in a position to manage the water supply and sanitation services of the whole country. Department of Works (DOW) used to be in charge of the water supply and sewerage services before the legislation of NWSS Act, and PNGWB succeeded from DOW. The water supply and sanitation service is the essential need for the residents' living conditions under various environments of the country. The Organic Law legislated and its amendment both enacted in 1995 lay down the status and functions of local autonomous bodies and have relevance with NWSS Act. Therefore, it was discussed whether the responsibility to provide water supply service will be under Provincial Governments (PG) and/or Local Level Governments (LLG) at the regional level or under PNGWB. However, it is recognized that NWSS Act which stands for national interest has the prevailing status to the Organic Law. The

PNGWB is responsible as a supervisor and an implementing agency of the water supply and sanitation service of the whole country including urban and rural areas. The PNGWB has not been involved in the water supply service in the District Towns, other smaller urban communities and rural areas as compared with the ones for Provincial Towns.

3) User Pay Policy

So-called "USER PAY POLICY" is an important policy of the PNG Government concerning the water supply service. A pay water supply service had not settled in the PNG before NWSS Act. Long time and ceaseless efforts were required under the support of the foreign aid organization, specially ADB to let PNGWB establish itself well and obtain the current financial status which is independent and healthy. In the residential area of low-income group, commonly called as "Settlement" in the Provincial Town where water is supplied, the fee collection is difficult and not practised, while neither the concept of the policy nor the water supply service have reached rural areas. This shows the difficulty to spread the "USER PAY POLICY". In the District Towns the cost sharing of the water supply service is hardly performed by the whole area.

4) PNGWB as Commercial Statutory Authority (CSA)

The PNGWB is a provider of public service. However, it is not possible to participate directly in the water supply and sanitation service on a non-commercial basis due to its status as CSA. This restriction is effective to sustain healthy financial conditions as the provider of the water supply and sanitation service to the public. At the same time, this restriction is one of the reasons why the spreading of the water supply service in the whole country was not accomplished. In addition, PNGWB is under the supervision of the Minister for Privatisation and Corporatisation and listed as one of the CSA for privatisation in the future. However, the water supply coverage in PNG is still low, and the difficulty to make the water supply service commercially viable is a reality. Therefore, currently privatising PNGWB is not appropriate yet considering such a facts. In case that PNGWB is privatised, it is predicted that PNGWB will not be able to contribute much to the improvement of small and medium-sized local urban and rural water supply.

5) Management system for District Town Water Supply

As a result of Study and analysis as mentioned above, the best way to achieve improvement of water supply in District Town must be the direct management by PNGWB.

i) Position of District Town water supply service in the business line of PNGWB

Currently in PNG, only PNGWB and Eda Ranu provide water supply service as a consistent business. Goroka Township has been managing the water supply in Goroka with stable service though the investment for improvement of water supply has hardly been done by them. Water supply service by Eda Ranu is limited to the area of NCD, and Eda Ranu can not work for the water supply in District Towns of the whole country. Therefore, currently PNGWB is only organization for water supply service to work on the service in District Towns.

The number of District Towns in the country is almost the same as the number of Open Electorate (election district for member of parliament) that count 89 in the whole country. Among them the areas covered by satisfactory water supply service are very limited. Water supply service of most District Towns has not only the problems of the facility but also the problems of the institutional framework and financial affairs. Therefore, a provision of satisfactory water supply services for these District Towns shall be a target that PNGWB should achieve in the future.

The PNGWB is supposed to play the role of promoter and facilitator to achieve the higher coverage under the NWSS Act. On the other hand, the District Town water supply service has vulnerable commercial viability. In the Corporate Plan for 1999 to 2003, PNGWB is indicating its view on their business development positively with the background that they have been making the surplus since 1997. In this Corporate Plan, together with extension of urban water supply services in Provincial Towns, promotion of rural water supply is clearly stated. The problem is that it is not easy to maintain the income-expenditure balance break-even because of the small scale of these District Town water supply services. It is a question on how to balance the two essential functions that PNGWB has, i.e., "To advocate provision of water supply service to the public" and "To protect its financial health as the self-contained CSA being managed independently".

On the other hand, the Study Area includes 6 District Towns and the number of customers receiving water supply service in these areas are assumed to hardly exceed 200 in each area. The scale of these water supply services is small. However, there is a possibility that several thousand to 10,000 numbers of customers in total can be newly acquired if about 200 numbers of customers as the average are secured in all District Towns (80 places or more). District Town water supply service is not only a public mission but also a potential market

for the future of PNGWB subject to solution of the financial balance problem of these small water supply systems.

Tbale-4.3 Number of Customers in the Study Areas

Provincial Town	Number of Existing Customers			
	Domestic	Commercial & Industrial	Institutional	Total
Popondetta	779	53	44	876
Daru	870	37	50	957
Sub-Total	1,649	90	94	1,833
District Town	Number of Expected Customers			
	Domestic	Commercial & Industrial	Institutional	Total
Mutzing	160	3	7	170
Finschhafen	243	7	15	265
Bereina	176	2	10	188
Kwikila	170	3	9	182
Kupiano	837	3	14	854
Oro Bay	158	2	5	165
Sub-Total	1,744	20	60	1,824

* Number of domestic customers will actually be less than the above-mentioned number because it is assumed that one contract will cover more than two households in the rural area and the settlement. In case of Kupiano because of the big rural population in the area, it seems that the number of actual customers will be around 500 or less.

4.4 Water Resources Development Situation

Department of Environment and Conservation (DEC), Water Resources Management Division is concerned with water resources management including river water, lakes, ponds and groundwater. When the survey of water resources is started, reporting to this office on the survey is necessary as well as reporting of the survey results. Considering groundwater development, permission based on the official form is required for drilling and pumping.

On the other hand, DEC manages the measurement of river discharge at certain gauge stations constantly. Therefore, PNGWB can work together with them and request the measurement of river discharge at the sites such as Binaturi intake station, Popondetta intake point, and other concerned intake points since the official records of river discharge for intake at these points are not available.

4.5 Water Supply, Health and Sanitation

The UNICEF's reports indicate that only 28% of the population in PNG had access to safe drinking water in 1997, and 22% of the population had adequate sanitation facility. On the other hand, Ministry of Health reported in the National Health Plan, 2001-2010 that about 30% of the population in the country has access to safe drinking water in 2000, and 22% of the same has adequate sanitation facility. Other relevant information for water supply in 2000 is showing that about 60% of the urban population is supplied with water while only 20% of the rural population is covered. The above figures are very low compared with the water supply coverage ratio in other countries in the Pacific Region. Because of this kind of situation, the PNG Government planned to improve the coverage of water supply to 50% in 2010.