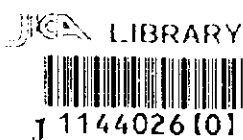


JAPAN INTERNATIONAL COOPERATION AGENCY
DEPARTMENT OF NATIONAL PLANNING
AND IMPLEMENTATION
THE GOVERNMENT OF PAPUA NEW GUINEA

**THE STUDY ON SEWERAGE SYSTEM
OF
PORT MORESBY
IN
PAPUA NEW GUINEA**

MAIN REPORT

JUNE 1998



TOKYO ENGINEERING CONSULTANTS CO., LTD.

In Association with

NIPPON JOGESUIDO SEKKEI CO., LTD.

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In this report, project costs are estimated based on November 1997 prices with an exchange rate of
1 Kina = ¥81.3 (IUS\$ = ¥124.20)



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PREFACE

In response to a request from the Government of Papua New Guinea, the Government of Japan decided to conduct a master plan and feasibility study on Sewerage System of Port Moresby in Papua New Guinea and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Papua New Guinea a study team headed by Mr. Kazufumi Momose, Tokyo Engineering Consultants Co., Ltd (TEC), and Nippon Jogesuido Sekkei Co., Ltd (NJS), four times between March 1997 and December 1997.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of Papua New Guinea for their close cooperation extended to the team.

June 1998



Kimio Fujita
President

Japan International Cooperation Agency

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

June 1998

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir

We are pleased to submit you the final report entitled "THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA". This report has been prepared by the Study Team in accordance with the contracts signed on 14 March 1997, 11 November 1997 and 12 May 1998 between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. and Nippon Jogesuido Sekkei Co., Ltd.

The report examines the existing conditions concerning wastewater systems in Port Moresby, and presents a master plan for wastewater systems and results of a feasibility study on a priority project selected from the master plan.

The report consists of the Summary Report, Main Report and Appendix. The Summary Report summarizes the results of all studies. The Main Report presents the results of the whole study including background conditions, formulation of the master plan, selection of the priority project and the feasibility study on the priority project. The Appendix describes in detail the same contents in the Main Report.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Construction, and Embassy of Japan in Papua New Guinea, and also to officials and individuals of the Government of Papua New Guinea for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study contribute to the improvement of the wastewater systems and the social and economic development in Port Moresby.

Yours faithfully,



Kazufumi Momose
Team Leader

ABBREVIATIONS

BOD	Biochemical Oxygen Demand
BOT	Build Operate Transfer
BWL	Bottom Water Level
COD	Chemical Oxygen Demand
CICL	Cast Iron pipe with Cement Lining
Coli	Coliform
CPI	Consumer Price Index
DEC	Department of Environment and Conservation
DO	Dissolved Oxygen
DPI	Department of Planning and Implementation
EIRR	Economic Internal Rate of Return
Elcom	Electricity commission
FIRR	Financial Internal Rate of Return
g	Gram (1/1000 th of a kilogram)
GDP	Gross Domestic Product
ha	Hectare (1/100 km ²)
JICA	Japan International Cooperation Agency
K	Kina (currency of Papua New Guinea; K1=US\$0.72)
km	Kilometer
L/s	Liter per second
Lcd	Liter per capita per day
m	Meter
mg	Milligram
MGd	Million Gallons per day
ML	Million Liters (thousand cubic meters)
MLD	Million Liters per Day (thousand cubic meters per day)
MSCL	Mild Steel pipe with Cement Lining
m ³ /d	Cubic meter per day
m ³ /s	Cubic meter per second (=86.4 MLd)
N	Nitrogen
NCD	National Capital District
NCDC	National Capital District Commission
NPF	National Provident Fund
NPO	National Planning Office
NPV	Net Present Value
NSO	National Statistical Office
OECD	Overseas Economic Cooperation Fund (of Japan)
P	Phosphorus
PEV	Protected Environmental Value
PNG	Papua New Guinea
PS	Pumping Station
PVC	Polyvinyl Chloride
RL	Reduced Level
SS	Suspended Solid
t	Ton (1000 kilograms)
T-N	Total Nitrogen
T-P	Total Phosphorus

TWL	Top Water Level
UCV	Unimproved Capital Value
UDSS	Urban Development & Services Study
UPNG	University of Papua New Guinea
WHO	World Health Organization

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SUMMARY

Objectives of the Study

Previous studies made on the sewerage system of Port Moresby had pointed out the deterioration of the near shore seawater quality due to the discharge of untreated waste-water via short outfalls, pan latrines or direct to the sea as in stilt houses over the water. On the other hand, the fairly developed system for the inland area has maintained the quality of the receiving water bodies (Waigani Swamp and the rivers downstream) since the effluents are being treated at the 3 existing treatment plants before discharge.

However, improvements for the future are necessary to meet the increase in population, in addition to the sustainable development of Port Moresby and the improvement/conservation of the sanitary conditions of inhabitants and the environmental conditions of the receiving water bodies.

Therefore, with reference to the 1980 Sewerage Study Report and other related reports, a master plan has been formulated for the sewerage system of Port Moresby of which a feasibility study was conducted to give priority to the coastal areas.

Planning Basis

The target years for the Master Plan and the Feasibility Study are 2015 and 2005, respectively. According to the 1996 Urban Development and Services Study (UDSS) for the National Capital District (NCD), the population of NCD will increase from the estimated 251,000 in 1996 to 381,000 in 2005 and finally to 531,000 for the year 2015. The population including commerce and industry will generate a wastewater volume of 239,000 m³/day in the year 2015. Out of the total volume, 160,000 m³/day will be generated from the inland area whilst the coastal area will have 79,000 m³/day.

Receiving Water Quality and Disposal Process

Wastewater is collected and disposed to rivers or sea in order to improve and conserve the sanitary conditions of the inhabitants. Wastewater has pollutant loads; therefore treatment is necessary to protect the quality of the receiving water bodies.

The degree of treatment or selection of treatment process is partly decided by the environmental values of the receiving water body be it for drinking, protection of aquatic life commercial application, recreation and aesthetic enjoyment. In the absence of legalized water quality standards, assumptions were made based on the environmental values of each watercourse and related legislative acts already enforced.

The Waigani Swamp will continue to receive the wastewater from the 3 existing treatment plants (Waigani, Gerchu and Morata) at an increased volume. The lagoon treatment process where BOD and SS are removed significantly, it is assumed that the environmental value of the swamp, e.g. "recreational and aesthetic uses" will be preserved. In as much as this process

is not capable of removing nutrients sufficiently enough to prevent eutrophication, the Waigani Swamp can continue as a natural wet land serving as tertiary treatment. Hence, the water quality downstream will be preserved to protect the aquatic ecosystem.

In the future, as population increases and the economy is developed, additional nutrient - removal facilities can be added to suit the beneficial usage of the Waigani Swamp.

The downstream end of the Laloki River will serve as the receiving water body for the proposed Bomana Sewage Treatment Plant (STP). Using a lagoon treatment process, it is assumed that the Bomana STP is adequate to preserve the environmental value of the river, e.g. "for the protection of the aquatic ecosystem in fresh water."

The western sector of the Papuan Coastal Lagoon (Walter Bay) will continue to receive wastewater from the Paga Point Outfall, whilst the eastern sector (Joyce Bay) is proposed to receive the waste-water from the Kila Kila zone extending from Koki to Pari. A long marine outfall similar to the Paga Point will be installed at Kila Kila. Additionally, primary treatment facilities to include sedimentation tanks with generated-sludge drying beds and a controlled dosage of disinfection will be provided to both outfalls before discharge.

The simulation made on the future water quality of the lagoon showed that the proposed treatment facilities could preserve the environmental value of the Papuan Lagoon, e.g. "for the protection of the aquatic ecosystem in marine waters." However, an environmental monitoring/estimation program shall be incorporated into the sewerage development plan. This monitoring program to include BOD, SS, nitrogen, phosphorous, chlorophyll, corals, tide, currents, etc., is necessary to monitor the nutrients that may lead to eutrophication.

Proposed Sewerage System

The inland sewerage system of the 3 existing zones (Waigani, Gerehu and Morata) has to be upgraded and improved to meet the increased wastewater volume. The proposed Bomana Zone will have a separate system with a STP located near the Laloki River. The sewage in all four zones will be gravitationally collected to their respective STP for treatment before discharge.

The existing smaller catchments along the coastal areas will be incorporated into two zones namely, the Paga Point which covers the western sector extending from Baruni, Tatana to Town area and Kila Kila which covers the eastern sector extending from Koki to Pari. Due to its topography, additional pumping stations will be installed. In addition, two separate zones are formulated for the planned urbanized areas of Vetorogo and Dogura Kohu.

The site of the existing Paga Point Pumping Station (PS) has to be expanded to cater for the proposed treatment plant and pumping station upgrading. However, with the proposed development plans of the National Capital District Commission (NCDC) in the nearby Sea Park, discussions were made between the parties concerned to settle the conflicts of zoning. It has been decided to proceed with the sewerage project partly due to the fact that the NCDC project is at a preliminary stage.

The collected sewage from the Paga Point and Kila Kila Zones will pass through a primary treatment process before discharge through an outfall into the Papuan Lagoon. The collected sewage from the Vektorogo and Dogura Kohu Zones will pass through secondary treatment process before discharge into the nearby coast.

Project Cost and Implementation Schedule

The total project cost estimated at 98 million Kina is divided into 63 M Kina and 35 M Kina for the coastal and inland areas, respectively. The development of the coastal area sewerage system has been given top priority to improve significantly the degraded water quality along the coast.

Organization and Management

EDA RANU succeeded the responsibility of operating the water and sewerage system of Port Moresby from NCDC on 1 November 1996. In order to strengthen EDA RANU's management and administrative capacities as an autonomous company the following are recommended.

- Public authorities hold a minimum of 51% shares.
- Management policy and a corporate plan are formulated.
- Long-term development policy and planning are made.
- Works Programme detailing estimates, schedule and volume of work to be contracted out be identified.
- Operation and maintenance manual to be created.
- Training Programme to be strengthened.
- Industrial effluents, communal and domestic septic tanks to be monitored periodically.

Financial Analysis

The proposed project is feasible (with a 3.01% FIRR) if the financial source is through a long-term loan having a low interest rate (about 2% to 3% level). An interest rate of 8.5% will give a disastrous output.

Feasibility Study

As a result of the study on the Master Plan, the Feasibility Study of the Coastal Region was given priority mainly due to the degradation of the water quality along the coast.

Sewerage System of the Coastal Region

The sewerage collected from the Paga Point Zone will be successively pumped (possibly 8 stations) towards Paga Point STP intercepting locally gravitated load. Similarly, the sewage collected from the Kila Kila Zone will be successively pumped towards the Kila Kila STP.

Management of the Sewerage Operation

The proposed sewerage system in the coastal area requires proper operation and maintenance to function efficiently. Operation of the series of pumping stations and STP need special skills different from the gravitationally existing system.

An organizational structure is proposed based on the existing structure. The total manpower requirement to include additional staff for the new STPs and pumping stations is 42. The works to be strengthened are the following:

- Keeping records.
- Formulating job procedural manual, and
- Providing staff training.

These indirect activities are easily neglected because their resultant effects are not seen.

Financial Plan

The financial analysis for the upgrading/development of the sewerage system in the Coastal Region shows a better FIRR.

Conclusion and Recommendation

In conclusion, the proposed sewerage system has to be implemented as early as possible for reasons and recommendations as follows:

- To improved the environmental condition of the receiving water bodies.
- The financial analysis indicated a viable result.
- Findings of the Inhabitants Behavior Survey reveal that the residents show high interest in the provision of the sewerage system and their willingness to pay the charges is encouraging.
- Consultations with the Department of Environment and Conservation is required.
- The water supply system should be improved since efficient operation of the sewerage system requires adequate water volume.
- A confirmation study on future water quality of the Papuan Lagoon is necessary to confirm the simulated model that has been developed.
- Effort to increase sewerage revenue to be enhanced.

CHAPTER 1
MASTER PLAN-INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Two years after being declared as an English protectorate in 1884, Port Moresby the capital city of Papua New Guinea started to develop along the coastal areas with a population of about 5000. In 1971, the population increased to 77,000 and to 251,000 in 1995.

As population increases, the development grows further inland eventually establishing Waigani as the city centre and the seat of the National Government.

The increased population resulted in an increased water demand and increased wastewater volume. The existing sewerage system which was developed in the late 1960's and early 1970's needs improvement as recommended in the Port Moresby Sewerage Study done by Camp Scott Furphy in 1980. The outdated planning program of the 1980 report, changes in population pattern, urban development, increased population, and the partial implementation of the recommended development works in the 1980 report resulted in the deterioration of the quality of the receiving water bodies. Therefore it is essential that augmentation and improvement to the sewerage system be made aside from the fact that the upcoming expansion of the water supply system that will result in a increased waste-water volume.

Due to the above situations and the recent formulation of the city planning, the PNG Government requested the Government of Japan for a technical aid to conduct a master plan and a feasibility study on the Port Moresby sewerage system. The request was granted, thus the Study on the Sewerage System of Port Moresby (hereafter referred to as "the Study") was conducted by the Japan International Co-operation Agency (JICA). The JICA is the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan in close coordination with concerned authorities of PNG.

In December 1996, JICA dispatched a mission headed by Mr. Takashi Dairaku to PNG for the preparatory study to include discussions on the scope of work. On the 10th of December 1996, the scope of work of the Study was agreed between PNG and the JICA mission.

Based on the scope of work, JICA called consultants to submit proposals for the Study in February 1997. Tokyo Engineering Consultants Co., Ltd. in association with Nippon Jagesuido Sekkei Co., Ltd. were selected and commenced the study in March 1997.

The study was conducted in 2 phases, namely: Phase I from April 1997 to September 1997 for the Master Plan and Phase II from November 1997 to May 1998 for the Feasibility Study.

