SUMMARY

SUMMARY - MASTER PLAN AND IMMEDIATE REMEDIAL MEASURES

1. INTRODUCTION

In August, 1992, Japan International Cooperation Agency (JICA) commissioned Tokyo Engineering Consultants in conjunction with Pacific Consultants International, to undertake the study on the Port Moresby Water Supply Development Plan. The study covered "the immediate remedial measures", "the master plan" and "the feasibility study". In addition, basic study on immediate remedial measures was conducted. The study was completed in March, 1994.

2. EXISTING CONDITION

The National Capital District (NCD) area comprises a rocky coastal strip and inland valley areas. The rocky coastal strip is mostly a developed area with brisk economic activities. On the other hand, the inland valley areas are newly developed and show sign of further developments.

Out of the some 200 thousand persons in 1990, approximately 60 thousand live along the coastal strip and the remaining 140 thousand live in the inland area. In the planned areas (where approximately 150 thousand people live) the population density is low. Most houses have large gardens, which makes the water supply system costly in terms of consumption for watering the gardens.

Ground elevations in the residential areas range widely from 0 to 120 m (refer to Fig. S.1) making it difficult to control the water pressure in the system.

Rainfall in NCD is extraordinarily low with an annual average of 1,200 mm (refer to Fig. S.2). With seasonal half-yearly dry spell, garden watering results in remarkably high water consumption.

3. EXISTING WATER SUPPLY FACILITIES

The existing water supply system was commissioned in 1977. Since then no major works have been implemented. The treatment plant has been producing 115 mld water, taking raw water from the Laloki river at the Rouna 1/3 head pond being fed by gravity.

This is supplemented by the Bomana pumping station, also which draws raw water from the Laloki river (refer to Fig. S.3).

The water that is treated at the Mt. Eriama treatment plant is found to be of very high quality throughout the system, that is from the plant down to the consumers. The water is basically distributed by gravity, with the exception of small high-elevation-pumped or boosted areas.

The daily maximum demand is 160 mld, exceeding the produced amount of water by 30 %. As a result, some areas have been suffering from low water pressures (refer to Fig. S.4). Those are mostly areas in the coastal strips and high-elevation areas remote from the Mt.Eriama treatment site.

4. CURRENT MANAGEMENT AND FINANCE

The water supply system is managed by the NCDC: the actual maintenance, operation and development work of the total physical system is being done by the water supply division, and the total financial affairs, from budgeting down to daily transactions, by the financial division. A good understanding of the financial and technical aspects among all staff is essential.

Many problems are observed concerning management of the water supply system. A certain amount of funds will be needed for improvement. Qualified staff must be recruited for management. Training is also required. More sophisticated techniques should be developed to monitor the whole system properly.

Besides these problems, there are other fields needing improvements: increase of meter connections, improvement in maintenance of standpipes, improvement in assets management and record keeping, increased bill collection etc.

The operating profit in 1990 was 5.1 million Kina, 48 % of sales, that went to reserved funds, out of which, though, 2.9 million was receivable. So actual cash flow generated was 2.2 million Kina, out of which, 1.4 million Kina was spent for capital investment, 0.3 million for partial payment of loans, and the rest, 0.5 million, was spent as general accounts.

The ratio of cash income to sales had been gradually going down since 1989, reaching 57 % in 1992. The ratio of administration costs to total expenditure for recent three years has been around 45 %. However, if the cost in the financial department is added, this ratio will surely increase.

5. DESIGN CRITERIA

System Design

The water source, intake facilities and raw water mains shall be able to supply a total volume of raw water equivalent to the total daily maximum demand, plus an allowance for treatment plant and raw water main losses.

The output from the treatment plant shall equal the total daily maximum demand, including an allowance for trunk and distribution system losses while the trunk mains and storage reservoirs shall be able to meet the peak hourly demand.

Population

Population is projected to increase from 195,382 in 1990 to 315,000 in 2000, and 526,000 in 2015 (refer to Fig. S.5). Growth rates projected are 4.88 % (between 1990 and 2000), 3.65 % (between 2000 and 2010) and 3.12 % (beyond 2010),.

Water Demand

Per capita consumption for high cost housing is 380 liters per day while that for both low cost housing and informal sector housing is 300 liters per day. Per capita consumption for non-residential use is 100 liters per day. Leakage ratio is to be reduced from the current 30 % to 20 %. Daily demand factor is 1.3. Peak hourly demand is 1.7.

Based on these figures, the daily maximum demand will increase to 370 mld in 2015 from the current demand of 160 mld, three times the existing supply capacity of 125 mld (refer to Fig. S.6).

6. IMMEDIATE REMEDIAL MEASURES

The chronic water supply shortage problem for Port Moresby is not merely a technical issue. The solution is technically easy and can be approached in two different perspectives: firstly to increase supply and distribution capacity to the demand level, and secondly to decrease the demand at the supply and distribution level. However, the underlying cause of the problem lies more in financial incapability and instability of the executing organization. This has subsequently led to no firm decision over action to be taken to develop and expand the water supply system to meet the present demand.

WATER CONSERVATION

Reduction of demand is the only effective measure for immediate implementation (refer to Fig. S.7).

"Supply side" water conservation measures such as leakage control, pressure control, arresting and penalizing people with illegal connections must be initiated immediately to reduce the demand. These measures will involve considerable manpower and large budget. Further, it should be remembered that "supply side" water conservation measures will require time to become effective, therefore the effect will not be visible immediately.

"Demand side" water conservation measures must be strengthened with the cooperation of mass media. Past experiences show that the effect was immediate, however, it did not last long.

WATER RATIONING PLAN

Water conservation measures must be enforced. However, it is known that the effects are limited. Hence, water rationing is necessary, particularly during the dry season when the demand is high. Rationing has the aim of distributing the limited water supply evenly throughout the NCD area. The introduction of the rationing plan would allow turning off water supply service to one part for a limited period. This amount of water would then be diverted to other areas. Since the NCD water supply system can be easily divided into some six areas, it would be appropriate for water supply to one area to be turned off every one week.

ADDITIONAL TRUNK MAIN

While water rationing is proposed for equitably distributing the water, the capacity of the trunk mains from the 9 Mile to Town area is found to be inadequate. Although adequate water can be made available by transferring the water to Town Area by shutting down one part of the city, the present network does not have the hydraulic capacity. There are two ways to improve the hydraulic efficiency: one is by pumping and the other is by installing an additional pipes.

From the viewpoint of capital investment, pumping would be cheaper. Nevertheless, installation of an additional pipe is proposed here because in the long run, operation and maintenance costs for pumps are normally high. Furthermore, pumping facility will become useless when long-term measures are implemented, based on the master plan.

The alignment proposed is shown in Figs. S.8 to S.9.

7. LONG-TERM PROGRAM

Water Source

The water supply system must meet the demand (370 mld) in the year 2015. The existing system can supply 125 mld so an additional 255 mld is needed.

The source amount from the Laloki river is found to be adequate for the foreseeable period in the master plan.

The downstream Rouna 4 head pond was agreed upon as an additional extraction point in May 1993. The Rouna 4 head pond will necessitate partial pumping for the NCDC water supply system and, will also reduce hydro-power generation for ELCOM.

The extraction point of Bomana, further downstream and which is now supplementing water to the Mt. Eriama treatment plant will be suspended again, and reserved only for *standby* use.

Pressure Zoning

It is time now to introduce pressure zoning system to supply water at appropriate pressures throughout the NCD area thereby reducing leakage. The current system has been constructed to serve all parts of the NCD with one treatment plant. This is the largest asset of the NCD water supply system, however, with one inherent disadvantage; there is unnecessary high pressure in some areas causing high leakage.

The trend for new development has been identified as shifting toward the northeastern parts of the city; that is Waigani, Moitaka and Bomana areas. This trend is favorable to investments for the expansion of the water supply system because new development is in the low-elevation area and near the treatment plant. These areas and Gerehu and Gordons can be supplied from the newly constructed low-elevation 9 mile treatment plant. The existing high-elevation Mt.Eriama treatment plant can be expanded to the degree the site will allow and will supply the remaining high elevation areas (refer to Fig. S.10).

Major Works

Based on the above concept and after comparative studies for the three options, the following works are proposed (refer to Fig. S..11).

1) Mt. Eriama WTP Expansion

a) Location: Mt. Eriama
b) Capacity: 180 mld (44 mld expansion)
c) Treatment Process:
Upward flow settling tank, filter, receiving well and chemical dosing system. At the existing rapid filters (No. 3 to 6), and filter media(sand and gravel) has not been changed for about 20 years. Therefore, the frequency of back washing is high. This problem should be solved by improvements.
d) Clear Water Reservoir:
Since the detention time is about 1 hour for 180 mld, no expansion is planned
e) Intake: Rouna 4 head pond and existing Rouna 1/3 head pond
f) Raw Water Main and Booster Pumping Station: 900 mm branching from the raw water main to the 9 mile water treatment plant by pumping

2) 9 Mile WTP

a) Location: near Jackson Airport
b) Capacity: 200 mld
c) Treatment Process:
Conventional method (horizontal flow sedimentation tank and gravity type filter) is recommended, giving priority to operation and maintenance.
d) Intake: Rouna 4 Head Pond
e) Raw Water Main: 1650 mm (Rouna 4 head pond to branch to Mt. Eriama plant) and 1300 mm (Branch to 9 mile plant) by gravity flow

3) Trunk Mains

34 km (Diameter 400 mm to 1,350 mm : between the treatment plants and the service reservoirs)

4) Service Reservoir

4 reservoirs at Gerehu, Erima, Laloki and 9 mile

5) Distribution System (from the service reservoirs)

334 km (Diameter 100 mm to 800 mm)

8. SYSTEM MANAGEMENT

The following are the fields to be improved;

- Effective meter reading
- Metering of all connections
- Elimination of illegal connections
- Decrease of standpipes
- Strengthening of asset management
- Improvement in bill collection
- Appropriate location of meters
- Promotion of PR activities
- Establishment of Water Committee in NCDC
- Proper record keeping
- Service improvement
- Strengthening of training system
- Development of maintenance plan

9. COST AND IMPLEMENTATION PLAN

Project cost is estimated at 321 million Kina for the facilities and 11 million Kina for management improvements.

Large scale capital works are required immediately since the gap between demand and supply has become larger as a result of inactivity since 1980. Normally, a work schedule is planned for satisfying the demand. The expansion of Mt. Eriama treatment plant and the first stage of the new 9 mile treatment plant are scheduled between 1994 and 1996 for this purpose. In addition, conveyance system and the distribution system are planned. This will cost nearly 223 million Kina in the first three years. Even though supply capacity will increase to 247 mld in 1997 according to this schedule, implementation of this schedule is difficult. After discussions with the NCDC officials, a more feasible schedule has been formulated which is shown in Figs. S.12 and S.13.

In this schedule, the works are first concentrated on the expansion of the Mt. Eriama treatment plant and conveyance system. After the expansion in 1996, construction of the

9 mile treatment plant will start, and complete in 1999. This schedule is recommended from the viewpoint of the magnitude of the work and the cost involved etc..

10. PROJECT EVALUATION

The reserved fund of WS & S of NCDC is nominal, and current assets include debtors only. Income does not cover costs if supporting activities are counted. The cash position of the NCDC is so tight that it always depends on a large overdraft. Internal financing for even a portion of this investment program is, therefore, out of the question at the moment.

The NCDC has to show its willingness to improve the present financial situation before it approaches the government or a foreign donor for grants or long-term loans.

A combination of government grant and aid from a foreign donor may be suitable funding this portion of investment; 20 percent of which may be shared by the federal government.

A summarized consolidated financial statement of the water supply service is given in Table S.1.

Average unit price for the new rate is set at 0.72 Kina. The assumption here is that the average unit price of 28 per cent of the total volume of water used, would be set at 0.24 Kina , the lowest category in the proposed water rate, and 72 per cent would be set at 0.91 Kina, a 40 per cent raise from 0.65 Kina, the average of the middle and the highest categories in the proposed water rate.

The central government must be requested to rescue the NCDC by paying the interest incurred between 1994 and 1996 when there will be no revenue from the new supply system. During 1994 and 1997 a total sum of 1.5 million Kina shall be covered by the NCDC general account for the cost of training. (Another 0.4 million Kina would be paid from the water supply account itself.) The money borrowed from the both sources would be returned later, between 2000 and 2002. After the fourth year cash inflow will continue, and on the 22nd year, the amount of reserved fund will reach 130 per cent of the accumulated depreciation.

The FIRR of the master plan is calculated at 8.65 per cent. This figure is above the socially admitted interest rate prevalent at present with reference to the long term loan for the BHN infrastructure development project. So, the master plan is financially sound, to start with.

TABLE S.1 FINANCIAL STATEMENTS OF WATER SUPPLY ENTERPRISE: M/P

BALANCE SHEET

Unit: Mil. Kinas in 1993 price

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Assets	16.93	58.07	117.87	149.89	171.40	216.58	219.13	221.92	229.17	231.73	247.55	262.21	265.67	268.38	271.09	283.59	294.57	302.94	307.58	312.22	316.85	321.36
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.55	5.73	5.79	6.19	6.56	6.64	6.71	6.78	7.09	7.36	7.57	7.69	7.81	7.92	8.03
(-)Accum.Depreciation	0.42	1.88	4.82	8.57	12.85	18.27	23.75	29.29	35.02	40.82	47.01	53.56	60.20	66.91	73.69	80.78	88.14	95.72	103.41	111.21	119.13	127.17
Assets: net	16.51	56.20	113.05	141.32	158.55	198.31	195.38	192.63	194.15	190.91	200.54	208.65	205.47	201.47	197.40	202.81	206.43	207.22	204.17	201.01	197.72	194.19
Current Assets	0.00	0.00	0.02	1.02	1.15	0.35	3.42	7.76	11.92	20.89	30.07	36.85	39.05	45.11	51.94	56.48	60.91	63.64	72.61	82.22	91.27	99.85
TOTAL ASSETS	16.51	56.20	113.07	142.34	159.69	198.67	198.81	200.39	206.06	211.80	230.62	245.49	244.52	246.58	249.34	259.29	267.34	270.86	276.79	283.23	288.99	294.04
Long Term Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Loan:Cumulative	16.93	58.07	117.87	149.89	171.40	216.58	219.13	221.92	229.17	231.73	246.70	258.46	256.03	251.24	245.38	247.05	247.08	244.35	237.53	230.59	222.84	214.24
[(-)Amortization:5%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	2.90	5.89	7.49	8.57	10.83	10.96	11.10	11.46	11.59	12.38	13.11
Reserved Fund	-0.42	-1.87	-4.80	-7.55	-11.71	-17.91	-20.32	-21.53	-23.11	-19.93	-16.09	-12.97	-11.51	-4.67	3.96	12.24	20.26	26.51	39.26	52.64	66.15	79.80
TOTAL LIABIL.&CAPITAL	16.51	56.20	113.07	142.34	159.69	198.67	198.81	200.39	206.06	211.80	230.62	245.49	244.52	246.58	249.34	259.29	267.34	270.86	276.79	283.23	288.99	294.04

