No.

DEPARTMENT OF NATIONAL PLANNING & MONITORING
PNG WATER BOARD
GOROKA URBAN LOCAL LEVEL GOVERNMENT
PAPUA NEW GUINEA

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
TOWN WATER SUPPLY
IN
PAPUA NEW GUINEA

January 2001

JAPAN INTERNATIONAL COOPERATION AGENCY
PACIFIC CONSULTANTS INTERNATIONAL

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PREFACE

In response to the request from the Government of Papua New Guinea, the Government of Japan decided to conduct a basic design study on the project for Town Water Supply in Papua New Guinea and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Papua New Guinea a study team from 1 August to 4 September, 2000.

The team held discussions with the officials concerned of the Government of Papua New Guinea, and conducted a field survey at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Papua New Guinea in order to discuss a draft basic design, and as this result, the present report was finalized.

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 teams.

January 2001

Kunihiko Saito
President
Japan International Cooperation Agency

January 2001

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the project for Town Water Supply in Papua New Guinea.

This study was conducted by Pacific Consultants International, under a contract to JICA, during the period from 26 July, 2000 to 14 February, 2001. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Papua New Guinea and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

Very truly yours,

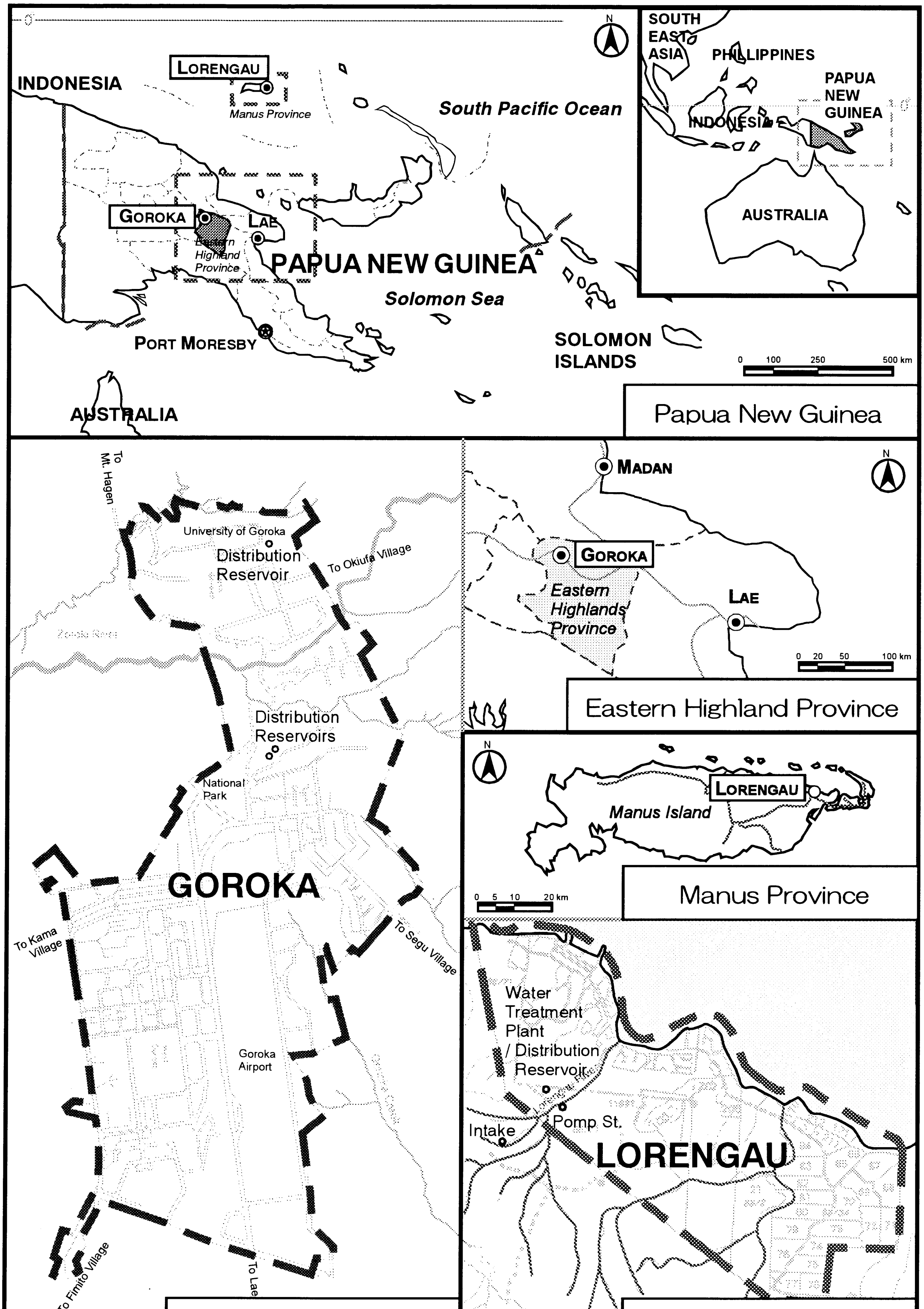
岡賀 敏文

OKAGA Toshifumi

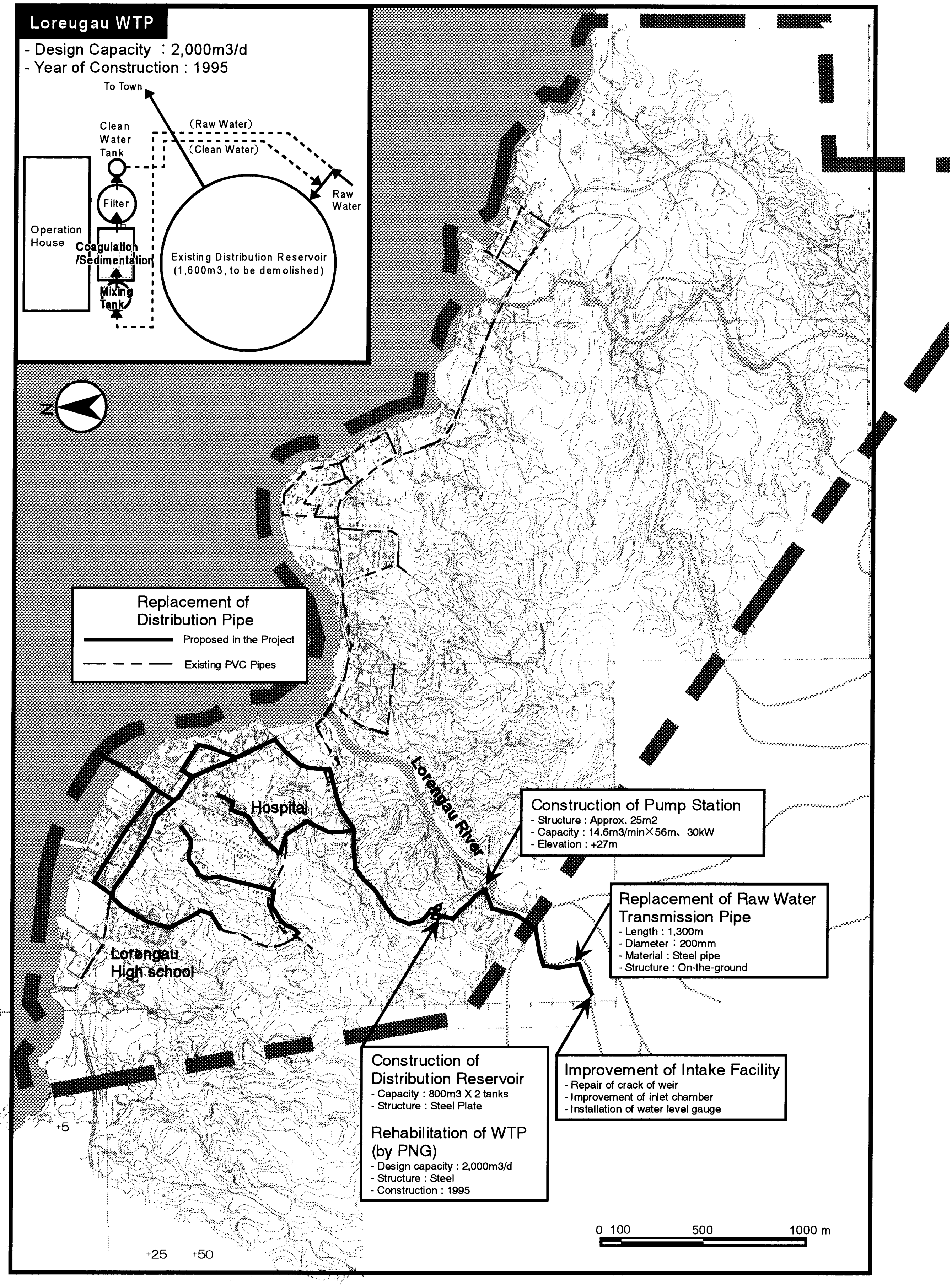
Project manager,

Basic design study team on
the Project for Town Water Supply
in Papua New Guinea

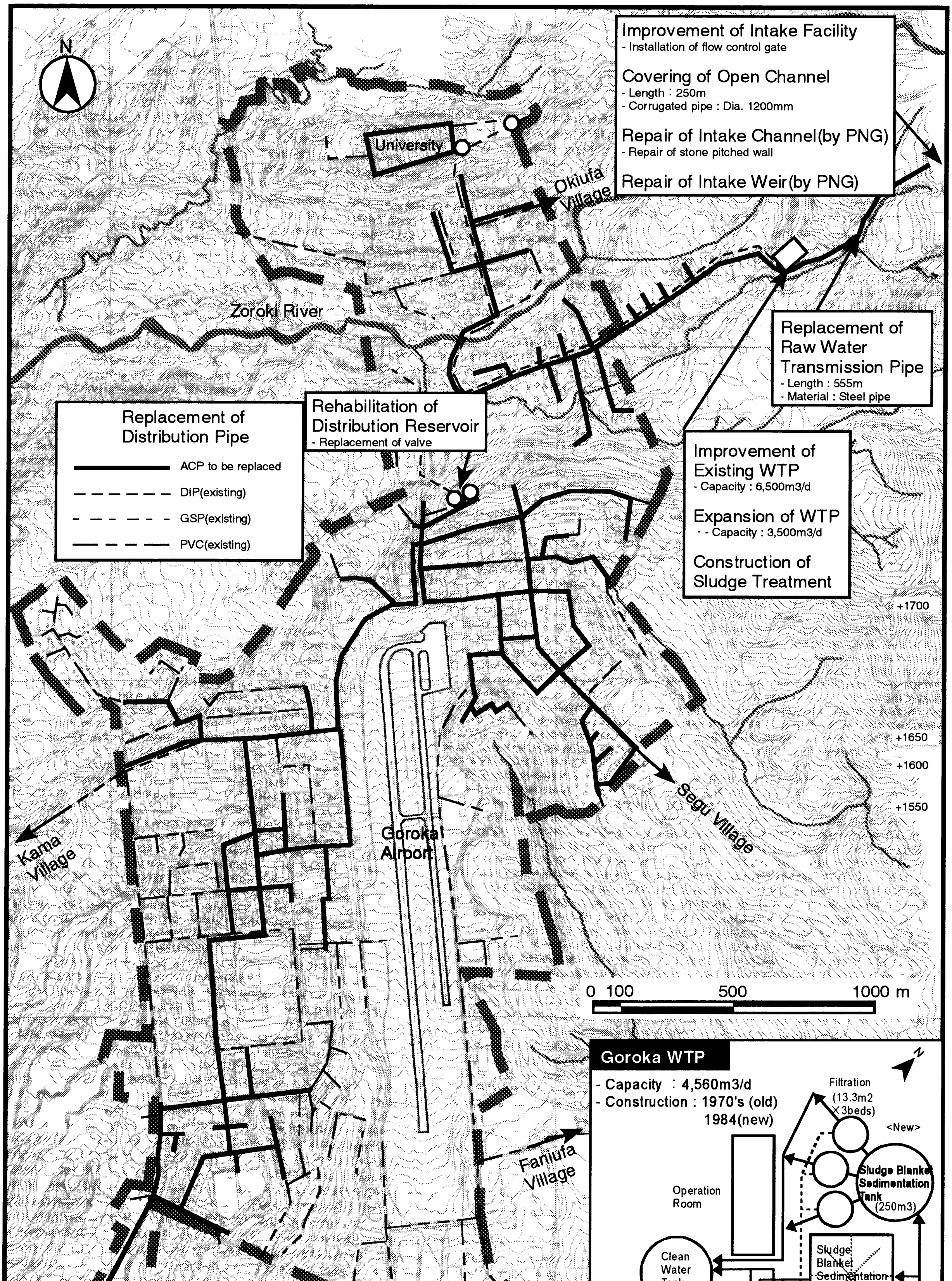
Pacific Consultants International.



LOCATION MAP



Project Site - Lorengau



PROJECT SITE - GOROKA

ABBREVIATIONS

ACP	Asbestos Cement Pipe
ADB	Asian Development Bank
AFW	Accounted-for Water
BHN	Basic Human Needs
DIP	Ductile Iron Pipe
GSP	Galvanized Steel Pipe
GULLG	Goroka Urban Local Level Government
JICA	Japan International Cooperation Agency
PNG	Papua New Guinea
PVC	Polyvinyl Chloride (Pipe)
SAP	Structural Adjustment Program
UFW	Unaccounted-for Water

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Chapter 1 *Background of the Project*

CHAPTER 1 BACKGROUND OF THE PROJECT

Papua New Guinea (PNG) has been lacking a precise nationwide development strategy which has clear link to government objectives, although PNG had been achieving moderate economic growth since its independence in 1975. The economic policies lacking long-term vision has caused economic depression.

In 1995, PNG formulated the Structural Adjustment Program (SAP) in an effort to establish macro-economic stability. Its target is to strengthen the responsibilities and functions of the central government, provincial and local level governments and private sectors, in order to make good use of affluent natural resources and human resources.

In the sector of water supply, provincial and local level governments have been vested with responsibility for water supply and sewerage service under New Organic Law enacted on basis of the SAP. However, the provincial and local level governments, being devoid of financial, technological and skillful human resource, are endeavoring to enhance water supply and sewerage service level and to ensure reasonable maintenance of the services by entrusting PNG Water Board, established in 1986, with managerial function of water supply service and sewerage service in urban areas.

In Lorengau City (population approx. 7000), the capital city of Manus Province, the water supply service will be transferred to PNG Water Board.
In Goroka City (population approx. 30,000), the capital city of Eastern Highland Province, the local level government is managing its water supply service by itself.

In PNG's urban areas including the project areas, water supply facilities have generally become deteriorated and have not been properly maintained due to budget shortage, causing a vast volume of water leak which, thereby, results in a serious problem of water supply shortage to inhabitants. PNG Water Board and local municipalities, which are in charge of water supply projects in local towns, have drawn up plans to rehabilitate and improve the existing facilities in an attempt to supply sufficient water to inhabitants and are implementing the plans with financial assistance from foreign countries and international organizations in addition to a subsidy provided from the central government. Most of the water facilities in the project areas have already exceeded their durability, intensifying the serious problem of water supply shortage. Furthermore, overloaded operation of the existing facilities, due to increased water demand accompanied by a rise in population served, is causing problem of water quality deterioration.

The inhabitants are obliged to use rain water and transport water from creeks in order to make up for the water shortage. However, in a dry season, the inhabitants are in serious need for water, since it is difficult to secure water from those sub-sources.

On the other hand, deteriorated service of water supply will demoralize the inhabitants to pay water charges, badly affecting the water works management itself. It is an urgent need to improve the existing water supply facilities as well as to strengthen managerial organizations, in order to supply sufficient water to the inhabitants and to manage sound water supply services.

Under these circumstances, the Government of PNG has requested to Japan a grant aid for the two projects of “Vanimo & Lorengau Water Supply Project” and “Goroka Town Water Supply and Sewerage Upgrading Project”. In response to the request of the Government of PNG, Japan International Cooperation Agency (JICA) has incorporated the two projects into one unit, on the basis of its preparatory studies conducted in 1999, selecting the studies on the system of water supply in Lorengau and Goroka.

JICA, furthermore, dispatched a preparatory study team in 2000 to ascertain the contents of the requests for the projects and scale of the requested facilities. As a result, the concepts of basic design study were formulated as follows:

1. In order to satisfy the basic human needs (BHN) in local areas, the project will be planned within the scope where improvement of the facilities is urgently needed.
2. The facilities will be planned to be as simple as possible in consideration of the maintenance capability in the sites.
3. The project will include procurement of equipment necessary but insufficient for maintenance and a reasonable maintenance system will be proposed, in consideration to the sites’ situation.
4. Lorengau:
    - A study will be conducted on the location of the existing water intake facility and water supply pressure in aspect of hydraulic analysis.
    - A study will be conducted on possibility of transferring the facilities to PNG Water Board and possibility of managing the facilities on basis of a self-supporting accounting system, such as water-charge collection system.

- The service areas will remain the same, based on the present situation.

5. Goroka:

- The capacity of the existing facilities will be appropriately assessed, and the project will be implemented within the scope where improvement of the facilities is urgently needed.
- As for water intake facilities, a study will be conducted on urgent rehabilitation and repairing work to the existing facilities.
- All of the asbestos cement pipes will be replaced. However, it will be ascertained that replacement of other pipes could be dependent upon PNG's self-reliance effort.

Based on the above concepts, the Basic Design Study was conducted, and this report was prepared.

Chapter 2 *Contents of the Project*

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Objective of the Project

The objective of the Project is to improve the existing facilities by the target year of 2003 under the Japan's grant aid in order to supply sufficient volume of safe water by means of increasing effective water volume and improving water supply pressure in the low water pressure areas.

2-2 Basic Concept of the Project

As a result of the preparatory study conducted in January 2000, the Project is positioned as a water supply improvement project. From a viewpoint of urgent necessity, the principles of the basic design study are directed as follows:

-1 The contents of the Project will be formulated within a scope where improvement of the facilities are urgently required.

-2 The facility to be proposed will be simplified in consideration of the maintenance ability of the implementation agency.

-3 The existing intake facility that are urgently required to be rehabilitated will be improved and repaired.

-4 Since steel pipes, distribution reservoir of Lorengau, asbestos cement pipes, and mechanical and electrical equipment of Goroka water treatment plant, have been extremely deteriorated, they will be replaced.

-5 Recommendations on procurement plan of equipment as well as appropriate organizations for operation and maintenance will be made.

-6 Sustainability of the Project will be assessed by confirming a transfer of water supply system to PNG Water Board.

Based on the above principles, field survey has been carried out. And the following basic design concepts were established:

- The target year is 2003.
- Water supply systems will be made through gravity flow by using differences in

geographical conditions. Operations of the water treatment plants will be made by manual at sites.

- The existing intake facility will be rehabilitated and repaired so as to secure a steady water intake volume.
- The leakage ratio of the existing distribution pipeline will be reduced from 59.8% (Lorengau) and 46.4% (Goroka) to 25%. For this purpose, deteriorated galvanized steel pipes (Lorengau) and asbestos cement pipes (Goroka) will be replaced.
- The present low water supply pressure will be increased to appropriate pressure level in order to improve the present water supply condition.
- For the water treatment plant in Lorengau, PNG Water Board guarantees a facility function of producing water 2000 m^3/d. Repairs necessary for this purpose are to be made by Water Board. At the same time, the existing distribution reservoir will be removed and replaced by a new tank with equal capacity.
- The mechanical and electric equipment of the existing water treatment plant in Goroka, that is outdated and deteriorated in functions, will be replaced. To meet water demand, a water treatment plant with a capacity of 3,500 m3/d will be added. When the existing facility is renewed and new equipment is added, the plant capacity will become 10,000 m^3/d.
- Since there is no equipment of water quality analysis that is necessary for maintenance, simple analytical tools for daily maintenance will be procured. For Goroka, moreover, a portable flow meter necessary for prevention of water leakage will be procured. After procurement, technology transfer will be scheduled through adequate guidance during the construction period.
- To ensure sustainable maintenance of facilities, strengthening of the water tariff system is necessary. Water meters and connection pipes to increase accounted-for water will be provided under the Project.