1.2 Objective of the Study

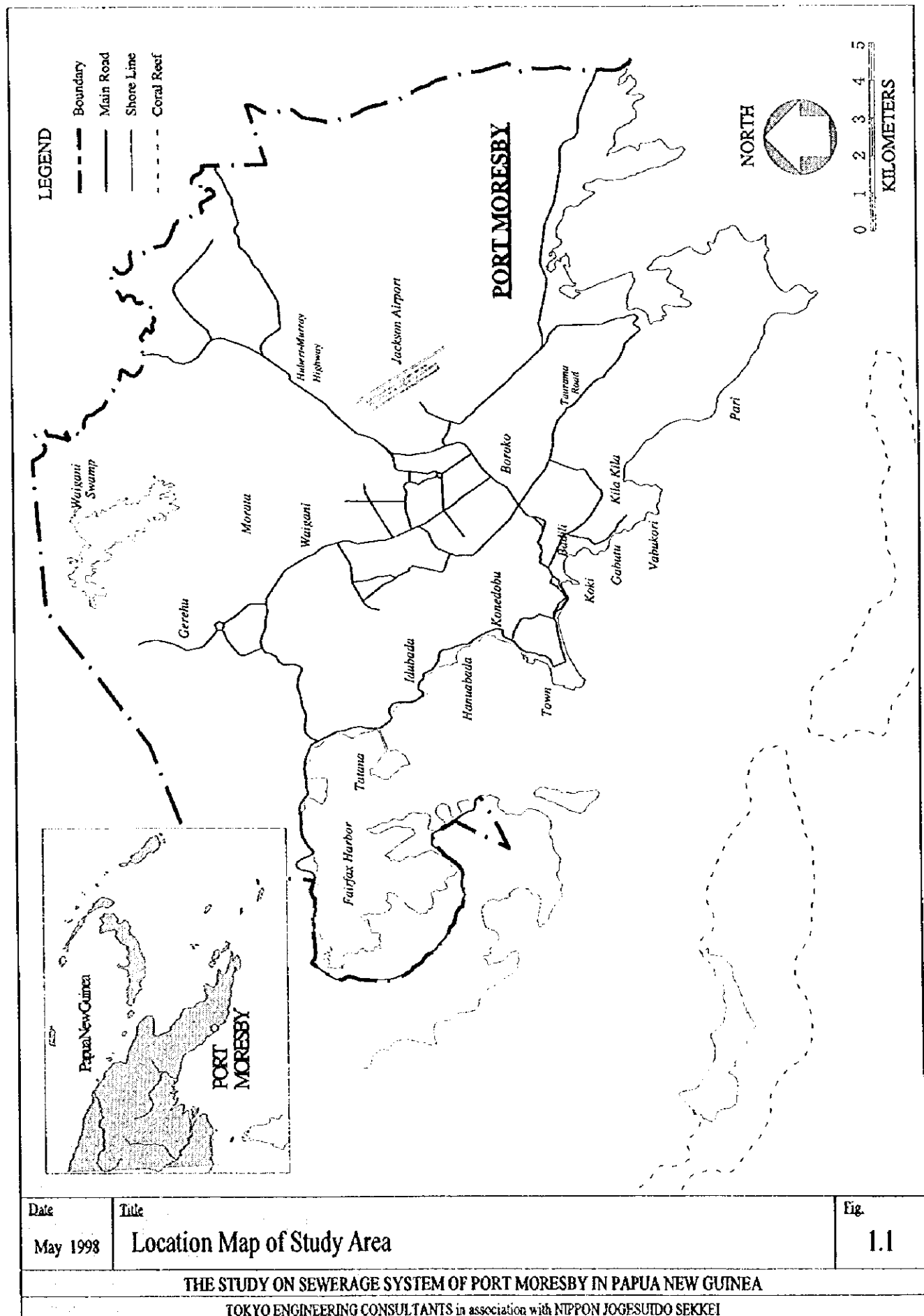
The objectives of the study are the following:

- To formulate a master plan for the target year 2015 that will help improve wastewater management, upgrade the sanitary and environmental conditions of Port Moresby with the view of reviewing existing plans.

- To conduct a feasibility study on priority project(s) selected from the master plan, and
- To transfer technology on planning method and skills to counterpart personnel in the course of the study.

1.3 Study Area

As shown in Fig. 1.1, the study area covers an area of about 250 km² in the National Capital District. The study area may be extended to such sites where the proposed sewerage treatment facilities and effluent disposal areas are located.



CHAPTER 2
STUDY AREA

CHAPTER 2 STUDY AREA

2.1 Natural Condition

2.1.1 Location

Port Moresby is located in the southeast portion of Papua New Guinea at longitude 9° 26' south and 147° 13' East. It is the capital of PNG, the centre of political, economic and cultural activities. The rocky coastal area is heavily developed with brisk economic activities. On the hand, the inland areas are slowly developing with some wide area reserve for future developments.

2.1.2 Topography and Geology

Port Moresby comprises of rocky coastal strip and inland valley areas, separated by 100 m to 200 m high ridges (see Fig. 2.1). There are few plains in the inland but steep areas along the coast with natural drainage towards the sea. The inland area is divided into East and West Region by the North-South boundary. The Western Region gently sloped towards Waigani Swamp whilst the Eastern Region gently sloped towards Laloki River. The geology of the hillside areas indicates widespread calcareous and siliceous mudstone and chert, mostly hard and strong. Angular chert, mudstone gravel, and sandy clay overlay the lower slopes. The flatter areas around Konedobu and Badili have soil, which is generally firm plastic clay with some gravel.

2.1.3 Climate

The climate throughout PNG with the exception of the Highlands is tropical. The altitude of the Highlands ameliorates the heat of the tropics and provides a stable warm climate throughout the year (13°C to 26°C).

In Port Moresby, the climate is determined by the influenced of 2 surface pressure systems, namely: the Northwest Monsoon (December to April) and the southeast trade winds (May to November) giving wet and dry seasons, respectively. The average temperature ranges from 22°C to 31°C with very little variation throughout the year. The lowest temperature ever recorded in the city was 10.4°C, and the highest was 36.3°C.

Port Moresby lies in a rain shadow with an average annual rainfall of just over 1,000 mm. There are parts in the Highlands with over 12,000 mm rainfall per year. Based on the 67 years of historical records before and after World War II, the total annual rainfall ranges from 684 mm to 1,732 mm with a mean of 1,019 mm. Most of the rain falls between December and April with February as the wettest month. Rainfall is unpredictable and can be very heavy at this time of the year. Unlike in many tropical countries, the city's rainfall has no regularity - it falls at any time of the day or night.

Humidity is always high; typically above 80% at 9:00 a.m. during the wet season and rarely drops below 60%. The Northwest Monsoon brings with it the occasional guba, a short and

sharp squall, which blows in over Fairfax Harbour.

During the southeasterly season, which occurs roughly between May to November, the city becomes very dry, brown and dusty. The southeasterly trade winds blow strongly and almost constantly. Late in the year, there is a period of doldrums, when it is hot and windless. The cycle starts again when the northwesterly rains come as a welcome relief.

2.2 Economic Conditions

According to the 1994 World Development Report, the 1993 GNP per capita in PNG is US\$ 1,130 at the level of the lower middle income economies. The growth rate of the GNP per capita is 0.6% annually from 1980 to 1993. During the past several years, the PNG economy has experienced turbulent period due to several reasons. The 1995 economy suffered high inflation and negative growth rate. But in 1996, the inflation rate has started to stabilize and a real economic growth was achieved. Employment rate increased by 8%. The consumer price index in NCD is a little higher than that of PNG as a whole.

In the area of foreign economic relations, the exports in PNG have continued to grow. Major exporting items are crude oil, gold, copper, log and coffee. Crude oil has now become the largest exporting item and compensates the stagnation of the export in copper. The income from these items has to be influenced from the international primary commodity markets. While the recent trend in terms of trade has not been bad for PNG, the foreign exchange rate of Kina against major international currencies has been deteriorating. In the past years, from 1995 to 1996 the Kina has appreciated against US Dollar and Japanese Yen.

Primary industries and constructions contribute up to of 60% of GNP in 1995. The development of secondary and tertiary industries is far behind and requires strong assistance for their development. The investments in public infrastructure will promote their development.

Along with the economic recovery, the governmental reserve of foreign currencies has reached a new record high at a level of just below 0.8 billion Kina. But the overseas public debt outstanding is still increasing and has to be watched carefully. Any major investment decision, which may blow up external debts, should be treated with cautious attitude.

As the inflation has now stabilized, the market interest rate began to decrease and the prime lending rate in PNG banks is less than 10%. Financial environment becomes favourable for long-term investment decisions, but wage; construction costs including construction materials have increased recently. Careful study will be required for major long-term investment decisions.

There is the worldwide trend to review the role of government and the more active utilization of private sector in public infrastructure service. The government of PNG has recently formulated "Medium Term Development Strategy 1997 - 2002" which puts stronger emphasis on the promotion and more active utilization of the private sector in the development of public infrastructure systems in PNG. Any public infrastructure investment programs that this study may propose should therefore be based on the careful examination of several novel alternative strategies, which accommodate these new worldwide trends.

2.3 Population and Land Use

2.3.1 Population

PNG conducts census once every 10 years with the latest census conducted in 1990. The population of the NCD has more than quadrupled from 1966 to 1990. The estimated population in 1995 is 251,000 that include about 7,500 non-citizen residents. The details on population, growth rate and densities are shown in Table 2.1 below.

Table 2.1 Population and Densities in NCD

Census Year	Population	Annual Growth Rate (%)	Density per km ²
1966	41,848		174
1971	76,507	12.9%	319
1980	123,624	5.5%	515
1990	195,570	4.7%	782
1995	251,000 (Estimate)	5.1%	1,003

NCD is divided into 9 census divisions (see Table 2.2 and Fig 2.2) consisting of 7 urban and 2 semi-urban areas. The 1980 and 1990 population figures along with the growth rate and the number of dwellings are noted below.

Table 2.2 Population according to Census Division in NCD

Census Division	1980 Pop.	1990 Pop.	No. of Dwellings (1990)	Growth Rate
Gerehu	14,761	22,727	2,931	4.8%
Waigani / Morata	11,054	16,362	2,265	4.4%
Hohola / Tokarara	20,375	32,362	4,276	5.0%
Gordons / Saraga	16,176	31,383	5,315	8.0%
Boroko / Korobosea	18,852	26,832	4,703	5.1%
Kila-Kila / Kaugere	18,288	28,874	3,899	4.9%
Town / Hanuabada	18,918	25,948	4,471	3.5%
Laloki / Napa Napa	1,052	3,015	432	11.1%
Bomana	4,418	8,067	1,149	6.2%
Total	123,624	195,570	29,441	4.7%

2.3.2 Land Use

According to the Urban Development & Services Study, the land use of NCD has been primarily divided into three major regions (Coastal Region, Central Region and Periphery Region) and further divided into fourteen zones detailing existing land use as shown in Fig. 2.3 and Fig. 2.4.

In the developed area of NCD (about 5,822 ha), the residential area is consist of 38% in which 82% of the total population is concentrated in the Coastal and Central Regions. On the other hand, 76% of the commercial area is located in the Central Region, specifically at Waigani, Gordons and Boroko. The industrial area is dispersed along Waigani, Gordons and the Periphery Regions where light industrial products are mainly produced. Public facilities such as schools, government offices and hospitals are located in Boroko, Waigani and Hohola in the Central Region.

2.4 Sanitary Condition

The inhabitants behaviour survey (refer to Appendix A) was undertaken in order to supplement existing information, and more precisely to determine:

- the knowledge and awareness of the public about health and sanitation;
- the level of public satisfaction/dissatisfaction with the sewerage system,
- the public willingness and ability to pay for a sewerage system based on public understandings of:
 - a) health and conservation issues
 - b) the existing sewerage system and its need for improvement
 - c) health conditions
 - d) awareness of the cause and effect of disease outbreak
 - e) current sanitary habits
 - f) household income
 - g) ability and willingness to pay

To meet these requirements a 28-question survey offering 256 response options was developed. The survey itself went through a number of preliminary drafts during the last two weeks of April 1997 before it reached the University of Papua New Guinea. With the support of Ms. Betty Lovai, Head of the Social Work Program, Research Methods Lecturer, Mr. Garry Sali, and his three classes participated in the survey. 724 households evenly spread throughout NCD and involve a similar percentage of each housing type to that identified in the 1990 Census were interviewed.

In general, the results confirmed and clarified census information and the results of other previous studies, but there were exceptions. Among other things the survey found out that household knowledge of the linkages between basic hygiene, the environmental and personal health was very good and did not appear to be directly related to the education level of local inhabitants or to the type of dwellings they occupy.

A second finding was that the need for a sewerage system in the NCD would appear to be a priority for many residents, particularly those without such service at the moment, and that most seem prepared to pay for it. However, without the provision of an adequate and constant public water supply, the potential benefits of any improvements to the sewerage system may be very limited, and local resident's present willingness to pay for it may be reduced.

More specifically, the following conclusions and recommendations were reached.

- a) That a large majority of households have a good understanding of the effects of pollution and poor personal hygiene on their health and on the environment.
- b) That despite public knowledge of basic health and hygiene practices, the public are experiencing a significant health problem, part of which may be due to inadequate water and sanitation services rather than a poor understanding of the causes.
- c) That half of the public consider the existing method of handling sewage as inadequate, including many who are now on the public sewerage system.
- d) That discontent with the existing sewerage system may be due in part to poor water pressure in some areas and the consequent inability of residents to use the flush toilets in their houses.
- e) That apart from those living in squatter villages, those in the water villages have the strongest desire in the NCD to see their sewerage disposal problem improved and are probably the most able to afford to pay for such improvements should they be undertaken.
- f) That most respondent households, except those living in high cost housing, consider the present provision of public sewerage service considerably less adequate than the present provision of public roads, suggesting that the relative funding priority of these two public expenditures could be reconsidered.
- g) That if given the opportunity, time and information, residents can see the relationship between water supply and sewage collection, and more importantly, would be willing to pay for them both.
- h) That approximately half of households are willing to pay at least 5 Kina per week for sewage collection, even in squatter villages and other unserved areas of NCD.
- i) That squatters and other residents living in unsewered areas of NCD appear to be willing to pay for an improved method of handling sewage in their housing areas despite some having very low income levels.
- j) That on average, one in six households in NCD has an income of less than 25 Kina a week, making payments for the use of a sewerage system services likely to be difficult for them.
- k) That the discretionary income of households in squatter areas is comparatively low and such households may not be able to afford to pay as much as they think they can for a sewage collection service.
- l) That the public would prefer to pay for sewerage services according to the amount of water they use.

- m) That even in areas where there are both public toilets and a high use of "bush" toilets, no one uses the public facilities as their primary toilet because they are inadequately maintained.
- n) That any sewerage system extended into unsewered areas should be accompanied by an improved solid waste collection system to ensure that the sewerage system is not abused as solid waste disposal system.
- o) That there would appear to be an effective health campaign already in operation in the water villages and other unsewered parts of NCD, and that any additional funding for health education may be better spent on the needed public works themselves (sewerage and water systems) or on the medical facilities caring for the consequences of not having adequate system in place.

2.5 Relevant Plan and Project

In the past, several plans were formulated to improve the sanitary conditions of the inhabitants and to upgrade the environmental conditions of the city. Among others, the five plans that were also used as references for the study are as follows:

- a) Port Moresby Sewerage Report (Department of Housing / K. Sajdeh, 1974). This study was prepared before the 1975 Independence aimed at improving the sewerage system of NCD to target year 1990. The existing sewerage system was improved mostly based on this study, including the construction of the Waigani Lagoons and trunk sewers.
- b) Port Moresby Sewerage Study, Final Report (Port Moresby City Council / Camp Scott Furphy Pty. Ltd., January 1980).

This study deals with the system expansion to target year 1985, separating NCD into the inland area and coastal area for sewerage planning. The most significant improvement made based on this study was the extension of the Paga Point Outfall.