INCOME AND EXPENDITURE STATEMENT

Income of Water	0.00	0.00	0.01	6.58	6.88	7.19	15.30	17.46	19.08	20.69	21.85	21.81	21.84	27.16	28.85	28.86	28.88	28.91	35.33	35.91	35.93	35.95
From NCDC	0.40	0.40	0.40	0.30	0.00	0.00	-0.40	-0.40	-0.40	-0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gov.Contribution	0.46	1.57	3.18	0.00	0.00	0.00	-0.46	-1.57	-3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Income	0.86	1.97	3.60	6.88	6.88	7.19	14.44	15.49	15.50	20.39	21.85	21.81	21.84	27.16	28.85	28.86	28.88	28.91	35.33	35.91	35.93	35.95
O/M Costs	0.40	0.40	0.40	1.83	2.13	2.13	5.46	5.16	5.16	5.16	5.16	5.16	6.82	6.82	6.82	6.82	6.82	8.49	8.49	8.49	8.49	8.49
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.55	5.73	5.79	6.19	6.56	6.64	6.71	6.78	7.09	7.36	7.57	7.69	7.81	7.92	8.03
Interest Payment:2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.99	6.19	6.26	6.66	6.98	6.91	6.78	6.63	6.67	6.67	6.60	6.41	6.23	6.02	5.78
Expenditure	1.28	3.42	6.53	9.62	11.04	13.39	16.85	16.70	17.07	17.21	18.01	18.69	20.38	20.31	20.22	20.58	20.86	22.66	22.59	22.52	22.42	22.30
BALANCE	-0.42	-1.45	-2.93	-2.74	-4.16	-6.21	-2.41	-1.21	-1.58	3.18	3.84	3.12	1.46	6.84	8.63	8.28	8.03	6.25	12.74	13.39	13.51	13.65

CASH FLOW

Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Income	0.00	0.00	0.01	6.58	6.88	7.19	15.30	17.46	19.08	20.69	21.85	21.81	21.84	27.16	28.85	28.86	28.88	28.91	35.33	35.91	35.93	35.95
Gov.Contribution+NCDC	0.86	1.97	3.58	0.30	0.00	0.00	-0.86	-1.97	-3.58	-0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Inflow	17.79	43.11	63.40	38.90	28.39	52.37	16.99	18.28	22.75	22.95	37.67	36.47	25.30	29.87	31.56	41.36	39.86	37.28	39.97	40.55	40.56	40.46
Investment	16.93	41.14	59.80	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
O/M Costs	0.40	0.40	0.40	1.83	2.13	2.13	5.46	5.16	5.16	5.16	5.16	5.16	6.82	6.82	6.82	6.82	6.82	8.49	8.49	8.49	8.49	8.49
Amortization: 5%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	2.90	5.89	7.49	8.57	10.83	10.96	11.10	11.46	11.59	12.38	13.11
Interest Payment:2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.99	6.19	6.26	6.66	6.98	6.91	6.78	6.63	6.67	6.67	6.60	6.41	6.23	6.02	5.78
Total Outflow	17.79	43.11	63.38	37.90	28.27	53.16	13.92	13.94	18.60	13.97	28.49	29.70	23.09	23.81	24.73	36.82	35.43	34.55	31.00	30.94	31.51	31.89
Net Cash Inflow	0.00	0.00	0.01	1.01	0.12	-0.79	3.07	4.34	4.15	8.98	9.18	6.77	2.21	6.06	6.83	4.54	4.43	2.73	8.97	9.61	9.05	8.57
Cash Balance	0.00	0.00	0.02	1.02	1.15	0.35	3.42	7.76	11.92	20.89	30.07	36.85	39.05	45.11	51.94	56.48	60.91	63.64	72.61	82.22	91.27	99.85

SUMMARY - FEASIBILITY STUDY

1 INTRODUCTION

As a result of a study of the master plan, the framework of the feasibility study was finalized as follows:

Target Year	:	2000
Projected Population in the year 2000	:	314,300
Proposed Water Production in the year 2000	:	280,000 m^3/day (including the existing 136,000 m^3/day capacity)
Proposed Works	:	1) Intake Facilities at Rouna 4 Head Pond 2) Raw Water Mains to Mt. Eriama and 9 Mile WTP 3) Mt. Eriama Pumping Station 4) Expansion (44,000 m^3/day) of the Mt. Eriama WTP 5) New 9 Mile WTP (100,000 m^3/day) 6) Related Transmission and Distribution lines 7) Erima Service Reservoir

2 ENGINEERING DESIGN

The following facilities are fully considered and designed in the feasibility study.

1) Rouna 4 intake :	New intake facilities at Rouna 4 head pond, of which land is owned by ELCOM. Design intake amount is 293,400 m^3/day. (380,000 X 1.03 - 98,000 = 293,400 m^3/day)
2) Raw Water Main :	From Rouna 4 to Mt. Eriama water treatment plant and 9 Mile water treatment plant. Design Capacity is 293,400 m^3/day. (Alternative A in Fig. S.14)
3) Mt. Eriama Pumping Station:	Boost the water from raw water main to Mt. Eriama water treatment plant. Design capacity is 87,400 m^3/day. (Fig. S.15)

4) Mt. Eriama water treatment plant :Design total capacity is 180,000 m^3/day.
An expansion of 44,000 m^3/day is proposed.
(Fig. S.16)

5) 9 Mile water treatment plant : New Water Treatment Plant near 9 Mile.
Design capacity is 100,000 m^3/day. (another 100,000 m^3/day plant is proposed under the master plan)
(Fig. S.17)

6) Erima Reservoir : New reservoir in Erima district.
Design capacity is 13,000 m^3.
(location is shown in Fig. S.18)

7) Transmission & Distribution Pipes : New or replacing lines related to the proposed facilities.
(Figs. S.18 and S.19)

Land issue in PNG is one of the major hindrances to the development. Therefore, government-owned land (9 mile and Mt. Eriama water treatment plants, Mt. Eriama pumping station, Erima reservoir) or road easements (raw water main, transmission lines) were chosen for the proposed facilities.

Table S.2 summarizes the outlines of proposed facilities under the scope of the feasibility study'.

Table S.2 SUMMARY OF PROPOSED FACILITIES

Facility	Type	Detention Time	Specifications
Intake			(Capacity 293,400 m^3/day)
Intake Weir	Partially Movable		W 5.5mxL 1.0mxH 1.0m
Intake Mouth			W 6.0mxL 14.0mxH 7.0m
Raw Water Main			(Capacity 293,400 m^3/day)
Pipe	Mild Steel with cement lining		1600 mm L=11.2 km 1350 mm L= 4.6km 900 mm L= 2.0 km (Total L=17.8 km)
Pumping Station			(Capacity 87,400 m^3/day)
Pump	Horizontal Axis Double Suction Volute Pump		Discharge Volume 20.2 m^3/min Head 50 m Electromotor 280 kW No. of Pumps 4 (1 standby)
Building			W 18.0 m x L 30.0 m S=1 A=540m^2
Mt. Eriama water treatment plant			(capacity 44,000 m^3/day)
Receiving Well		1.5 min.	D 7.0m x H 5.0m V= 192 m^3
Circular Clarifier	Clarifier	40 mm/min.	D 41.2m x H 6.4m A=1160 m^3
Filter basin	Pressure	194 m/day	W 3.82m x L 3.82m 12 cells/basin 2basins A=350m^2
Drainage System	Lagoon		W 12.5m x L 80.0m 4 basins A=4000m^2
Chemical Dosing Equipment	Alum, Lime, Chlorine		
Electrical Equipment			
Administrative Building			W10.0m x L20.0m S=2 A=400m^2
9 Mile water treatment plant			(capacity 100,000 m^3/day)
Receiving Well		1.5 min.	W4.5mx L6.0m x H4.0m 2 basins V=216 m^3
Rapid Mixing Chamber	Flush Mixer	2 min.	W4.0mx L4.0m x H5.0m 2 basins V=160 m^3
Flocculation Basin	Baffling	20 min.	W1.15mxL153.0mxH4.0m 2 basins V=1410m^3
Sedimentation Basin	Conventional horizontal Flow	30 mm/min.	W25.3mxL46.0m xH4.0m 2 basins A=2330m^2
Filter Basin	Gravity, Backwashing-tank	150 m/day	W 9.6m x L 10.0m 8 basins A=768m^2
Chlorination Chamber	Baffling	5 min.	W1.65m x L42.2mxH2.6m 2 basins V=362m^3
Clear Water Reservoir		1 hrs (6 hrs)	W20.0mxL50.0mxH6.0m 2 basins V=12000m^3
Drainage System	Lagoon		W12.5m x L80.0m 5 basins A=5000m^2
Chemical Dosing Equipment	Alum,Lime,Chlorine		W12.0xL25.0m S=3 A=900m^2
Administrative Building			W30.0mxL40.0m S=2 A=2400m^2
Transmission Pipes	Mild Steel Pipe (D>700mm) Ductile Cast Iron Pipe (D<600mm)		500 mm to 1350 mm, L=32 km
Distribution Pipes	Mild Steel Pipe (D>700mm) Ductile Cast Iron Pipe (D<600mm)		100 mm to 800 mm, L= 98 km
Erima Reservoir		6 hrs	D 46.0m x h 8.0m V=13000 m^3

3 MANAGEMENT

The administrative system of NCDC was reorganized; the previously heavily loaded Finance/Adm Dep. was divided into three Departments. NCDC now has five departments; Administration, Personnel, Finance, Health/Social Services and Engineering. This will increase the efficiency of the new management. Nevertheless, the existing and new management for water supply is too widely separated to work as a united body.

The Water Supply division of the Engineering Department responsible only for operation and maintenance of the water supply system. But it is important for the O/M manager of the Water Supply division to understand the financial and planning/design aspects, such as metering and connection matters for routine maintenance. On the other hand, the financial and planning/design managers should understand the daily on-going operations. The present system cannot guarantee two-way communications for improvement. They would certainly need the feed-back from the other side. This is essential for efficient management of water supply. It is also true that it will take some time to achieve this goal. But the organization set-up is a step along the right direction.

The JICA study team suggests that a commonly encountered water supply organization is balanced with respect to the following functions.

(1) Administration and finance,
(2) Engineering (planning and construction)
(3) Operation and maintenance

The more the service area/population is expanded, the more is the staff required. The ratio of staff to service population is also largely dependent upon the qualification and efficiency of the staff. The staffing ratio is rather experimental. Based on the figures obtained by experience from many countries, the staffing ratio to service connection is roughly in the range of 100 to 200.

The existing connections of NCDC are about 19,000, of which about 75% are metered. The total operating staff for water supply and sewage is 235, not necessarily filled. A rough calculation indicates that one staff member in water supply is responsible for a little over 100 connections.
The staff requirement in the year 2000 will be about 300, proportional to the increase in connections. This number is based on the fact that all the staff in the administration, finance, planning, construction is included in the Water Supply division.

The total number of employees of NCDC is presently a little over 1,000. This figure will also increase, as the population of the city increases. Assuming an annual increase of 4%, the total number of employees in 2000 will be about 1,500. This means that the percentage of water supply staff will be 20% of the total staff in 2000, which is almost the same as the present figure.

4 OPERATION AND MAINTENANCE

Certain improvements for operation and maintenance will be required. They are:

- Metering of all connections
- Leakage Prevention
- Mapping
- Tariff study
- Asset registration
- Bill collection

5 COST AND IMPLEMENTATION SCHEDULE

The total project cost for the feasibility study is approximately 219 million Kina, of which foreign and local currency portions are 198 million Kina (90 %) and 21 million kina (10 %) respectively, as shown in Table S.3 (Local currency is used mostly to cover local labor cost).

Table S.3 PROJECT COST

Unit: million Kina

Classification and Work Item	F.C	L.C	Total
1. Intake Facility	1.68	0.18	1.86
2. Raw Water Main	29.24	3.14	32.38
3. Pumping Station	3.05	0.27	3.32
4. Mt. Eriama Expansion	25.05	2.82	27.87
5. Nine Mile WTP	57.07	6.44	63.51
6. Transmission Pipe	28.22	3.02	31.24
7. Distribution Pipe			
1) Mt. Eriama System	8.29	1.13	9.42
2) 9 Mile System	11.18	1.52	12.70
8. Reservoir	4.63	0.57	5.20
9. Sub Total	168.41	19.09	187.50
10. Physical Contingency	8.42	0.95	9.38
11. Engineering Fee	20.83	1.42	22.25
12. Total Project Cost	197.66	21.47	219.13

In general, a capital investment of about 200 million Kina for this kind of project is relatively high. This has mainly resulted from the fact that there has been no major investments for water supply system for a long time, despite the rapid expansion of the NCD. It is also noted that the portion of this capital cost (feasibility study) is about 70 % of the total project cost (master plan), indicating importance of feasibility study in the implementation of the project.

The scope of the feasibility study includes two main construction works, viz., expansion of Mt. Eriama WTP and construction of new 9 Mile WTP. The first stage is up to 1996 (completion of expansion works), and the second stage is from 1997 to 2000. Table S.4 shows the staging cost. The implementation schedule for the project is shown in Fig. S.20 while Table S.5 shows the schedule for transmission and distribution pipes.

Table S.4 COST ESTIMATION BY YEAR

	1994	1995	1996	1997	1998	1999	2000
Cost (million Kina)	16.93	41.14	59.80	32.02	21.51	45.18	2.55
Capacity (mld) (A)	125	125	125	180	180	180	280
Demand (Daily Max.)(B)	192	201	205	209	213	217	221
Balance (A - B)	-67	-76	-80	-29	-33	-37	+59

Table S. 5 TRANSMISSION AND DISTRIBUTION PIPES BY LENGTH

Unit: m

Item	Total Length	Pipe Length by year						
		1994	1995	1996	1997	1998	1999	2000
Transmission lines (500 mm to 1350 mm)								
Mt.Eriama System (High Zone)	21160	5135	5135	5130	1920	1920	1920	0
9 Mile System (Low Zone)	11113	1854	1854	1852	1781	1781	1778	213
Total	32273	6989	6989	6982	3701	3701	3698	213
Distribution Pipes (100 mm to 800 mm)								
Mt.Eriama System (High Zone)								
Urban Area (Improvement)	25,679	6,460	6,460	6,460	2,047	2,047	2,046	159
Development area (New)	15,959	2,503	2,502	2,191	2,191	2,191	2,191	2,190
Subtotal	41,638	8,963	8,962	8,651	4,238	4,238	4,237	2,349
Nine (9) Mile System (Low Zone)								
Urban Area (Improvement)	12,525	0	0	0	4,130	4,130	4,130	135
Development area (New)	43,388	4,681	4,680	6,525	6,525	6,525	6,525	7,927
Subtotal	55,913	4,681	4,680	6,525	10,655	10,655	10,655	8,062
Total	97,551	13,644	13,642	15,176	14,893	14,893	14,892	10,411
Grand -total	129,824	20,633	20,631	22,158	18,594	18,594	18,590	10,624

6 PROJECT APPRAISAL

Financial statements for the F/S is given in Table S.6. The flows are given up to 2015. Investments in the first phase will end in 2000, consequently the volume of gross production would stop at the level of 2006.

The project life is set as 37 years, i.e., 30 years after the completion of the first phase. With the above mentioned assumptions, the FIRR of the project is calculated as 7.37 per cent while the EIRR of the project is calculated as 5.73 per cent.

The FIRR of the project in phase one is a little less than that of the master plan. This implies that the initial investment is meant for total expansion of the system. The first phase is a part of the master plan, and the second phase will reap the extra benefits of this investment to conclude the system.

The value of the EIRR of phase one works may indicate that its implementation is viable within the context of national economy, besides the fact that the project is indispensable for the development of the capital district.