2-3 Basic Design

2-3-1 Design Concept

(1) Natural conditions

The Project areas are considerably different in geographical conditions. Therefore, an energy saving design based on gravity flow will be proposed to reduce the operational electric power cost.

(2) Local contractors, materials and equipment

Local contractors are available in Port Moresby and Lae, which have experienced in water supply projects, bridge construction, road construction, etc. and worked as the subcontractors of the past Japan's grant aid projects and ADB projects. Taking into account of these experiences, these contractors are considered to be capable of working as the subcontractors under the Japanese contractor for the Project. Although construction machineries are unavailable in the Project sites, they are available in Lae where is the proposed import port and the place to supply the construction materials. Consequently, a Japanese contractor is to direct the local subcontractors to perform the construction work.

Concerning procurement of labors, local staff for labor control will be suggested to support the Japanese engineers. Under them, the local foremen will be positioned. Technical transfer will be made throughout the construction period in the form of OJT (On-the Job Training). Common labors are also be locally procured.

Equipment for the water treatment plant and pump facilities are the main equipment of the Project. Therefore, they will be procured in Japan. Although straight PVC pipes are manufactured in PNG, they are inferior in quality, so that the PVC pipes will be procured in Australia where the materials are stably available in good quality.

As there are several companies for leasing the construction machineries in Port Moresby and Lae, they are to be leased in Lae and transported to the Project sites.

(3) Maintenance ability of the implementing agency

- Lorengau:

PNG Water Board, which is to take charge of maintenance of the Lorengau water supply system, is engaged in a transfer procedure for 2003. It is also contemplating to apply the governmental equity contribution to the most cost of the work (land acquisition, temporary operation, installation of water meters) under construction to be borne by PNG. Past experience shows that the Water Board has executed the procedure from budget application to completion of work in an ADB project (US$9.4 million：Third Urban Water Supply and Sanitation Project 1993 to 2001). In view of these achievements, it is expected that application procedures of the subsidy and transfer procedures be executed smoothly.

The progress of the procedures and budget allocation plans, prepared by the PNG Water Board in the basic design study period, will be monitored in the succeeding detailed design as well as construction stages.

- Goroka:

Goroka Urban Local Level Government has already acquired lands for this plan, and the expenses to be borne by PNG for construction are small (K91,200). Its share in the budget related with water supply (K601,000：estimated for the year 2000) is small, and it is expected that application of the budget will be smooth.

The progress of the procedures and budget allocation plans, prepared by Goroka Urban Local Level Government in the basic design study period, will be monitored in the succeeding detailed design as well as construction stages.

2-3-2 Basic Design

(1) Water demand

1) Service area

The service areas are limited to the existing service areas. The rates of population served are to be the same as present; 77% for Lorengau and 100% for Goroka.

2) Population served

The population served was forecast on the basis of the assumed national average population growth rate of 2.3% that was determined in the 2000 census, while taking into account the growth rate of the Project areas. The forecast total population and the population served in the year 2003 are shown in Table 2-1.

Table 2-1 Total population and population served（year 2003）

	Total population	Population served	Rate of population served
Lorengau	5,672 persons	4,341 persons	77 %
Goroka	23,589 persons	23,589 persons	100 %
Total	29,261 persons	27,930 persons	-

3) Water demand forecast

(a) Unit water demand

Unit water demands by consumers' categories are shown in Table 2-2.

Table 2-2 Unit water demands by consumers' categories

Consumers' categories	Unit demand
Domestic water	165 Liters/capita/day
School (resident student and daytime student)	70 Liters/capita/day
School (faculty men)	165 Liters/capita/day
Hospital	500 Liters/bed
Hotel	400 liters/room
Restaurant	2,500 liters/restaurant
Commercial	1,500 liters/shop
Office	1,000 liters/office

Domestic water：

According to the Design Manual of PNG Water Board, the unit demand for domestic use is 225 L/c/d. However, the proposed unit demand in the Project is 165 L/c/d, as a result of assessments of the current water consumptions in the Project areas and comparisons with the neighboring countries.

Other water demands (school, hospital, hotel):

The numerical values of the Design Manual of PNG Water Board were verified and formulated, in consideration of the actual situation of the Project areas.

Other water demands (restaurant, shop, office):

The monthly water consumption data of the Goroka's water charge ledger was reviewed. Unit demands were formulated based on the actual values.

2) Water demand forecast

The domestic water demand was forecast from the population served and the unit water demand in the year 2003.

For the other water demands, demands of year 2000 were calculated, based on the results of the survey on actual consumers' number and unit demand. The ratios of the other demand to the domestic water demand were achieved as 41% for Lorengau and 33% for Goroka respectively. Then, the other water demands in year 2003 were calculated by assuming that the ratios would remain the same. Table 2-3 shows the results of the calculation.

Table 2-3 Water demand forecast (year 2003)

	Unit demand	Lorengau		Goroka	
		Consumers	Demand	Consumers	Demand
Domestic water (Project area)	165 L/c/d	4,341 persons	716 m^3/d	23,589 persons	3,892 m^3/d
Domestic water (village)*	40 L/c/d	-	100 m^3/d	-	489 m^3/d
Sub total（A）			816 m^3/d		4,382 m^3/d
Other demands		41 % of (A)	331 m^3/d	33 % of (A)	1,427 m^3/d
Total			1,147 m^3/d		5,809 m^3/d

Note) The water demand of inhabitant in Goroka village is estimated by multiplying the projected population (12,235 persons) by unit demand (40 L/c/d) from the Design Manual of PNG Water Board.

(2) Design Capacity

To determine the design capacity, the design factors were employed as shown in Table 2-4.

Table 2-4 Design factors

(a)	Treatment Plant Use (TPU)		10 %
(b)	Leakage ratio		25 %
(c)	Daily maximum factor	Domestic water	1.2
(d)	Daily maximum factor	Other use	1.1
(e)	Hourly peak factor	Domestic water	1.8
(f)	Hourly peak factor	Other use	1.6

(a) Treatment Plant Use (TPU)

The consumption of the water treatment plant is approx. 115 m^3/d for Lorengau and 580 m^3/d for Goroka, or 10% of each demand, as determined from the requirement of water treatment plant facilities, including the filter washing water, etc.

(b) Leakage ratio

The leakage ratio is targeted to be 25% after the Project, through the following calculation.

-1 The leakage ratio by pipe materials after the Project was calculated. The leakage ratio of new pipes is assumed to be 10% for calculation. The leakage ratios of the existing distribution pipelines were calculated using the leakage volume calculation formula (“Practical Leakage Survey”, Japan Water Supply Technology Research Center).

-2 From the leakage ratio by pipe materials, the overall leakage ratio is calculated to be 14.2% (Lorengau) and 11.3% (Goroka), by using the weighted average of surface area ratio.

-3 Calculation of the leakage ratio of service pipes distributes the number of service pipes connected as of 2003 over the distribution pipeline length by materials. Assuming that the leakage ratio after replacement of service pipes is 10%, determine the weighted average from the number of pipes connected. The leakage ratio from service pipes can be calculated as 10.9% (Lorengau) and 25.1% (Goroka).

-4 Overall leakage ratio (2+3)
Lorengau：25.2%
Goroka：25.1%

(c) - (f) Daily maximum factor and hourly peak factor

The numerical values of the Design Manual of PNG Water Board were verified and formulated, in consideration of the actual situation of the Project areas.

The design capacities are shown in Table 2-5.

Table 2-5 Design capacities

<table>
<tr><th colspan="2"></th><th>Lorengau</th><th>Goroka</th></tr>
<tr><td colspan="2">Daily average water demand
(Total water demands)</td><td>1,147 m^3/d</td><td>5,809 m^3/d</td></tr>
<tr><td rowspan="2">Water supply volume</td><td>Daily average water supply
(Demand + Leakage volume)</td><td>1,529 m^3/d</td><td>7,745 m^3/d</td></tr>
<tr><td>Daily maximum water supply
(Daily ave. water supply x Daily max. factor)</td><td>1,791 m^3/d</td><td>9,104 m^3/d</td></tr>
<tr><td rowspan="3">Design capacities</td><td>Daily average intake capacity
(Daily max. water demand + TPU)</td><td>2,000 m^3/d</td><td>10,000 m^3/d</td></tr>
<tr><td>Design treatment capacity</td><td>2,000 m^3/d</td><td>10,000 m^3/d</td></tr>
<tr><td>Hourly peak water supply</td><td>111 m^3/hr.</td><td>565 m^3/hr.</td></tr>
</table>

(3) Facility plan

1) Lorengau

As above calculated, the design treatment capacity is 2,000 m^3/d. The existing plant constructed in 1995 is capable enough because its treatment capacity is 2,200 m^3/d

The flowchart of the Lorengau water supply system is illustrated as Fig. 2-1. The Project's components are summarized as Table 2-6.

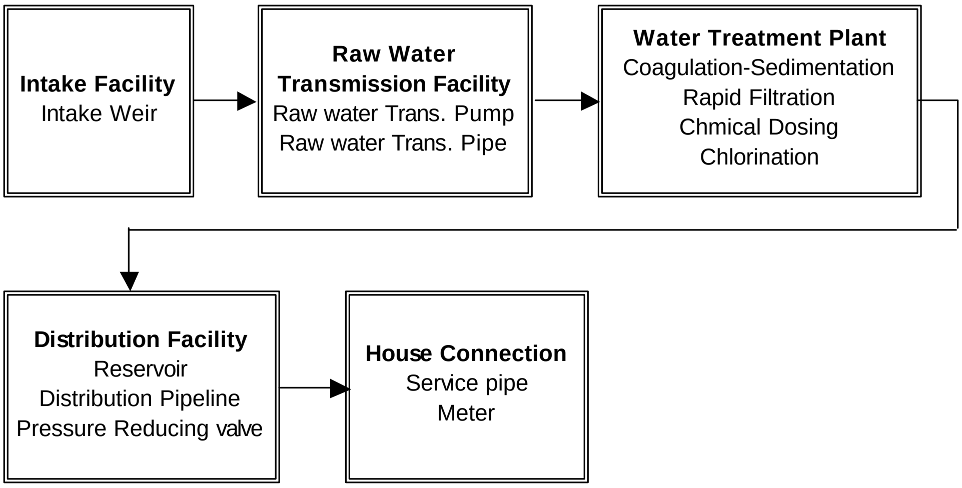


Fig. 2-1 Flowchart of the Lorengau Water Supply System

Table 2-6 The Project Components for Lorengau

Item	Implementation Plan	Quantity
-1 Intake facility	- Installation of water level indicator - Construction of intake (intake and screen)	1 unit 1 set
-2 Raw water transmission facility	- Replacement of raw water transmission pipe line, galvanized steel pipes Dia. 200mm - Replacement of raw water transmission pump - Construction of pumping house	Approx. 950 m 2 units 1 building
-3 Distribution reservoir	- Replacement of steel panel tank, total capacity 1,600m^3	2 units
-4 Distribution facility	- Replacement of galvanized steel pipes, PVC Dia. 50 - 200mm - Installation of pressure control equipment (Pressure reducing valve, Dia. 200 mm)	Approx. 6,470 m 1 set
-5 Flow meter	- Installation of flow meter to raw water and distribution pipes (Dia. 200 mm)	2 units
-6 Provision of equipment	- Water meter and cock - Small piping for meter installation (polyethylene pipe) - Water quality test kit	912 sets 912 sets 1 set

-1 Intake facility

Water intake for Lorengau is made with the weir installed directly upstream of the fall (approx. 37 m above sea water level) that is located about 2.5 km upstream from an estuary of the Lorengau River. Although the catchment area is small at about 9 km^2, the flow rate is stable even during dry season, because of constant rainfall throughout the year and forests covering the area. The annual average precipitation exceeds 3,000 mm, and the maximum flow at the fall point from 1979 to 1991 recorded 250 m^3/s.

There are records of the mean daily flow at the intake site from 1979 to 1991, although some data is missing. According to the record of 1982, 1987, 1988, and 1990 when river flow was low, the minimum river flow was 23 L/s recorded in November 1990. This is converted to an available water volume.

The existing water treatment capacity is 2000 m^3/day (23 L/s), that is approximately equivalent to the above available water volume. Minimum flow occurred once in eleven years, therefore the design intake capacity of 2000 m^3/day is reasonable.

Locations of the intake site are compared between the following two alternatives, A: Intake at the existing site and B: Intake at the down stream nearby the pump station.

Table 2-7 Alternative Intake Sites for Lorengau

	Alternative A Intake at the existing site	Alternative B Intake at the down stream
Intake weir	Repair of the existing facility	New construction of concrete weir H7m x W20m
Transmission pipeline	Dia.200 mm x 1.14 km	Dia.200mm x 190m
Altitude of the pump station	+27 m	+5 m
Total head of pump	Approx. 55m	Approx. 77m
Pump capacity	30 kW	42 kW

Alternative A includes replacement of existing raw water transmission pipeline of a total length of 1.14 m. Increase in the pipe size from the current 150 mm to 200 mm enables raising of the pumping yard location to a 27 m point. A pumping head of 55 m is enough in this case. On the other hand, Alternative B involves provision of the weir on the river channel for water intake, which requires the pumping head of 75 m. Differences between Plans A and B are compared in terms of the cost of "replacement of raw water transmission pipeline" and "weir construction cost plus the increment of maintenance cost due to an increase in the pumping head".

In Alternative B, an overflow type concrete weir is considered. With the existing maximum overflow rate of 250 m^3/s and the specific run-off of 30 $m^3/s/km^2$, the overflow rate for this project is assumed to be 270 m^3/s. As a tidal barrier, the crest height of overflow section is set to +1.0 m, so that the height of overflow section is about 3.0 m from the river bed. When the overflow water depth is added, the weir height can be determined. If the overflow width is assumed to be 20 m-long, the overflow water depth needs to be 4 m. Judging from the overflow rate, a 20 m-long or more energy dissipator is necessary on the downstream side.

Temporary cofferdam is a half-river closure, with a part of overflow section provided in a waterway on the right-bank side. Then, water is directed through the overflow section and the work on the left-bank side is made.

As aforementioned, Alternative B is disadvantageous in that it becomes a large scale work and the turbidity of raw water is high during flood. Comparison of these plans in terms of the work difficulty and construction cost, Alternative A is more inexpensive than Alternative B. In addition, Alternative A is more advantageous in maintenance and water quality. In consequence, Alternative A (using the existing intake facility) is adopted.

The weir main structure is constructed with concrete on the rock foundation and proves durable. Since there are leakage points on the right-bank side, the leakage prevention work is carried out for effective utilization.

Since the intake has a broken screen and the pipe position is difficult to be pinpointed, making maintenance difficult, it is necessary to replace. This is about 1.5 m-long and provided with a screen and a flashboard.

-2 Raw water transmission facility

The function of the raw water transmission facility is to transmit raw water from intake site (+37 m above sea water level) to the receiving well of the water treatment plant (+72 m). Raw water will be transmitted by gravity to the proposed pump station (+27m), and pumped up to the treatment plant (+72 m).

The existing transmission pipes (GSP, Dia. 150 mm) are so deteriorated that they will be replaced by new ones (GSP, Dia. 200 mm). The pipeline route up to the pumping station is the same as the existing one, but the route from the pumping station to the treatment plant is proposed to shift its route to under the public road, on account of maintenance.

Four water pipe bridges are to be constructed at points where the pipeline crosses the rivers and creeks. The general specifications of the proposed bridges are as Table 2-8.

Table 2-8 Proposed pipe bridge for raw water transmission facility

No.	Span length	Quantity	Specifications
1	Approx. 23 m	1 unit	Pipeline supported with a steel structure. Catwalk necessary for maintenance. Structure supporting columns made from concrete.
2	Approx. 18 m	1 unit	Ditto
3	Approx. 15 m	1 unit	Pipes dead weight to be supported by pipes themselves. Pipe to be galvanized steel pipe
4	Approx. 10 m	1 unit	Ditto

Gate valves, air valves, drain valves, and flexible joints necessary will be installed in accordance with the topographic conditions.

The booster pumping station consists of a pump suction pit and a pump house. Specifications of them are as follows:

Pump suction pit

- Structure：Rectangular shape concrete structure
- Capacity：Approx. 50m^3
- Accessories：Drain pipe, overflow pipe

Pump house

Structure：Concrete block wall, Reinforced concrete foundation
Area：Approx. 25m^2
No. of building: 1 no.

Two booster pumps will be installed in the pump house. The installation level of the pumps is to be lower than the pump suction pit LWL. The pumps can be operated control panels to be installed at both of the pump house and the treatment plant. The pump operation will be controlled by interlocking with the distribution reservoirs water level gauge. At HWL in the distribution reservoirs, the pump will stop automatically. In order to protect the pump, a pump idling prevention device and if necessary, a water hammer prevention device are to be installed. General specifications of the booster pumps are as follows:

- Type： Horizontal shaft centrifugal pump
- Capacity： 1460 Liters/min. x H56 m
- Power source： 415 V x 3 phase x 50 Hz
- No. of pumps： 2 sets (including one standby)
- Local control panel： Steel plate, self-stand type

-3 Distribution reservoir

The existing distribution reservoir is to be removed on account of its supperannuation. The HWL of the proposed reservoirs will be designed lower than LWL of the clean water tank of the existing water treatment plant, so that the water flows from the plant to the proposed reservoirs by gravity. In view of the construction space and maintenance, two tanks will be constructed. In line with construction of the reservoirs, piping around the tanks is disconnected from the existing reservoir and reconnected to the new ones.

The tank capacity is to be 1,600 m^3, the same as the existing tank. The capacity is composed of as follows:

- Daily maximum water supply for 12 hours： 900 m^3
- Backup in case of stop of intake： 417 m^3
- Backup for power failure： 167 m^3
- For fire fighting： 100 m^3
- Total： 1,584 m^3

Concrete and steel tank structures were compared for the reservoir. For the concrete tank structure, aggregates (sand and gravel) are difficult to procure locally and ready-mixed concrete is not available. Accordingly, aggregates must be transported from outside the island and construction of a large scale batch plant is not desirable economically when considering the concrete volume necessary for construction and that several units of mixers must be operated in the site. Under the above local conditions, it will require considerable technical skill and costs to maintain the concrete at the specified quality. The steel tank is satisfactory in workability and its durability is acceptable when considering that the existing steel panel tank has been used for 50 years or more. In consequence, a steel tank was designed for this project. The tank specifications are as follows:

- Material : Mild Steel
- Dimensions : 16m diameter x 5m height
- Capacity : 800 m^3
- No. of units : 2 units
- Accessories : Overflow pipes, drain pipes, air valves, inspection hole, check gallery

To adjust raw water and distribution flows, a flow meter is provided at the booster pump outlet and to the distribution reservoir outlet pipe. The type of the flow meter is direct indicator system with integrator.

-2 Distribution facility

Details of the distribution pipes to be constructed under the Project are shown in Table 2-9.

Table 2-9 Material, diameter and length of distribution pipes of Lorengau

Material	Diameter	Length
GSP	200 mm	920 m
GSP	100 mm	12 m
GSP	80 mm	45 m
PVC	200 mm	462 m
PVC	100 mm	1,869 m
PVC	80 mm	3,167 m
Total		6,475 m

Replacement of galvanized steel pipe

Galvanized steel pipes (GSP) are to be totally replaced because of considerable leakage at many points as well as at service pipes. The proposed material is PVC pipes (AS standard) that are locally available. GSP will be employed for water pipe bridges and the aboveground pipeline. After replacement with new pipes, the existing pipes will be left buried at the present position.

Change of route

The existing pipelines in the private lands and difficult accessibility will be relocated to new routes, along the public road in principle.