- c) Environmental Plan - Joyce Bay Sewerage Outfall Study (Waterboard, June 1987). This plan and the study (d) below were made specifically to improve the sewerage system along the coastal areas since previous improvements were done mostly in the inland areas.
- d) Hanuabada Village Feasibility Study on Storm Water and Sewerage (NCDIC/Camp Scott Furphy Pty. Ltd., October 1990). This study was purposely made for stilt houses over the water choosing Hanuabada as a pilot project. However, the project was never implemented until now.
- e) Urban Development and Services Study for NCD, Draft Final Report (NCDC/Wilbur Smith Associates, May 1996 as financed by World Bank). This comprehensive study is comprised of 20 working papers. It sought to establish a master-planning framework for all urban services in NCD to the target year 2015 based on the projected population and growth rate scenarios. The study suggested a conservative estimate of 531,000 population

for the year 2015. This population is considered a sustainable community with improvements to existing urban services and encouragement of employment alternatives.

Reviewing the above 5 studies and using the UDSS as the framework for population and land use, the Port Moresby Sewerage System Master plan was formulated. Additional information on water consumption was taken from the Water Supply Development Plan done by JICA in 1994.

2.6 Water Supply System

2.6.1 Service Level

EDA RANU operates water supply and sewerage system in NCD. The existing water supply system is mostly gravity-fed from the Mt. Eriama Water Treatment Plant at R.L. 160 m to the service area. The system has been designed so that the treated water will reach all areas except where the elevation exceeds 100 m of which a booster pump is installed.

The sources of raw water are drawn by gravity from the Rouna 1/3 head pond at R.L. 273 m and by pumping from the Laloki River at the Bomana Pumping Station (refer to Fig. 2.5). The production output of the Mt. Eriama Water Treatment Plant has remained practically constant at 120 MLD (1.38 m³/s) since 1977. With the ever-increasing demand and constant supply, critical areas suffer inadequate pressure or no water supply at all, especially during peak hour. In areas where the distribution mains passes through as in Boroko, Gordons, Hohola, and Saraga water pressure is constantly high.

2.6.2 Facilities

The main features of the existing water supply system are:

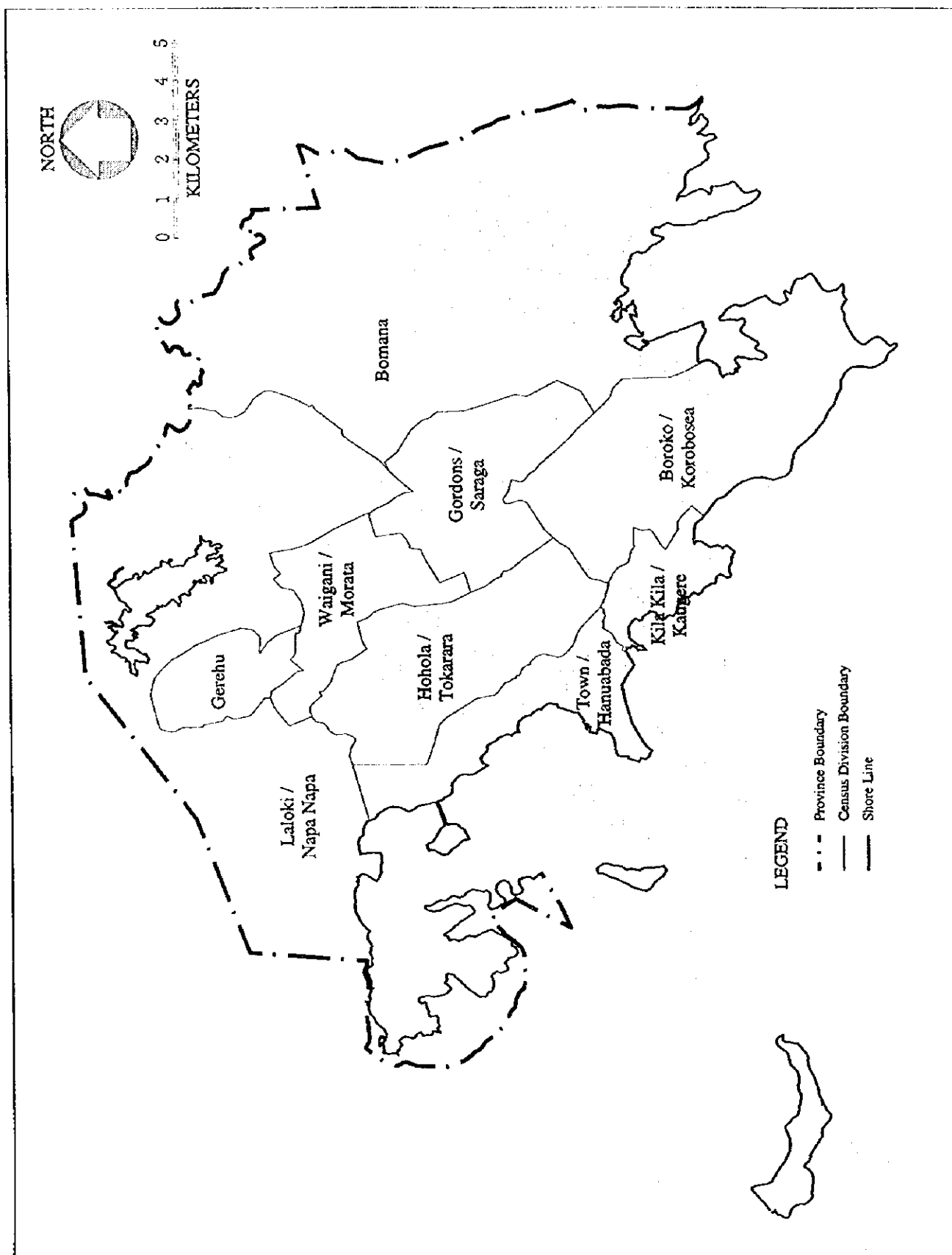
- Water is mostly distributed by gravity where the operation and maintenance costs are low and chances of troubles relating to pumps are low as well.
- The treatment plant is functioning at nearly 85% of the designed capacity.
- There is a large difference in the effective pressures within the system, ranging from as high as 80 m to below zero.
- There is leakage in the high-pressure areas of the distribution system.
- Besides ordinary uses, water is also used for irrigation, particularly during dry periods. In addition, large quantity of water is used for filling up swimming pools.
- The per capita consumption is relatively high.

2.6.3 Future Development Plan

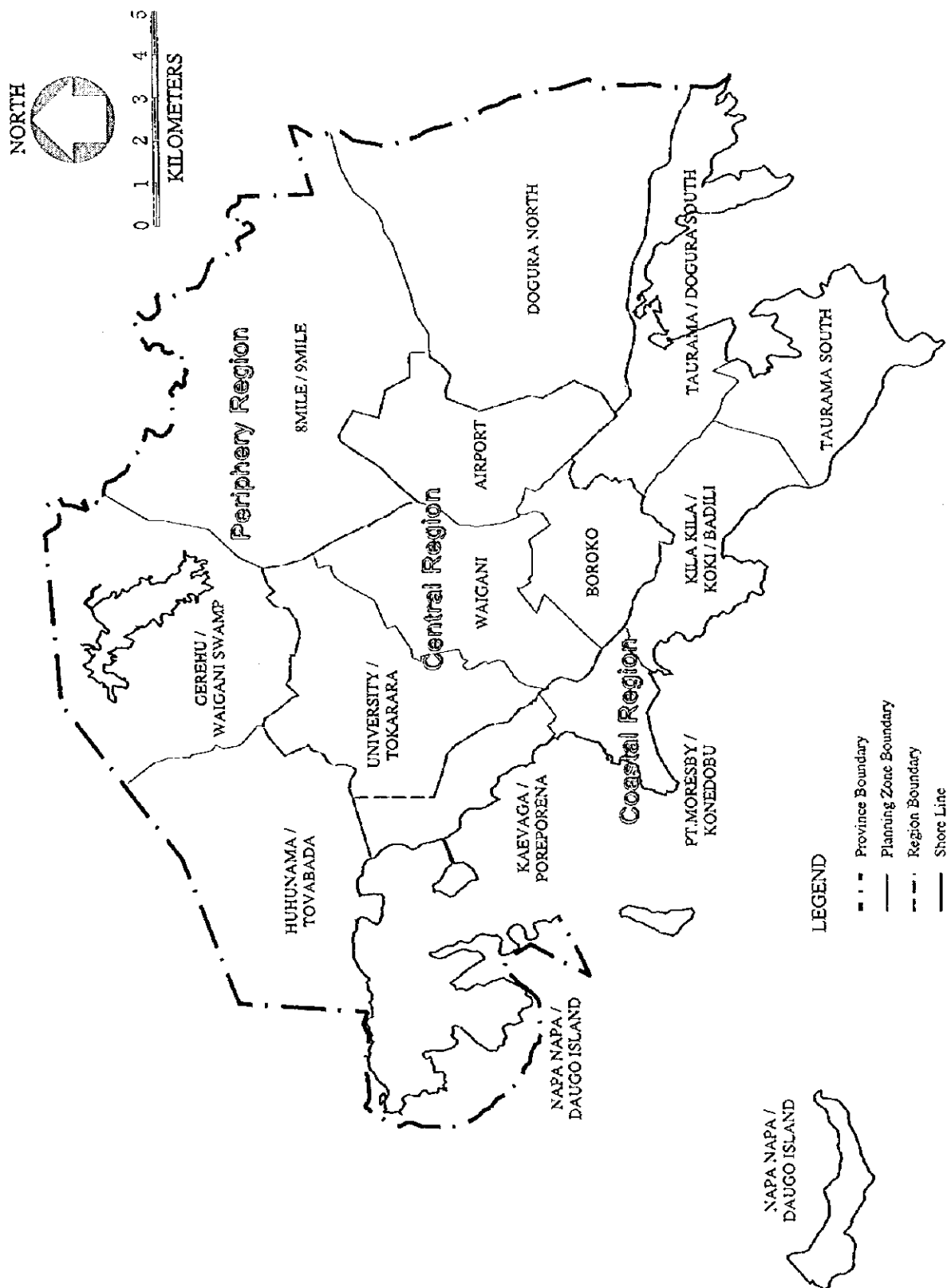
The JICA Study Team formulated the Water Supply Master Plan in 1994. Water demand (daily maximum) for the year 2015 was estimated as 370 MLD. The basis for the estimation is as follows:

Population	:	526,000 persons
Per-capita consumption		
High-cost housing	:	380 Lcd
Low-cost and informal housing	:	300 Lcd
Non-residential consumption		
Public use	:	12.9% of residential consumption
Industrial	:	12.4% of residential consumption
Commercial	:	4.8% of residential consumption
Leakage	:	20% of net consumption
Daily maximum factor	:	30% higher than the average daily demand

Stage 1 of the development plan will be implemented on a Build-Operate-Transfer (BOT) scheme. The development plan seems to follow the master plan except that JICA suggested a zoning system in order to reduce leakage. The BOT scheme seems to ignore the zoning system, which will result in an increased chance of water leakage.

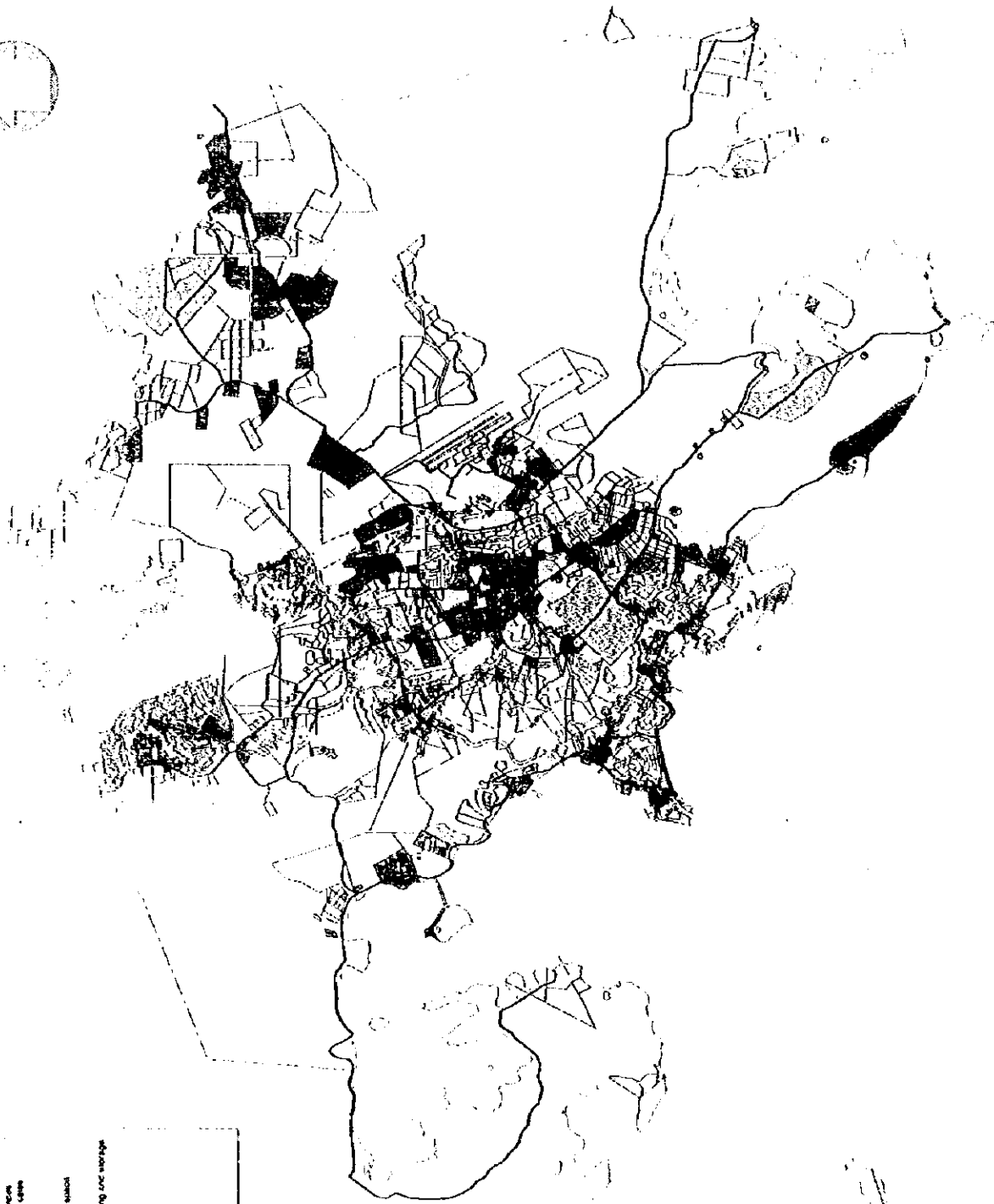


Date May 1998	Title Census Divisions	Fig. 2.2
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI		