TABLE S.6 FINANCIAL STATEMENTS OF WATER SUPPLY ENTERPRISE: F/S

Unit: Million Kinas in 1993 price

BALANCE SHEET

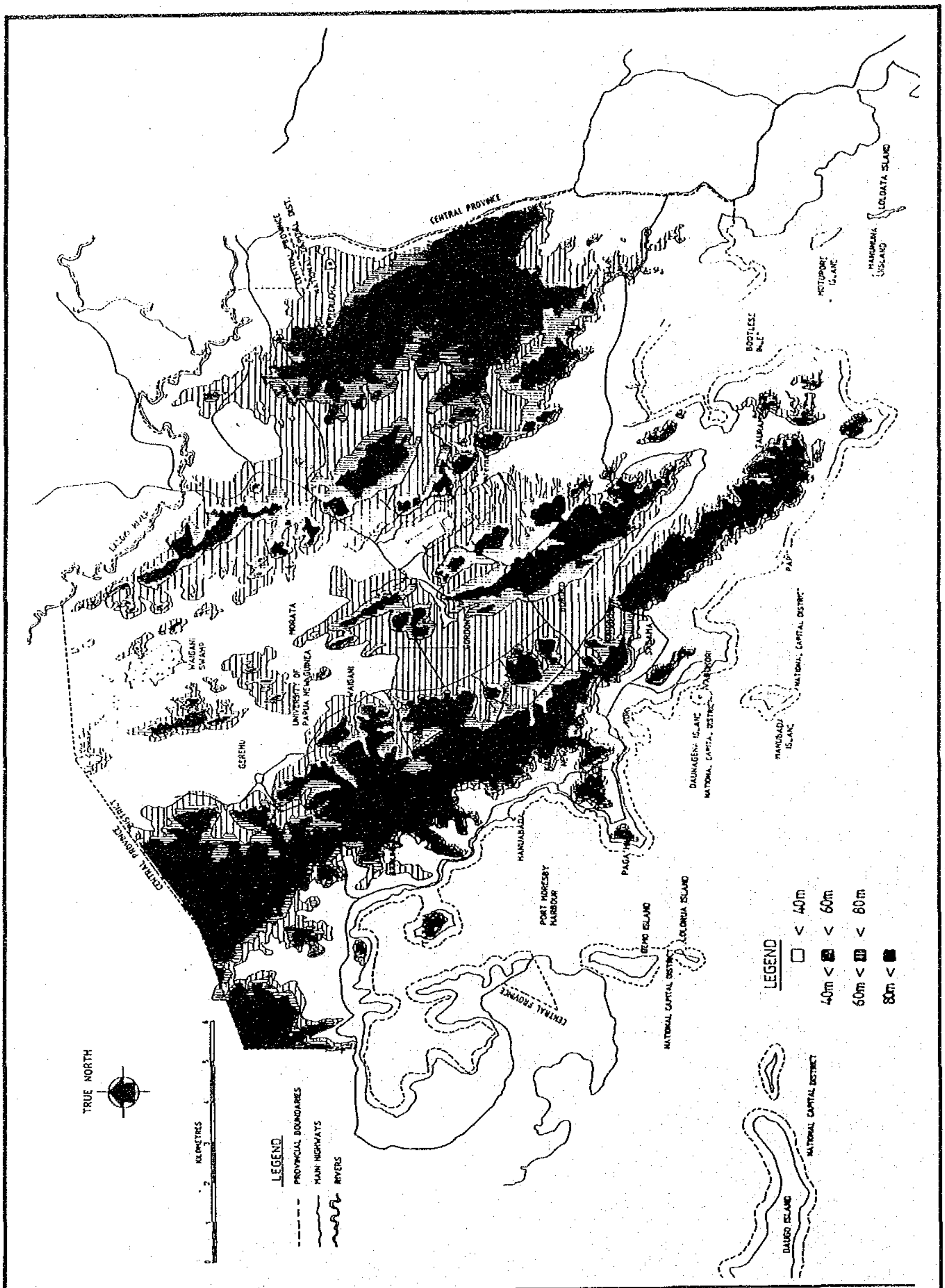
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Assets	16.93	58.07	117.87	149.89	171.40	216.58	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13	219.13
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
(-)Accum.Depreciation	0.42	1.88	4.82	8.57	12.85	18.27	23.75	29.23	34.70	40.18	45.66	51.14	56.62	62.09	67.57	73.05	78.53	84.01	89.49	94.96	100.44	105.92
Assets: net	16.51	56.20	113.05	141.32	158.55	198.31	195.38	189.91	184.43	178.95	173.47	167.99	162.51	157.04	151.56	146.08	140.60	135.12	129.64	124.17	118.69	113.21
Current Assets	0.00	0.00	0.02	1.02	1.15	0.35	3.43	7.85	12.26	21.58	31.53	39.46	44.59	48.35	51.34	52.33	53.52	55.02	56.91	59.05	61.52	64.30
TOTAL ASSETS	16.51	56.20	113.07	142.34	159.69	198.67	198.81	197.75	196.69	200.53	205.00	207.46	207.11	205.38	202.90	198.41	194.12	190.15	186.55	183.22	180.21	177.51
Long Term Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Loan:Cumulative	16.93	58.07	117.87	149.89	171.40	216.58	219.13	219.13	219.13	219.13	218.28	215.38	209.49	201.99	193.42	182.59	171.64	160.68	149.72	138.77	127.81	116.85
[(-)Amortization:5%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	2.90	5.89	7.49	8.57	10.83	10.96	10.96	10.96	10.96	10.96	10.96
Reserved Fund	-0.42	-1.87	-4.80	-7.55	-11.71	-17.91	-20.32	-21.38	-22.44	-18.60	-13.28	-7.92	-2.38	3.39	9.48	15.82	22.48	29.47	36.83	44.45	52.40	60.66
TOTAL LIABIL.&CAPITAL	16.51	56.20	113.07	142.34	159.69	198.67	198.81	197.75	196.69	200.53	205.00	207.46	207.11	205.38	202.90	198.41	194.12	190.15	186.55	183.22	180.21	177.51

INCOME AND EXPENDITURE STATEMENT

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Income of Water	0.00	0.00	0.01	6.58	6.88	7.19	15.30	17.46	19.08	20.69	21.85	21.81	21.84	21.86	21.94	21.91	21.93	21.96	22.04	22.01	22.03	22.05
From NCDC	0.40	0.40	0.40	0.30	0.00	0.00	-0.40	-0.40	-0.40	-0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gov.Contribution	0.46	1.57	3.18	0.00	0.00	0.00	-0.46	-1.57	-3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Income	0.86	1.97	3.60	6.88	6.88	7.19	14.45	15.49	15.49	20.39	21.85	21.81	21.84	21.86	21.94	21.91	21.93	21.96	22.04	22.01	22.03	22.05
O/M Costs	0.40	0.40	0.40	1.83	2.13	2.13	5.46	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16
Depreciation	0.42	1.45	2.95	3.75	4.29	5.41	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
Interest Payment:2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.92	5.92	5.92	5.89	5.82	5.66	5.45	5.22	4.93	4.63	4.34	4.04	3.75	3.45	3.16
Expenditure	1.28	3.42	6.53	9.62	11.04	13.39	16.85	16.55	16.55	16.55	16.53	16.45	16.29	16.09	15.86	15.57	15.27	14.97	14.68	14.38	14.09	13.79
BALANCE	-0.42	-1.45	-2.93	-2.74	-4.16	-6.21	-2.41	-1.06	-1.06	3.84	5.32	5.36	5.54	5.77	6.09	6.34	6.66	6.98	7.36	7.62	7.94	8.26

CASH FLOW

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Loan	16.93	41.14	59.80	32.02	21.51	45.18	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Income	0.00	0.00	0.01	6.58	6.88	7.19	15.30	17.46	19.08	20.69	21.85	21.81	21.84	21.86	21.94	21.91	21.93	21.96	22.04	22.01	22.03	22.05
Gov.Contribution+NCDC	0.86	1.97	3.58	0.30	0.00	0.00	-0.86	-1.97	-3.58	-0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Inflow	17.79	43.11	63.40	38.90	28.39	52.37	17.00	15.49	15.49	20.39	21.85	21.81	21.84	21.86	21.94	21.91	21.93	21.96	22.04	22.01	22.03	22.05
Investment	16.93	41.14	59.80	32.02	21.51	45.18	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O/M Costs	0.40	0.40	0.40	1.83	2.13	2.13	5.46	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16	5.16
Amortization: 5%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	2.90	5.89	7.49	8.57	10.83	10.96	10.96	10.96	10.96	10.96	10.96
Interest Payment:2.7%	0.46	1.57	3.18	4.05	4.63	5.85	5.92	5.92	5.92	5.92	5.89	5.82	5.66	5.45	5.22	4.93	4.63	4.34	4.04	3.75	3.45	3.16
Total Outflow	17.79	43.11	63.38	37.90	28.27	53.16	13.92	11.07	11.07	11.07	11.90	13.88	16.71	18.11	18.95	20.92	20.75	20.45	20.16	19.86	19.57	19.27
Net Cash Inflow	0.00	0.00	0.01	1.01	0.12	-0.79	3.07	4.42	4.42	9.32	9.95	7.93	5.13	3.75	2.99	0.99	1.18	1.50	1.89	2.15	2.47	2.79
Cash Balance	0.00	0.00	0.02	1.02	1.15	0.35	3.43	7.85	12.26	21.58	31.53	39.46	44.59	48.35	51.34	52.33	53.52	55.02	56.91	59.05	61.52	64.30



TITLE

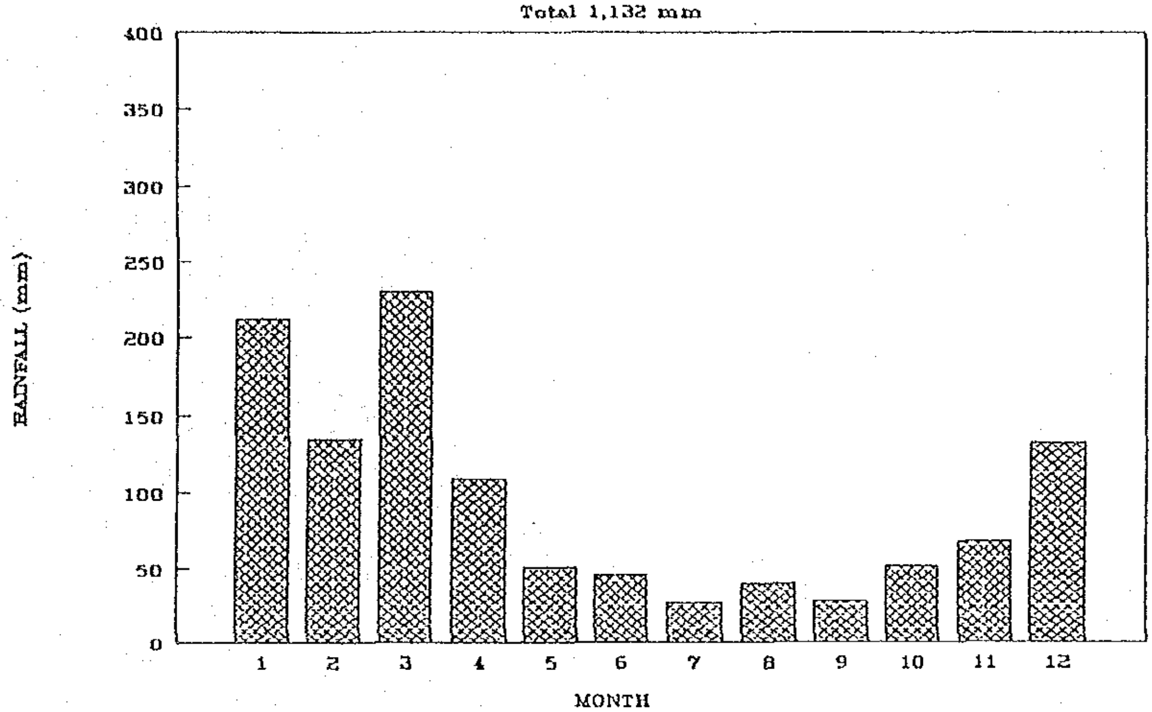
ELEVATIONS IN PORT MORESBY

Fig. No.
S.1

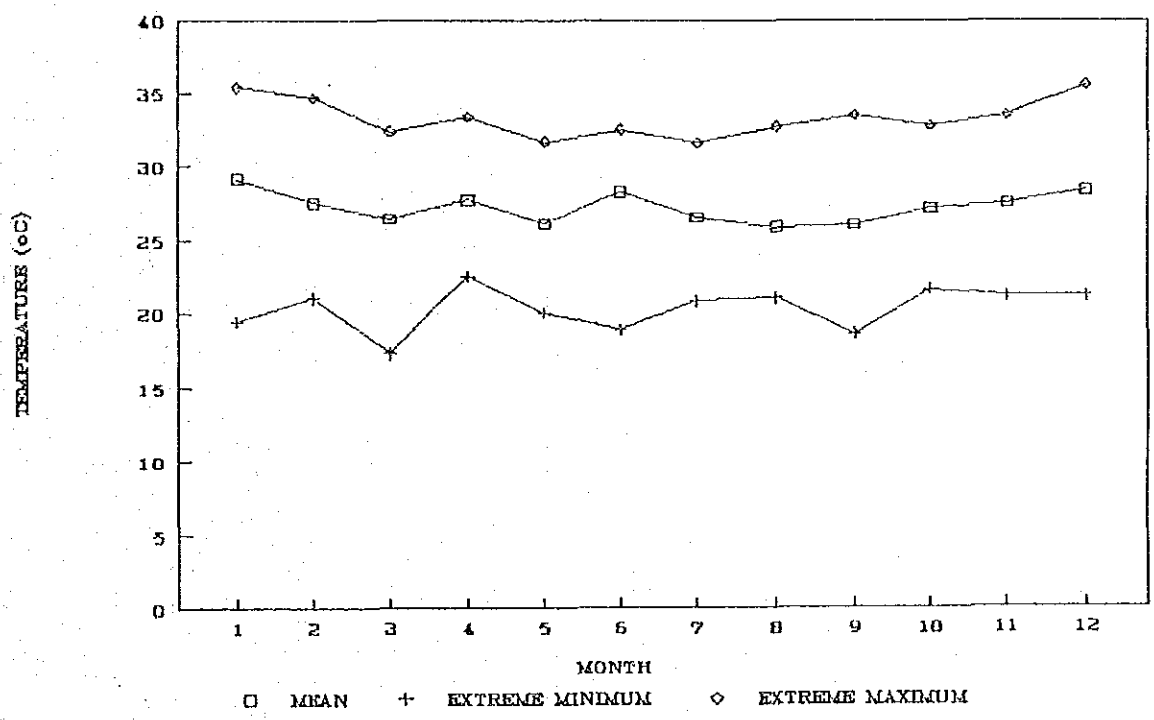
PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

RAINFALL IN PORT MORESBY (1980 – 1991)



TEMPERATURE IN PORT MORESBY (1991)