Enlargement of the pipe diameter/ pressure control

Distribution to the service area is made by gravity flow from the distribution reservoir. In an upland or area at the terminal of the pipeline, insufficient supply and other troubles occur due to pipeline leakage or insufficient pipe size. On the other hand, the middle portion of the distribution area faces a high risk of rupture of outdated pipes due to excessively high pressure. It is therefore essential to adjust the pressure. In order to overcome these problems, pipe network analysis must be conducted to review the pipe size. Loop pipeline must be employed to improve the insufficient pressure in the upland and at the terminal area. At the same time, pressure control must be used in the central area to ensure appropriate supply pressure.

Installation of hydrants

At present, there are only a few hydrants in Lorengau. In line with pipe replacement, new hydrants will be installed.

Connection of service pipes

For the section where the existing consumer service pipes are to be replaced by new ones, saddle and accompanying polyethylene pipes become necessary for restoration. Efforts must be made for completion of work within the short period for the service pipeline section where replacement is not made. PNG is to install the new water meters. The small piping up to the meter included in the scope of maintenance by Water Board will be procured.

2) Goroka

The flowchart of treatment process of the water supply system of this project is shown in Fig. 2-2. The contents of the project implementation is shown in Table 2-10.

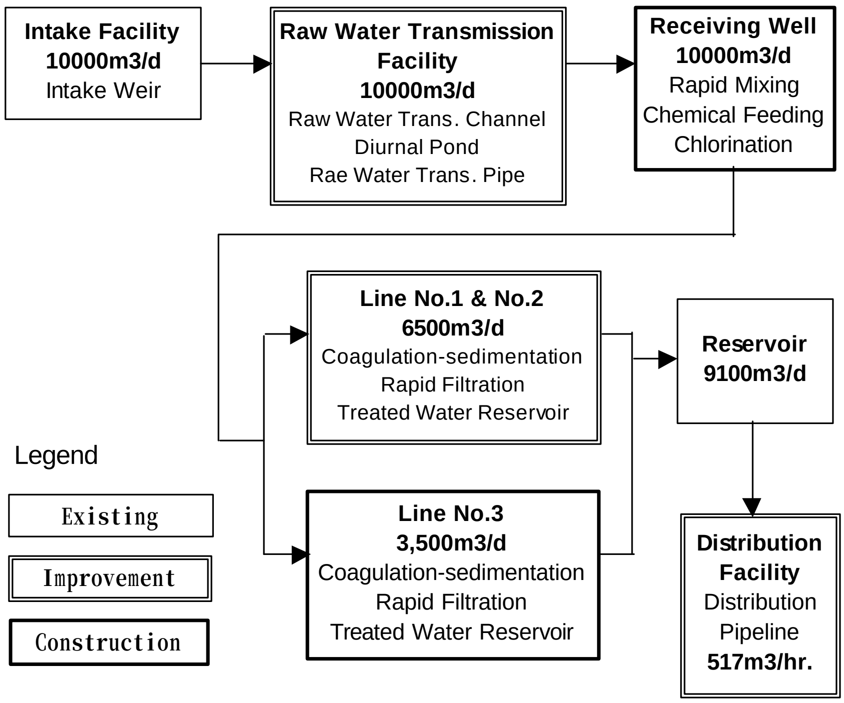


Fig. 2-2 Flowchart of the Goroka Water Supply System

Table 2-10 Project Components for Goroka

Item	Implementation Plan	Quantity
-1 Raw water transmission facility	- Partial improvement of raw water transmission channel (installation of corrugated steel pipe, Dia. 1,200 mm) - Replacement of flow regulating gate door (manual sluice gate、W1.2 m x H2.5 m) - Installation of inflow screen to raw water transmission pipeline - Replacement of raw water transmission pipeline (from reservoir outlet to water treatment plant, GSP, Dia. 300 mm)	231 m 1 gate 1 unit 900 m
-2 Rehabilitation of water treatment plant Design capacity : 6.500m^3/d	- Replacement of valves in the plant - Removal of chemical dosing equipment - Removal of disinfection equipment - Replacement of filter sand - Reconstruction of filter backwashing system	8 pieces 1 set 1 set 5 tanks 1 set
-3 New construction of receiving/mixing tank	- Construction of receiving well (tank and diversion device) - Construction of rapid mixing tank (tank, mixer)	1 set 1 set

Design capacity : 10,000 m^3/d	- Installation of the chemical dosing system (alum, soda ash) - Installation of chlorine dosing system - Construction of chemical dosing chamber	1 set 1 set 1 building
-4 Addition of water treatment equipment Design capacity: 3,500 m^3/d	- Construction of the coagulation/ sedimentation facility - Construction of rapid filtration facility - Installation of mechanical and electric equipment - Installation of connection pipes and valves	2 tanks 8 beds 1 set 1 set
-5 Drainage facility	- Construction of sludge sedimentation lagoon	2 lagoons
-6 Miscellaneous work	- Construction of access roads in the plant - Leveling of the land planned for the plant	1 set 1 set
-7 Distribution reservoir	- Replacement of drain valve (Dia. 250mm)	1 piece
-8 Distribution pipes	- Replacement of ACP with PVC (Dia. 80 mm to 300mm) - Restoration of the existing service pipes	19.3km 2000 points
-9 Provision of equipment	- Water meter, service pipes - Sludge discharge pump - Water quality testing apparatus - Portable flow meter	1200 pcs. 1 set 1 set 1 unit

-1 Raw water transmission facility

Raw water flows through the open channel, reservoir, and raw water transmission pipeline to reach the water treatment plant. The existing raw water transmission facility will be rehabilitated and renewed.

The existing sluice gate installed near the intake in the open channel is to be removed and replaced with a new manual sluice gate. The sluice gate is provided to stop intake and to regulate the flow for maintenance and emergencies. Dimensions and other specifications are the same as those for the existing sluice gate. Design conditions of channels where the gate is installed are as follows:

- Channel width : Approx. 1.2 m
- Average water depth : Approx. 1.1 m
- Ground height from channel bottom : Approx. 2.0 m

In the open channel, corrugated steel pipes for a length of 250 m will be newly installed. As the water from this channel is used for a fish-breeding pond, etc., the existing flow must be secured. Therefore, the size of corrugated steel pipe is Dia. 1.2 m to secure the flow equal to the flow running through the existing channel section. The existing average flow is estimated to be about 48,000 m^3/d to 53,000 m^3/d. The corrugated steel pipe is buried in the existing channel and covered with embankment.

Raw water is transmitted from the reservoir outlet to the water treatment plant through the raw water transmission pipeline. Water intake is made with the existing intake in the reservoir. A coarse bar screen is provided at the intake to remove of wood chips and vinyl into the raw water transmission pipeline.

The existing GSP and ACP provided from the reservoir to the water treatment plant are replaced by new ones Dia. 300 mm. The design conditions are as follows:

- Flow rate ： 10,000 m^3/d （0.116 m^3/sec.）
- Distance ： approx. 250 m
- Flow velocity in pipeline ： 1.63m/sec

-2 Rehabilitation of the existing water treatment plant

The maximum operation capacity of the existing water treatment plant is 6,500 m^3/d. Of existing equipment, chemical dosing and chlorination equipment that are either deteriorated in performance or unusable are all removed. Together with the newly added facility of 3,500 m^3/d, the equipment with a capacity of 10,000 m^3/d will be installed within the additional facility. Integration of equipment will offer merits, such as easy operation and maintenance and reduction of construction costs.

Filter sand in the existing filter are either reduced in size due to wear or unhygienic due to adhesion of sludge, so that they are totally replaced. The volume of sand for replacement is about 40m^3. Filter sand specifications are 2.57～2.67 in specific gravity and 0.6 mm in the effective size.

Backwashing of the existing filter is made by feeding the washing water to the filter by a pump. As the existing pump performance is deteriorated, it is necessary to replace the pump. Since the new water treatment plant to be added is located at a place higher than the existing plant, the difference in elevation is used to provide the washing water through natural gravity flow from the clean water reservoir of the new plant. Therefore, the pump in the existing plant is removed.

Valves in the existing equipment are removed if damaged. Table 2-11 shows valves to be replaced.

Table 2-11 Replacement of valves in water treatment plant

Facilities	Name of valve	Specifications	Quantity
No.1 facility	Raw water valve	Dia. 200 mm sluice valve	2 sets
	Reservoir inlet valve	Dia. 200 mm sluice valve	1 set
	Filter inlet valve	Dia. 200 mm sluice valve	1 set
No.2 facility	Sedimentation tank inlet valve	Dia. 200 mm sluice valve	1 set
	Filter drainage valve	Dia. 300 mm butterfly valve	2 sets
	Filter clean water valve	Dia. 250 mm butterfly valve	1 set
Total			8 sets

-3 Construction of new receiving and mixing tanks

When the receiving well is constructed, inflow of raw water into the existing and the added facilities can be put together. The receiving well is to measure the raw water flow. The facility design capacity is 10,000 m^3/d. Considering water detention time in the receiving well, the tank capacity will become about 34m^3. The concrete tank structure will be of a rectangular shape. For the raw water flow meter, an electromagnetic flow meter is used, which enables indicating, recording, and integration.

The concrete-made mixing tank is necessary to mix raw water with chemicals and will be a rectangular in shape. The tank capacity is about 32m^3 when detention time is assumed to be 4 minutes. A mechanical mixer is installed in the tank to enhance mixing efficiency. The mixer to be used will be of a suspension type to facilitate maintenance.

Raw water that has passed through the mixing tank will be distributed to facilities, including the existing No.1 and 2 lines and the added No.3 line. The direct indicating type flow meter and regulating valve are used for water distribution.

Chemicals are dosed before the mixing tank. Such chemicals are alum for coagulation, soda ash for pH control, and chlorinated lime for disinfection. Because of safe quality of raw water, the chlorine consumption through the treatment process is small. By integrating dosing points into one, the common machinery can be used for all systems, which in turn makes maintenance easier and construction cost lower.

The chemical dose rate relative to the facility design water supply is shown in Table 2-12. The chemical dosing ratio was determined through a dosing test in the site.

Table 2-12 Chemical dosing rate

Chemicals		Alum (10% solution)	Soda ash (5% solution)	Chlorinated lime (3% solution)
Maximum	Dosing rate	30 mg/L	8 mg/L	2 mg/L
	Dosing volume	119 L/h	63.5 L/h	27.8 L/h
Average	Dosing rate	20 mg/L	5.5 mg/L	1 mg/L
	Dosing volume	79.4 L/h	47.67 L/h	13.9 L/h
Minimum	Dosing rate	10 mg/L	3 mg/L	1 mg/L
	Dosing volume	39.6 L/h	23.8 L/h	13.9 L/h

Note：Chlorine content of chlorinated lime is 65%.

The required number of chemical dosing pump is three at 10,000 m^3/d with reference to the raw water flow of 3,500 m^3/d. One is used as a standby and in cases of high turbidity.

Table 2-13 Specifications of chemical dosing equipment

		Alum	Soda ash	Chlorinated lime
Dissolving tank	Capacity	2,000 liters	2,000 liters	1,000 liters
	Material	Polyethylene	Polyethylene	Polyethylene
	Quantity	2	2	2
Dosing pump	Capacity	0.7 L/hr.	0.37 L/hr.	0.16 L/hr.
	Type	Diaphragm	Diaphragm	Diaphragm
	Quantity	4	4	4
Others		Dissolution basket, mixer	Dissolution basket, mixer	Dissolution basket, mixer

Assuming that the storage of chemicals is for one month of average dosing rate, the required overall storage space is about 20 m^2.

The building space necessary for the chemical dosing equipment is about 180m^2.

The chemical chamber will be constructed near the mixing tank of block structure.

-4 Addition of water treatment equipment

The design supply flow of the facility to be added is 3,500 m^3/d. Analysis of raw water showed that all items excluding turbidity met the drinking water standard of PNG. The turbidity is high throughout the season and 10 to 20 degrees for 125 days on an average during the rainy season (January to March, September to November). The number of days when turbidity exceeds 2 degrees of the PNG drinking standard value is a total of 200 days a year. This facility is constructed mainly to remove the turbidity.

Principal equipment in the water treatment facility includes the coagulation/sedimentation tank and filter. Their design specifications are shown in Table 2-14.

Table 2-14 Equipment design specifications of water treatment facility

	Coagulation tank	Sedimentation tank	Filter	Clean water tank
Detention time	30.2 min	191 min	120 m/d (filtration rate)	68 min
Tank volume	73.5 m^3	463 m^3	30m^2 (filtration bed area)	165 m^3
Head loss	500 mm	50 mm	3,200 mm	—
Structure	RC	RC	RC	RC
Type	Vertical baffling type	Horizontal baffling type	Rapid filtration	—
No. of units	2 nos	2 nos	8 nos	1 no
Others	—	—	Self-washing＋surface washing	—

-5 Construction of the drainage facility

The drainage facility will treat the sludge drainage effluent from the sedimentation tank and backwashing drainage from filtration tank. The quality of effluent from the existing facilities is approximately as shown in the table below.

Table 2-15 Water quality (drainage)

Item	Backwashing drainage from filtration tank	Sludge drainage from sedimentation tank	Effluent standard
BOD_5	3 mg/L	15 mg/L	120 mg/L
Chloride ions	≦ 1 mg/L	≦ 1 mg/L	—
Total coliforms	0 colonies/100 mL	0 colonies/100 mL	3,000 colonies/100 mL
Dissolved oxygen	6.9 mg/L	3 mg/L	—
PH	7.4	7.0	5.8 - 8.6
Total nitrogen	1.02 mg/L	2.5 mg/L	—
SS	130 mg/L	2,500 mg/L	150 mg/L

There is no effluent standard in PNG. Consequently, General Standard of the Water Pollution Control Law of Japan will be applied. Heavy metals are not contained in the raw water, so their content in drainage is less than the effluent standard value. All of water quality items in filter washing water are below the discharge standard level and filter-washing water need not be treated. Drainage from the sedimentation tank has high SS and must therefore be treated. Most of the SS consists mainly of grit and soil from the river.

In the drainage facility system, SS is treated to 150 mg/L with a lagoon in which gravity sedimentation is made after charge of coagulant. Supernatant water is released into a river. Settled sludge is dried by the sun and discharged to the outside with a truck. The design specifications for the drainage lagoon are as follows.

- Average turbidity of raw water : 5 mg/L
- Chemical dosing ratio : 20 mg/L (aluminum sulfate)
- Mass of SS : 96.9 kg-DS/d
- Drainage volume : 38.8 m^3/d
- Sedimentation velocity : 10 mm/min
- Lagoon area : 31.9 m^2
- Structure : Reinforced concrete

-6 Miscellaneous works at the water treatment plant

The water treatment plant yard is divided into the existing treatment plant space and the additional new plant space. It is essential to establish communications between these spaces. For this purpose, a connection road is necessary within the yard. This road will be a 5 m wide concrete made. The new treatment plant system is based on gravity flow utilizing difference in elevation. Therefore, it is necessary to prepare the land to ensure the correct ground height of the facility according to the hydraulic calculation.

-7 Development of distribution reservoir

Among the distribution reservoirs in Mt. Kiss, Reservoir No.1 is suffering leakage from the distribution pipeline valve, which will be replaced. The size of the drainage valve, which is a sluice valve of cast iron, is 250mmφ.

-8 Distribution facility

The pipe type, size, and length of pipeline work implemented in this project are shown in Table 2-16.

Table 2-16 Renewal of distribution pipeline

Material	Diameter	Length
PVC	300 mm	345 m
PVC	250 mm	880 m
PVC	200 mm	3,133 m
PVC	150 mm	1,641 m
PVC	100 mm	7,823 m
PVC	80 mm	7,356 m
Total		21,178 m

Replacement of asbestos cement pipes

The existing asbestos cement pipe (ACP) was installed in 1960s and has exceeded its life serviceability (25 years as stipulated in the Cabinet Order for The Local Public Enterprise Law of Japan). Actually, a rupture accident related to pressure resistance is reported. All of these ACPs are to be replaced by PVC, and existing ACPs will be left buried there after being replaced.

Blocked distribution area

Distribution is made through natural gravity flow, but control of the water volume and pressure are not set up for each area. In certain highland areas, there is almost no water pressure and each house has to take self-help measures such as installing a booster pump or rainwater storage tank. On the other hand, in areas near the distribution main or in low-elevation areas, the risk of leakage from outdated pipes is extremely high because of excessive water pressure, causing leakage within the house.

Therefore, the distribution area is divided according to the topographical conditions to enable control of the water volume and pressure in each block (block division). In pipelines where the hydraulic analysis shows the problem of pressure fluctuation, the pressure-regulating valves are provided to secure the appropriate water pressure.

Installation of flow meters for neighboring villages

The existing system has almost no flow meter. Direct indicate type with integrator water meters are provided at the distribution reservoir outlet and main branch section to ensure efficient water supply distribution. Additionally, to enable water rate collection and reduce waste of water, flow meters are installed at eight points along the service pipes to ten villages.

Construction of portable flow meter pit for control of distribution volume

A portable ultrasonic flow meter procured to be in Japan is used to control the distribution volume. For this purpose, a flow control installation pit (concrete) is constructed at required locations. This will facilitate control of the distribution flow rate and enable effective reduction of leakage.

Connection restoration work of service pipes

During replacement of pipes, connection to the service pipe and hydrant of each house from the existing pipeline will be changed over to a connection from the new distribution pipeline.

(4) Provision of Equipment

The result of a review over the necessity of equipment requested from PNG is shown below. Equipment necessary for this project is summarized in Tables 2-17 and 2-18.
Water charge collection is essential for sound operation of the water utility. At present, water charge collection using water meters is executed only in part of Goroka. The project's executive agency plans to collect water charges. In PNG, piping materials are imported. General procurement of materials will contribute to reduction of the meter installation work period while the use of polyethylene pipes will minimize the number

of connections, promoting prevention of leakage.

At present, there are no water quality testing appliances, which hinders adequate facility operation and assurance of safe water supply. Therefore, the PNG counterpart is requesting procurement of water quality analysis equipment. Water quality control includes analysis that should be executed routinely, that is, (i) daily, (ii) monthly, and (iii) yearly. In the case of (ii) and (iii), the equipment will become large in scale and moreover it is difficult to recruit qualified operators. Therefore, (ii) and (iii) must be entrusted to public agencies, such as the university, etc. Consequently, simple analysis apparatus will be procured for daily water quality inspection. All apparatus must be simple ones enabling manual analysis, and a Japanese contractor will explain the usage thoroughly during the construction period.

Table 2-17 List of equipment to be procured under the Project for Lorengau

Purpose	Equipment	Quantity	Applications
Water charge collection	Water meter and cock	912 sets	Installed to service pipes to measure water consumption of consumers for collection of water charges
	Saddle and small piping for installation of the water meter	912 sets	Material for connection from distribution pipeline to water meter
Water quality analysis	Jar-tester	1 unit	Used for coagulation test and checks the optimum chemical feeding ratio to ensure optimum flocculation
	Turbidimeter	1 unit	Used for the above test
	PH meter	1 unit	Used to determine the alkaline agent feeding ratio to adjust pH of treated water.
	Residual chlorine meter	1 unit	Used to check if disinfecting chlorine is left in the effective volume at the pipe end. According to the Japanese Waterworks Law, the residual total chlorine should be 0.3mg/L or more.
	Total coliforms, standard plate count bacteria	1 set	Used to check for pollution of the treated water.