Date	Title	Fig.
May 1998	Planning Area	2.3
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKI		

NORTH



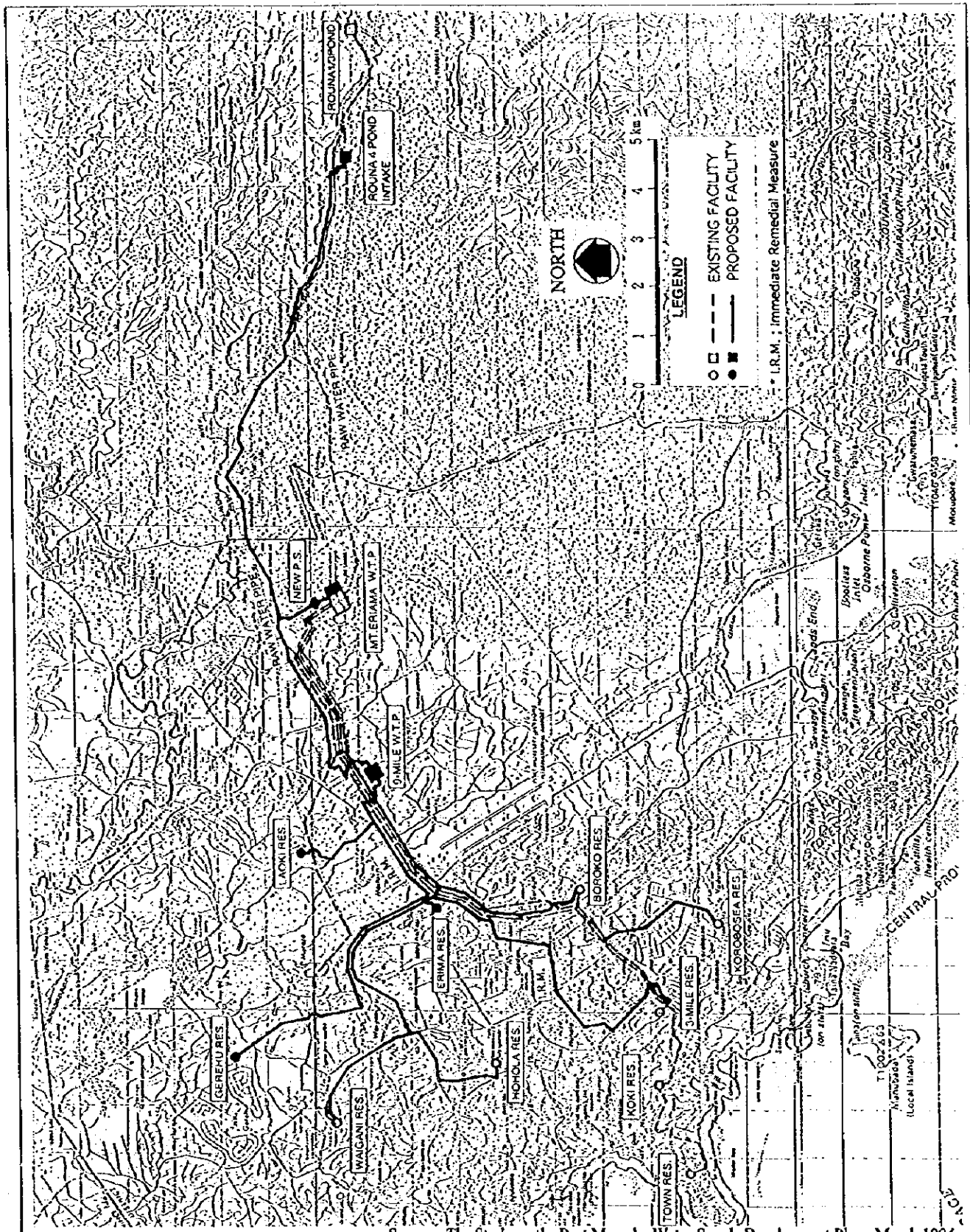
EXISTING LAND USE CATEGORIES:

- Residential gardens, nurseries
- Retail shops, and basic retail and services
- Shopping centres, banks, markets, retail shops
- Office buildings
- Factories, warehouses
- Storage integrated with residential
- Leisure parks, sports fields, public open spaces
- Manufacturing and heavy industry
- Warehousing, storage and light industry
- Petroleum and hazardous materials refining and storage
- Public buildings
- Social and community facilities
- Government offices, embassies
- Military facilities
- Religious and charitable organisations
- Police and fire stations, hospitals, clinics
- Traditional settlements
- Traditional gardening sites
- Traditional villages
- Unclassified or other

0 1000 2000
Metres

Source : Urban development & services study for the National Capital District, November 1996

Date	Title	Fig.
May 1998	Existing Land Use Distribution in the NCD, 1995	2.4
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI		



Source : The Study on the Port Moresby Water Supply Development Plan, March 1994

Date	Title	Fig.
May 1998	Water Supply System in NCD	2.5
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON KOGESUIDO SEKKI		

CHAPTER 3
PRESENT CONDITIONS OF
SEWERAGE SYSTEM

CHAPTER 3

CONDITIONS OF THE EXISTING SEWERAGE SYSTEM

3.1 Facilities

3.1.1 Outline

The current sewerage system covers most formal houses of NCD. About 42% of the population in NCD have access to the reticulated sewerage system. The system is geographically divided into two catchments, viz.; coastal and inland. About 30% of the flow are taken by the coastal catchment and the remainder 70% goes to inland treatment plants.

The Waigani STP takes about 80% of the sewage flow of the inland catchment and the remainder of the sewage flow is treated by Morata (Gerehu I) and Gerehu (Gerehu II) Lagoons before the effluent is discharged to Waigani Swamp (refer to Fig.3.1). On the other hand, the sewage of the coastal catchment is discharged to the sea via short outfalls near the shore except for Paga Point outfall where large dilution is expected after the 3 km pipeline (refer to Fig.3.4). Paga Point outfall was commissioned in 1982 to serve the city center of Port Moresby. Extension has been made so that this outfall now services Konedobu, Touaguba Hill, Paga Hill and the Town areas.

Some parts of the city such as Baruni, Hanuabada, Korobosea, Vabukori and Pari are served by septic tanks, and some urban settlements are provided with pit latrines. These unsewered areas rely on very poor soil absorption for disposal of effluent. Some land villages along the coast rely on pan system for collection of human excreta. The pan system has serious overflow problem as pans are collected twice a week and has insufficient capacity to hold the human waste. Villages such as Tatana, Hanuabada, Koki and Pari with stilt houses over the water have no proper sewerage services. Sewage is deposited on the beach or discharge direct into the sea and is carried away by tidal movements.

3.1.2 Inland Area

The inland area is divided into 3 zones, namely: Waigani, Morata and Gerehu. The sewage collected from the Waigani Zone (Gordons, Boroko, Korobosea, Hohola, Six-Mile, Waigani, Morata and Tokarara) gravitates to the Waigani STP for treatment. The sewage collected from the Morata (Gerehu South) and Gerehu (Gerehu North) Zones gravitate to the Morata and Gerehu STP, respectively for treatment. Details of the STPs and pumping stations are tabulated in Table 3.1 and Table 3.3, respectively.

About 70% to 80% of the sewerage facilities in the Waigani Zone particularly the Waigani STP had been developed in the past years, but various problems still remain to be solved. Among these problems are deterioration of facilities, replacement of the existing clay and asbestos pipes to PVC, and inadequate capacity of trunk sewers. Although part of these overloaded sewers have been upgraded and additional sewers been installed during the NCDC years, more upgrading works are necessary to meet the increasing volume of wastewater.

The STP's are located in an ideal site where residences are far. Thus, it is necessary to acquire the adjoining government land for expansion. All STP's use the stabilization pond

method where sewage is treated through the anaerobic and facultative ponds before discharge into the Waigani Swamp and nearby river systems without disinfecting.

All the STP's are well maintained in relation to yard mowing, cleaning the screen and other physical maintenance. However, the most essential work of the stabilization pond system, which is desludging, has not been carried out since construction. The accumulated sludge in the ponds could reduce the treatment capability where the treated effluent will show sign of deterioration, due to large capacities and less retention time. Desludging work at the Waigani STP is expected in the near future.

The Morata and Gerehu STP's have single basin for anaerobic and facultative ponds (refer to Fig. 3.2) which will cause difficulty in desludging. The Waigani STP consists of 4 anaerobic ponds and a single facultative pond (refer to Fig. 3.3). The installed automatic screen was destroyed by vandalism and thus cleaning of the screen is done manually.

Table 3.1 shows the capacity estimation of each STP and its adequacy to cater for the present (1995) population. The capacities of the anaerobic and facultative ponds have been worked out based on 2 days and 4 days retention time, respectively. All STPs have adequate capacity to treat the present sewage inflow except for the Gerehu facultative pond.

Table 3.2 shows the sewage quality and efficiency of the STPs. The water quality analysis was conducted by EDA RANU in February 1997 and reveals that the STPs are performing well above expectation.

In addition, a number of government institutions to include the Defense and Police Forces have their own sewerage system independent from the city's system.

Table 3.1 Capacity Evaluation of Existing STP's

STP	Year Constructed	Pond	Depth (m)	Volume (m ³)	Capacity (m ³ /day)	Estimated Sewerage Inflow (1995)(m ³ /day)	Adequacy (1995)
Waigani	Early 1970's expanded 1982	Anaerobic	2.2	207,600	103,800	57,176	Yes
		Facultative	1.8	228,700	57,175		Yes
Morata	Early 1970's	Anaerobic	2.1	10,800	5,400	3,785	Yes
		Facultative	1.5	21,900	5,475		Yes
Gerehu	Late 1960's	Anaerobic	2.1	19,500	9,750	8,826	Yes
		Facultative	1.5	29,300	7,325		17% less

Table 3.2 Sewage Quality of Existing STP's

STP		BOD		SS	
		(mg/L)	Removal Efficiency (%)	(mg/L)	Removal Efficiency (%)
Waigani	Influent	136	-	123	-
	Effluent	53	61	30	76
Gerehu	Influent	132	-	136	-
	Effluent	36	73	55	60
Morata	Influent	217	-	165	-
	Effluent	49	77	25	85
Average	Influent	162	-	141	-
	Effluent	46	72	37	74

3.1.3 Coastal Area

Sewage collected from the coastal areas are discharged directly into the sea through 7 different outfalls located at Idubada, Hagara, Kaevaga, Treasury, Paga Point, Badili and Kila Kila (Joyce Bay). These outfalls vary in size from a long and large diameter outfall at Paga Point to a smaller diameter at a few hundred meters length for the rest. Location of the outfalls is shown in Fig. 3.4. Major outfalls are described below.

1) Paga Point

The Paga Point outfall receives the major share of the town's sewage. Previously, sewage was discharged at Paga Point Pumping Station (PS-7 in Fig.3.1), through a few hundred meters outfall, which had caused serious environmental disorder to the coastal shore. Thus, a 3 km outfall was installed in the early 1980s' to replace the old one. At present approximately 15,000 m³/day of sewage after grit removal is pumped through the 3km pipeline to the middle of the Papuan Lagoon at depth 30 m. There are 2 x 300 mm diameter overflow pipe that directly discharges sewage into the Paga Point foreshore during power failures.

The northern side pumping stations such as Konedobu (PS-10), Yacht Club (PS-9), and Stanley Esplanade (PS-8) pump the collected wastewater to the Paga Point Pumping Station. Lawes Road (PS-5) and Davara (PS-6) pump sewage collected from the Old Town area and the southern catchment sewage into the Paga Point Pumping Station.

2) Kila Kila (Joyce Bay)

Approximately 8,000 m³/day sewage in the Kila Kila area is discharged into Joyce Bay by gravity through a septic tank. This outfall is located in the southeast of Port Moresby and services the coastal suburbs of Kaugere and Kila Kila. Large areas of Joyce Bay catchment are made of self-help housing and squatter settlements. These housing are unsewered and will remain so for many years. Joyce Bay is relatively shallow (less than 15 meters) and influenced by tidal currents. Wave forces at Joyce Bay are restricted by the influences of the Papuan barrier reef and the fringing reef.

3) Koki/Badili

Paga Point borders Koki/Badili to the west and by Kila Kila to the east. This zone has a steep terrain and is divided into two sub-zones by the north-south low ridge.

The sewage in the Koki sub-zone is collected by gravity to the Koki Pumping Station. It was previously discharged directly into the sea but is now pumped to the adjacent Badili sub-zone. The sewage of about 4,000 m³/day from both sub-zones passes through a septic tank before it is discharged into the sea through a short outfall.

3.1.4 Pipe and Pump

The city's extensive sewer network system has total length of about 400 km classified as reticulation sewers, trunk sewers, and rising mains. With the exception of about 12km of

asbestos cement or PVC, the balance is entirely made out of vitrified clay (235 km) and concrete (150 km). Record shows that the use of vitrified clay pipes waned that towards the 1970's and was superseded by concrete pipes. The diameter of the sewer pipes varies from 150 mm to 600 mm.

PVC is now replacing asbestos and clay pipes, especially in problem areas. PVC pipes have become widely used for pipes up to 300 mm diameter and reinforced concrete pipes are used for larger diameter.

There are a total of 10 pumping stations. PS-1 (Morata) is located inland while all the other nine stations (PS-2 to PS-10) are situated along the coast. The capacity and the estimated peak flows of all the pumping stations are shown in Table 3.3.

Table 3.3 Capacity of Existing Pumping Station

Pump Station	Morava	Kaugere	Badili	Koki	Lawes Rd.	Davara	Paga P.	Stanley E.	Yacht C.	Konedobu
Pump	CP3127	CP3127	CP3152	CP3152	CP3152	CP3201	CP3300	CP3201	CP3127	CP3201
Motor Output (kw)	7.4	7.4	13.5	13.5	13.5	22	44	30	7.4	30
Duty Pump	1	1	1	2	1	1	1	1	1	1
Stand-by Pump	1	1	1	1	1	1	1	1	1	2
Rising	250	150	300	300	150	150	560	150	100	300
Main	1.28	1.41	1.13	1.84	2.36	2.59	1.14	2.45	1.27	1.23
L	415.0	195.0	322.0	191.2	350.0	330.0	2926.0	310.0	120.2	1021.0
Level	12.31	20.88	0.00	7.95	0.64	1.72	0.00	15.81	13.58	10.83
Down	8.00	11.50	-1.65	-0.98	-0.02	-0.77	-1.65	-0.32	-0.50	-2.34
Up	4.31	9.38	1.65	8.93	0.66	2.49	1.65	16.13	14.08	13.17
Dynamic	3.80	3.89	1.89	2.75	17.97	20.21	8.34	17.11	3.17	6.95
Head	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total	9.11	14.27	4.54	12.68	19.63	23.70	10.99	34.24	18.25	21.12
Flow	3.78	1.50	4.80	7.80	2.50	2.75	16.80	2.60	0.60	5.20
Flow-1995	2.22	1.38	1.74	2.94	0.78	0.30	5.04	1.38	0.18	2.76
	0.037	0.023	0.029	0.049	0.013	0.005	0.084	0.023	0.003	0.046
Flow-2005	3.78	1.38	2.22	4.68	1.08	0.30	6.24	1.92	0.24	3.66
	0.063	0.023	0.037	0.078	0.018	0.005	0.104	0.032	0.004	0.061
Flow-2015	3.78	1.38	2.40	4.80	1.26	0.30	7.14	2.16	0.24	4.20
	0.063	0.023	0.040	0.080	0.021	0.005	0.119	0.036	0.004	0.070

3.2 Operation and Maintenance (O&M)

3.2.1 O&M of Sewerage Facilities

Certain works related to sewerage facility operation and maintenance are contracted out to the private sector, while the Sewerage Operations workforce carries out most day-to-day operational works. Planning and design of new sewerage facilities including sewer reticulation and extension of services are being done by the Planning and Works.