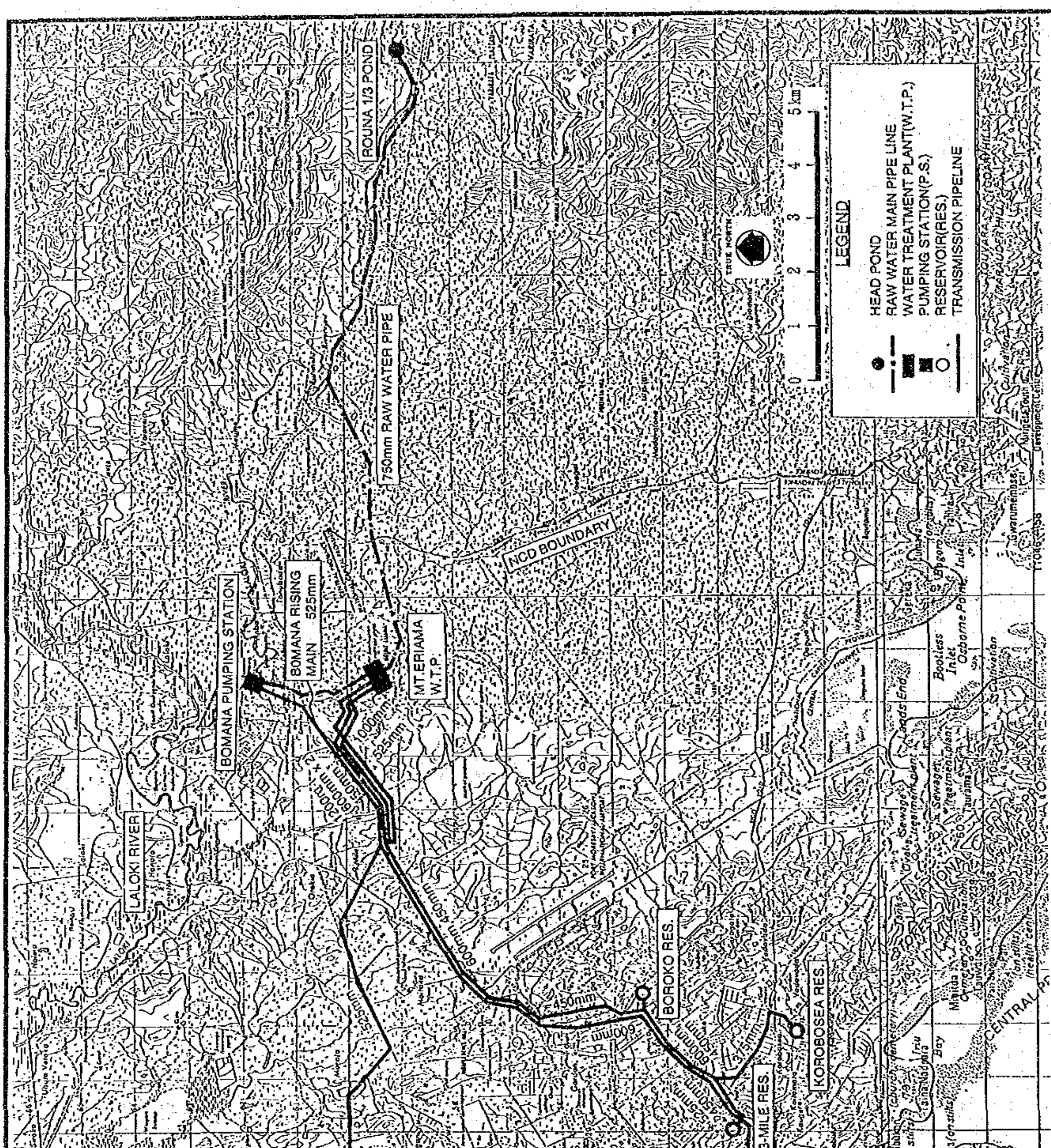
TITLE

SEASONAL VARIATION IN RAINFALL AND TEMPRERATURE

Fig. No. **S.2**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

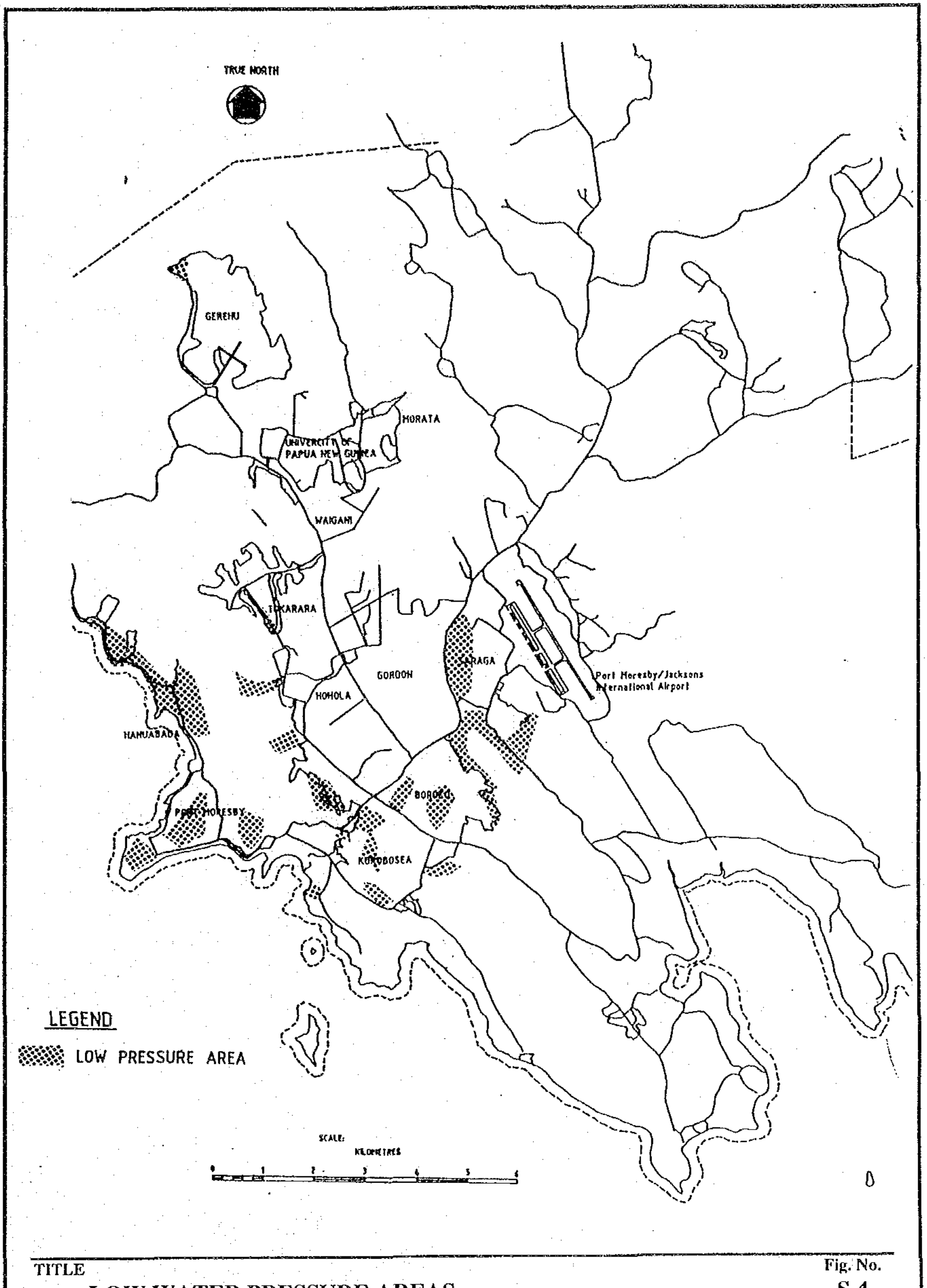
Fig. No.

TRUNK MAIN SYSTEM

S.3

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

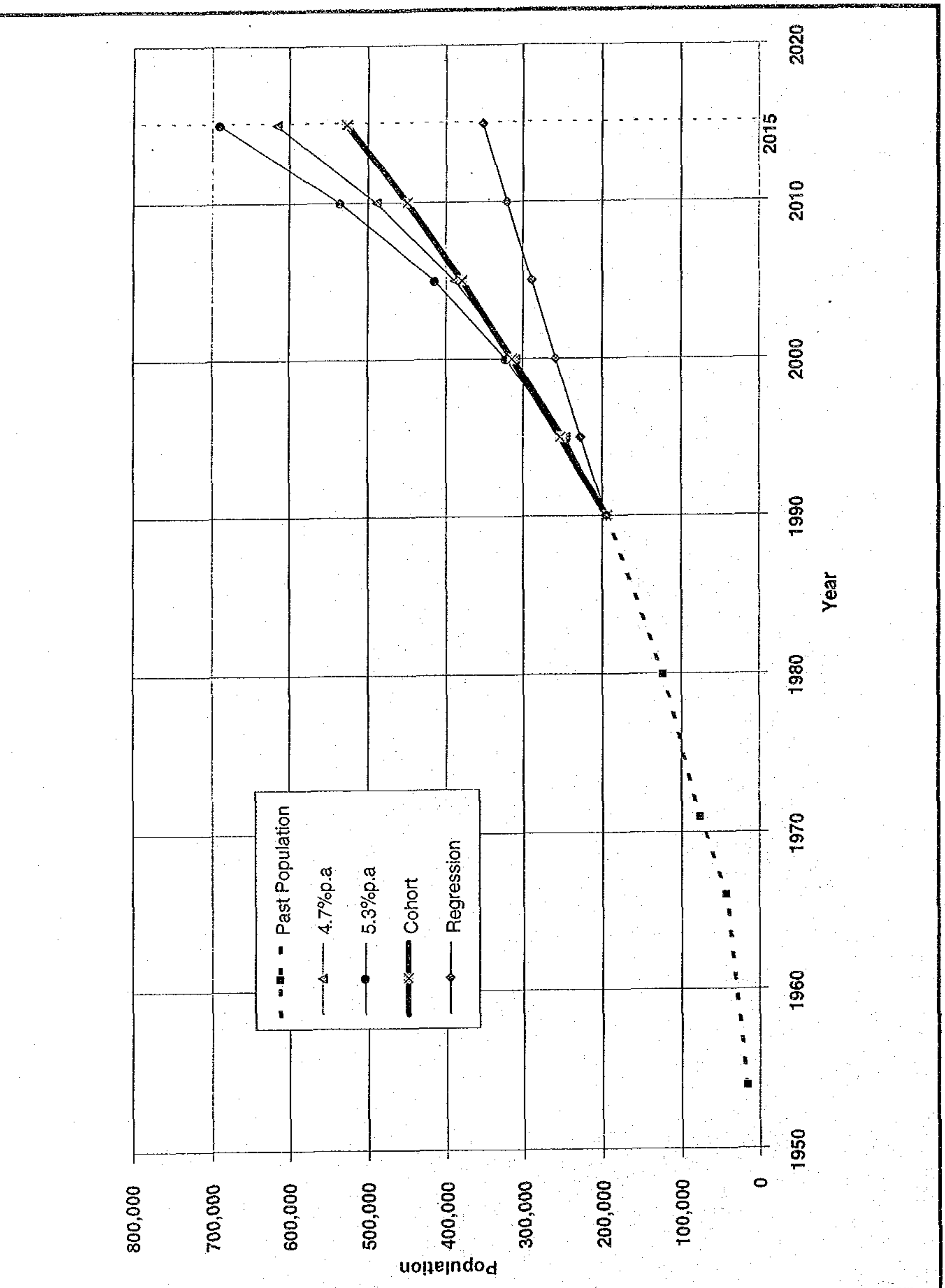
LOW WATER PRESSURE AREAS

Fig. No.

S.4

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



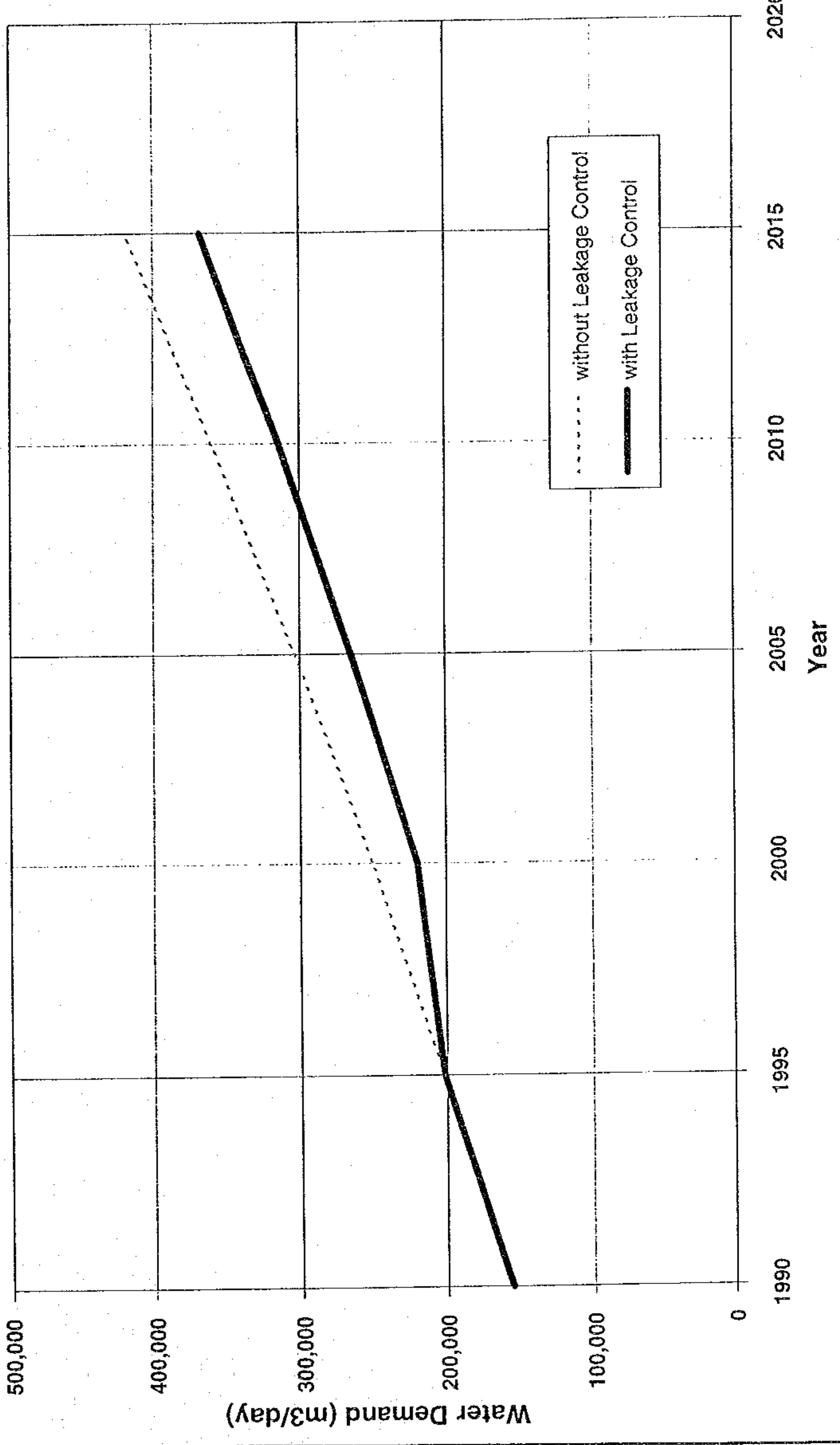
TITLE

POPULATION ESTIMATION

Fig. No.
S.5

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

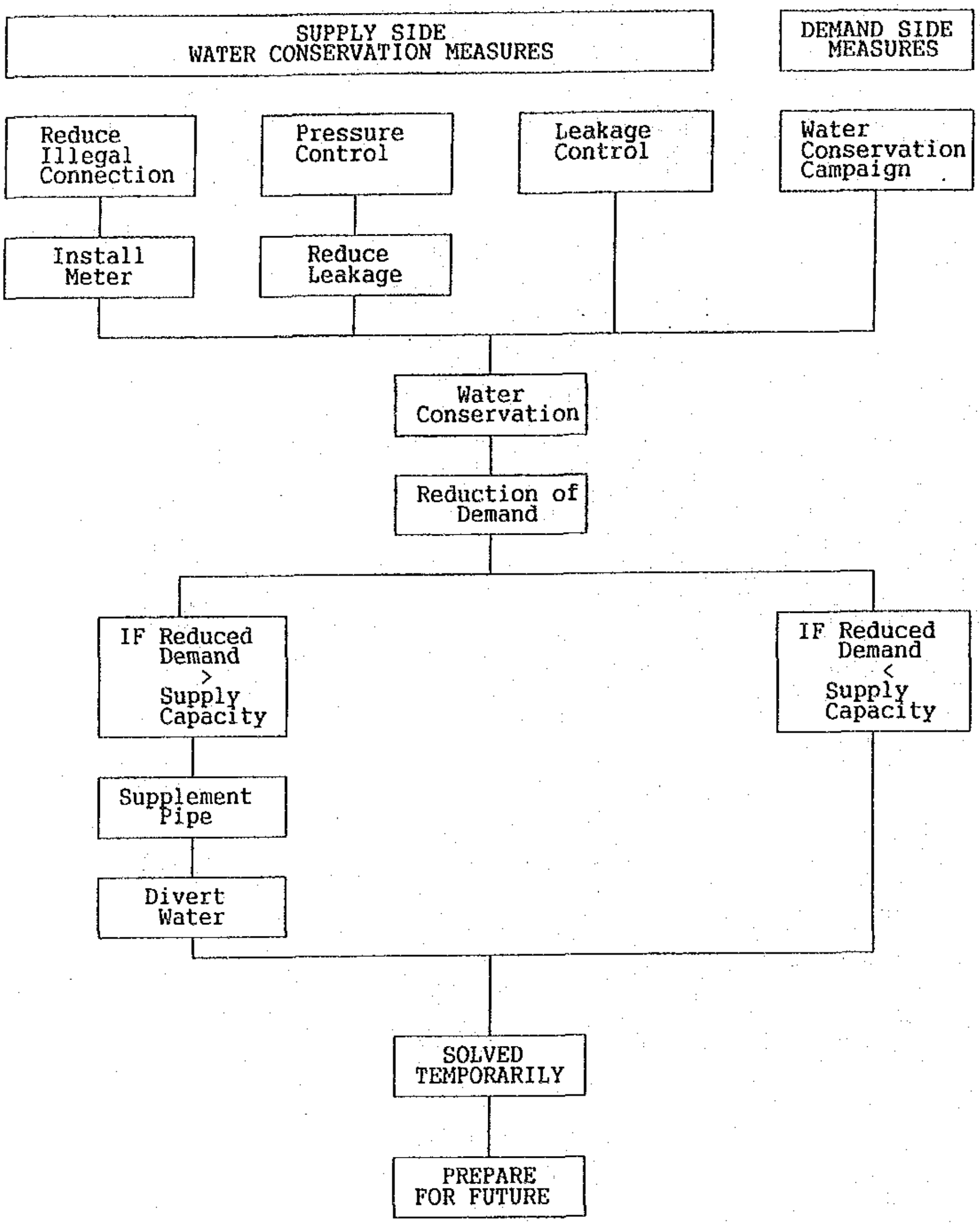
Fig. No.