Table 2-18 List of equipment to be procured under the Project for Goroka

Purpose	Equipment	Quantity	Application
Water charge collection	Water meter and cock	1,200 sets	Installed to service pipes to measure water consumption of consumers for collection of water charges
Water quality analysis	Jar tester	1 unit	Used for coagulation test and checks the optimum chemical feeding ratio to ensure optimum flocculation
	Turbidimeter	1 unit	Used for the above test
	pH meter	1 unit	Used to determine the alkaline agent feeding ratio to adjust pH of treated water.
	Residual chlorine meter	1 unit	Used to check if disinfecting chlorine is left in the effective volume at the pipe end. According to the Japanese Waterworks Law, the residual total chlorine is 0.3mg/L or more.
	Total coliforms, standard plate count bacteria	1 set	Used to check for pollution of the treated water.
Maintenance of raw water transmission facility	Sludge discharge pump	1 set	Improvement of sludge discharge from the reservoir from manual to mechanical operation
Leakage check	Portable flow meter	1 unit	Flow meter for leakage check (ultrasonic)

List of Drawings

(1) Lorengau

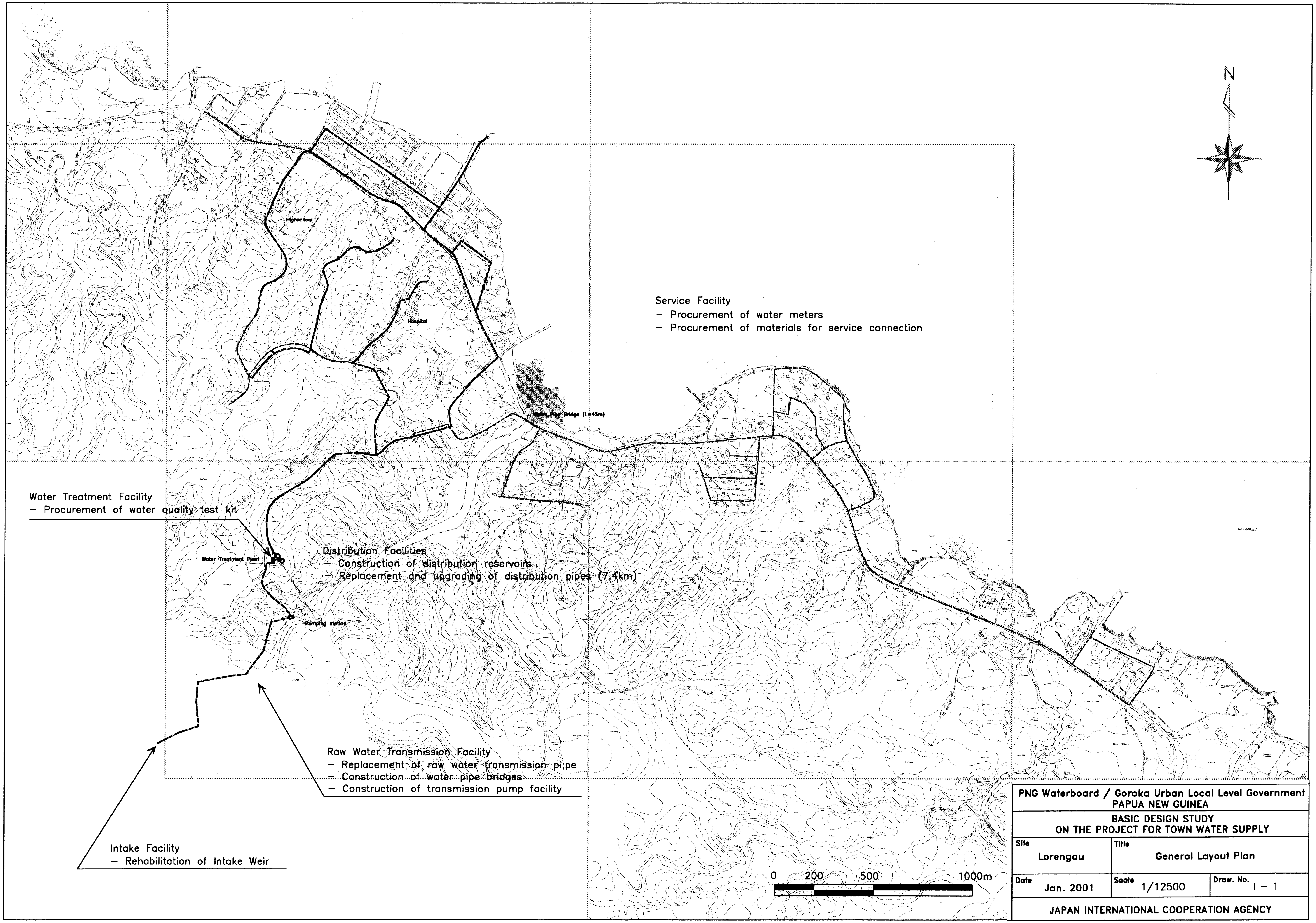
No.	Title	Scale
I-1	General Layout Plan	1/12500
I-2	Intake / Raw Water Transmission Facilities	1/3500
I-3	Raw Water Transmission Pump Station	1/60
I-4	Water Treatment Plant Layout Plan	1/150
I-5	Distribution Reservoir	1/150
I-6	Distribution Pipelines (Key Plan)	1/12500
I-7	Distribution Pipelines (1)	1/6500
I-8	Distribution Pipelines (2)	1/6500

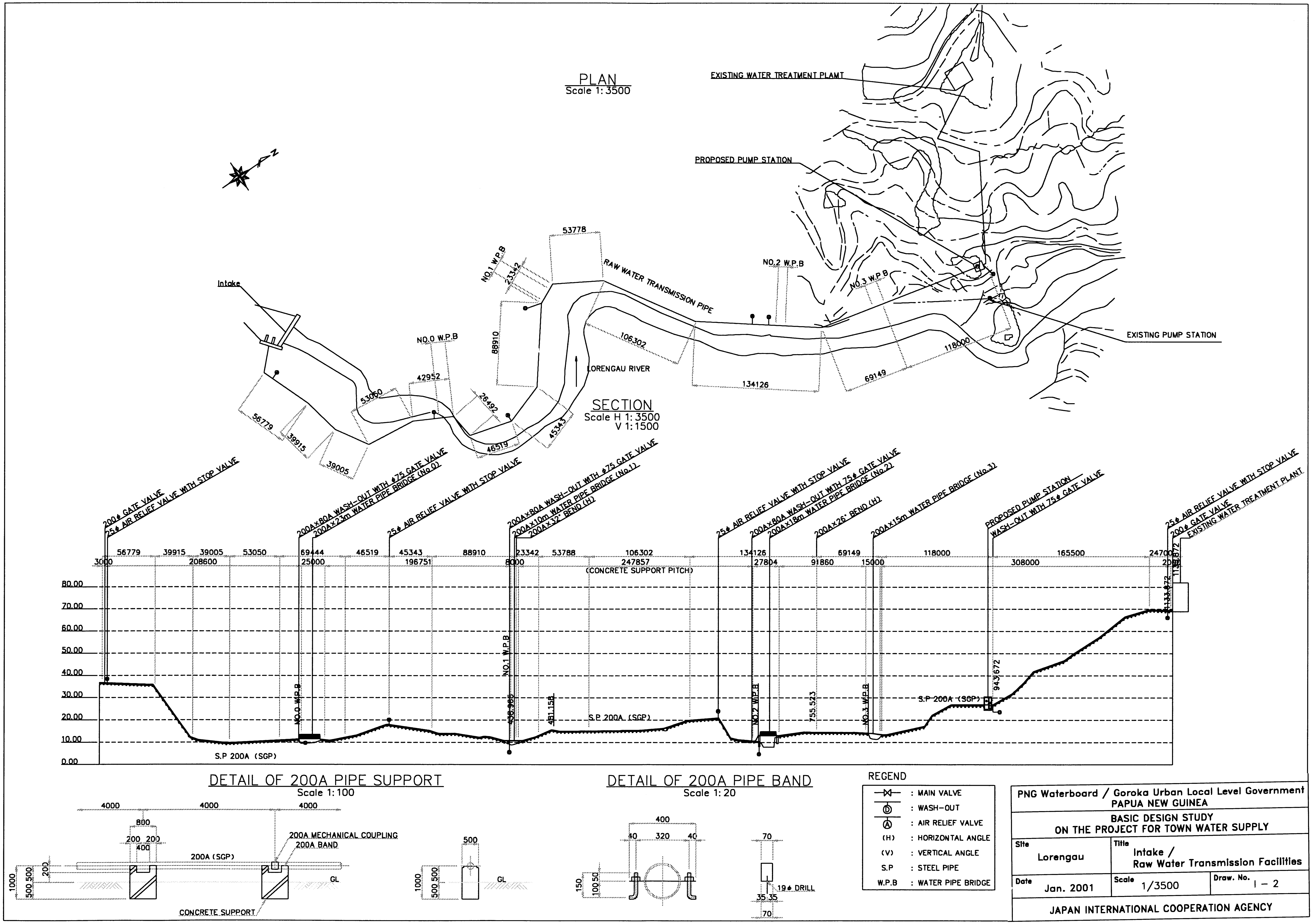
(2) Goroka

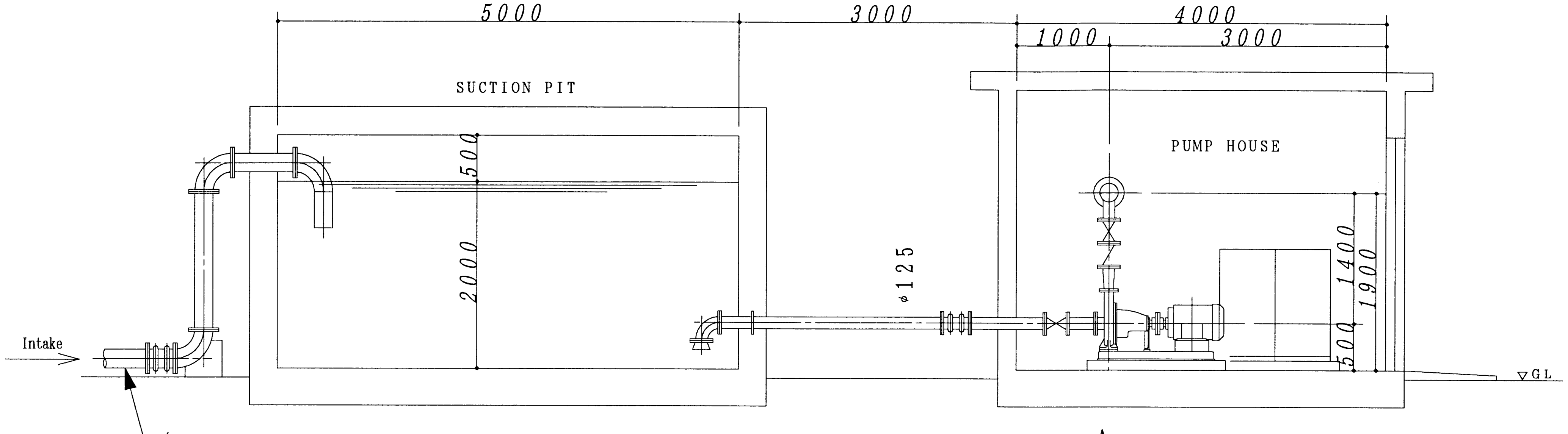
No.	Title	Scale
II-1	General Layout Plan	1/12500
II-2	Intake Facility	1/50
II-3	Raw Water Transmission Facility	Non
II-4	Water Treatment Facilities – Flow Diagram	Non
II-5	Water Treatment Facilities – Layout Plan	1/800
II-6	Existing WTP – Improving Plan	1/200
II-7	Proposed WTP ー Receiving Well	1/100
II-8	Proposed WTP ー Sedimentation Basin	1/100
II-9	Proposed WTP ー Filter Bed	1/100
II-10	Proposed WTP ー Chemical Room	1/100
II-11	Proposed WTP ー Sludge Sedimentation Lagoon	1/100
II-12	Distribution Pipelines (Key Plan)	1/12500
II-13	Distribution Pipelines (1)	1/6500
II-14	Distribution Pipelines (2)	1/6500
II-15	Distribution Pipelines (3)	1/6500

(3) Common

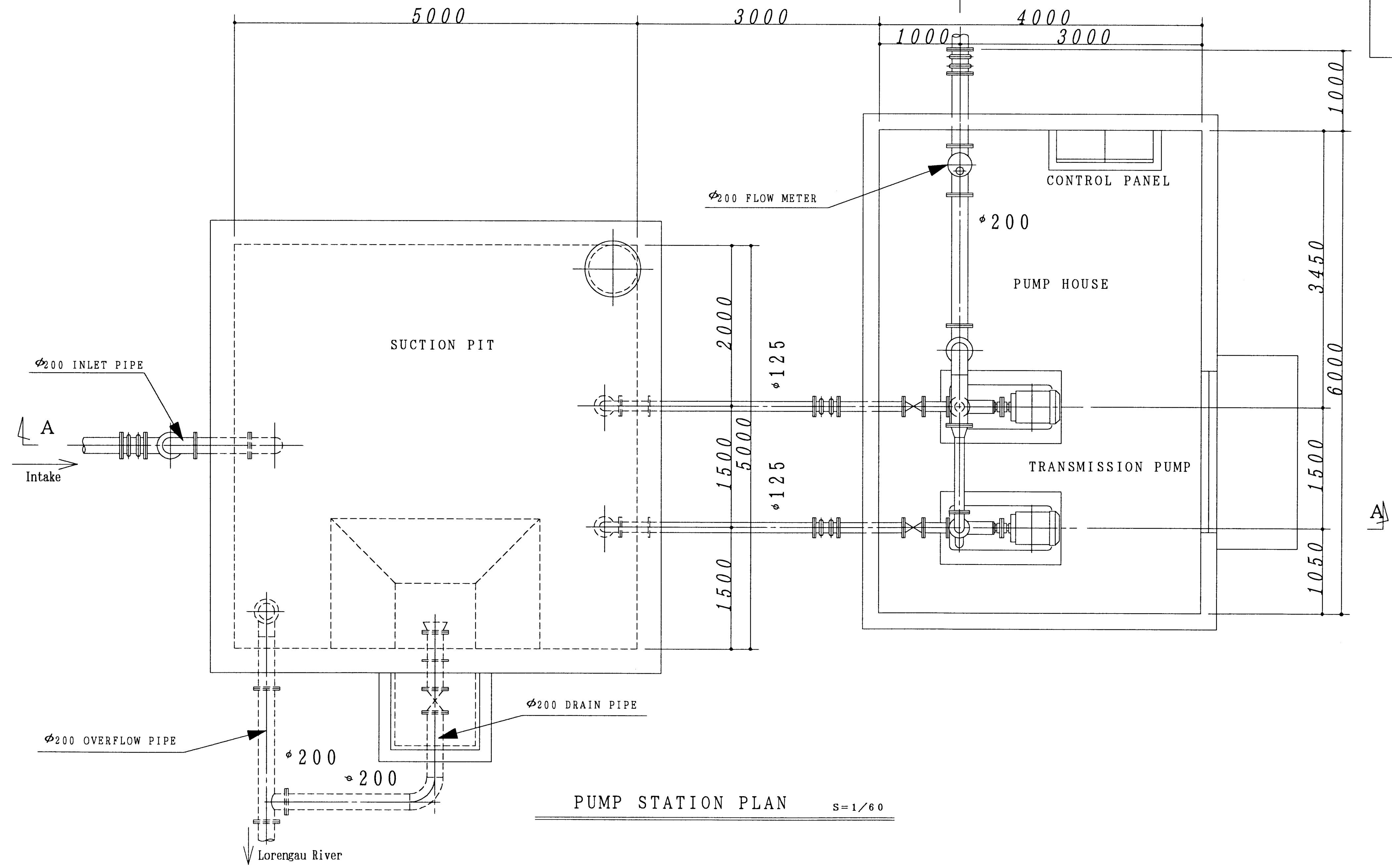
No.	Title	Scale
III-1	Trench Work Standard (Intake / Transmission Line)	1/10
III-2	Trench Work Standard (Distribution Line)	1/10


N
Service Facility
– Procurement of water meters
– Procurement of materials for service connection
Highschool
Hospital
Water Pipe Bridge (L=45m)
Water Treatment Facility
– Procurement of water quality test kit
Water Treatment Plant
Distribution Facilities
– Construction of distribution reservoirs
– Replacement and upgrading of distribution pipes (7.4km)
Pumping station
Raw Water Transmission Facility
– Replacement of raw water transmission pi;pe
– Construction of water pipe bridges
– Construction of transmission pump facility
Intake Facility
– Rehabilitation of Intake Weir
0 200 500 1000m
PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY
Site
Lorengau
Title
General Layout Plan
Date
Jan. 2001
Scale
1/12500
Draw. No.
I – 1
JAPAN INTERNATIONAL COOPERATION AGENCY

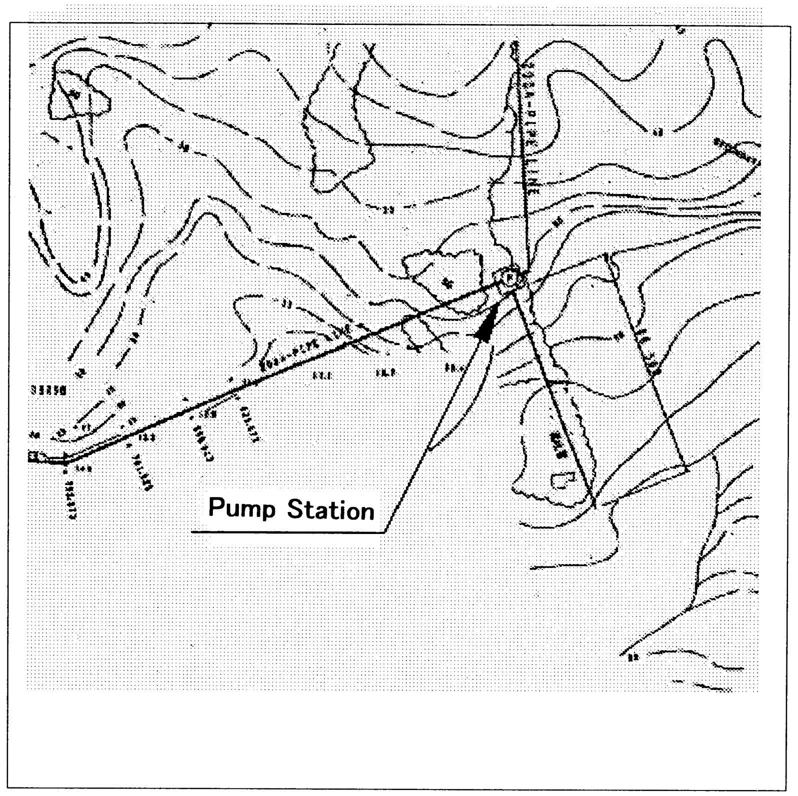

PLAN
Scale 1: 3500
EXISTING WATER TREATMENT PLAMT
PROPOSED PUMP STATION
EXISTING PUMP STATION
Intake
RAW WATER TRANSMISSION PIPE
LORENGAU RIVER
NO.0 W.P.B
NO.1 W.P.B
NO.2 W.P.B
NO.3 W.P.B
SECTION
Scale H 1: 3500
V 1:1500
200φ GATE VALVE
25φ AIR RELIEF VALVE WITH STOP VALVE
200A×80A WASH-OUT WITH φ75 GATE VALVE
200A×23m WATER PIPE BRIDGE (No.0)
25φ AIR RELIEF VALVE WITH STOP VALVE
200A×80A WASH-OUT WITH φ75 GATE VALVE
200A×10m WATER PIPE BRIDGE (No.1)
200A×32° BEND (H)
25φ AIR RELIEF VALVE WITH STOP VALVE
200A×80A WASH-OUT WITH 75φ GATE VALVE
200A×18m WATER PIPE BRIDGE (No.2)
200A×26° BEND (H)
200A×15m WATER PIPE BRIDGE (No.3)
PROPOSED PUMP STATION
WASH-OUT WITH 75φ GATE VALVE
25φ AIR RELIEF VALVE WITH STOP VALVE
200φ GATE VALVE
EXISTING WATER TREATMENT PLANT
(CONCRETE SUPPORT PITCH)
S.P 200A (SGP)
DETAIL OF 200A PIPE SUPPORT
Scale 1: 100
200A MECHANICAL COUPLING
200A BAND
200A (SGP)
CONCRETE SUPPORT
GL
DETAIL OF 200A PIPE BAND
Scale 1: 20
19φ DRILL
REGEND
: MAIN VALVE
: WASH-OUT
: AIR RELIEF VALVE
(H) : HORIZONTAL ANGLE
(V) : VERTICAL ANGLE
S.P : STEEL PIPE
W.P.B : WATER PIPE BRIDGE
PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY
Site Lorengau
Title Intake / Raw Water Transmission Facilities
Date Jan. 2001
Scale 1/3500
Draw. No. I – 2
JAPAN INTERNATIONAL COOPERATION AGENCY