1) Pump Station O&M

All 10 pumping stations are automatically operated and require no resident operators. However, a crew composed of a plumber and five general laborers patrol all around the pumping station daily to check the operational condition of the pumps, to do routine cleaning and other minor maintenance work on the stations. Major operational faults that the crew could not handle are given out to qualified contractors. The pumps appear to be fairly maintained with 2 newly purchased pumps and with older ones newly overhauled. There is no regular maintenance schedule formulated for the pumping stations.

2) Sewer (Trunk Sewers) Cleaning and Maintenance

For an efficient cleaning and maintenance of the sewers, the system is divided into the Inland (Northern) and Coastal (Southern) Region. EDA RANU Sewerage Operations teams make regular manhole inspection, while level (horizontal and vertical position) adjustments and cleaning are done when necessary.

Generally, the maintenance crew cleans the sewer when a blockage occurs. The Control Room of EDA RANU normally receives complaints on sewer blockages from city residents. Although there is no regular cleaning schedule in existence, clearing and cleaning of blocked sewers are done manually by the use of sewer rods and other cleaning tools.

Control Room: EDA RANU operates a Control Room 24 hours a day on a 3-shift system at the main office (Aopi Centre) and Operations Depot (4 Mile). It is manned by 8 base clerks at different shift schedule, who receive complaints and problems related to water supply and sewerage operations. These reports are then forwarded to the Water & Sewerage Operations for appropriate action. Reports regarding bills are being attended to by the JC-KRTA.

So far, all problems on sewer cleaning and maintenance have been taken care of, and appropriate measures were done to prevent recurring sewer blockages. Among the measures instituted by EDA RANU following NCDC's efforts is the replacement of the existing earthenware clay and asbestos pipes with PVC. About 853 m length of pipe replacement works (done by private contractors) has been completed and still continuing. Cleaning of the trunk sewer has never been carried out except for the sea outfall pipeline, which has been checked and cleaned out in June 1997.

The maps on the layout of the sewer pipe network remain to be updated. Engineers gradually make their manual correction and updating on the reproduced copies for their own use. Although groundwork on the computerized mapping system has started for the water supply network as part of the Management Improvement Agreement with JC-KRTA, the sewer pipe network should also be considered.

3) Lagoon Cleaning

EDA RANU maintains 3 existing sewage treatment plants (sewage lagoons) within NCD. Regular cleaning of screens, pruning of grass, removal of water hyacinths and other aquatic plants growing in the ponds at Waigani and Morata STP are contracted out to private contractors. The EDA RANU crew is maintaining the GEREHU STP.

4) Material Control

EDA RANU has one warehouse and two stockyards where materials for water supply and sewerage such as pipes, fittings, water meters and others are kept.

The warehouse and one stockyard are located at the Operations Depot and the other yard is at Bomana. Inventory control, stores and purchasing are being handled by the Technical Services of EDA RANU. In October 1997 about 2000 items for water supply & sewerage operations and for administrative use were purchased valued at approximately 1.3 million Kina and stocked in the warehouse and stockyard.

5) Machine and Equipment Management

EDA RANU does not own special and heavy equipment and machinery since most major maintenance works are contracted out. Backhoes and other equipment used for normal operation and maintenance works are hired from private contractors. However, EDA RANU of which 8 vehicles are allocated for sewerage operations owns the operation vehicles.

6) Contracting Out Jobs

EDA RANU carries out routine cleaning works and regular check of facilities condition while other maintenance works that are given out to private contractors include the following:

- Mechanical and electrical maintenance of pumping stations.
- Pipe replacement works.
- Regular cleaning of screens and lawn mowing of the Waigani and Morata STP.
- Other major maintenance works.

EDA RANU supervises the works and the performance of these contractors is closely monitored for re-evaluation of their term of engagement.

3.2.2 Consumer Services

1) Sewer Service Connection

Customers who wish to apply for a new sewer service connection are required to comply with the procedure as follows:

- The applicant fills up an application form with the attached documents such as building permit, physical planning board approval, certificate of completion of the building, approved plan showing the layout of the services and payment of headwork charges receipt.
- Inspection is then made by the EDA RANU Operation's supervisor/engineer and an estimate on the connection charges is made.
- The applicant pays the connection charge at the EDA RANU cashiers office managed by JC-KRTA.
- The sewer connection, whether installation of Y-Junction to sewer main or connection into the manhole is done by EDA RANU.

As of 11 December 1997 a total of 13,355 connections are registered with EDA RANU comprising of 4,272 high covenant, 7,301 low covenant and 1,782 others.

Between 01 January - 31 November 1997 a total of 168 new connections was made of which half of the connections were directly done by the client themselves for not knowing the procedure newly introduced. It is expected that the procedure will be completely followed in the years ahead. Table 3.4 below shows the 1997 Sewer Connection Charges.

Table 3.4 Sewer Connection Charges, 1997

Type of Connection	Charges, Kina
100 mm x 150 mm diameter Y-connection into sewer main	125
100 mm diameter connection into manhole	300
150 mm diameter connection into manhole	350
Larger than 150 mm diameter connection into manhole	By quotation

The current connection procedure seems adequate in general, while the only discussion that might be raised is the number of connections and the scope of works that may be contracted out.

2) Sewerage System Service Charges

EDA RANU charges water and sewerage tariffs as specified in the NCD Water and Sewerage Act of 1996. Charges are levied either on flat charge basis or volume of water consumed. The sewerage tariff is imposed on an annual basis as shown in Table 3.5.

Table 3.5 Annual Sewerage Service Charges (1997)

Consumer Type	Charges, Kina
Low Covenant	90.00
High Covenant	180.00
Large premises	90.00 per water closet & urinal

The sewerage bills are sent to consumers annually apart from the water bills that are sent quarterly and monthly for domestic and commercial users, respectively. Domestic sewerage charges are determined by the commercial land value where the house is located. High covenant houses are those located in a land valued at more than K12,000 UCV (Unimproved Capital Value) whilst low covenant houses, the UCV of the land is K12,000 or less.

3) Billing and Collection

As previously mentioned in Section 3.2.2.1 all applications for services are entered into the consumer register book after all procedures are followed. The process is computerized and subsequently linked to the billing of customers as follows:

- JC-KRTA bills the consumers on behalf of EDA RANU using a computerized billing system.
- All bills indicate EDA RANU as the issuer.
- Bills are directly mailed to the consumer or discharger of wastewater.
- Bills are issued annually for sewerage, quarterly and monthly for domestic and commercial water consumers.
- JC-KRTA conducts all water meter readings.

Almost all corporate accounts and large volume consumers make payments of their bills by cheque to the cashier's office operated by JC-KRTA. Small volume consumers including domestic account holders make payments by cash. JC-KRTA deposits all collections into the trust account (a joint bank account between EDA RANU and JC-KRTA).

The Consumer Service Agreement is one of the agreements NCDC previously entered into with JC-KRTA. This contract which was subsequently handed over to EDA RANU includes billing and collection of both service's charges. In return, JC-KRTA charges EDA RANU 7% to 9% from the collected revenue. Other tasks including collection of arrears previously made during NCDC years and disconnection of services to faulty customers. JC-KRTA has its own manpower to carry out its consumer services as shown in Table 3.6 below.

Table 3.6 JC-KRTA Consumer Service Structure (1997)

Particulars	No. of Staffs
Management, Administration including drivers and others	7
Meter Readers	10
Cashier	3
Data Encoders	2
Total	22

4) Arrears

Since both water and sewerage billing and collection have been delegated to JC-KRTA, EDA RANU would largely depend on their efforts to reduce arrears. There has been a large improvement in service charge collections since EDA RANU started its operation. Arrears from sewerage bills carried over from NCDC are estimated at about 2.4 times the annual collection capacity of the billing amount for this year.

To prevent these arrears from building up, EDA RANU may impose the provisions of the NCD Water and Sewerage Act 1996 whereby EDA RANU has the power to disconnect and terminate the services. As provided for in Sections 15, 16, 26 & 27, methods to inflict penalties and make recovery of unpaid rates are as follows:

- Non-Payment of Rates (Section 15) states that EDA RANU may stop or suspend the supply of water to any person who owes EDA RANU money in respect of rates or water supplied under the Act, where the charges remain unpaid for 14 days.
- Penalty for Non Payment of Rates (Section 26) states that where water and sewerage rates are in arrears, EDA RANU may charge a penalty at the rate of the 5% of the amount per annum from the time it becomes due and payable until payment is received.
- Recovery of Rate (Section 27) states that where water and sewerage rates and the penalty due is not paid for a period of six months, EDA RANU shall notify the owner of the outstanding rates for the respective area of service for which payment has not been made nor a satisfactory arrangement regarding payment been made. Within 30 days of notification, EDA RANU may institute legal proceedings in court and so forth.

3.3 Organization and Institution

3.3.1 EDA RANU's establishment

EDA RANU started the operation of both the water supply and sewerage systems for the NCD on 1 November 1996. Previously this was the responsibility of the Water and Sewerage Division of NCDC until the transfer. EDA RANU is responsible for operating and maintaining the water supply and sewerage system facilities however water treatment plant operation (including facility development and maintenance) and tariff billing and collection

(both water and sewerage) have been contracted out to the private sector for a period of 22 years.

National Capital District Commission (NCDC) is the city authority of the NCD, which includes Port Moresby and the Motu Koitabu areas. NCDC is part of the local government established in 1990 in accordance with the NCDC Act and under the control of the Department of Provincial and Local Government Affairs. It is responsible for developing the social infrastructure of NCD, including water and sewerage works until these function were transferred to EDA RANU.

NCDC Water and Sewerage Division was one of the executing units within the NCDC structure fully responsible for NCD's water and sewerage development, operation and maintenance. Most of the division's 235 staffs for facility operation and maintenance and 5 from administration moved to EDA RANU along with the transfer of the function.

NCDC (Transfer of Assets, etc.) Act 1996, made provision for the transfer from NCDC to NCD WATER & SEWERAGE PTY. LIMITED, (trading as EDA RANU, meaning "Our Water") the responsibility to provide the supply of fresh water and treatment and disposal of sewage within the NCD and to vest in the NCD WATER & SEWERAGE PTY. LIMITED, the assets required for the supply of treated water and the treatment of sewage and to provide for the net value of such assets after taking into account all loans and grants to the NCDC from the State and all other agencies and institutions for the provision of those areas and related matters.

NCD Water and Sewerage Act 1996 was specifically formulated for EDA RANU. This Act authorizes and regulates the operations of the water supply and sewerage systems. It also defines that all customers of water and sewerage services shall pay water and sewerage rates. The water rate is based on the water consumption for consumers with meters installed and flat rates for unmetered consumers, while the sewerage rate is determined by premises category, number of toilets, etc.

To establish EDA RANU legally, the Department of Finance purchased GODOLPHIN No. 12 Pty. Ltd. from a legal firm and instructed the firm to change its name to NCD WATER & SEWERAGE PTY. LIMITED on 30 April 1996. Duties of the NCDC's Water and Sewerage Division were absorbed as of 1 November, 1996 in accordance with the two acts namely, "NCD Water and Sewerage Act 1996" and "NCDC (Transfer of Assets, etc.) Act 1996" enacted on the same day.

GODOLPHIN No. 12 Pty. Ltd. was a separate national company established by a legal firm under the Company Act. It is a common practice in PNG for legal firms to establish national companies known as "paper companies" and is available for purchase to interested parties when required.

Main duties of EDA RANU

- Conducting water and sewerage works with respect to Water Resources Act.
- Developing and maintaining water supply source for the public and residents of NCD.
- Developing, operating and maintaining sewerage system for NCD.
- Supplying sufficient water.
- Taking all responsibility for planning, developing and maintaining water and sewerage facilities in NCD.

The two (2) shares of EDA RANU with a face value of 1 Kina per share are fully owned by the State Government and as such EDA RANU is not a private company. Because of the government's full ownership of EDA RANU, the Minister for Finance has the authority to order the issue of new shares, the power to appoint/dismiss any member of the Board of Directors, and to give concessions to the company on the execution of any transaction over K100,000 Kina. Furthermore, EDA RANU is registered as a propriety limited company, whereby the number of shareholders is limited to 50, and is prohibited to issue shares / bonds and not allowed to borrow fund from the general public.

External control: The Government has the authority to impose its administrative rights over EDA RANU's operations by nominating directors. This right also require EDA RANU to seek the approval of the Minister for transactions amounting over One Hundred Thousand Kina (K100,000) and the approval of the Head of the State, to execute any transaction, including remuneration, amounting to over Five Hundred Thousand Kina (Kina 500,000). EDA RANU has borrowed Five Million Kina (Kina 5,000,000) from the National Provident Fund as operating expenses.

Internal control: In addition to the government's control, an internal control system has been established. All procurement/expenditure shall be approved either by the Board of Directors, the top management (Executive Chairman and General Manager) or department managers (Chief Engineers and Financial Controller) as the case may be. Table 3.7 below explains the financial delegation of EDA RANU.

Table 3.7 Financial Delegation

Transaction amount/value	To be approved by
a) Government approval	
over 0.5 million Kina	Head of the State
0.1 to 0.5 million Kina	Minister of Finance
b) EDA RANU Internal control	
over 50,000 Kina	Board of Directors
5,000 to 50,000 Kina	Executive Chairman or General Manager
less than 5,000 Kina	Chief Engineer or Financial Controller

3.3.2 Assets Transfer

The transfer of all assets of the water and sewerage facility from NCDC (actual physical assets, such as water reticulation, treatment plants, etc.) to EDA RANU was carried out in accordance with the NCDC (Transfer of Assets, etc.) Act 1996. The Act requires the complete transfer of all assets, including staff of the Water Supply and Sewerage Division of NCDC, effective 01 November 1996.

Valuation of transfer of assets is being conducted by three bodies, namely: Auditor General, NCDC and a consulting company. However, valuation has yet to be determined.