WATER DEMAND ESTIMATION(DAILY MAX)

S.6

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CÓNSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



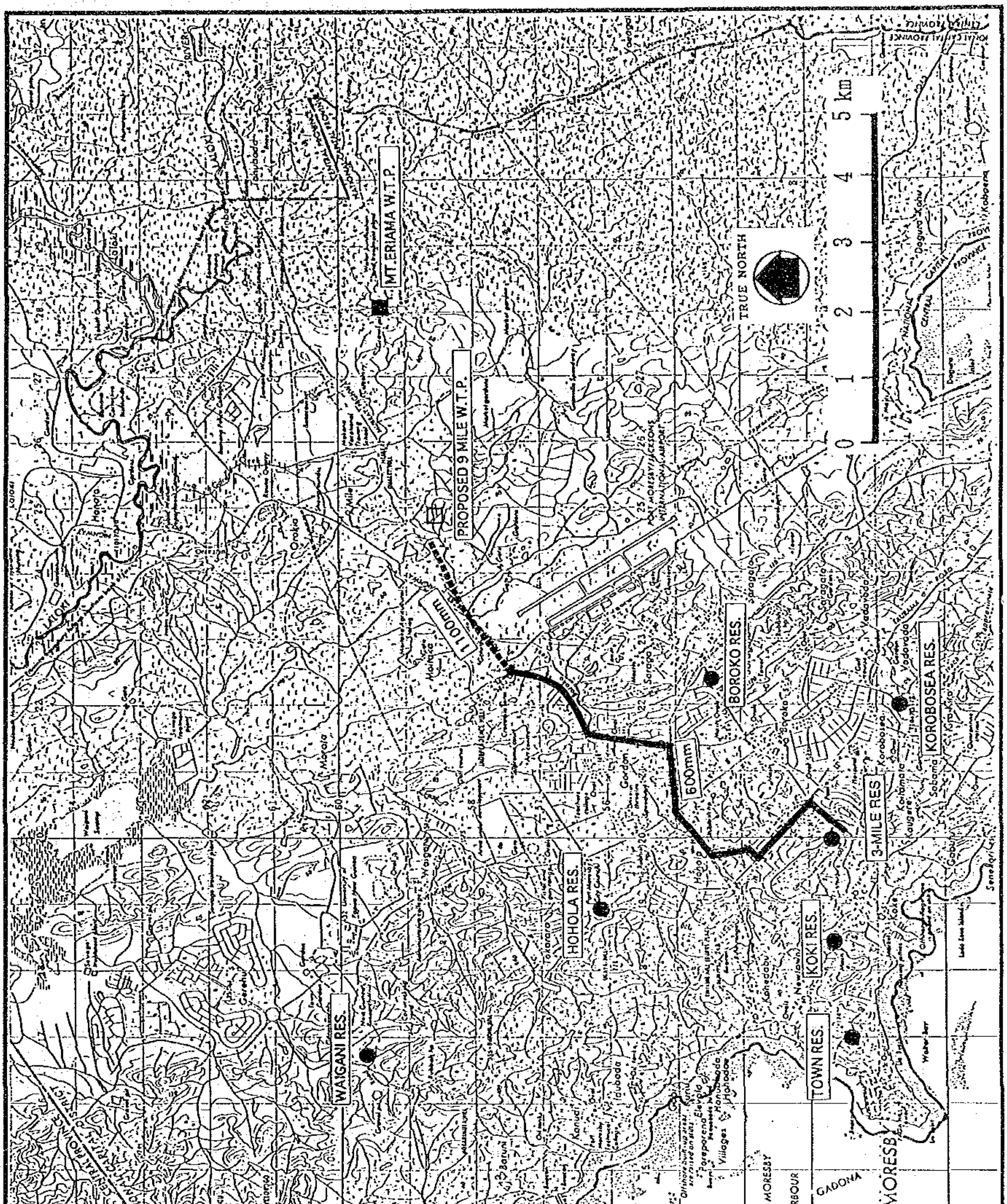
TITLE

CONCEPT OF IMMEDIATE REMEDIAL MEASURES

Fig. No. S.7

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



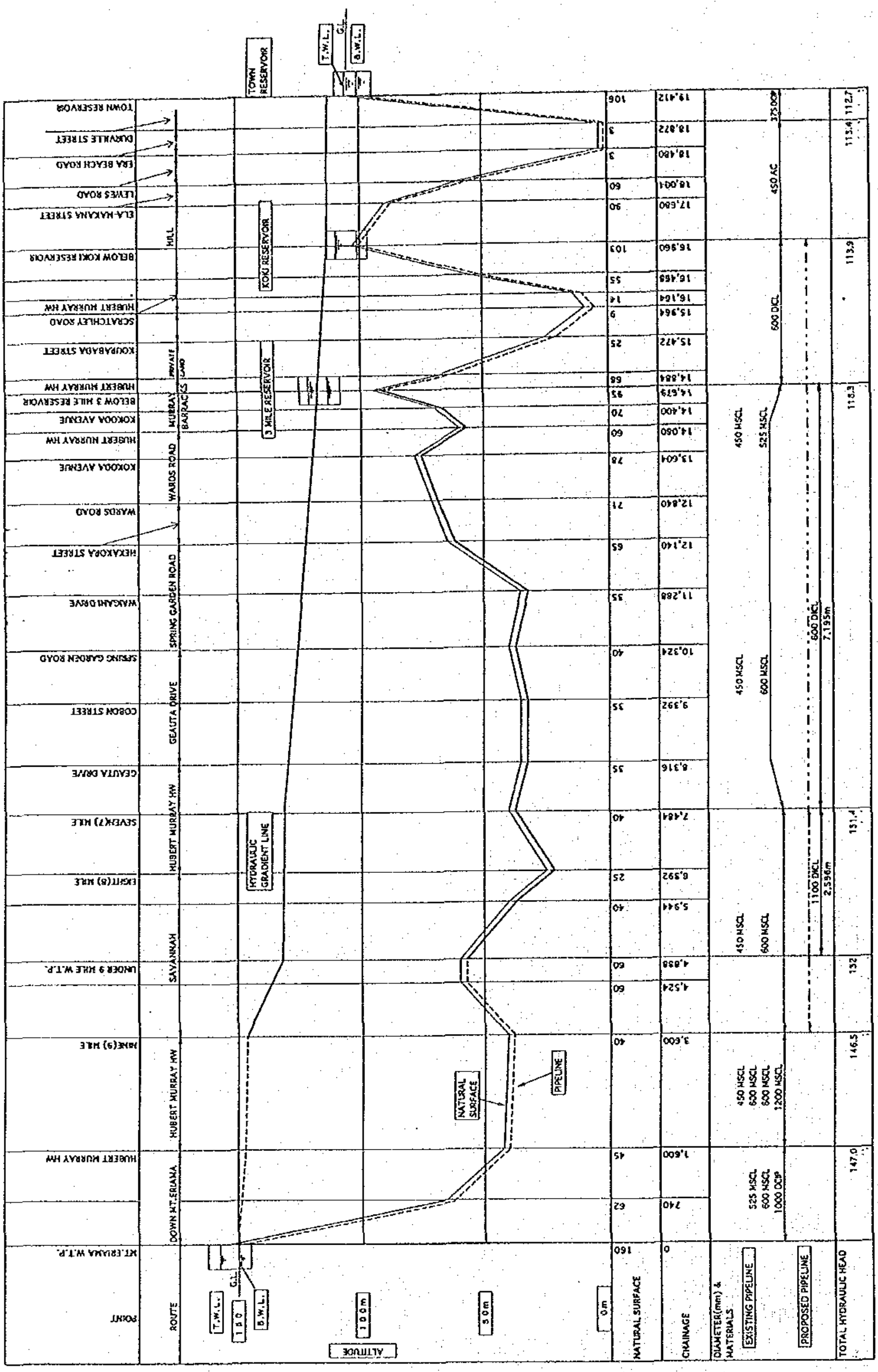
TITLE

TRUNK MAINS ALTERNATIVES

Fig. No.
S.8

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



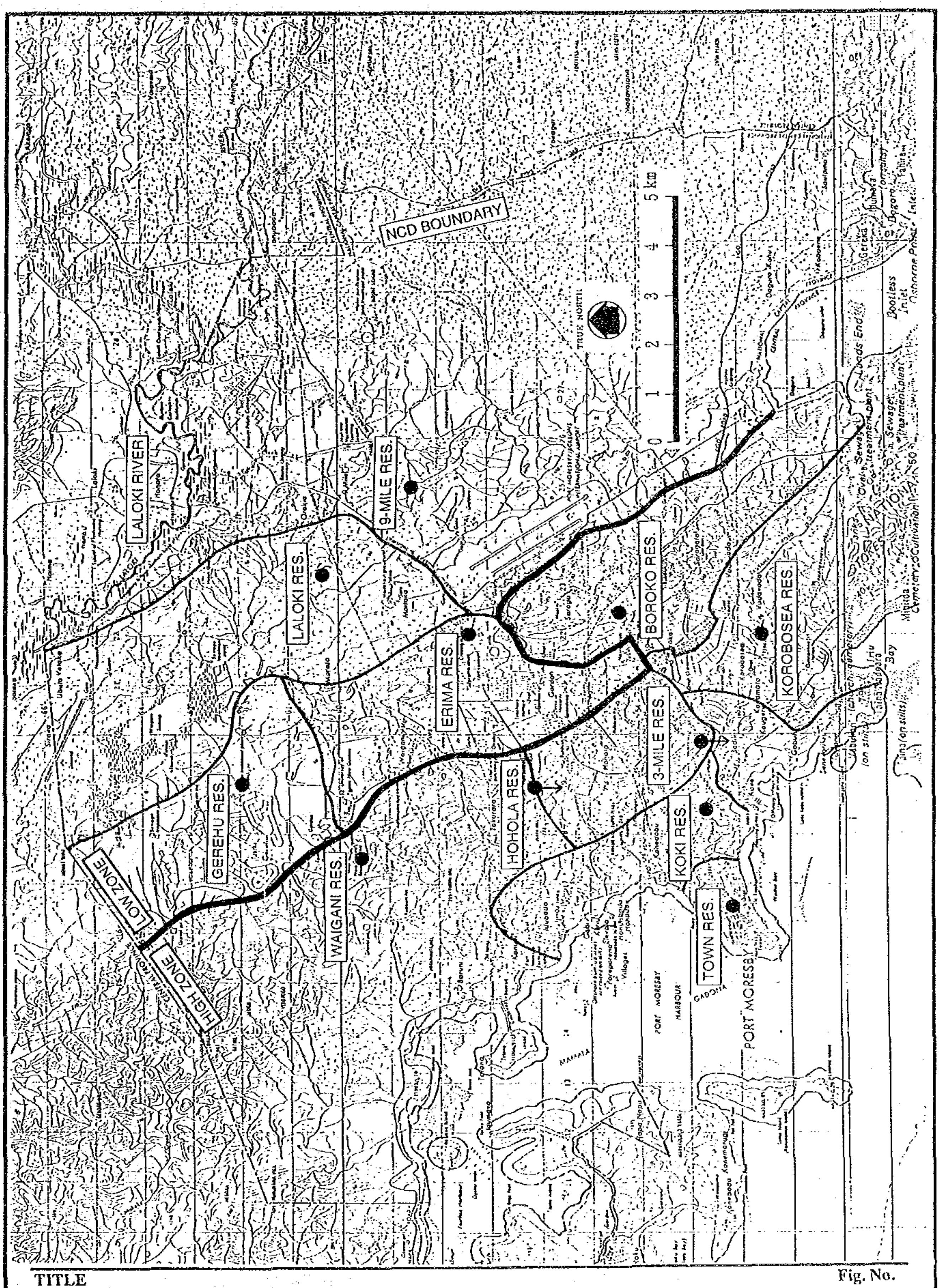
TITLE

LONGITUDINAL SECTION OF PROPOSED TRUNK MAINS

Fig. No. S.9

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



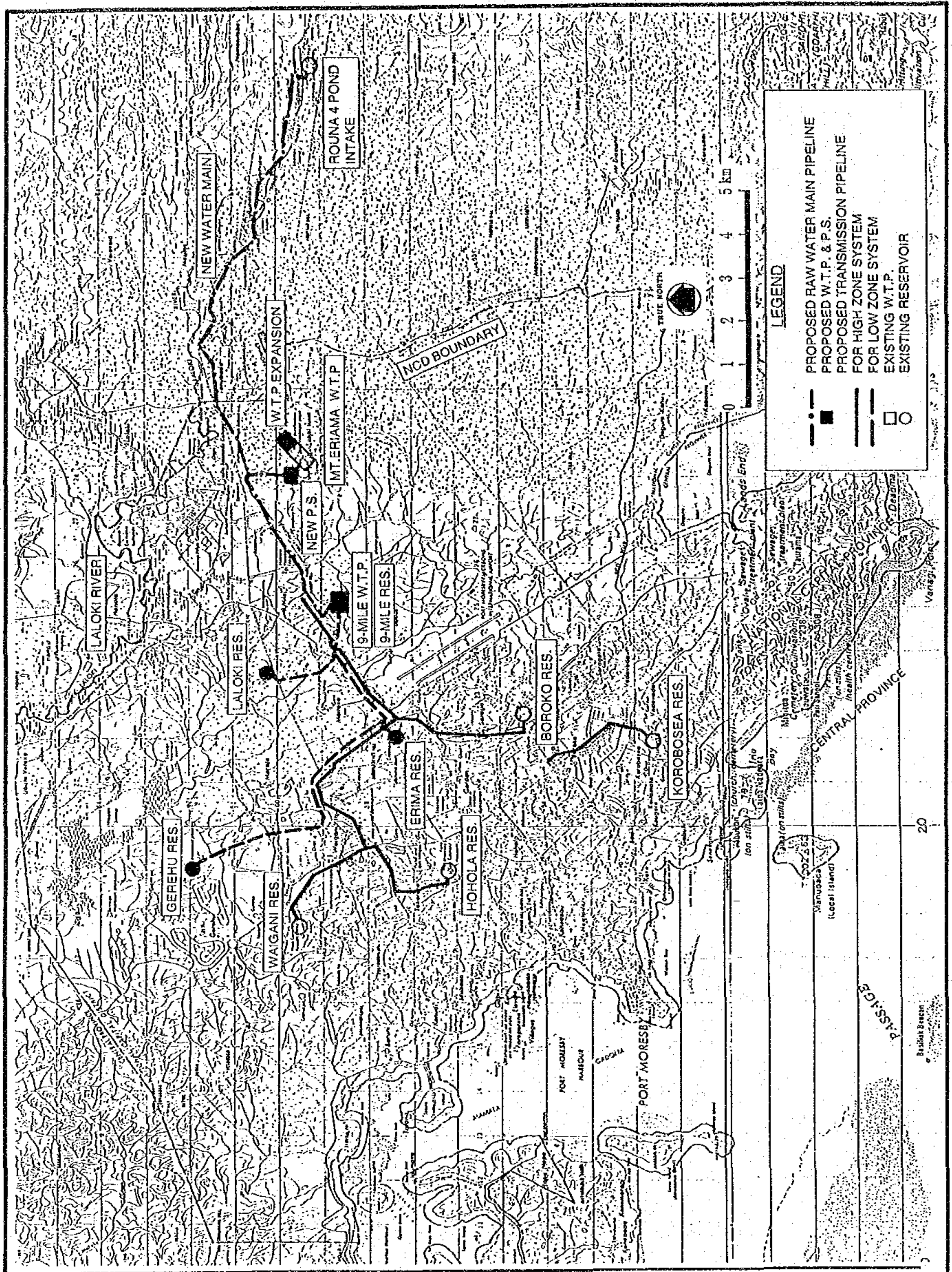
TITLE

DISTRIBUTION ZONING

Fig. No.
S.10

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

PROPOSED FACILITIES FOR MASTER PLAN

Fig. No.
S.11

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

Cost : Million Kina Capacity : mld

Program Item	Total Cost	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		NCD Water Supply System Works Program																					
Phase		First Phase 219.15							Second Phase 49.25							Third Phase 52.98							
Cost	321.36	16.93	41.15	59.79	32.02	21.51	45.18	2.55	2.79	7.25	2.56	15.82	14.66	3.46	2.71	2.71	12.50	10.98	8.37	4.64	4.64	4.63	4.51
Capacity		136	136	136	180	180	180	280	280	280	280	280	280	330	330	330	330	330	380	380	380	380	380
Demand (Daily Max)		192	201	205	209	213	217	221	230	239	249	258	267	277	287	296	306	316	326	336	347	357	367