SECTION A - A S=1/60

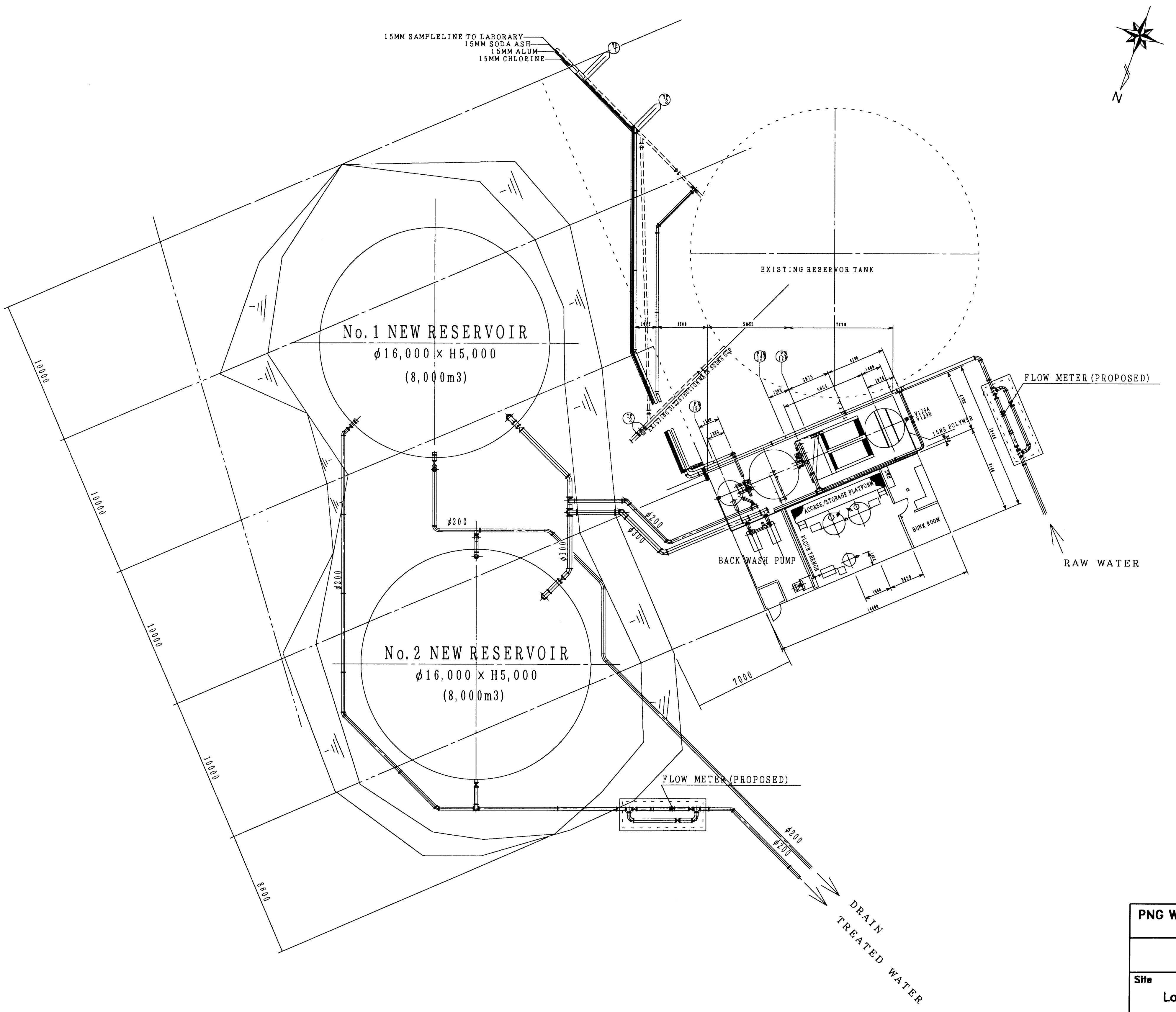


PUMP STATION PLAN S=1/60



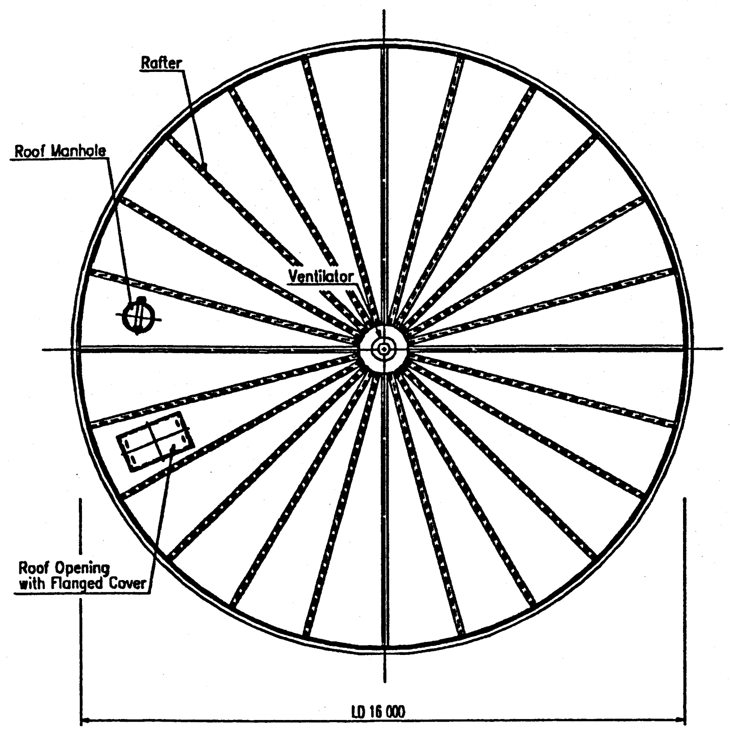
Location Map (Non scale)

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA	
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY	
Site: Lorengau	Title: Raw Water Transmission Pump Station
Date: Jan. 2001	Scale: 1/60 — Draw. No. I - 3
JAPAN INTERNATIONAL COOPERATION AGENCY	

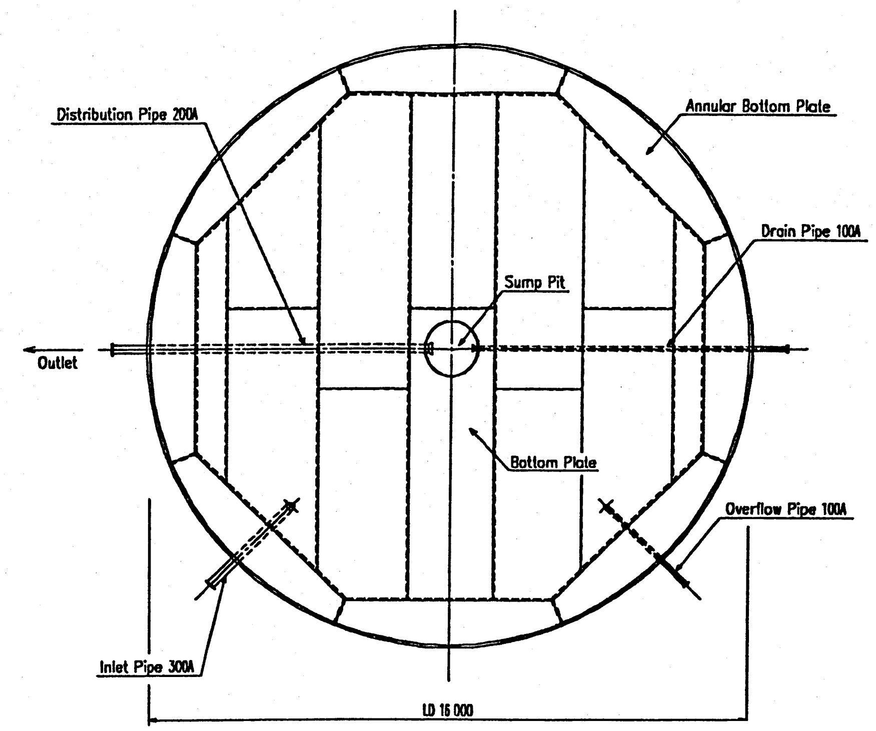


PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Lorengau	Title: Water Treatment Plant Layout Plan	
Date: Jan. 2001	Scale: 1/150	Draw. No.: I – 4
JAPAN INTERNATIONAL COOPERATION AGENCY		

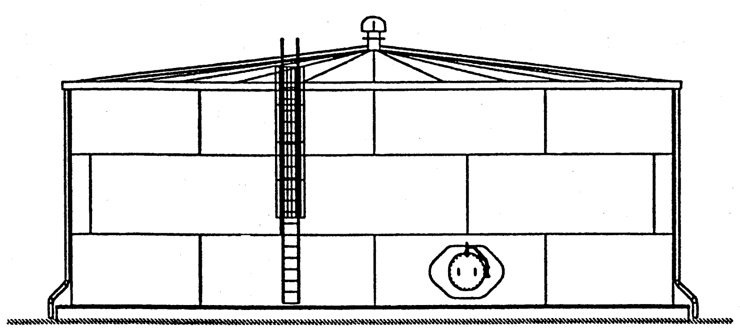
ROOF PLAN



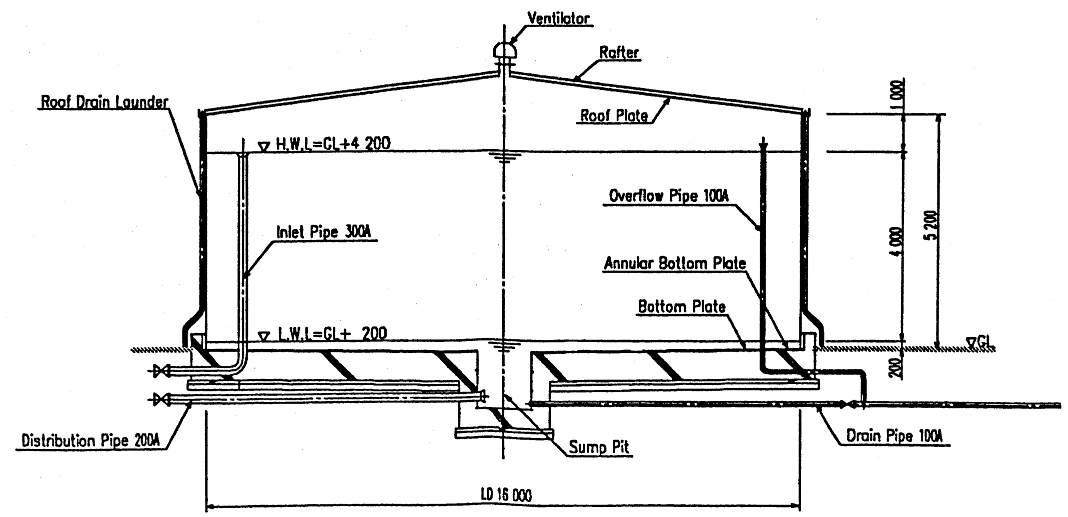
BOTTOM PLATE PLAN



SIDE VIEW

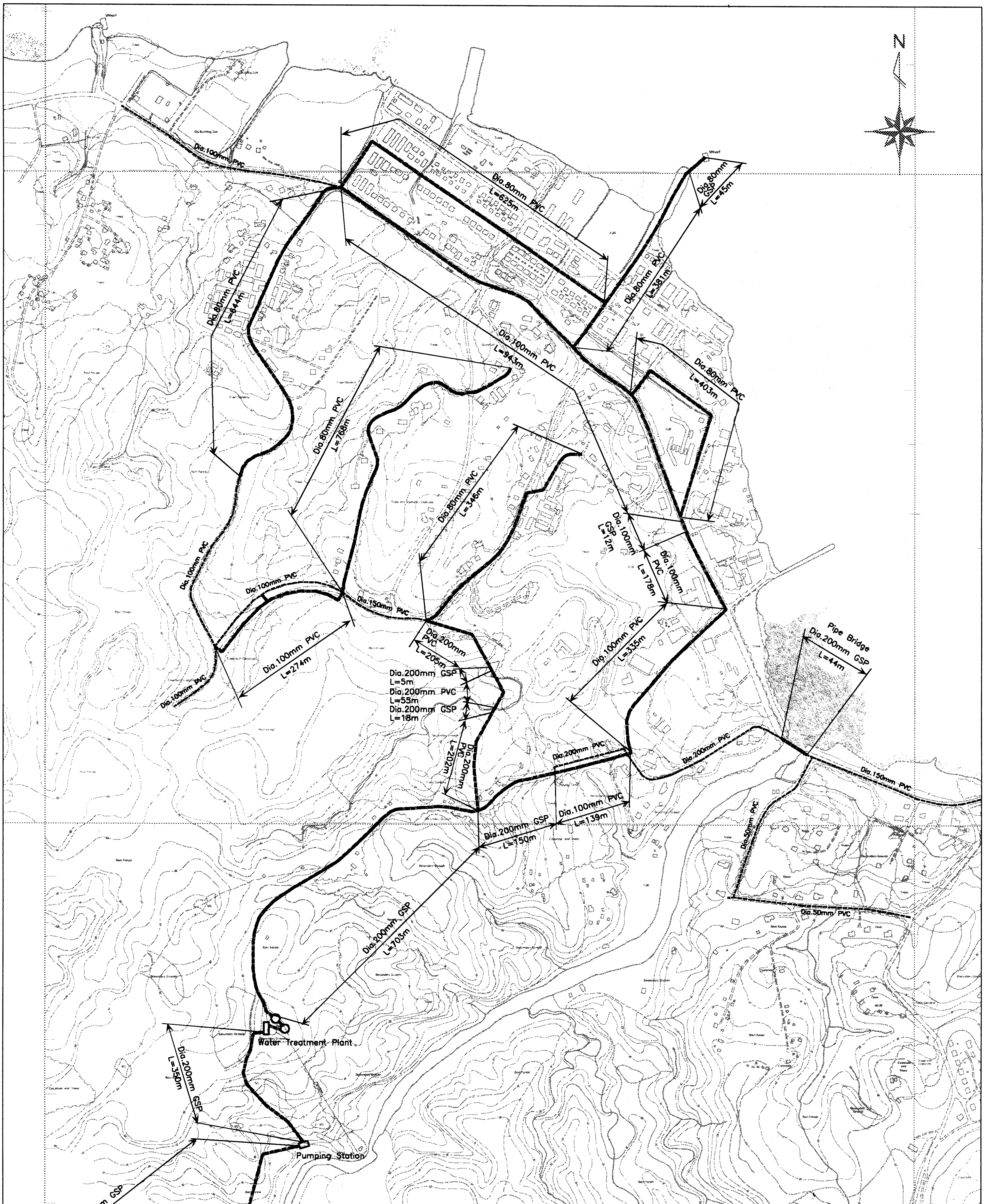


CROSS SECTION

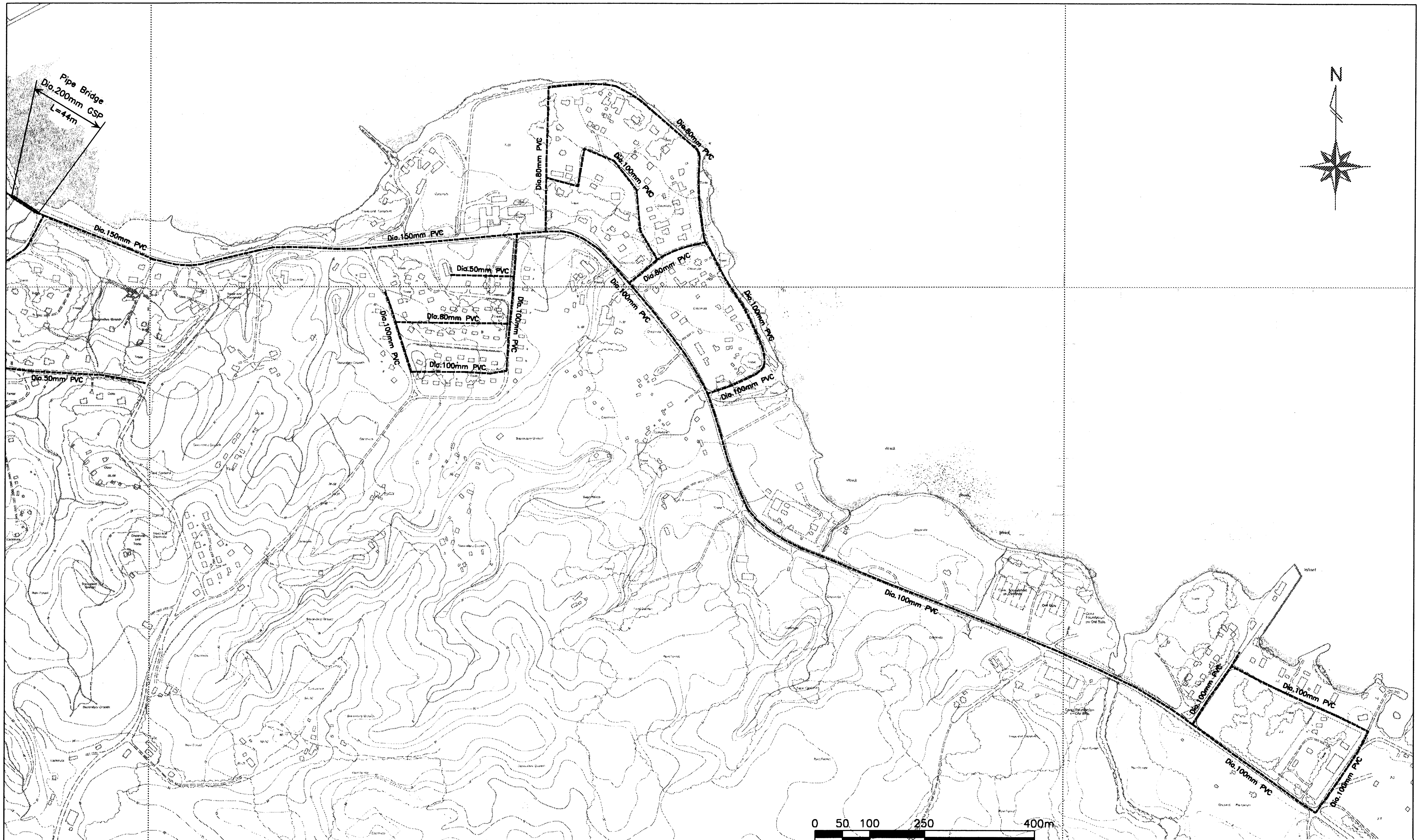


PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Lorengau	Title Distributution Reservoir	
Date Jan. 2001	Scale 1/150	Draw. No. I – 5
JAPAN INTERNATIONAL COOPERATION AGENCY		

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Lorengau	Title Distribution Pipelines (Key Plan)	
Date Jan. 2001	Scale 1/12500	Draw. No. I – 6
JAPAN INTERNATIONAL COOPERATION AGENCY		



PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Lorengau	Title: Distribution Pipelines (1)	
Date: Jan. 2001	Scale: 1/6500	Draw. No.: I – 7
JAPAN INTERNATIONAL COOPERATION AGENCY		