As provided for in Section 7 of the NCDC (Transfer of Assets, etc.) Act 1996 the following stipulations have to be made, whereby:

- Immediately following the transfer of all assets as per the Act, the NCDC, the Auditor General on behalf of the State and an independent third party, shall undertake determination of the value of the assets to be transferred to the successor company, EDA RANU.
- Should the NCDC and the Auditor General be unable to reach an agreement for the appointment of an independent third party, the Minister shall appoint the third party.
- The valuation of all assets transferred shall be completed within 90 days and shall be assessed at this value. However, this has yet to be achieved due to inconsistencies between the valuing parties.
- After completion of the valuation, EDA RANU shall be required to pay (after taking into account the unpaid value of all loans and grants relating to the assets), the outstanding amount to the State and NCDC over a period of ten years by equal installments inclusive of interest, at a rate to be agreed upon by the State and the NCDC.

It should be noted though, that once this value has been determined, the government is required to reimburse NCDC. The State's assets will eventually become the capital investment of the government or the capital of EDA RANU.

3.3.3 EDA RANU'S Management and Organizational Structure

EDA RANU's organization is structured with top management and operations units (with 135 engineering and administrative staff). The top management unit is an executive body made up of an executive chairman and seven boards of directors.

The current members of the board were nominated for a limited term by the Minister for National Planning & Implementation (NPI). The board members include officials from the NPI, officials from the Department of Finance, landowner's representative, officials from NCDC and one private sector representative.

The organizational structure of EDA RANU is shown in Fig.3.6. The general manager heads all departments and sections. Under his control there are the operations and financial department headed by the chief engineer, and financial controller, respectively while the personnel and administration division is controlled directly by the general manager. The water treatment plant operation and consumer services have been contracted out to the private sector.

Total manpower of EDA RANU: In 1996, most of the 230 staff of NCDC's Water Supply and Sewerage Division transferred to EDA RANU. Their employment status has been changed from public servant to a private sector. About 30 joined JC-KRTA for consumer services and 27 joined PNG Water Limited for operation and maintenance of the Mt. Eriama Water Treatment Plant. Restructuring were made to both the operations and administrative/financial divisions. As of 30 November 1997, the total number of staff was reduced to 135. Table 3.8 shows the number of the employees by skill category. Number of staffs (as of November 30,1997) in the respective divisions and sections are shown in the Table 3.9.

Table 3.8 EDA RANU Manpower by Category

Category	Number of Staffs
Professional	10
Skilled	21
Semi-skilled	46
Unskilled	58
Total	135

Compensation System: EDA RANU employs a grade system for determination of salary and benefits. The salary grade is structured from 1 to 10 (10 being the highest). In addition to the basic salary, overtime allowances are also authorized to employees who fall below grade 7. All other benefits such as accommodation and airfare were integrated into the basic salary since November 1997 when the employment contract was introduced. Working hours at EDA RANU was changed to 8:00am - 5:00pm from the usual government working hours of 7:45am - 4:06pm.

Management Improvement Agreement (MIA): This is one of the agreement EDA RANU has inherited from NCDC for the purpose of improving the operational and financial performance of the Water Supply Operations, in order to provide consumers with an agreed level of service at least cost. As provided for in the agreement, JC-KRTA has to provide consultancy in (1) metering, (2) leakage control, (3) record drawing, (4) digital mapping, (5) distribution analysis, (6) tariff study, (7) asset registration and (8) management development and training. Since this agreement is specifically for water supply, a separate improvement program for sewerage operations should be provided.

3.3.4 Functions of Each Organizational Unit

1) Administration Department

This department that is responsible for administrative work, financial and all personnel matters is consists of the Finance and Personnel/Administration Divisions. Since most of the personnel that were transferred from NCDC were the operators of the water and sewerage system, new workers were recruited to the Administration Department.

2) Operation Department

This department is responsible for all works, planning, design, construction and daily operation and maintenance of water supply and sewerage system. The department consists of two major divisions headed by the operations managers for water supply and sewerage. Staff of the quality control, planning and works and technical service support the 2 major operations. Organizational structure of this department seems appropriate enough to operate water supply and sewerage services from a functional structure point of view.

3) Finance Division

This division is responsible for all works related to financial transactions of EDA RANU. All detail transactions are maintained in a computerized accounting system consisting of the general ledger, accounts payable, cash book, fixed assets and payroll, while the customer ledger including the accounts receivable ledger are kept in the JC-KRTA 's computers.

Computer systems connection: The plan to interconnect the computer system of EDA RANU and JC-KRTA's system is underway to enable EDA RANU to gain access to data on accounts receivable and customer ledger and to closely monitor the billing and collection.

Asset management: Since the valuation of the assets transfer has not been completed, EDA RANU has to maintain asset registration for depreciation value computation as provided for in the Act. It is also necessary to develop a management control scheme and procedure for asset registration.

4) Personnel/Administration Division

This division is responsible for all matters pertaining to personnel administration, recruitment, payroll, staff matters and workers performance evaluation. It is also responsible for the operation of the control room that receives reports including complaints, suggestions, and other matters related to water supply and sewerage operations.

5) Water Supply Operation Division

This division is responsible for all works related to water supply operations, including operation and maintenance of water distribution facilities, service connections, water pump

operations and water storage tanks. This division is only responsible for the engineering and technical matters of water supply technology, excluding commercial services.

6) Sewerage Operation Division

This division is responsible for all works related to sewerage system operation, including maintenance of main sewer and reticulation, service connection, operation and maintenance of pumping stations and sewage treatment plants and sea outfalls. The organizational structure of the sewerage operations is shown in Fig. 3.5.

7) Engineering and Support Services

As engineering and operational support units, the three sections that falls under the control of the chief engineer are as follows:

(1) Quality Control

This section is responsible for monitoring the quality of water in the distribution system and the effluent of the STP and outfalls. Since the staff (presently one member) of this section has no chemical background, his function is limited to the collection of samples while an external laboratory does examination and analysis. Examination results are then forwarded to the chief engineer.

(2) Planning & Works

This section is responsible for the planning and design of the water supply and sewerage system, including engineering; survey and supervision of contracted works related to water supply, sewerage and administration. All new development projects of the city require the inputs and approval of the Planning and Works Section of EDA RANU concerning the water and sewerage services. This section is also evaluating water and sewerage services connection applications before any approval is given.

(3) Technical Services

This section is responsible for the stores, purchasing and stock control of materials, equipment and machinery for use by the EDA RANU workforce.

Table 3.9 Number of Staff of Administration Units

Position		Number of staff
Finance Division		2
	Division manager (Financial controller)	1
	Financial accountant	vacant
	General ledger officer	vacant
	Account payable clerk	1
Personnel and Administration Division		19
	Manager	vacant
	Personnel officer/Trainer	vacant
	Payroll officer	1
	Time record clerk	1
	Administration officer	1
	Control room clerks (6 in AOPI, 2 in Depot)	8
	Receptionist, Clerk, Driver, General labour, etc.	8
Water Operation Division		64
	Water operation manager	1
	Operation engineer	1
	Supervisors & Shift supervisors	7
	Record technician	1
	Leakage control	1
	Electrician, technician	1
	Refilling clerks	8
	Customer service	5
	Water liaison officer	1
	Plumbers	12
	Secretaries, Drivers	10
	General Labour, etc.	16
Sewerage Operation Division		31
	Sewerage operation manager	1
	Operation engineer	1
	Pumping supervisor	vacant
	Custom service supervisor	1
	Lagoon supervisor	1
	Sewerage supervisor (North)	vacant
	Sewerage supervisor (South)	1
	Plumbers	4
	General labour	18
	Secretary, Drivers	4
Planning and Works		9
	Manager	vacant
	Planning engineer	1
	Works engineer	1
	Surveyor	1
	Draftsman/Supervisor, Draftsman	2
	Secretaries, Drivers and General labour	4
Quality Control		2
	Chemist and bacteriologist	vacant
	Water sampler and assistant	2
Technical Service		5
	Supervisor	1
	Purchasing officer, Storage officer	2
	Purchase clerk, General labour	2

3.3.5 Concession and Consulting Agreements

Prior to the transfer, NCDC entered into 3 agreements with private parties which EDA RANU has honoured and signed accordingly. Table 3.10 shows the list of the agreements with third parties.

Table 3.10 Agreements with Third Parties

Agreements	Purpose	Date Signed and Term
Concession Agreement, (CA) with PNG Water Limited	Concession for the operation and maintenance of water treatment plant.	Jun. 1997 for 22 years
Consumer Service Agreement, (CSC) with JC-KRTA Consulting Group (PNG) Ltd.	Billing and collection of water and sewerage charges.	Nov. 1996 for 22 yrs.
Management Improvement Agreement, (MIA) with JC-KRTA Consulting Group (PNG) Ltd.	Consultant in water supply engineering, technical and management improvement capacity.	Nov. 1996 for 4 yrs.
Other consultancy contracts related to the Concession Agreement, such as engineering consultancy and interface are made between organizations concerned.		

Involvement of the Sewerage Operations to the agreements listed above comes only when required to matters related to sewerage charges of the CSC.

3.4 Financial Condition

3.4.1 Introduction

On 1 November 1996, simultaneously with the transfer of the water and sewerage function, the Consumer Service Agreement also took effect. The bad debt issue, which was the chronic problem during the NCDC era, started to improve remarkably. However, in the area of expenditure management to include management accounting system and budget control remain to be enforced.

3.4.2 The Current Capital Structure of EDA RANU

As provided for in the transfer of assets, the government has 10 years to pay NCDC all assets that were transferred to EDA RANU. Since the valuation has not yet been settled, and no payment been done, the balance sheet of EDA RANU could not be finalized. As a result, the government is reluctant to invest the 10 million Kina with EDA RANU. Originally, 5 million Kina was partly to be paid at the beginning of EDA RANU's creation, but did not materialize. Instead, a loan of 5 million Kina was secured from NPF and guaranteed by the government.

Until now the total share capital of EDA RANU amounting to Two Kina is still owned by the government. The long-term policy to sell a portion of the shares to the public is not listed as the immediate agenda of the government.

3.4.3 The Financial Performance of EDA RANU (Revenue)

The revenue collection of EDA RANU for the first 12 months until October 1997 is shown in Table 3.11. The revenue is increasing steadily as a trend in the water bills. The sewerage customers are billed annually. In June 1997 a total of 2,773,710 Kina was billed to the customers divided into 2,034,990 Kina and 738,720 Kina for domestic and commercial customers, respectively.

The Final collection performance for sewerage bills will not be known until 1998, although it is assumed to be far better than during NCDC era. The management has considered increasing the frequency of billing the sewerage from the current annual to quarterly basis. The increase in revenue will largely depend on the charge system structure and the expansion of the sewerage service. The future charge system is discussed in Chapter 9.

JC-KRTA handles the water and sewerage bills by classifying the new and the old bills (arrears during NCDC years). The old bills amount to 30 million Kina and 4.8 million Kina for water and sewerage, respectively. As estimated by the JC-KRTA, collection of the old bills could be expected at a maximum of 50% for sewerage and 20% for water. Therefore, an old bill collection of 9 million Kina is equivalent to 40% of the expected revenue collection of EDA RANU, annually. At present, the assets of EDA RANU whose total value has not been settled yet, include the collectible bad debt of water supply assessed by a third party at 5.9 million Kina and the collectible bad debt of sewerage service assessed at 0.22 million Kina. Although it is hard to maximize the collection of the bad debts incurred during the NCDC years but it is expected to be collected partially through the efforts of JC-KRTA.

The number of new sewer connection for just over a year (1 November 1996 to 10 December 1997) is 176. It is necessary to extend the service for the benefit of the sanitary condition of the inhabitants and to increase revenue.

3.4.4 The Financial Performance of EDA RANU (Expenditure)

While a remarkable improvement was seen in revenue collection, the expenditure aspect has not stabilized yet, as shown in Table 3.12. In 10 months period (1 January 1997 to 31 October 1997), the actual amount of disbursement is 17 million Kina almost equal to the budgeted amount.

The delay in the effectivity of the Concession Agreement (took effect in June 1997) has saved EDA RANU some 7 million Kina since only 5 M Kina was paid out of the budgeted 12 M Kina. However, once this agreement is completely adhered to, every drop of treated water that flows out from Mt. Eriama will be paid by EDA RANU to PNG Water Limited. A budget deficit will be expected if the current trend of expenditure will continue.

As shown in Table 3.12, actual expenditure exceeded the budgetary in most items. This scenario is reasonably expected for the first fiscal year since a precise budget estimate is hard to achieve. However, to minimize budget deficit, expenditures in all areas must be reasonably cut within the limit of the company's affordability.

The 5 M Kina loan from the NPF has roughly balanced the 13 M Kina revenue collection against the 17 M disbursement for the 10 months period (January 1997 to October 1997). As a result, the bank balance of EDA RANU as of end of October 1997 is almost zero.

Moreover, expenses to both water supply and sewerage service has to be classified according to their use. Since it is desirable to introduce a solid management accounting system once EDA RANU operation stabilizes; the Financial Controller is going to begin the disbursement classification starting with the electricity charges.

3.4.5 The Financial Condition of Water Supply & Sewerage During NCDC Years

The survey on the financial situation of the water supply and sewerage in the NCDC era done by the World Bank Study in 1994 is shown in Table 3.18. Based on the study, surplus was noted in the 10 years record (1985 - 1994) except for 1992. However, the actual surplus is perceived to be less if the general administrative expenses were included in the calculation. Also, there is the assertion in some areas that the true bad debt was actually far bigger than reported and actual business in the NCDC era was not a black-ink balance.