1. Conveyance System	39.69	39.69							0.00							0.00							
Intake	2.14																						
Raw Water Main	37.55																						
2. Transmission pipe	37.47	36.01							0.98							0.48							
3. High Zone System	51.99	47.29							1.71							2.99							
(Mt.Eriama W.T.P.)	Capacity	136	136	136	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
W.T.P. & P.S.	36.36																						
Distribution pipe	15.63																						
4. Low Zone System	192.21	96.14							46.56							49.51							
(9 Mile W.T.P.)	Capacity	0	0	0	0	0	0	100	100	100	100	100	100	150	150	150	150	150	200	200	200	200	200
Water Treatment Plant	119.97																						
Distribution reservoir	14.84																						
Distribution pipe	57.40																						

W.T.P. : Water Treatment Plant

P.S. : Pumping Station

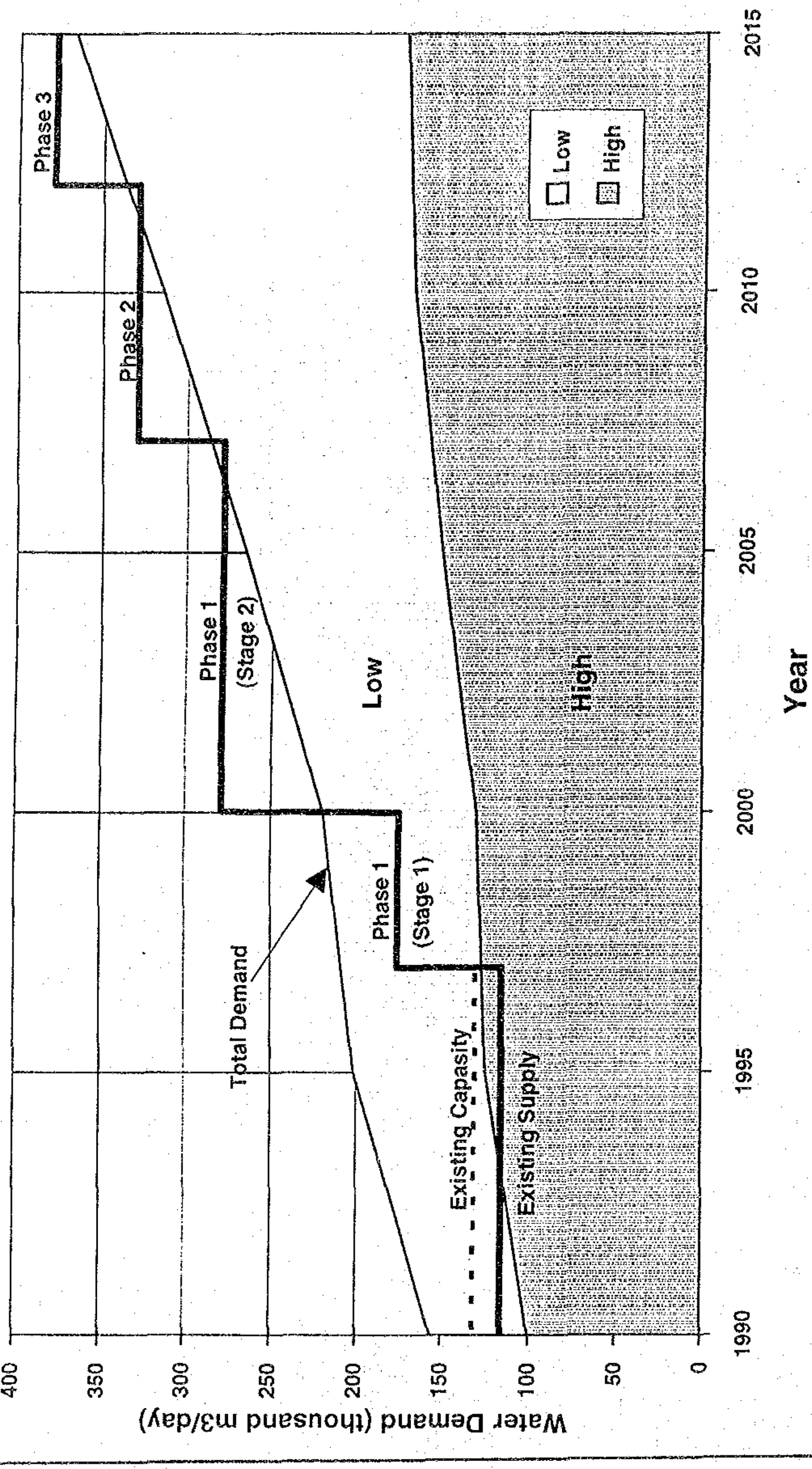
TITLE

IMPLEMENTATION SCHEDULE (OPTION B)

Fig. No. S.12

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

WATER SUPPLY AND DEMAND (OPTION B)

Fig. No.
S.13

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

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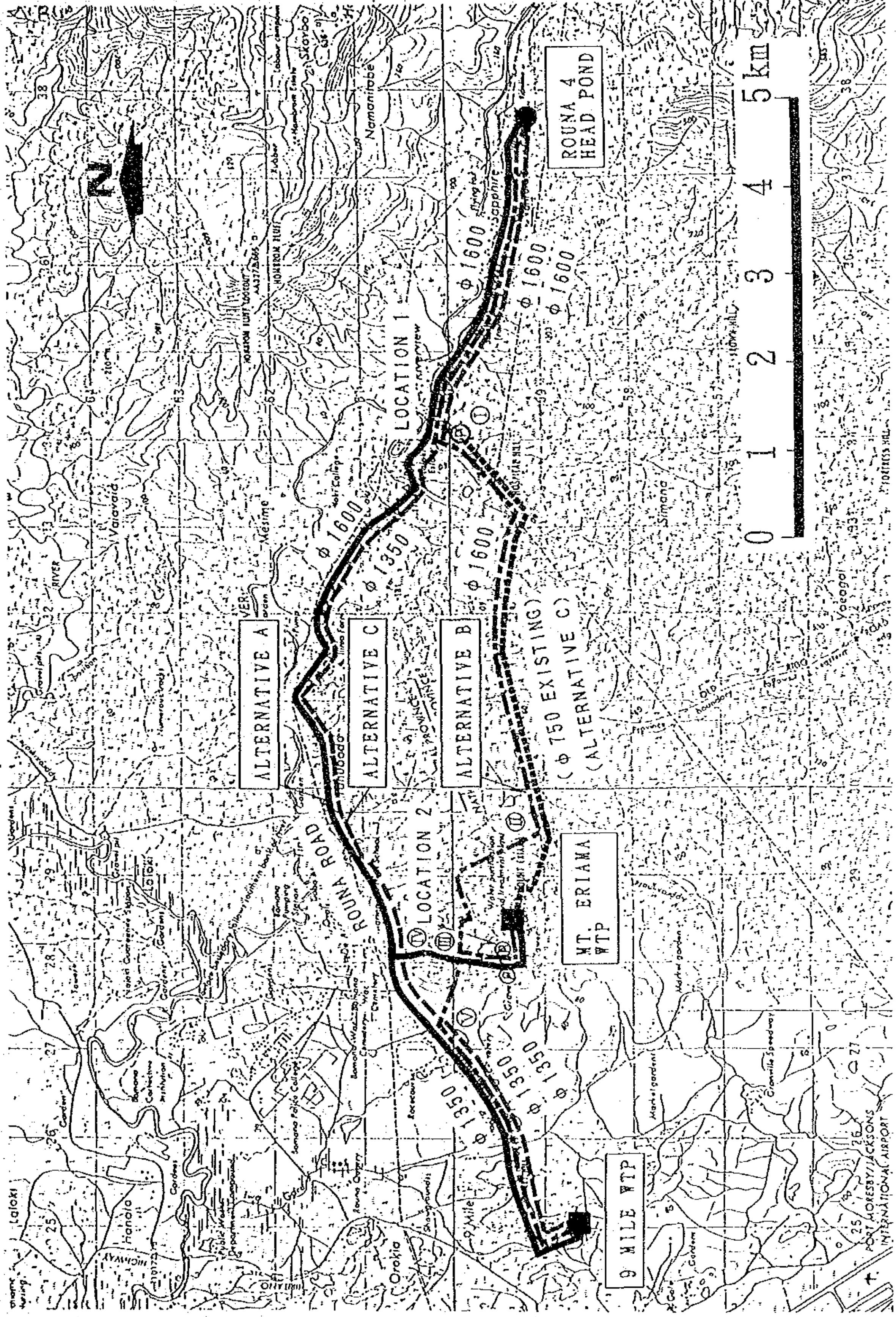

TITLE

ALTERNATIVE ROUTES OF THE RAW WATER MAIN

Fig. No.
S.14

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

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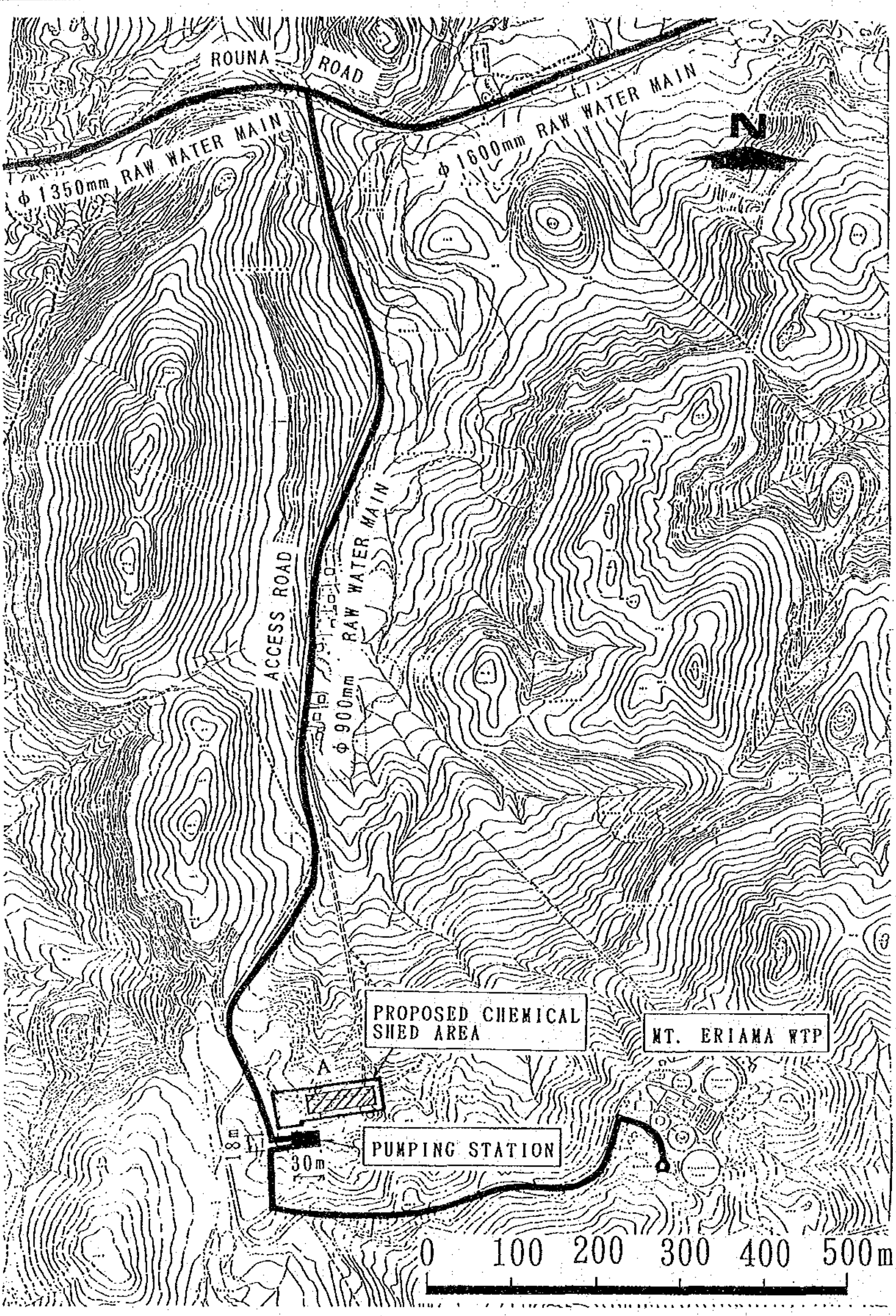