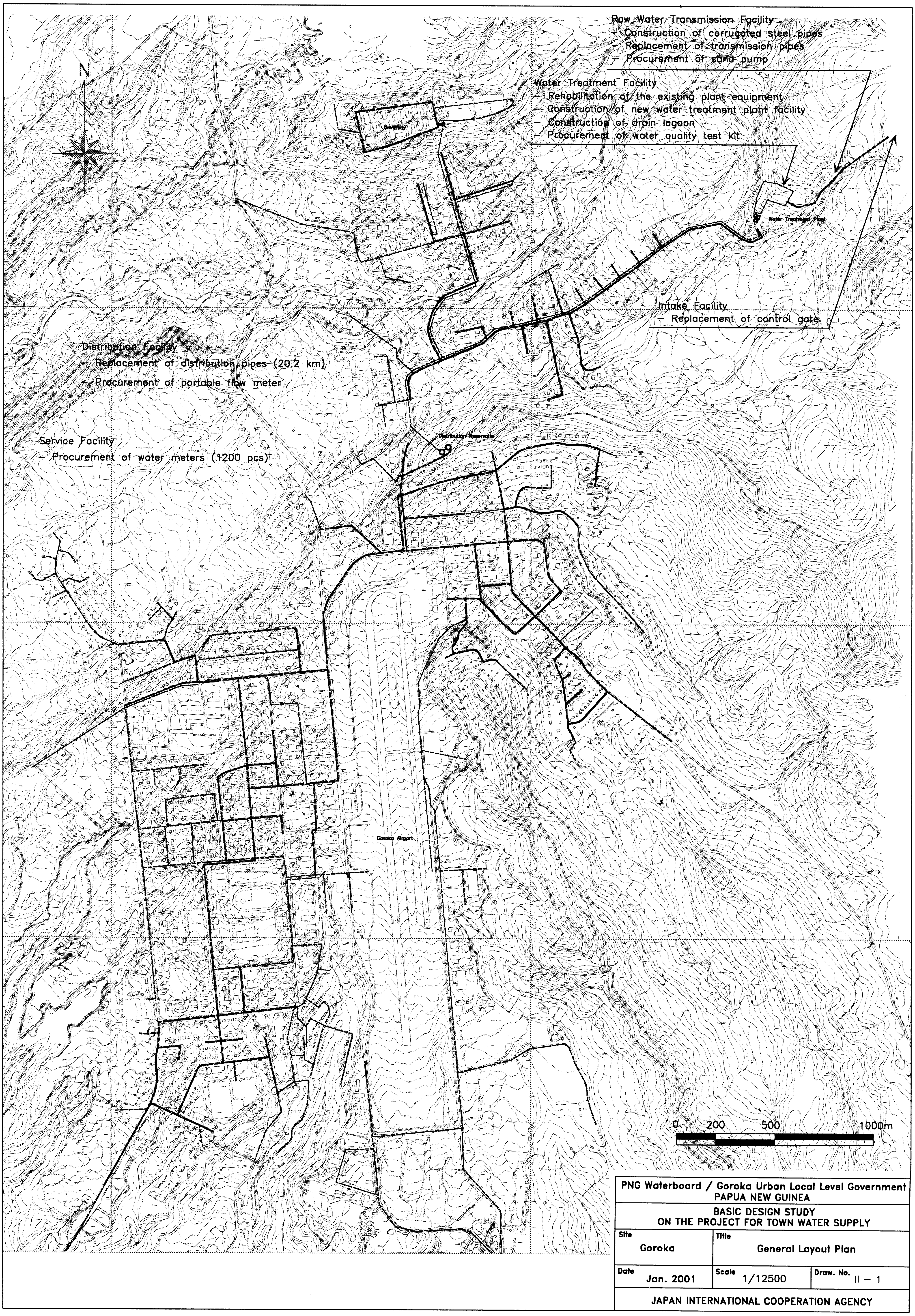


PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA

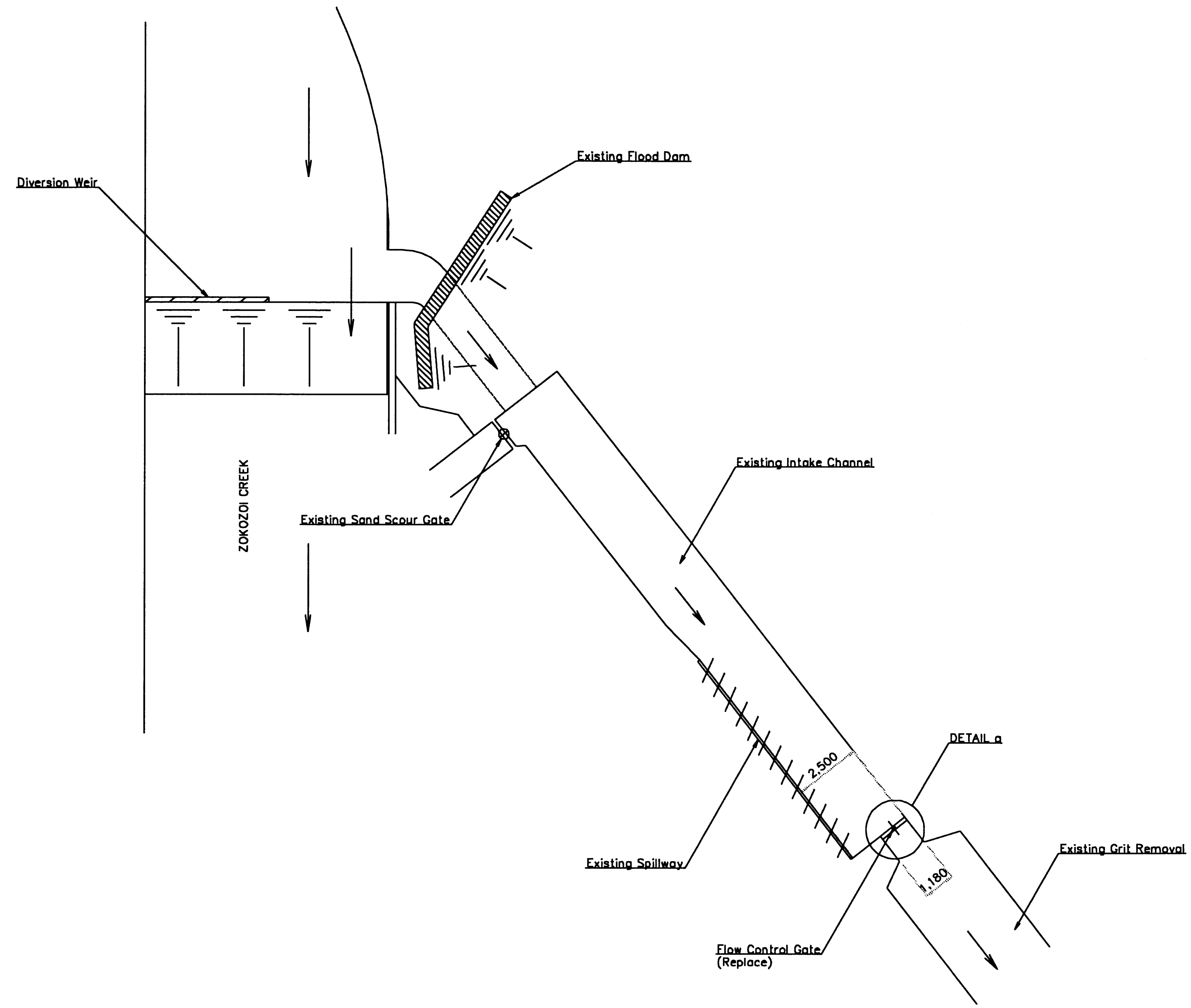
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY

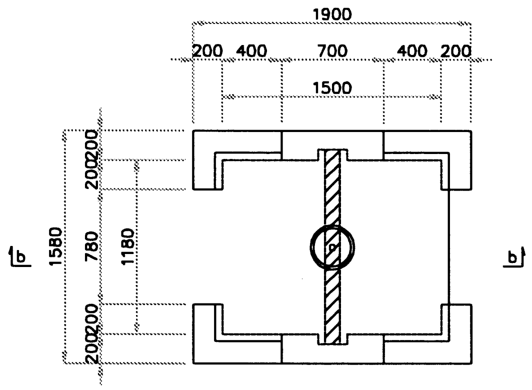
Site	Title	
Lorengau	Distribution Pipelines (2)	
Date: Jan. 2001	Scale: 1/6500	Draw. No.: I – 8

JAPAN INTERNATIONAL COOPERATION AGENCY

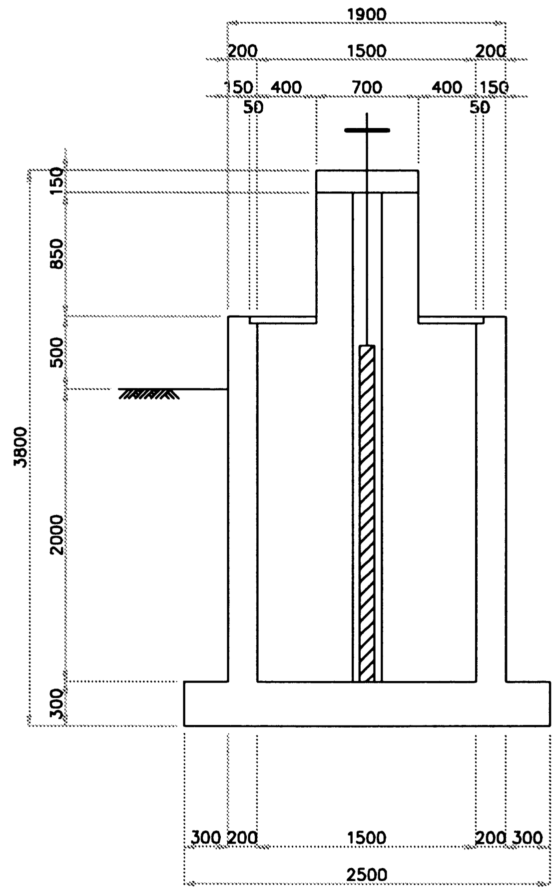


PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Goroka	Title: General Layout Plan	
Date: Jan. 2001	Scale: 1/12500	Draw. No. II – 1
JAPAN INTERNATIONAL COOPERATION AGENCY		





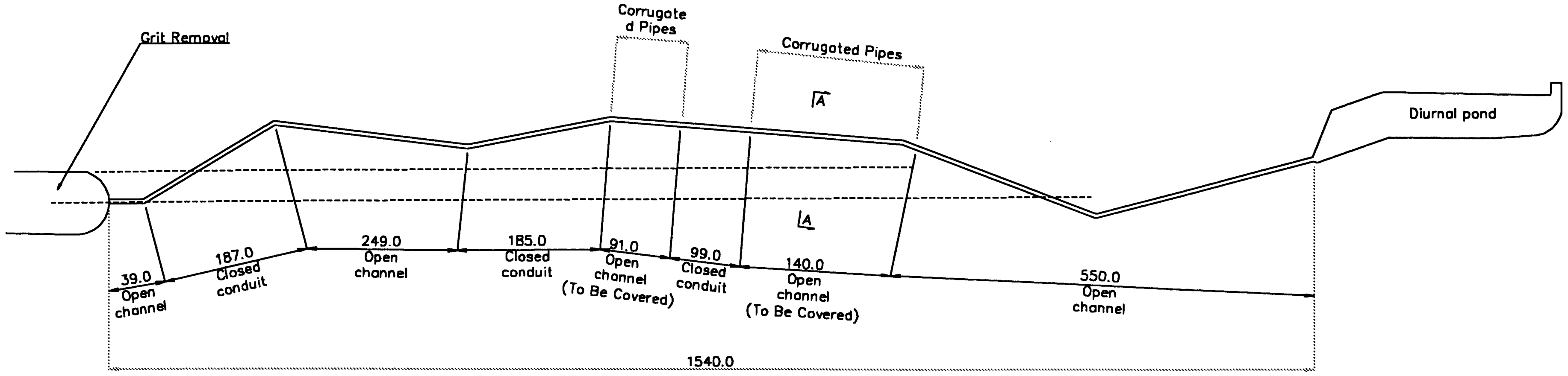
DETAL a
S=1:50



SECTION b−b
S=1:50

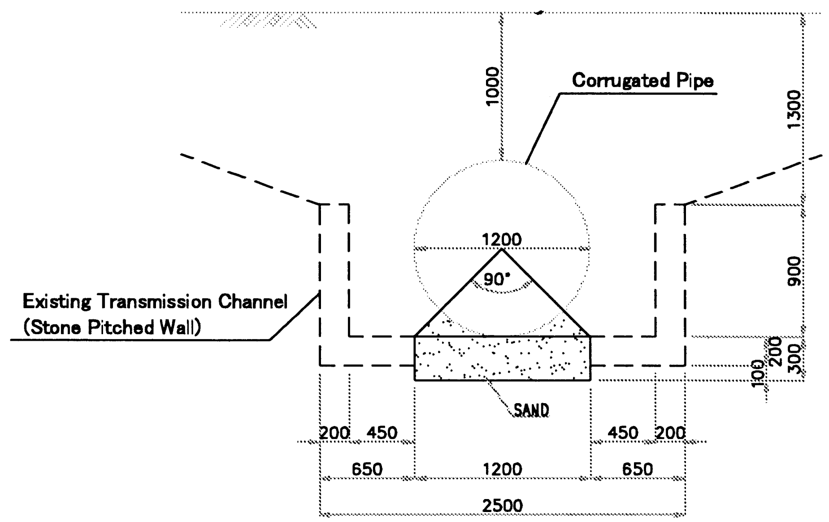
PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Goroka	Title Intake Facility	
Date Jan. 2001	Scale 1/50	Draw. No. II − 2
JAPAN INTERNATIONAL COOPERATION AGENCY		