Table 3.11 Cash Collection

(From 1 November 1996 to 31 October 1997)

(Unit: 1000 Kina)

Month	Nov-96	Dec-96	Jan-97	Feb-97	Mar-97	Apr-97	May-97	Jun-97	Jul-97	Aug-97	Sep-97	Oct-97	Total
Water	770	613	1,178	1,168	705	1,137	1,427	1,021	1,388	1,331	1,220	1,684	13,643
Sewerage	154	34	50	38	50	81	71	46	730	437	332	125	2,147
Total	924	647	1,228	1,206	755	1,218	1,499	1,067	2,118	1,768	1,553	1,809	15,790

Cash Collection

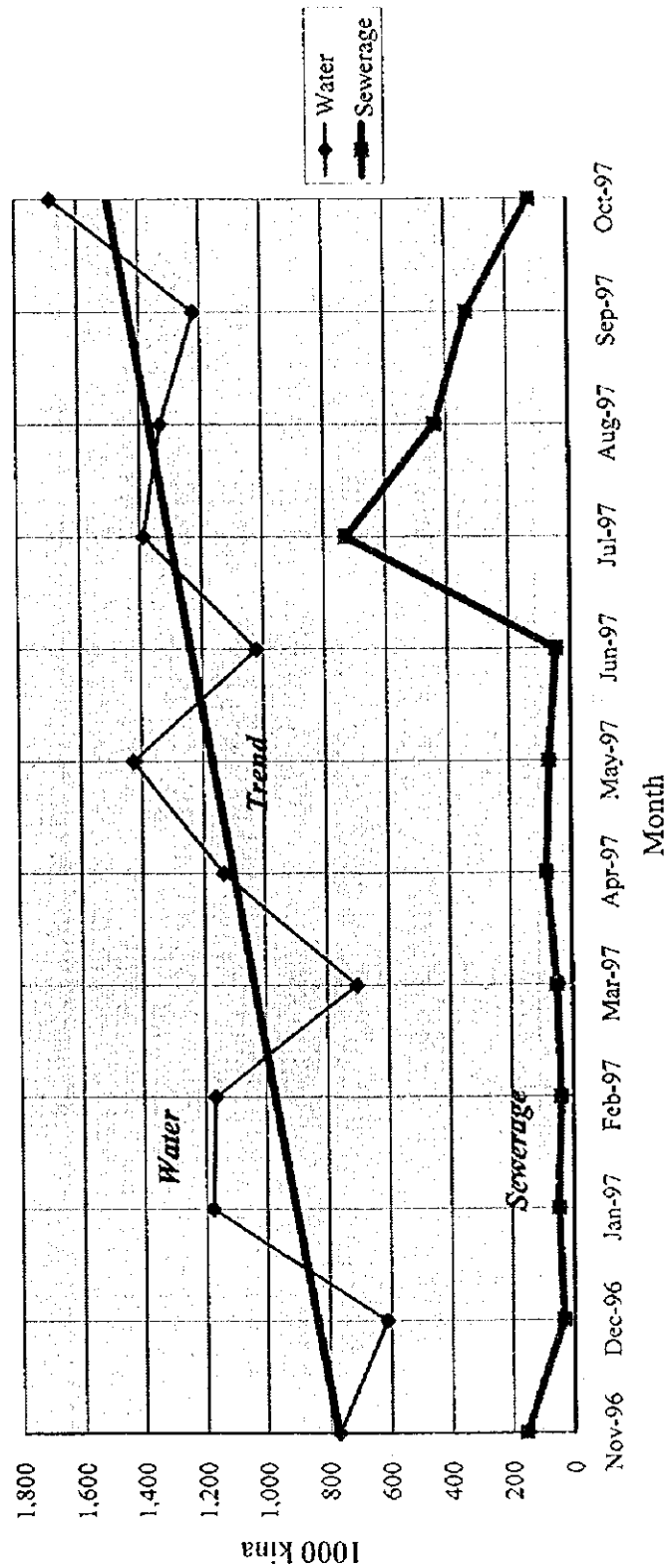


Table 3.12 The Summary of EDA RANU Expenditure
(From 1 January 1997 to 31 October 1997)

(Unit: 1000 Kina)

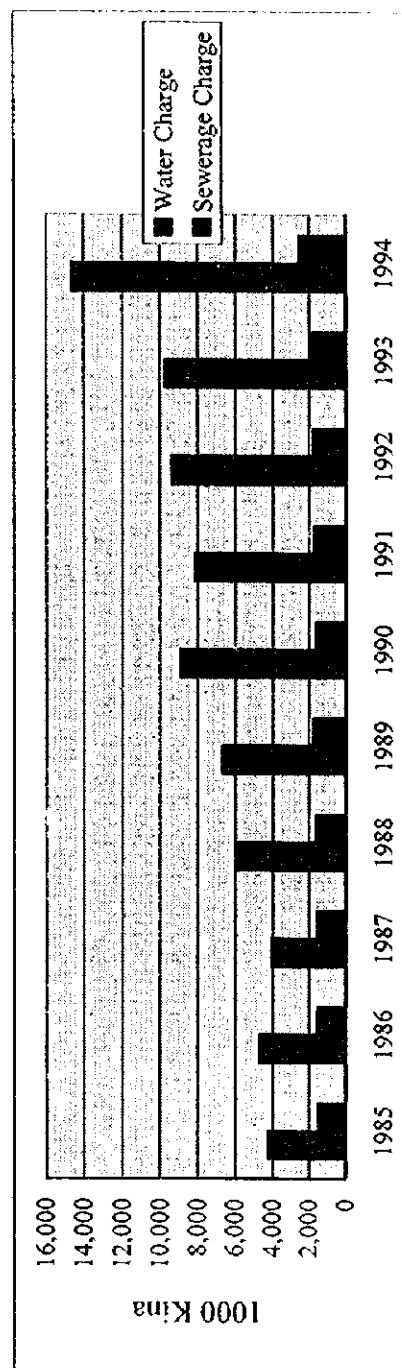
Items	Actual	Budget	Variance
Operating Expenses	6,145	3,106	-3,039
Salaries-Shed 20	990	827	-163
Salaries-Eda Ranu	505	595	90
Leasing	252	400	148
Hire of Tipper Trucks	51	38	-13
Hire of Heavy equip	328	138	-190
Tools & Accessories	52	15	-37
Minor Works	378	80	-298
Materials	479	263	-216
Repairs & Maintenance	887	135	-752
Water Delivery	827	440	-387
Mt. Eriama Treatment Plant Exp.	958	0	-958
Chemical Shed Rental	49	0	-49
Electricity	343	156	-187
Customs Duty	1	0	-1
Clothing-Uniforms & Work Boots	45	20	-25
Administrative Expenses	2,491	790	-1,701
Security Services	235	50	-185
Telephone	23	100	77
Stationery	201	20	-181
Motor Vehicle Costs	237	100	-137
Computer Consumable	3	10	7
Office Rental	507	286	-221
Legal & Secretarial	177	65	-112
Accounting	86	0	-86
Other Consulting	309	0	-309
Advertising	183	74	-109
Insurance	90	37	-53
Bank Charge	3	0	-3
Entertainment	6	0	-6
Office Expense	157	0	-157
Training Expenses	21	0	-21
Directors Fees	61	48	-13
Medical Fees	49	0	-49
Staff Accommodation	143	0	-143
Financial Expenses	1,884	1,109	-775
Interest-NPF	649	1,109	460
Ex-Gratia Payment to Ex NCDC Staff	833	0	-833
Sales Tax	266	0	-266
Finance Dept (IDG)	108	0	-108
Stamp Duties	28	0	-28
Capital Expenditure	1,443	255	-1,188
Office Equipment	239	0	-239
Plant & Equipment	837	0	-837
Office Fixtures & Fittings	369	0	-369
Motor Vehicle	-2	0	2
Contingencies	0	250	250
NPF - Setup Fees	0	5	5
Aopi Center Fitout	0	0	0
Payments to Concession Agreement	5,086	12,003	6,917
Bulk Sales	2,132	9,013	6,881
MIA	1,782	1,730	-52
CSA	1,172	1,259	87
Total	17,049	17,263	214

Note: The Budget is prorated from the annual budget provision.

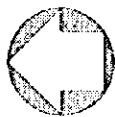
Table 3.13 Water Supply & Sewerage Charge in NCDC
(From the World Bank Study in 1994)

(Unit: 1000 Kina)

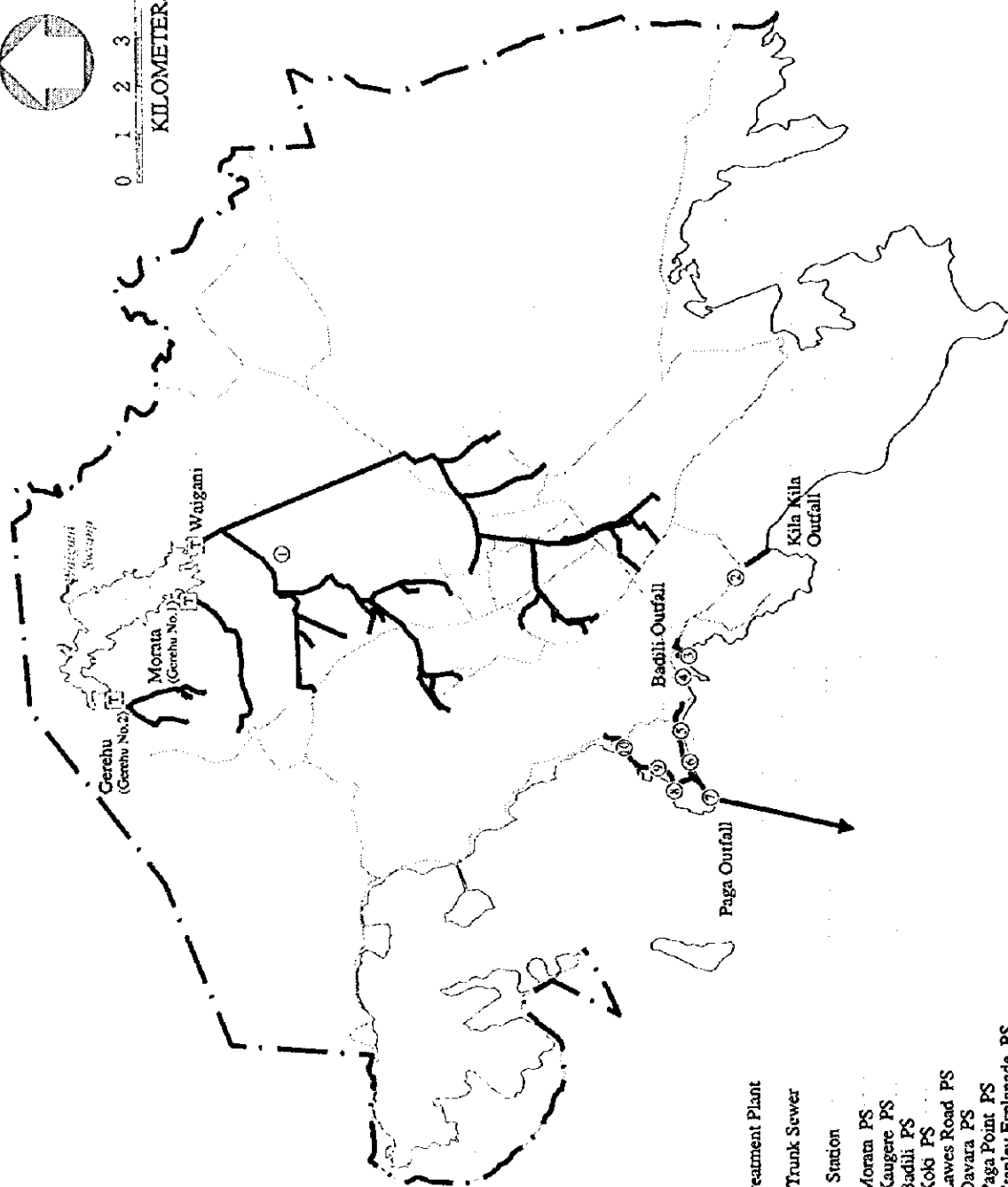
Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Water Charge	4,232	4,700	4,076	5,965	6,673	8,900	8,105	9,368	9,690	14,591
Sewerage Charge	1,479	1,539	1,533	1,657	1,740	1,639	1,717	1,778	1,884	2,525
Water & Sewerage Charge, total	5,711	6,239	5,609	7,622	8,413	10,539	9,822	11,146	11,574	17,116
Water, sewerage admin.	1,657	1,845	1,330	2,655	4,094	3,387	3,884	7,530	1,314	3,618
Water, supply, purification	698	807	539	645	599	796	809	465	746	821
Water, storage & distribution	803	769	1,019	1,139	839	904	1,198	2,801	1,445	1,352
Sewerage systems	394	403	431	403	291	423	391	327	304	293
Development works: w&s	0	0	0	0	0	0	390	209	957	1,086
Expenditure, Water & Sewerage	3,552	3,824	3,319	4,842	5,823	5,510	6,672	11,332	4,766	7,170
Surplus, Water & Sewerage	2,159	2,415	2,290	2,780	2,590	5,029	3,150	-186	6,808	9,946



NORTH



0 1 2 3 4 5
KILOMETERS



LEGEND

- Sewer Treatment Plant
- Existing Trunk Sewer
- ① Pumping Station
- 1. Morata PS
- 2. Kaugere PS
- 3. Badili PS
- 4. Koko PS
- 5. Lawes Road PS
- 6. Davara PS
- 7. Paga Point PS
- 8. Stanley Esplanade PS
- 9. Yacht Club PS
- 10. Konedobu PS