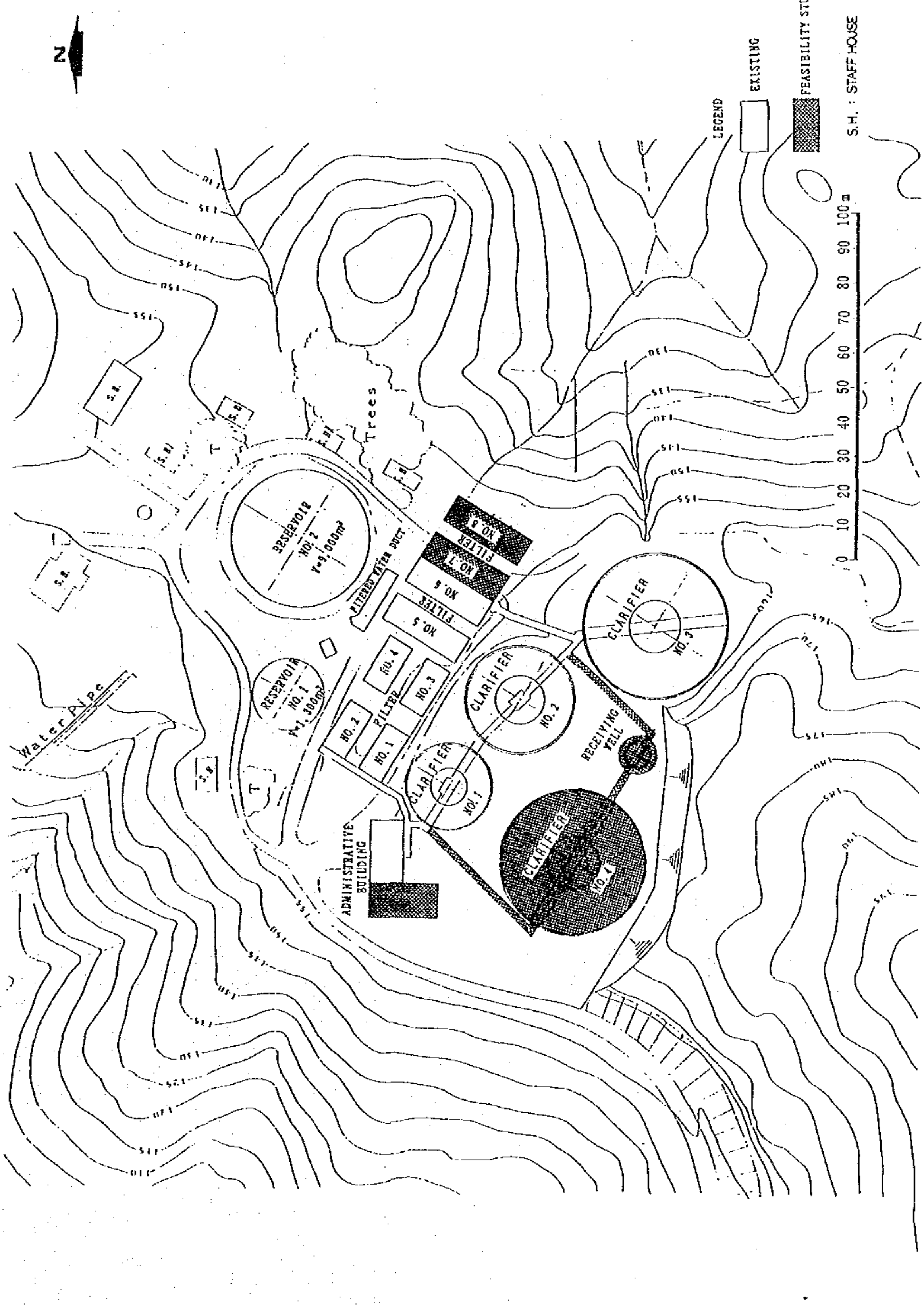
TITLE

PROPOSED LOCATION OF PUMPING STATION

Fig. No. **S.15**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



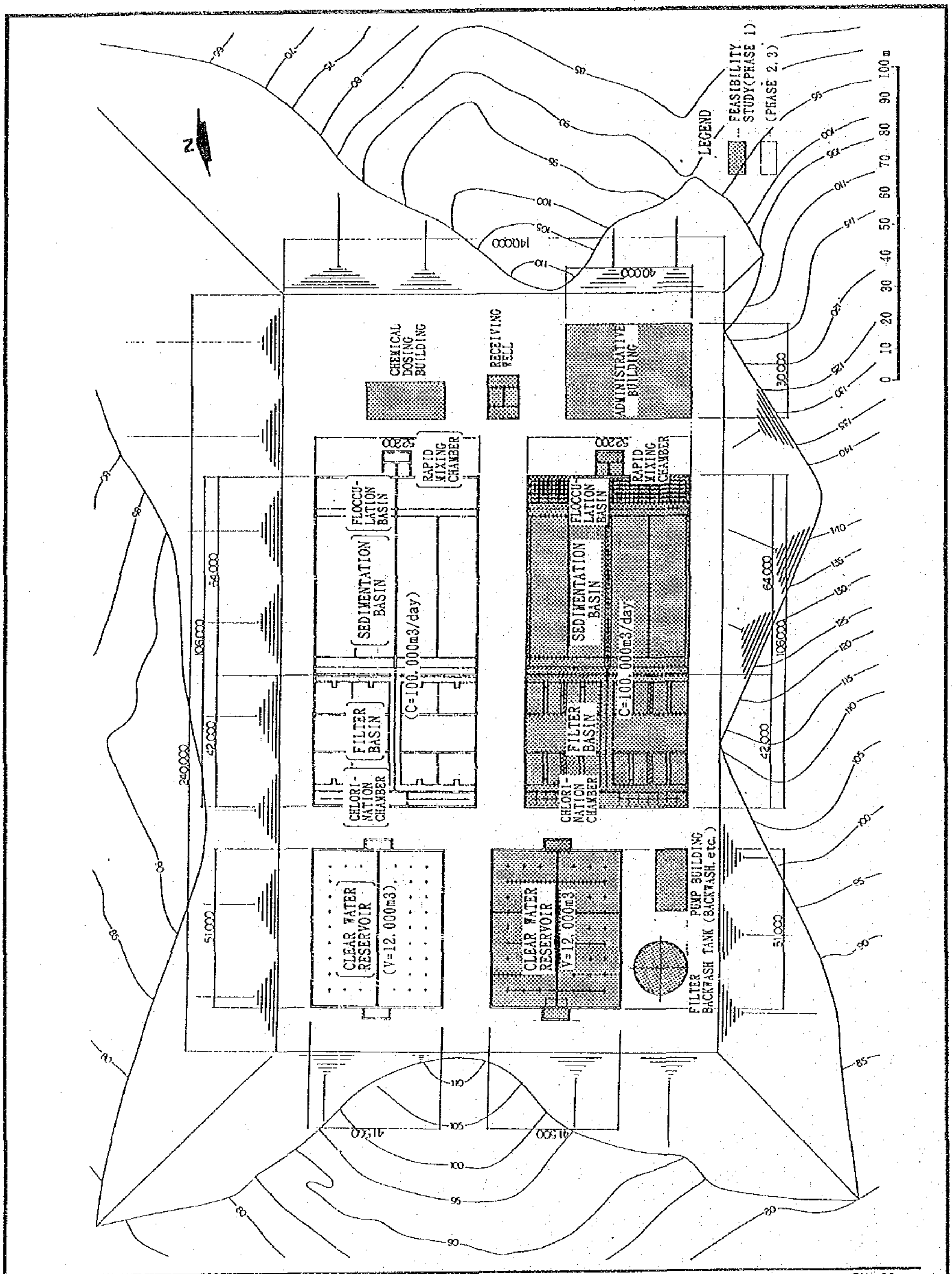
TITLE

Fig. No.

PROPOSED FACILITIES FOR MT. ERIAMA TREATMENT PLANT **S.16**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



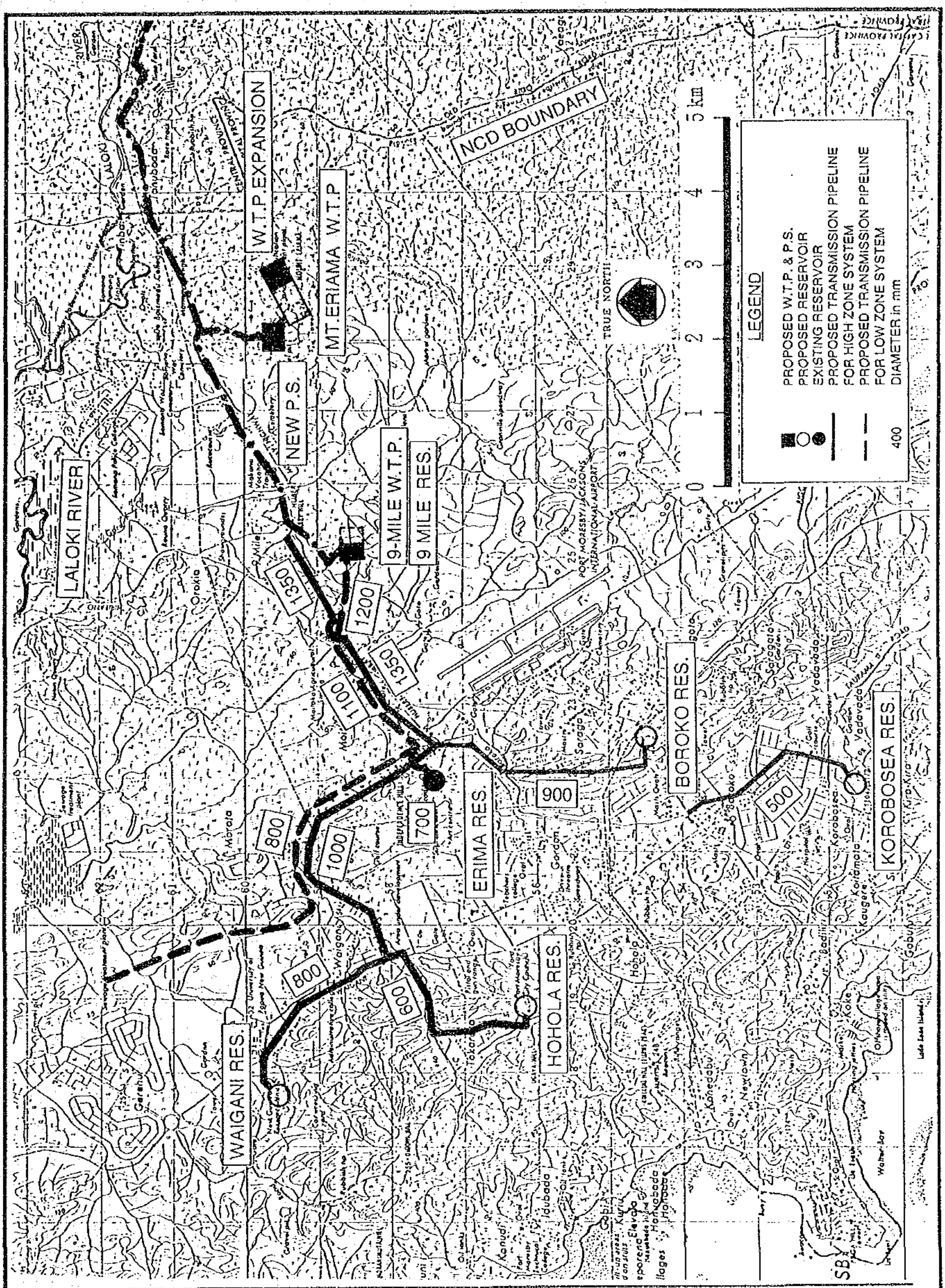
TITLE

PROPOSED FACILITIES FOR 9 MILE TREATMENT PLANT

Fig. No. **S.17**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



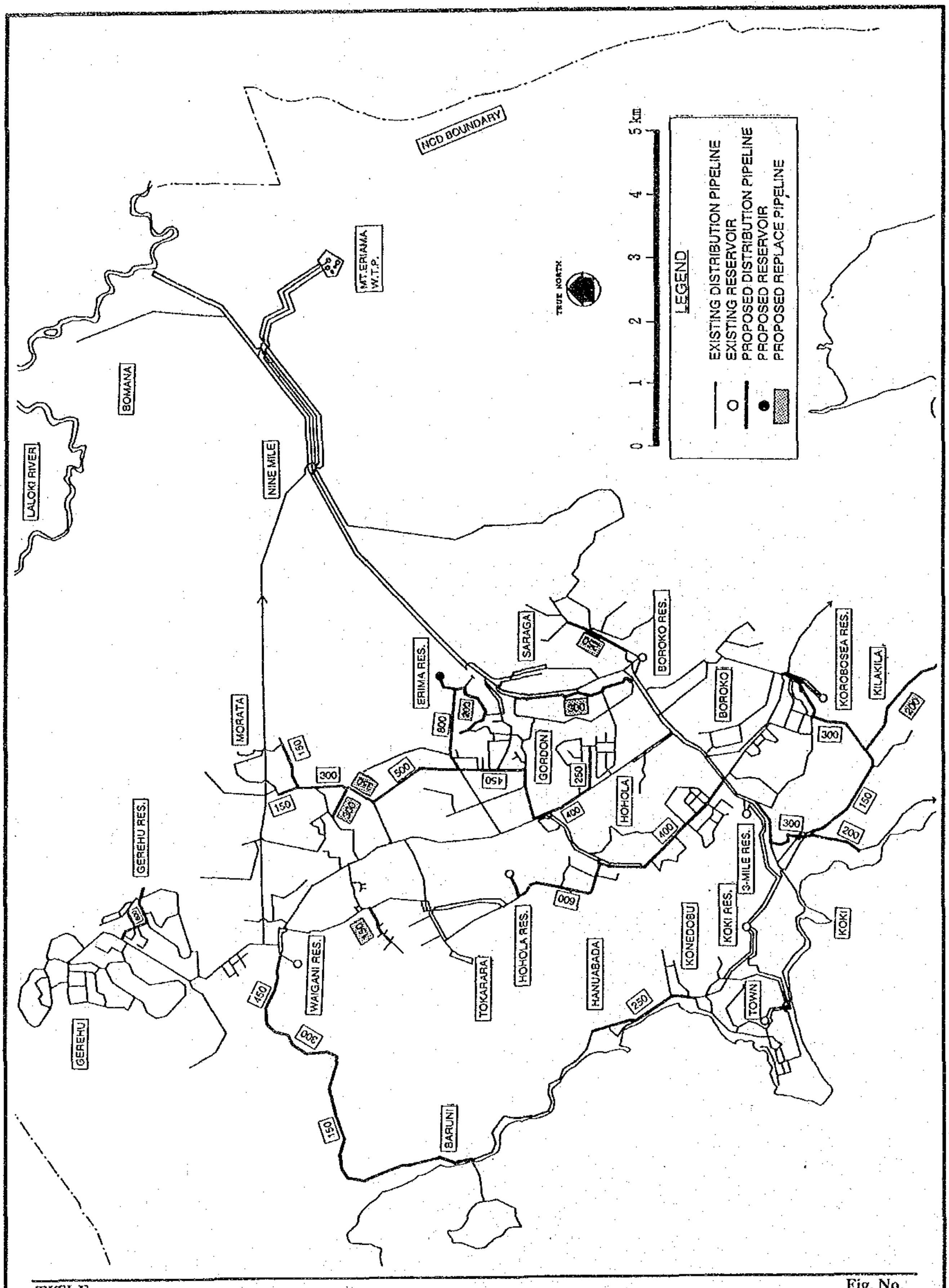
TITLE

PROPOSED TRANSMISSION LINES FOR THE FEASIBILITY STUDY

Fig. No. **S.18**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL



TITLE

PROPOSED DISTRIBUTION LINES FOR THE FEASIBILITY STUDY

Fig. No. **S.19**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANTS in association with PACIFIC CONSULTANTS INTERNATIONAL

Cost : Million Kina   Capacity : mld

Program Item		Total Cost	NCD Water Supply System Works Program						
Phase			First Phase			219.13 kina			
			Stage 1		117.87	Stage 2			101.26
Year			1994	1995	1996	1997	1998	1999	2000
Cost		219.13	16.93	41.15	59.79	32.02	21.51	45.18	2.55
Capacity			115	115	115	180	180	180	280
Demand (Daily Max)			192	201	205	209	213	217	221
1.	Conveyance System	39.69	2.32	14.26	14.29	0.00	0.69	8.13	0.00
	Intake	2.14	0.02	2.12					
	Raw Water Main	37.55	2.30	12.14	14.29		0.69	8.13	
2.	Transmission pipe	36.01	8.79	8.79	8.81	3.16	3.16	3.16	0.14
3.	High Zone System (Mt.Eriama W.T.P.)	47.29	4.96	16.62	22.74	0.84	0.84	0.82	0.47
		Capacity	125	125	125	180	180	180	180
	W.T.P. & P.S.	36.36	2.29	13.95	20.12				
	Distribution pipe	10.93	2.67	2.67	2.62	0.84	0.84	0.82	0.47
4.	Low Zone System (9 Mile W.T.P.)	96.14	0.86	1.48	13.95	28.02	16.82	33.07	1.94
		Capacity	0	0	0	0	0	0	100
	Water Treatment Plant	75.38		0.62	12.71	18.71	13.54	29.80	
	Distribution reservoir	6.03				6.03			
	Distribution pipe	14.73	0.86	0.86	1.24	3.28	3.28	3.27	1.94

W.T.P. : Water Treatment Plant
P.S. : Pumping Station

TITLE

IMPLEMENTATION SCHEDULE FOR THE FEASIBILITY STUDY

Fig. No. **5.20**

PORT MORESBY WATER SUPPLY DEVELOPMENT PLAN

TOKYO ENGINEERING CONSULTANS in association with PACIFIC CONSULTANTS INTERNATIONAL

PART 1 MASTER PLAN

1 INTRODUCTION

1.1 Background of the Study

The water supply system of National Capital District (NCD), constructed in 1970's, could not cope with the water demand in the middle of the 1980's. To combat with problem, a water master plan was formulated in 1980 with the target year as 1985. The proposed contents were;

* upgrading of raw water pipeline/treatment plant
* augmentation of trunk mains and distribution network, and
* maintenance and water conservation.