Transmission Channel

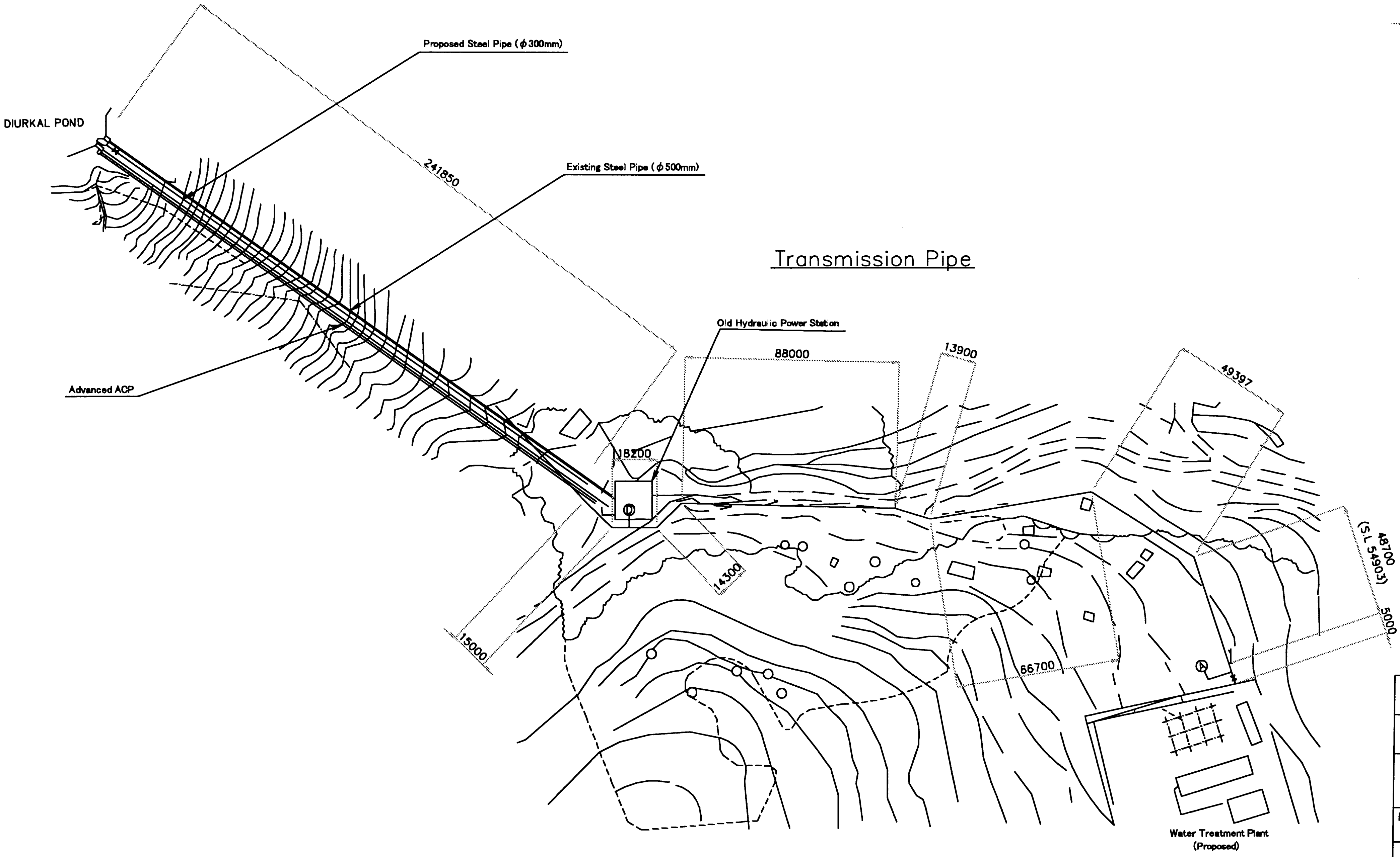


SECTION A–A

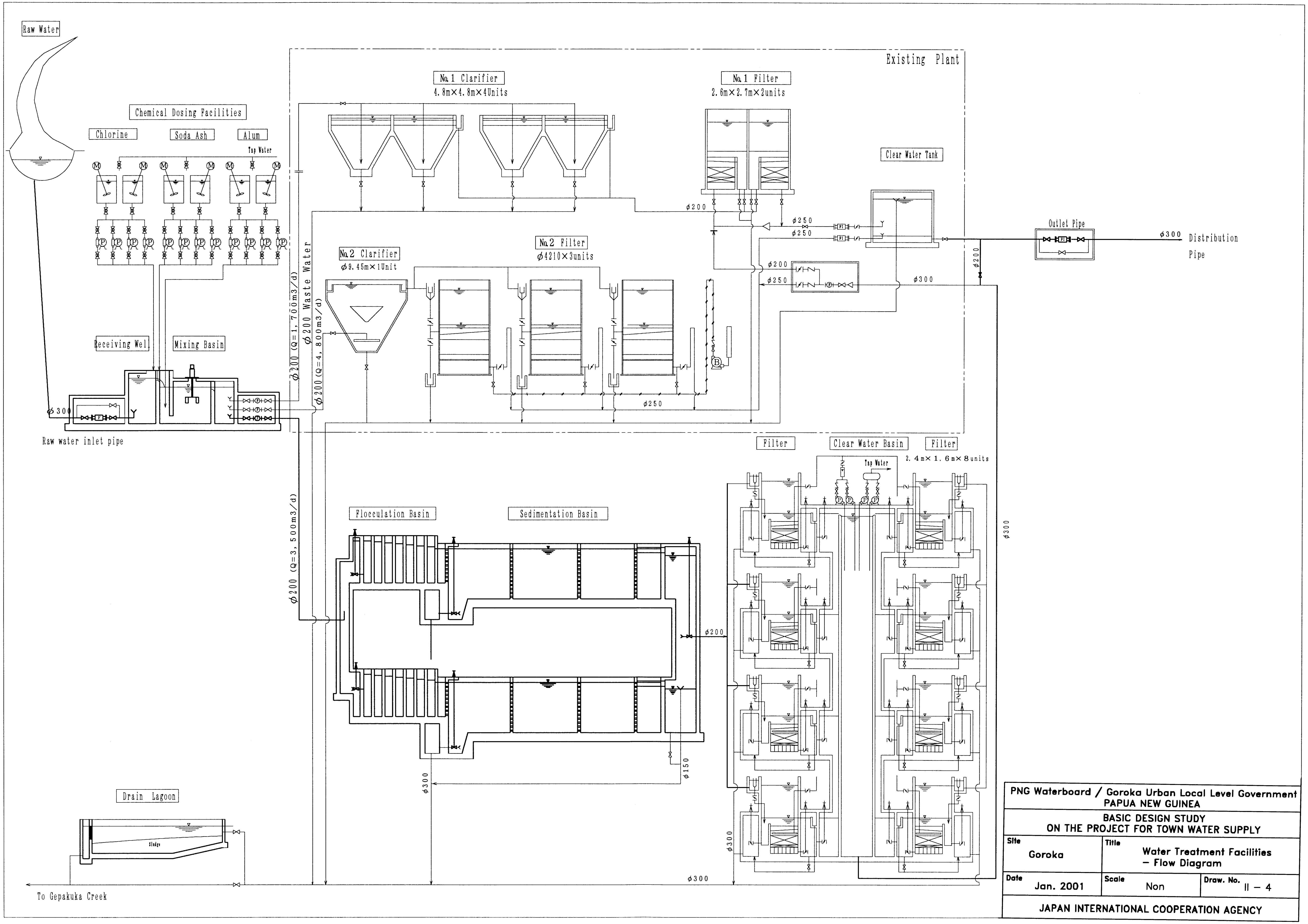
S=1: 50



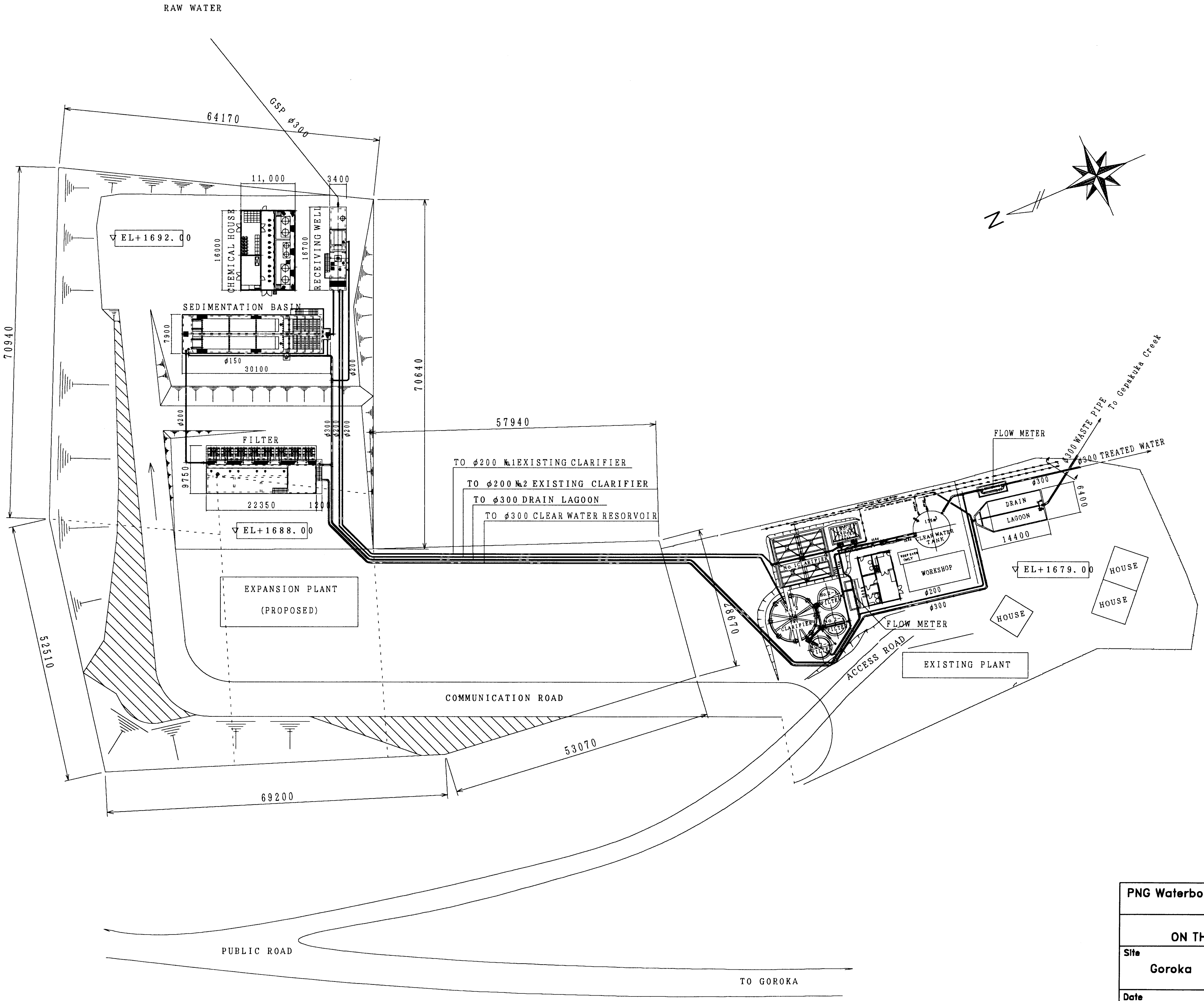
Transmission Pipe



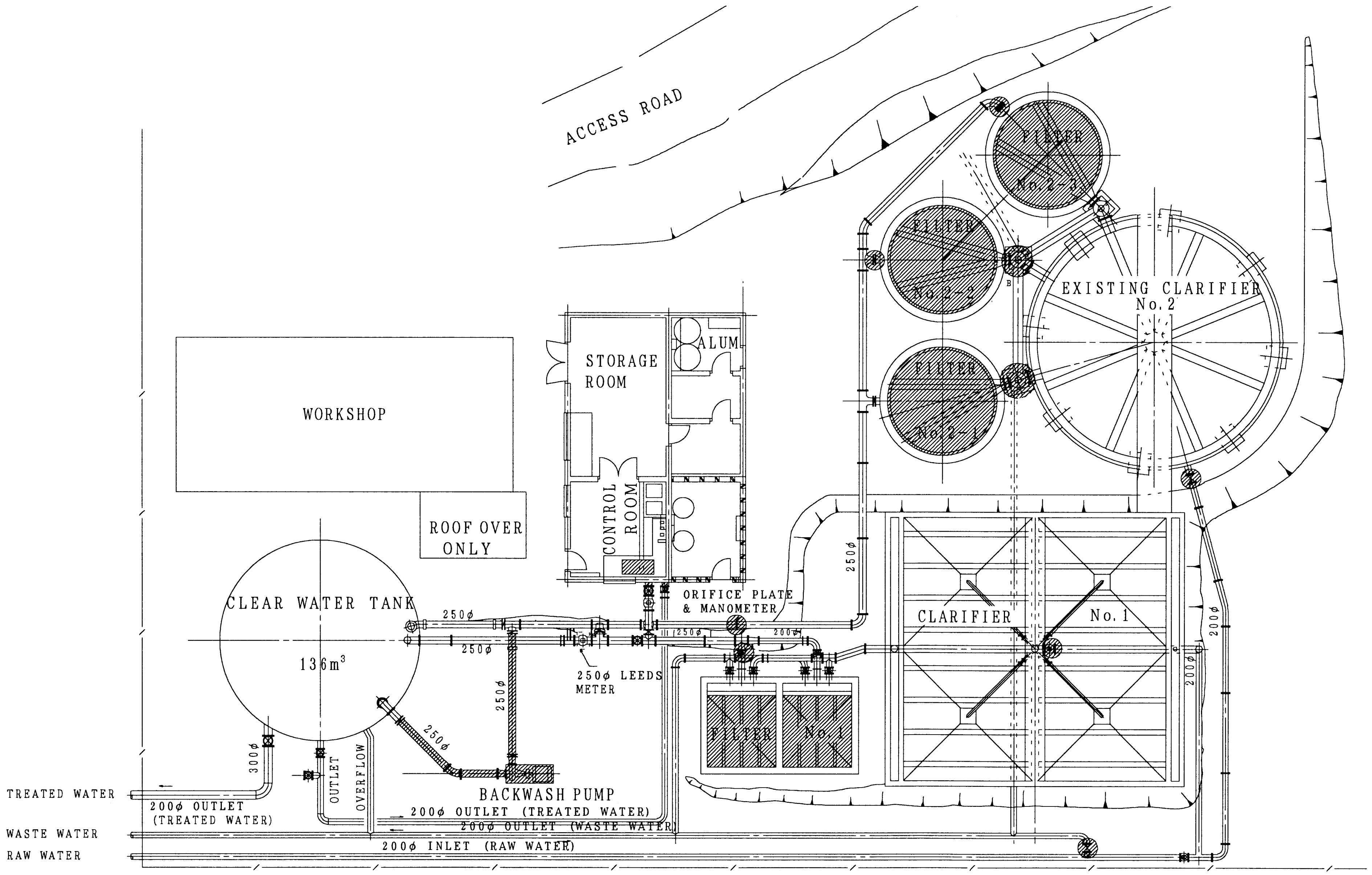
PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Goroka	Title Raw Water Transmission Facility	
Date Jan. 2001	Scale Non	Draw. No. II – 3
JAPAN INTERNATIONAL COOPERATION AGENCY		



Raw Water
Existing Plant
No.1 Clarifier
4.8m×4.8m×4Units
No.1 Filter
2.6m×2.7m×2units
Chemical Dosing Facilities
Chlorine
Soda Ash
Alum
Tap Water
Clear Water Tank
φ200
φ250
φ250
Outlet Pipe
φ300 Distribution Pipe
No.2 Clarifier
φ9.45m×1Unit
No.2 Filter
φ4210×3units
φ200
φ250
φ300
φ200
φ200 (Q=1,700m3/d)
φ200 Waste Water
φ200 (Q=4,800m3/d)
Receiving Well
Mixing Basin
φ300
Raw water inlet pipe
φ250
Filter
Clear Water Basin
Filter
2.4m×1.6m×8units
Tap Water
φ200 (Q=3,500m3/d)
Flocculation Basin
Sedimentation Basin
φ200
φ300
φ300
φ150
φ300
Drain Lagoon
Sludge
To Gepakuka Creek
φ300
PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY
Site
Goroka
Title
Water Treatment Facilities
– Flow Diagram
Date
Jan. 2001
Scale
Non
Draw. No.
II – 4
JAPAN INTERNATIONAL COOPERATION AGENCY



PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Goroka	Title: Water Treatment Facilities – Layout Plan	
Date: Jan. 2001	Scale: 1/800	Draw. No.: II – 5
JAPAN INTERNATIONAL COOPERATION AGENCY		



Improvement Parts

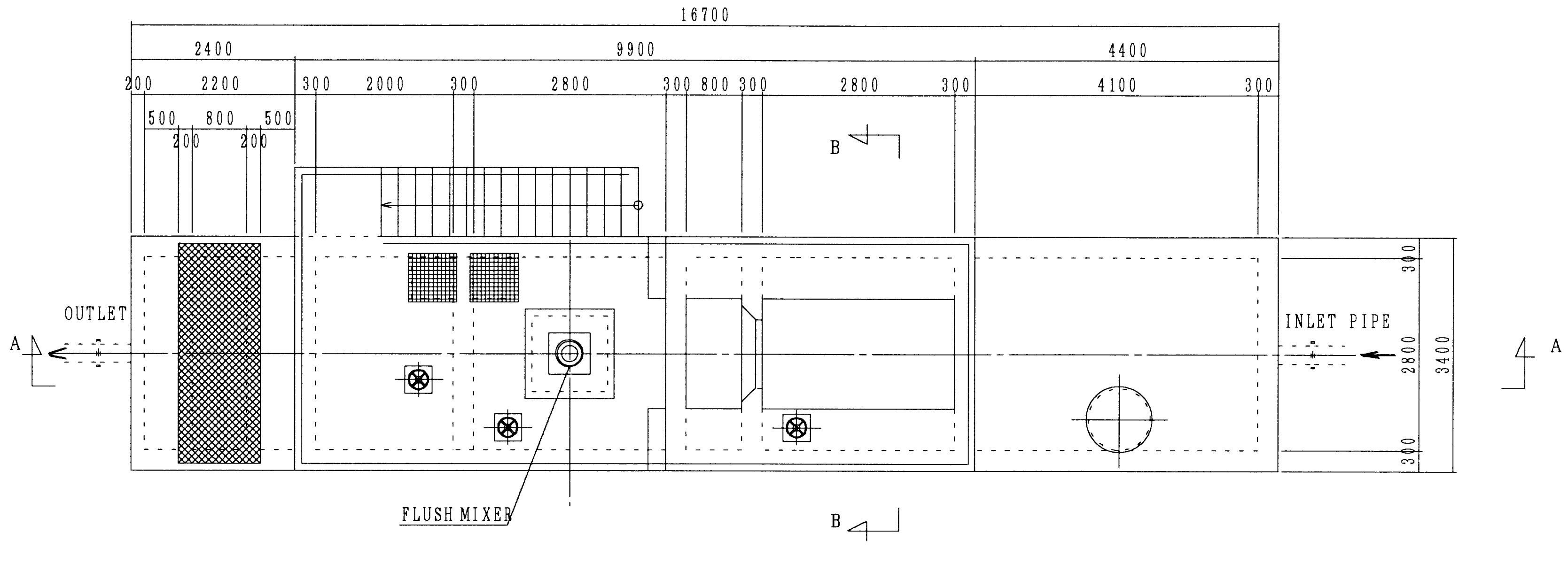
1) No.1 Filter Sand	2 units
2) No.2 Filter Sand	3 units
3) No.2 Flow Meter	1 unit
4) Valves	
φ200 Raw water inlet sluce valve	1 unit
φ200 No.1 clarifire inlet sluce valve	1 unit
φ200 No.2 clarifire inlet sluce valve	1 unit
φ250 No.1 filter outlet sluce valve	1 unit
φ250 No.2 filter outlet butterfly valve	2 units
φ250 No.2 filter waste butterfly valve	2 units
5) Remoove back wash pump	2 units
6) New back wash pipe from new WTP	

PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA

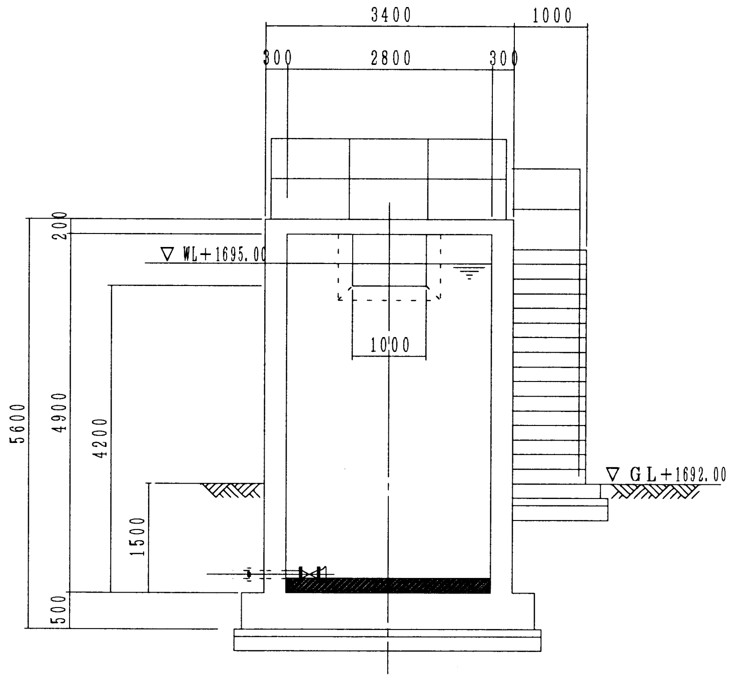
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY

Site	Title	
Goroka	Existing WTP – Improving Plan	
Date: Jan. 2001	Scale: 1/200	Draw. No. II – 6