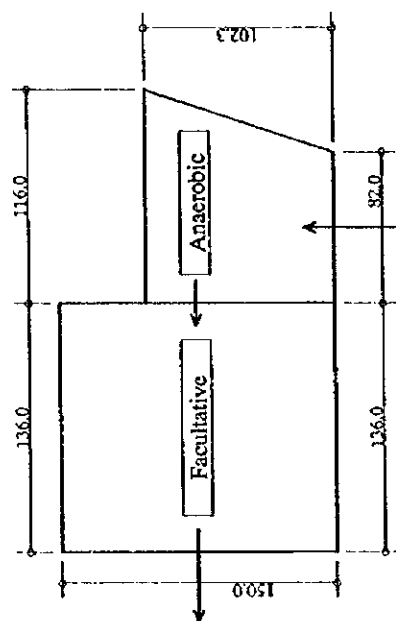
Date
May 1998

Title
Location of Existing Trunk Sewer and Pumping Station

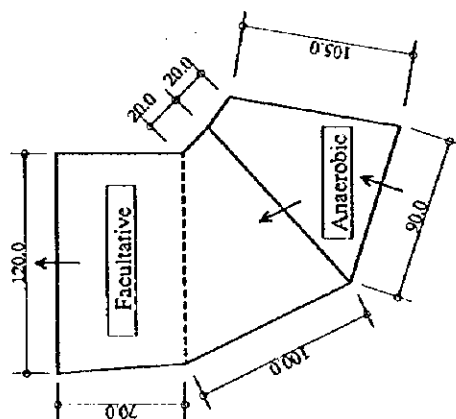
Fig.
3.1

THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA

TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI



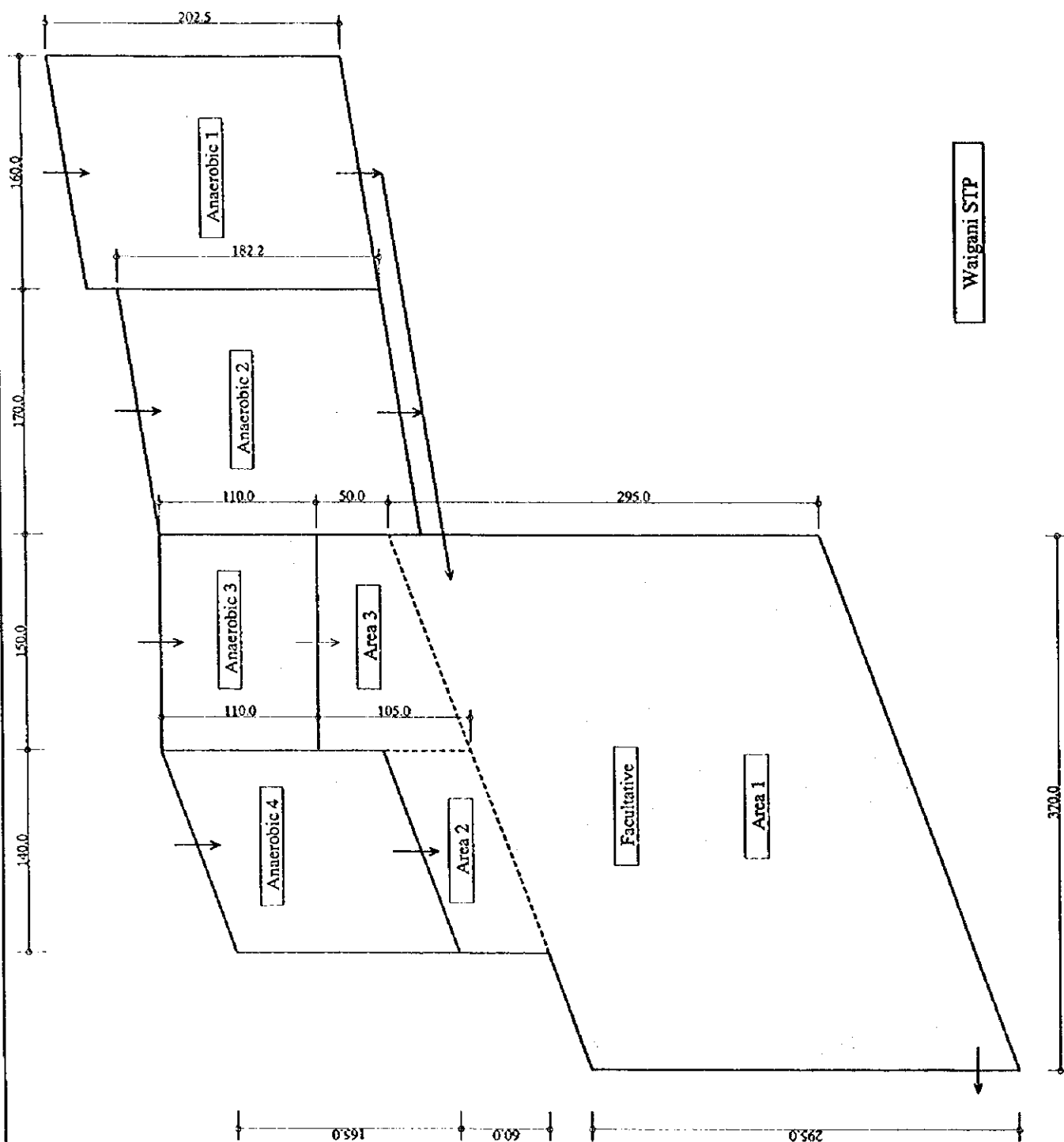
Gerehu STP



Morata STP

Scale = 1 : 400

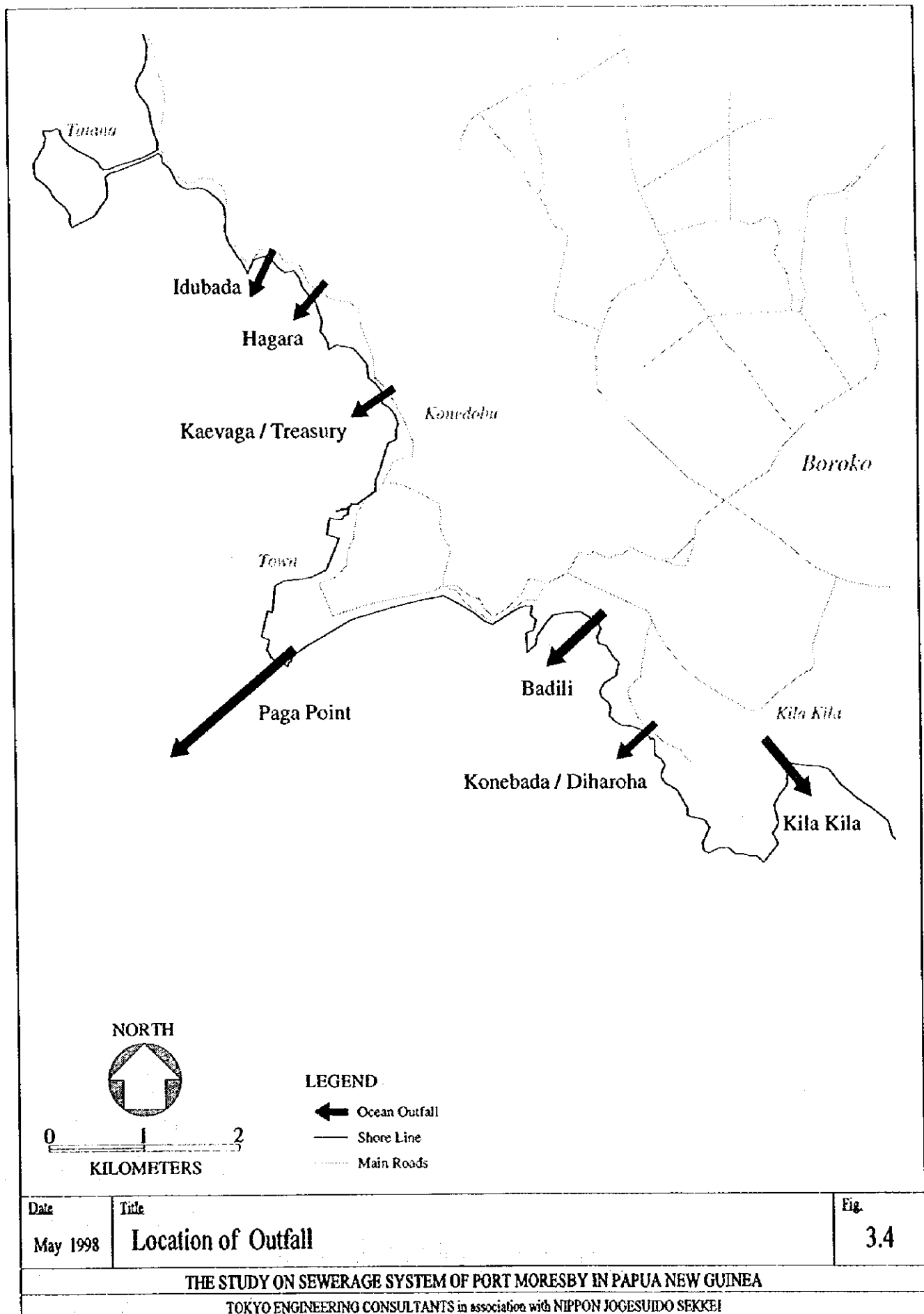
Date	Title	Fig.
May 1998	Schematic Diagram for Gerehu and Morata STPs	3.2
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI		

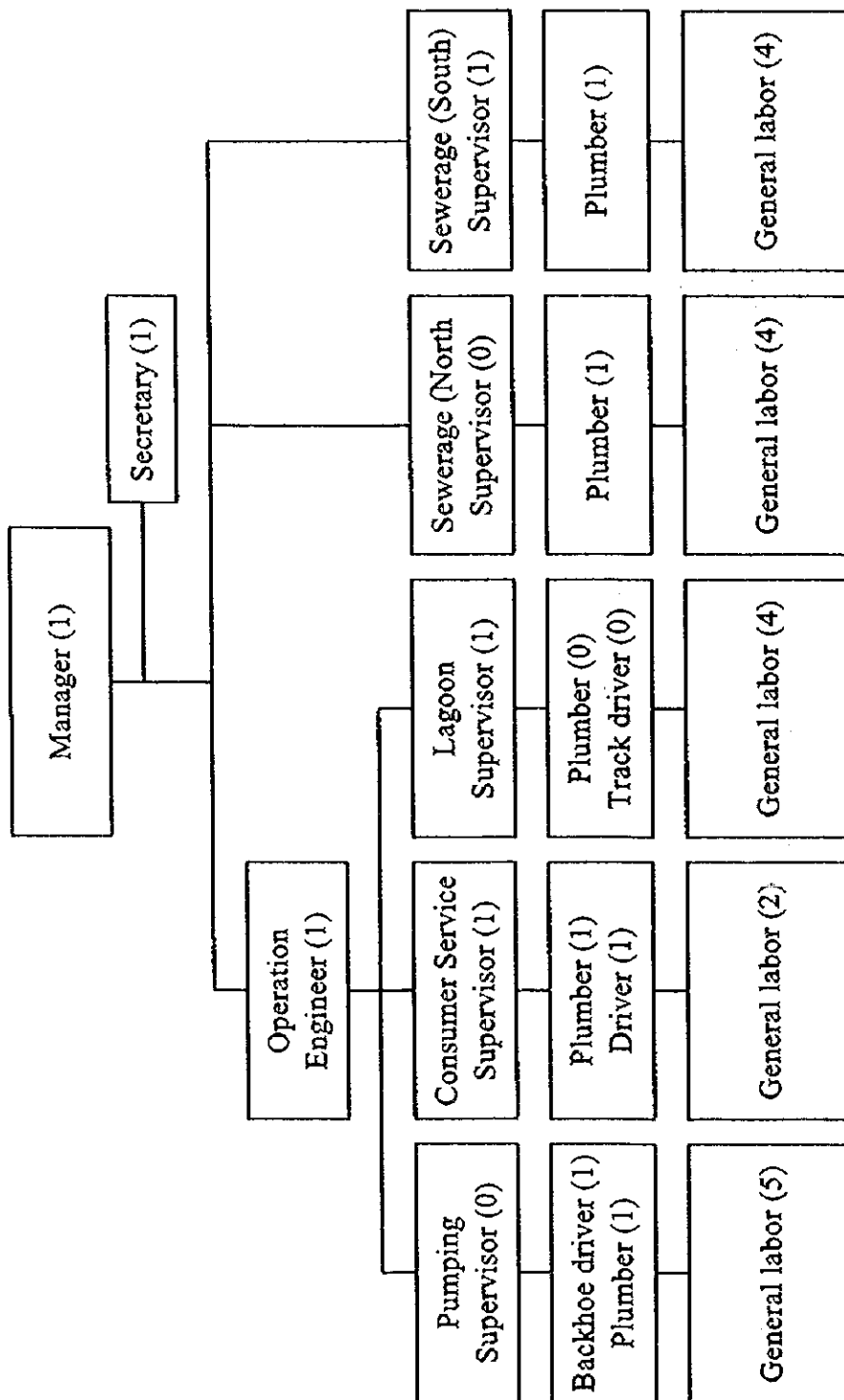


Waigani STP

Scale = 1 : 400

Date May 1998	Title Schematic Diagram for Waigani STP	Fig. 3.3
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUJIDO SEKKEI		

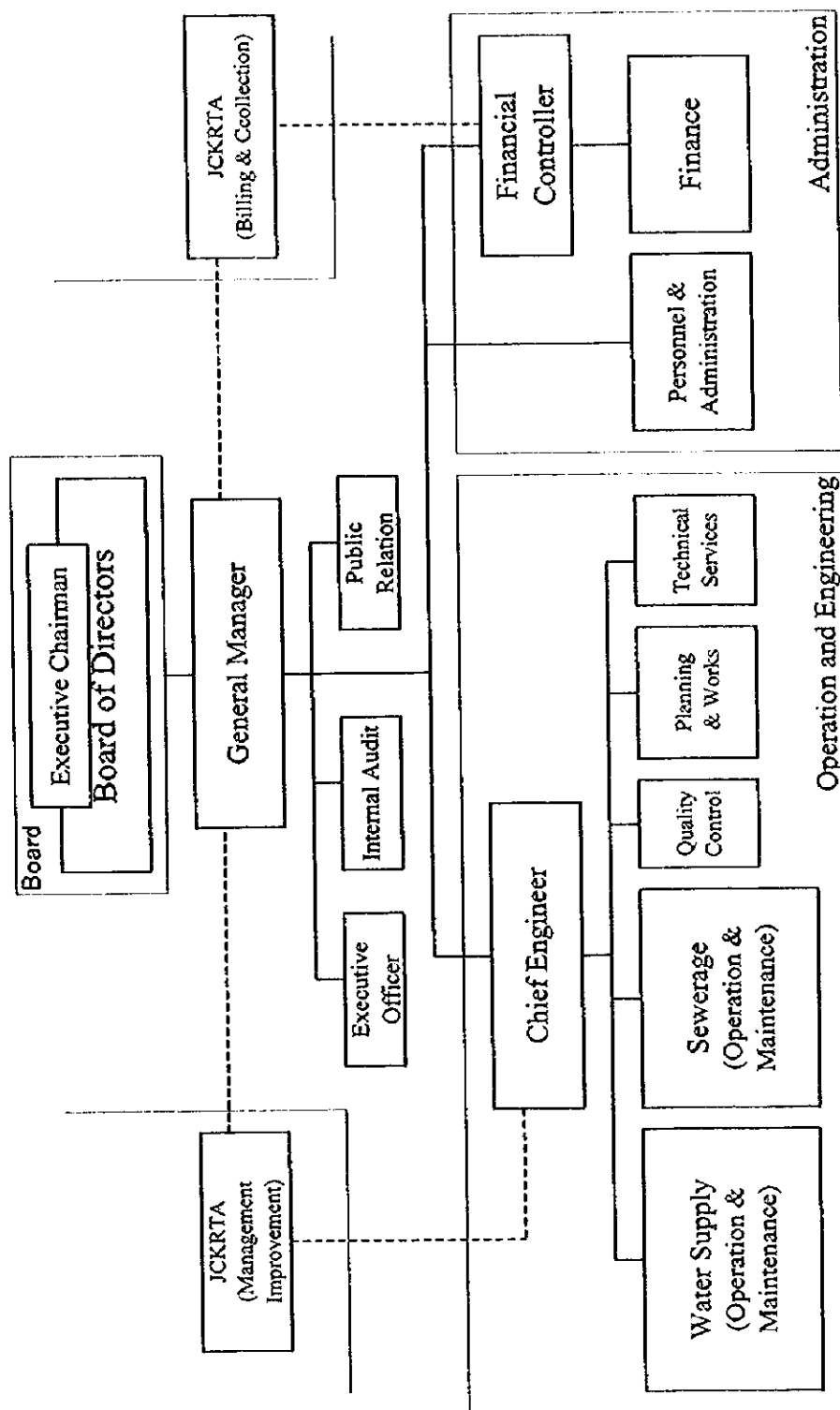




Total staff is 31, as of December 8, 1997

Number in parentheses indicate the number of staff.

Date	Title	Eig.
May 1998	Sewerage Operation Division Organization	3.5
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI		



Number of Employees : 140, as of November 25 '97

Date	Title	Fig.
May 1998	EDA RANU Organization	3.6
THE STUDY ON SEWERAGE SYSTEM OF PORT MORESBY IN PAPUA NEW GUINEA		
TOKYO ENGINEERING CONSULTANTS in association with NIPPON JOGESUIDO SEKKEI		