However, these programs, except some tentative remedial programs have not been implemented. One of the most influential measures was the re-commissioning of the Bomana raw water pump station which had been abandoned when the existing Mt. Eriama water supply system commenced operation in the 1970's. The re-commissioning resulted in a fairly improved water supply. However, the increase in water demand has gradually deteriorated and water service has been causing inconvenience to the citizens recently. As a result, the existing water system is inadequate for the present and future growth of the city.

In aiming to alleviate the water crisis, the National Capital District Commission (NCDC) has been proposing the capital works, but the works are mainly based on the old-fashioned 1980 master plan. Hence, to set up a sound water supply system for the short-term and the long-term, a master plan together with an immediate interim plan is needed after a detailed review of the existing water supply system.

In response to the request of the Government of Papua New Guinea (PNG), the Government of Japan decided to conduct a Study of the Port Moresby Water Supply Development Plan (hereafter referred to as "the Study"). Accordingly, Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, has undertaken the Study in close cooperation with the concerned authorities of PNG.

In April 1992, JICA dispatched a mission headed by Prof. Yoneji Sato to PNG for the preparatory study and for discussions on the scope of work of the Study. The scope of work was agreed upon between PNG and the JICA mission on April 14, 1992.

In response to a letter of invitation from JICA dated July, 1992, Tokyo Engineering Consultants (TEC) in association with Pacific Consultants International (PCI) prepared a proposal for undertaking the study and was selected by JICA to do the study in August, 1992. The study was conducted in two stages; one from August 1992 to March 1993 for the master plan and immediate remedial measures and another from June to January 1994 for the feasibility study.

In addition, the basic design study on the immediate remedial measures was conducted between December 1993 and March 1994. A report of the basic design study is prepared separately.

1.2 Objective and Study Area

According to the agreed scope of work, the objectives of the Study are:
1) to formulate a master plan for the rehabilitation and expansion of the existing water supply system in the National Capital District (NCD) for the next twenty years.
2) to formulate immediate remedial measures for the existing water supply system in the NCD.
3) to carry out a feasibility study of the high priority project selected from the master plan.

The Study covers the NCD (240 km^2) area and its surrounding in the Central province. NCD is located on the southeast coast of the main island of Papua New Guinea at a latitude of 9 29' south of the equator.

It is bounded by the Laloki river to the northeast, the old Rigo road to the east, the Coral sea to the south and Napanapa to the west. It is the biggest and the most developed area in Papua New Guinea today, and accommodates the seat of the Government of Papua New Guinea and the Central province.

1.3 Scope of the Study

The scope of the Study was agreed upon between the Government of Papua New Guinea and JICA in April 14, 1992 and is as follows:

1.3.1 Master Plan

(1) Data collection and analysis

* Socio-economic conditions
* Natural conditions
* On-going water supply projects and other relevant projects
* Water supply plans and studies
* Socio-economic development plans and studies
* Topographical, geological and hydrological maps
* Data on meteorology, hydrology and geology
* Organization for operation and maintenance
* Financial conditions for management

(2) Study of the existing water supply system

* Review of design criteria
* Review and analysis of structure, capacity and performance of water supply facilities
* Water flow and pressure measurement
* Water leakage measurement
* Institutional aspects
* Operations and maintenance
* Water tariff collection system
* Financial conditions

(3) Study of water resources

* Hydrological analysis
* Water quality analysis
* Sectoral allocation of water resources
* Availability of alternative water sources
* Study of intake site

(4) Strategies for water supply development

(5) Determination of the service area

* Existing service area
* Proposed service area
* Priority of the area to be developed

(6) Determination of the population in the service area

(7) Water demand projection and allocation

* Determination of per capita daily consumption for domestic use
* Determination of commercial and industrial water consumption
* Forecasting of water demand
* Water allocation for each distribution block

(8) Alternative study

* Intake facilities
* Transmission facilities

* Treatment facilities
* Distribution facilities

(9) Formulation of rehabilitation and expansion plan
(10) Operations and maintenance plan
(11) Preliminary cost estimates
(12) Implementation schedule
(13) Water tariff and financial plan
(14) Environmental aspects
(15) Project evaluation
(16) Identification of high priority projects

1.3.2 Immediate Remedial Measures

(1) Formulation of the rehabilitation plan
(2) Formulation of an operations and maintenance plan
(3) Preliminary design and cost estimates
(4) Evaluation of the plans

1.3.3 Feasibility Study of the High Priority Project

(1) Supplementary data collection and analysis
(2) Topographical and geological surveys
(3) Environmental assessment
(4) Preliminary design
(5) Construction schedule and procurement of equipment and materials
(6) Organization and operation/maintenance plan
* Water tariff collection system
* Leakage prevention strategy
* Repair shop
* Overall training program

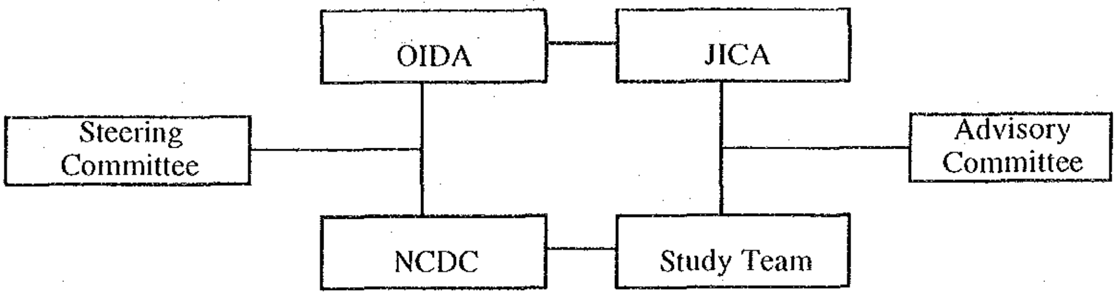
(7) Cost estimates
* Construction
* Operations and maintenance

(8) Project evaluation

1.4 Organization and Staffing

The OIDA (Office of International Development Assistance of Ministry of Finance and Planning) acts as the counterpart agency under which a steering committee was established. The committee comprises the Bureau of Water Resources, PNG Electricity commission (ELCOM) and National Capital District Commission (NCDC) which acted as the technical counterpart:

The overall organizational structure is shown below.



The Study Team and Committees consist of the following members respectively:

Members of the Study Team

Mr. Kazufumi MOMOSE	: Team Leader/Water Supply Planning Tokyo Engineering Consultants(TEC)
Mr. Soichiro YUMOTO	: Water Resources Planning, Pacific Consultants International (PCI)
Mr. Kaoru SUZUKI	: Water Treatment Plant Planning/ Facilities Design (TEC)
Mr. Katsutoshi IWASAKI	: Distribution Planning (TEC)
Dr.Jayamohan SOMASUNDARAM	: Hydrology/Water Quality (PCI)
Mr. Hirotaka SATO	: Facilities Design (TEC)
Mr. Wataru SAIKA	: Network Design (TEC)
Mr. Toru OHTOMO	: Mechanical & Electrical Facilities Design (TEC)
Dr. Norihiro NODA	: Management/Operation and Maintenance (PCI)
Mr. Osamu NAKAGOME	: Construction Schedule/Cost Estimation (TEC)
Mr. Fumiaki ONODA	: Economics and Financial Analysis (PCI)

Members of the Advisory Committee

Professor Yoneji SATO	: Chairman (Hachinohe Institute of Technology)
Mr. Kiichiro MIMURA	: Facilities Planning (Okayama Prefectural Bulk Water Supply Enterprise)

Mr.Yoshihiko MIYAYAMA	: Operations and Maintenance (Osaka Municipal Water Works Bureau)

Members of the Steering Committee

Ms.Marianna Ellingson	: Office of International Development Assistance
Mr.Francis Wagaia	: Office of International Development Assistance
Mr.Tony Kuman	: Bureau of Water Resources
Mr.N Lovai	: Bureau of Water Resources
Mr.Michael Wae	: Bureau of Water Resources
Mr.Sev Maso	: Electricity Commission

Members of the Technical Committee

Mr.Gerard Poigeno	: Manager (Corporate Planning Unit)
Mr.Billy Imar	: Assistant Manager (Technical Service Unit)
Mr.B.M. Karunarantne	: Senior Construction Engineer (Technical Service Unit)
Mr.Sevese Eafeare	: Assistant Manager (Water Supply & Sewerage)
Ms.Dinah Minol	: Physical Planner (Corporate Planning Unit)
Mr.Allan Nema	: Water Supply & Sewerage Engineer
Mr.Gabriel Kapris	: Engineer
Mr.Leslie Alu	: Engineer
Mr.Simon Vai	: Engineer

2 EXISTING CONDITIONS

2.1 Physical Environment

Geography

The National Capital District area comprises a rocky coastal strip and an inland plain divided by a rugged ridge which falls steeply to the sea. The Study Area together with its elevations, is shown in Fig. 2.1.

The landscape of the inland plain is dominated by a series of parallel ridges separated by broad, flat or gently undulating valleys. The ridges rise to about 200 m above sea level and the valleys are generally less than 50 m above sea level. To the north and east of the city the ridges are lower and merge into the flat, poorly-drained Waigani swamp and the Laloki river flood plain.

Vegetation and Soil

The NCD is dominated by savanna vegetation consisting of grassland with trees, primarily of the eucalyptus species. The savanna owes its existence to artificial clearing and burning. Only remnant pockets of lowland forest, which once covered the area, now remain in the upper reaches of the valleys.

Soils are uniformly poor. The reddish or brownish lithosol and vertisol soil types occurring on hill crests and slopes are stony and of variable depth. Within valleys, dark swelling clay which is unstable dominates the remnants of swamps which have now disappeared.

Climate

The climate of NCD is determined by the influence of two surface pressure systems. From May to October trade winds originating from a sub tropical high pressure system located to the south of the NCD, blow consistently from the southeast. Wind speeds of up to 25-30 knots are common late in the season although lower velocities occur at the start of the season. During this period the city experiences a marked dry season (refer to Fig. 2.2) and water demand is significantly high.

From December to March the city is influenced by the movement of the Inter Tropical Convergence zone, first southward and then northward. Air streams pass over the NCD and moist north-westerly winds occur bringing daily rainfall in this zone.

In both April and November, transitional periods between the two seasons influence the two pressure surface systems, and the NCD experiences humid and still conditions.

The average annual rainfall in NCD is 1200 mm approximately, which is unusually low for Papua New Guinea. Annual average evaporation is about 1780 mm.

Temperatures are high throughout the year. Seasonal variation is small, and is exceeded by daily variation with night time minimum widely differing with day time maximum.

Table 2.1 Temperature in Port Moresby in 1991

(°C)

	Extreme Max.	Mean Max.	Mean	Mean Min.	Extreme Min.
January	35.4	32.6	29.1	25.6	19.4
February	34.7	31.9	27.5	23.1	21.0
March	32.4	30.5	26.4	22.3	17.3
April	33.4	31.7	27.7	23.7	22.5
May	31.7	30.0	26.1	22.1	20.0
June	32.5	30.2	28.2	26.1	18.9
July	31.6	30.0	26.5	22.9	20.8
August	32.7	28.7	25.8	22.9	21.0
September	33.5	30.6	26.0	21.3	18.6
October	32.8	30.8	27.1	23.3	21.6
November	33.5	31.7	27.4	23.0	21.1
December	35.6	33.1	28.3	23.5	21.1
Annual	35.6	31.0	27.2	23.3	17.3

(Source : National Weather Service)

Table 2.2 Monthly Rainfall for 1980 to 1991 and Mean Monthly Evaporation (1991) in Port Moresby

(mm)

	Rainfall			Evaporation
	Average	Highest	Lowest	
January	212.4	421.4	53.2	192.3
February	134.4	288.4	82.8	164.8
March	229.8	498.4	100.4	229.0
April	109.2	320.4	6.0	147.6
May	51.5	148.4	0.0	143.0
June	45.9	161.2	0.0	150.6
July	27.1	122.3	1.0	156.4
August	39.8	157.4	0.0	147.4
September	28.4	162.6	0.0	187.8
October	52.0	207.6	0.0	192.8
November	68.4	199.4	0.4	180.8
December	133.0	291.4	3.2	195.6
Annual	1131.9	2237.5	780.0	2088.1

(Source : National Weather Service)

2.2 Population and Development

The population of NCD was only 4,000 in 1945. It increased from 76,507 in 1971 to 195,382 in 1990. The annual growth rate was 5 %. The present population (1992) is estimated as approximately 215,000. More than half of the indigenous male population in 1990 was under 30 years, indicating that a large number of young men came in search of education and jobs. Expatriates totaled 7,503 in 1990.

The types of development in each area of Port Moresby is shown in Table 2.3 and Fig. 2.4. The descriptions are general in nature, but give an indication of the type of water use expected from each area. In 1987 it was reported that about 30 % of the population live within settlements and villages, while 30 % live in high-cost formal housing. The remainder live in low-cost rental accommodation.

TABLE 2.3 PORT MORESBY DEVELOPMENT AREA

District	Description of Typical Developments						LEGEND
	High Cost housing	Low Cost housing	Self -help housing	government	commercial	Industrial	
Gerehu	HHH	LLL	---	---			
Morata	---	LLL	SSS	---	---	---	
Tokarara	---	LLL	---	---	---	---	Some high cost houses
Hanuabada/Konedobu/New town	HHH	LLL	SSS	GGG	CCC		non-water intensive
Town (residential)	HHH	---	---	---	---	---	with quarters
Town (Industrial and							non-water intensive
Koki/Badili	HHH	LLL	SSS	---	---	---	water intensive industry
Kaugere/Kila Kila	---	---	SSS	---	---	---	
Korobosea/ Boroko	HHH	---	---	---	---	---	with quarters
Murray Barracks	HHH	LLL	---	---	---	---	Army Barracks
Hohola	---	LLL	SSS	---	---		
Gordons	HHH	---	---	---	---		water intensive industry
Waigani	HHH	LLL	---	GGG	---	---	
University	HHH	---	---	GGG	---	---	
Six-Mile/Saraga/Erima	HHH	---	SSS		---	---	
Taurama	HHH	LLL	---	GGG	---	---	
Pari/Gabutu/Tatana /Baruni/Vabukori	---	---	SSS	---	---	---	
Idubada	HHH	---	---	---	---	---	Technical college dormitories
Bomana	---	LLL	SSS	---	---	---	

(Based on 1990 Census)