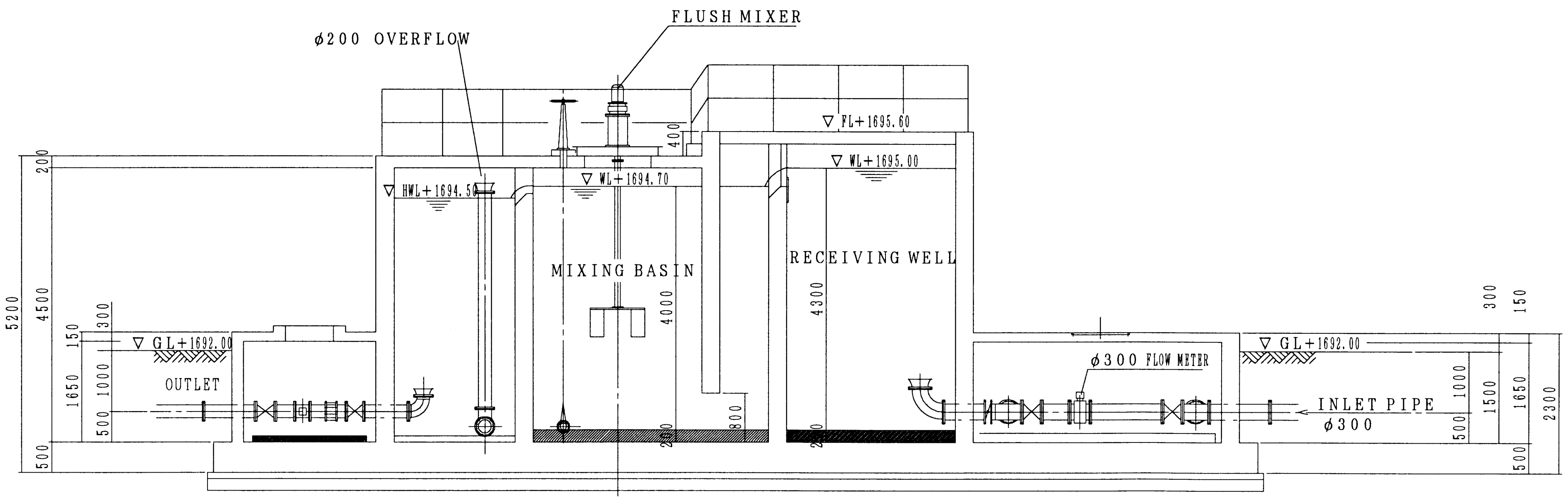
JAPAN INTERNATIONAL COOPERATION AGENCY



PLAN

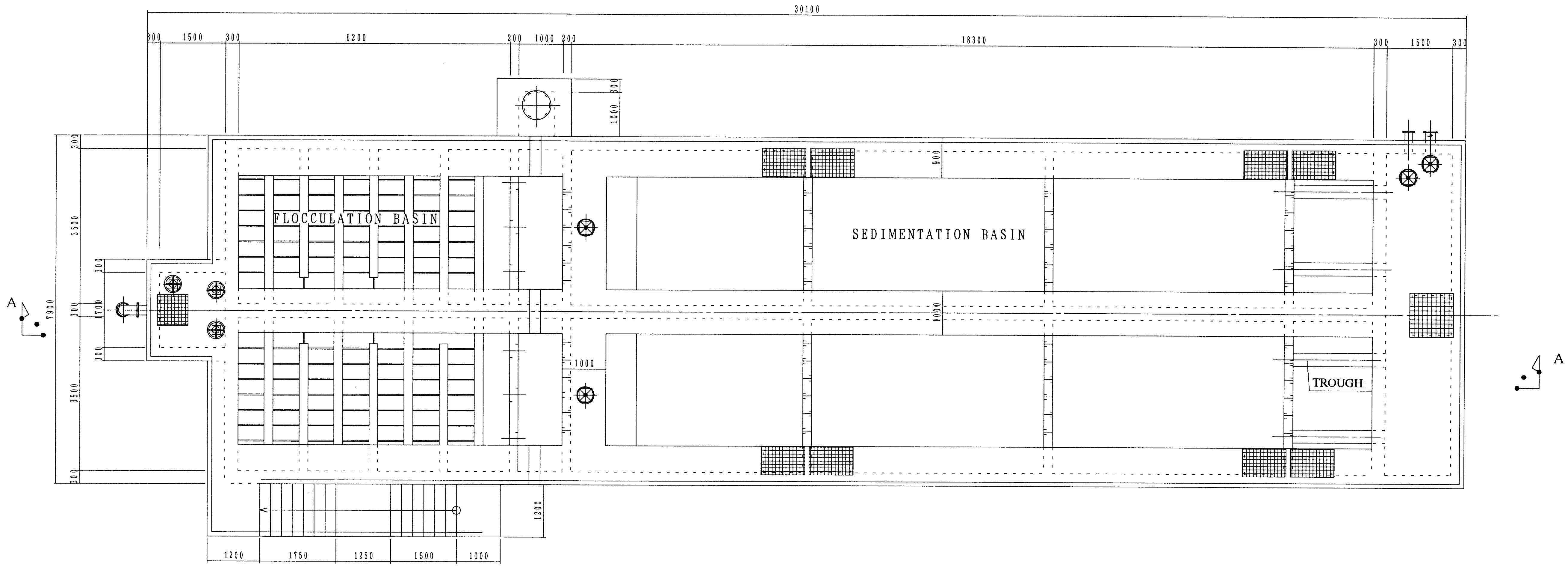


SECTION B-B

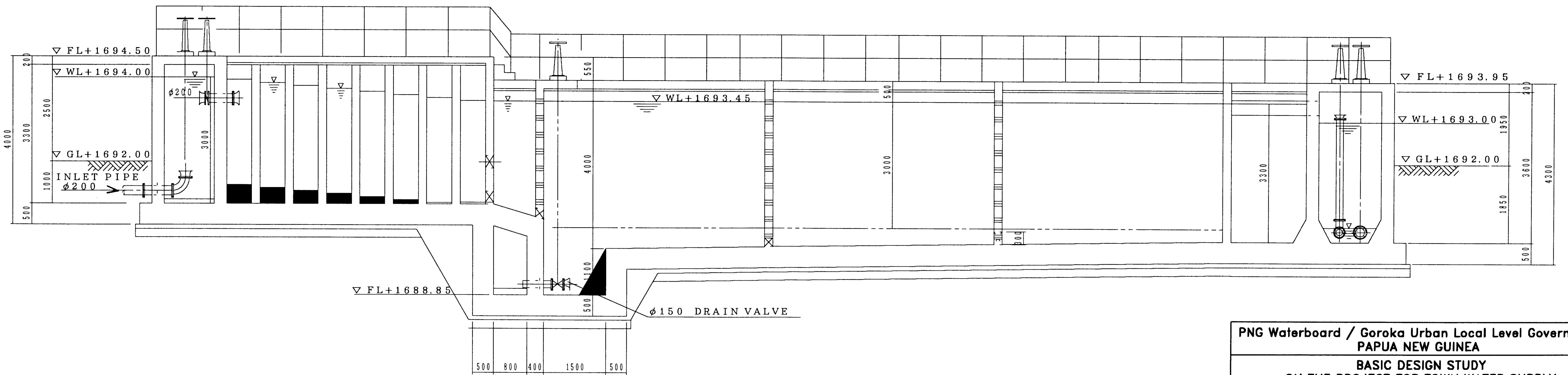


SECTION A-A

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Goroka	Title: Proposed WTP – Receiving Well	
Date: Jan. 2001	Scale: 1/100	Draw. No. II – 7
JAPAN INTERNATIONAL COOPERATION AGENCY		

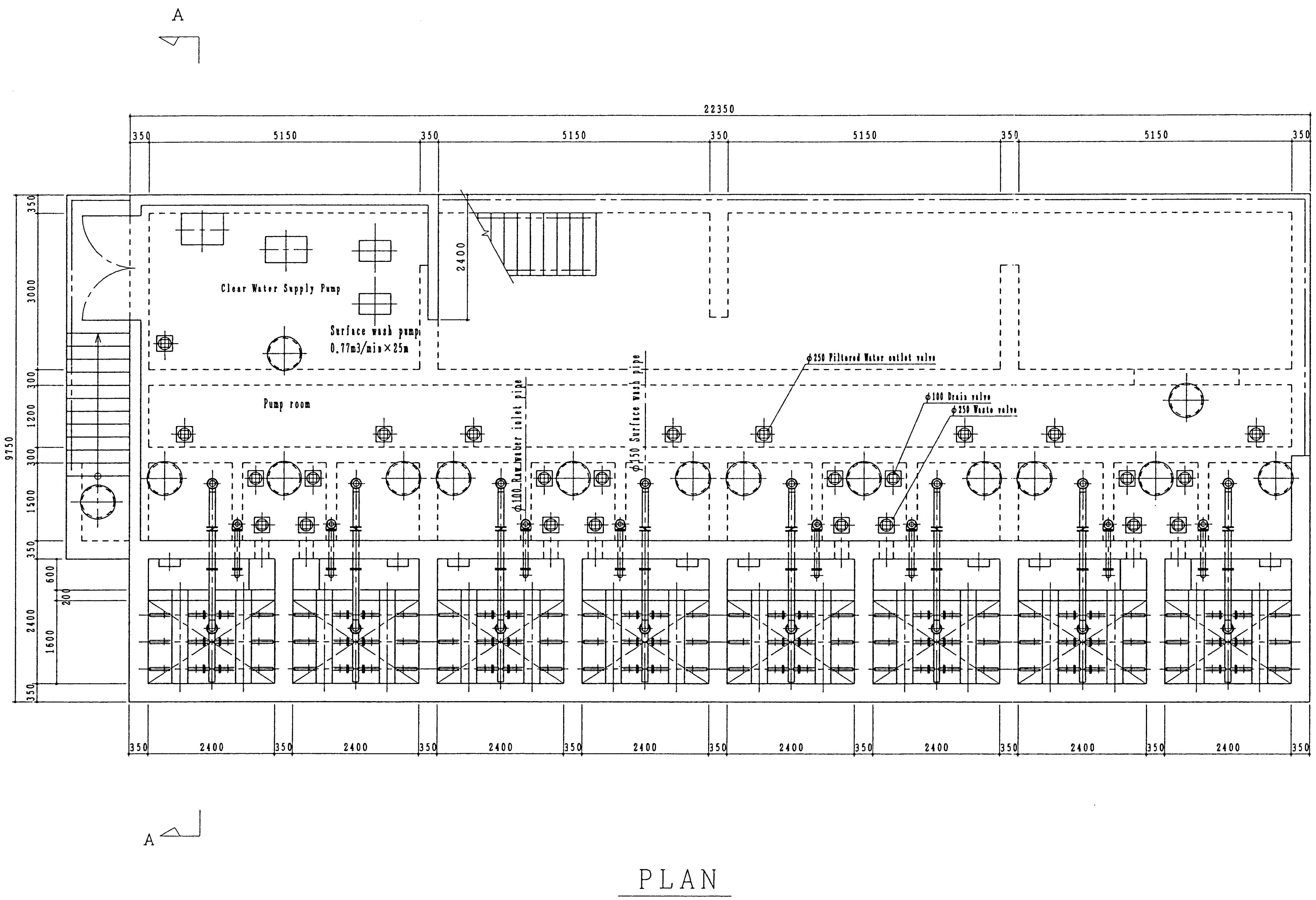


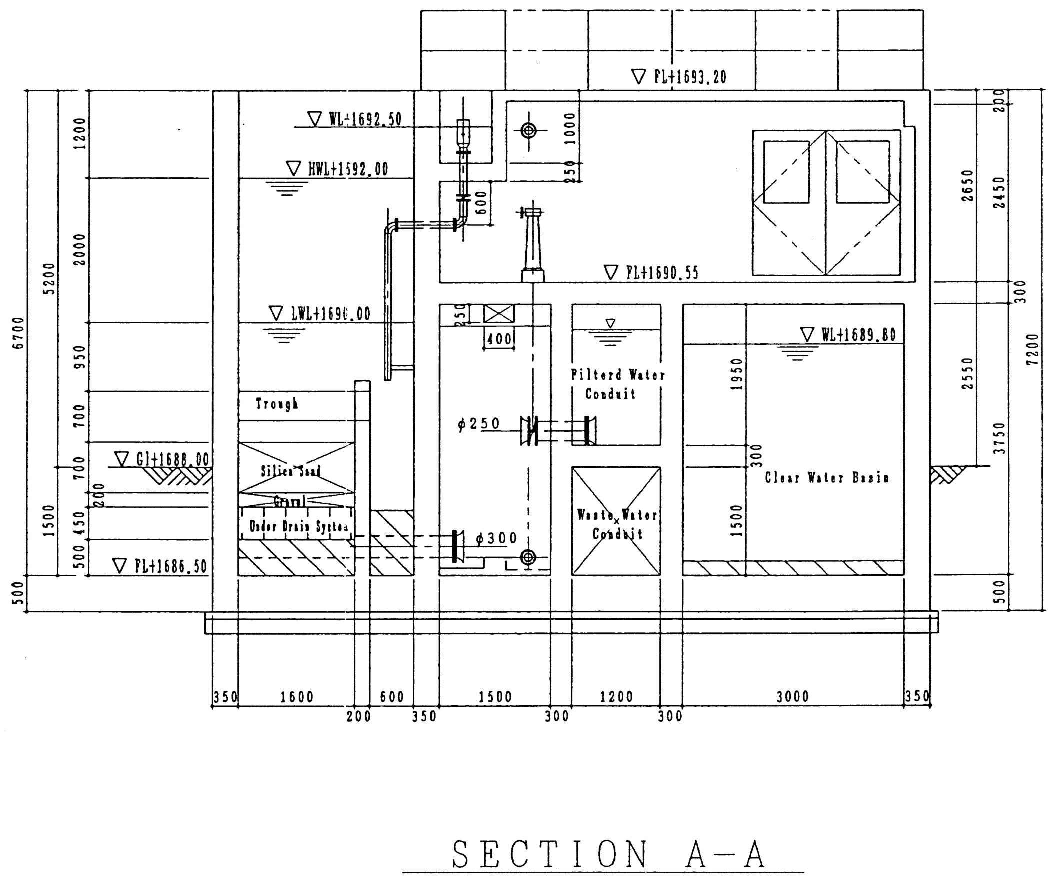
PLAN



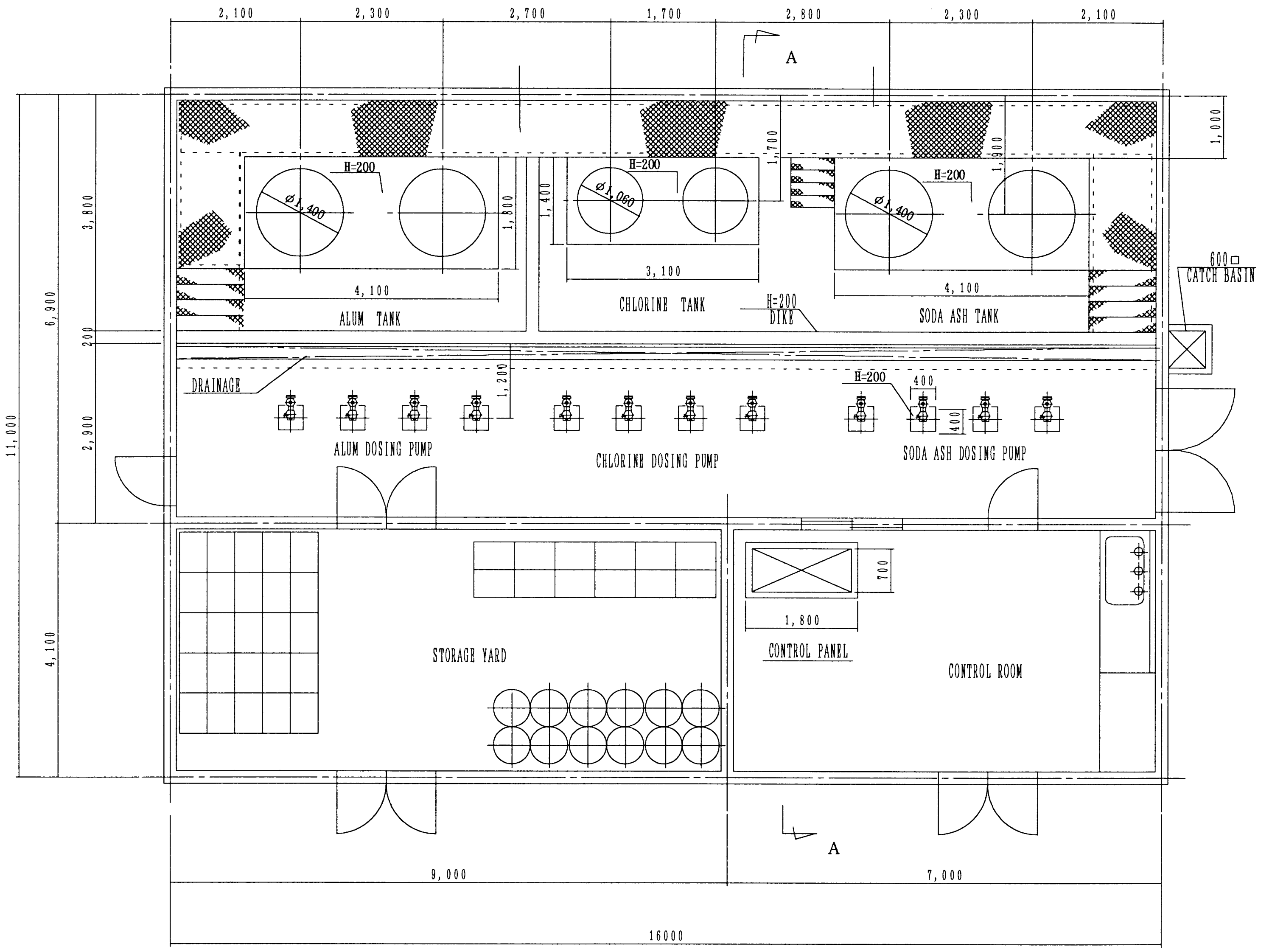
SECTION A-A

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Goroka	Title Proposed WTP – Sedimentation Basin	
Date Jan. 2001	Scale 1/100	Draw. No. II – 8
JAPAN INTERNATIONAL COOPERATION AGENCY		

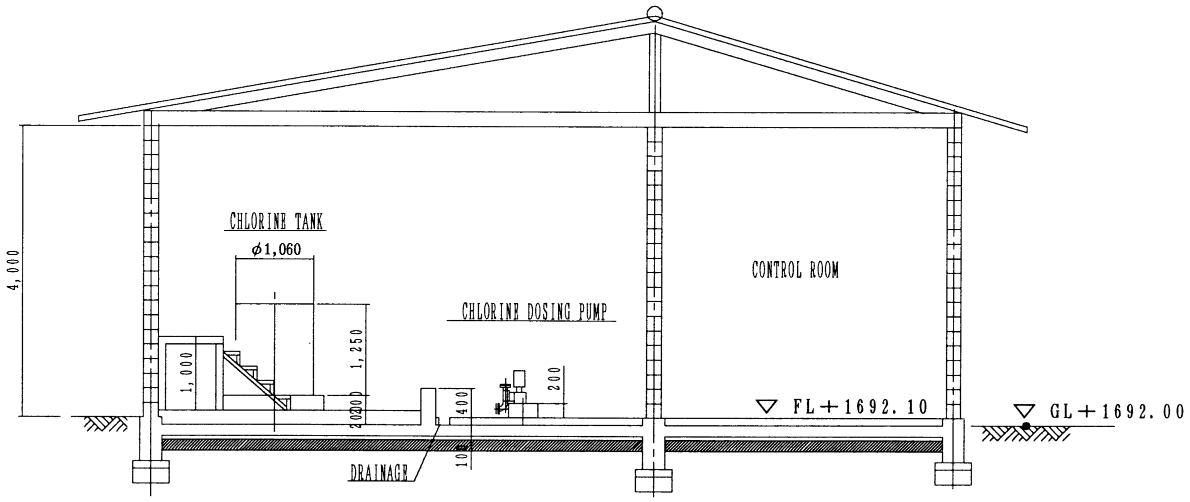




PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Goroka	Title: Proposed WTP – Filter Bed	
Date: Jan. 2001	Scale: 1/100	Draw. No. II – 9
JAPAN INTERNATIONAL COOPERATION AGENCY		

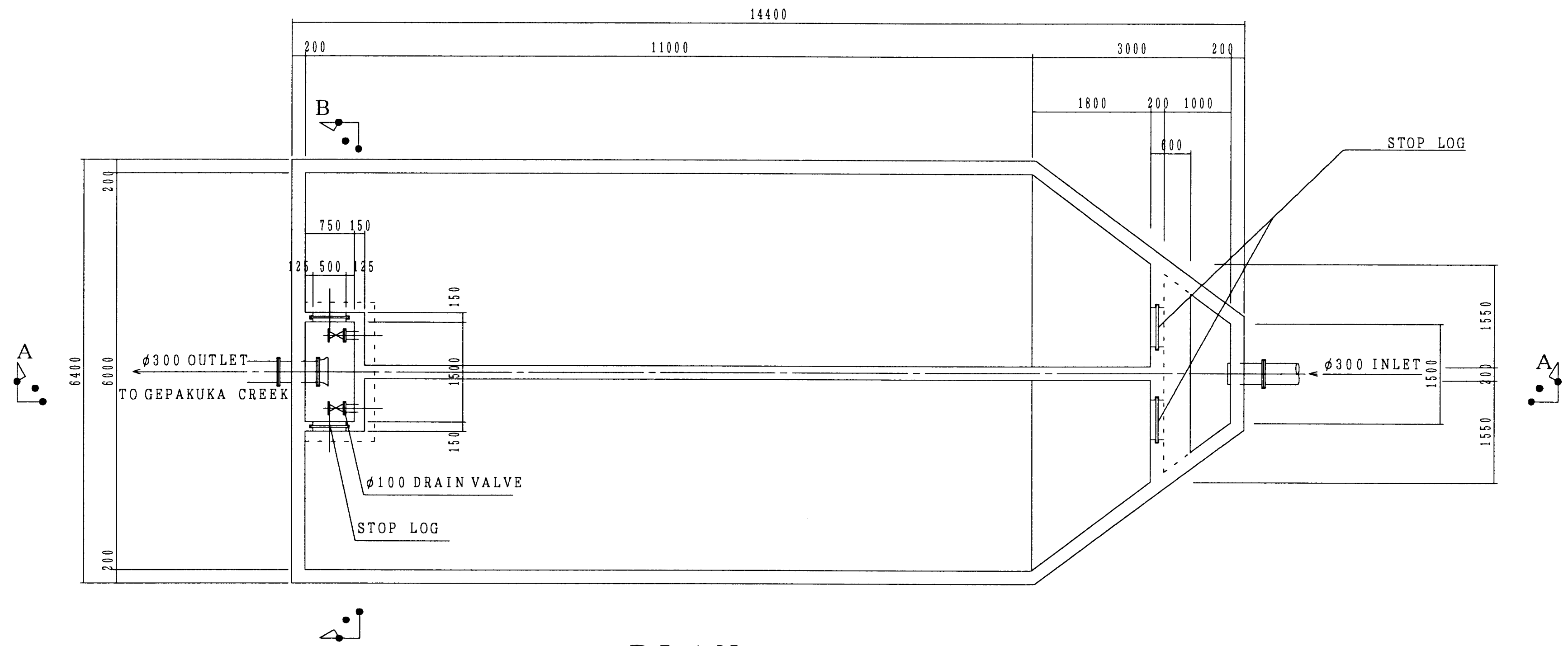


PLAN

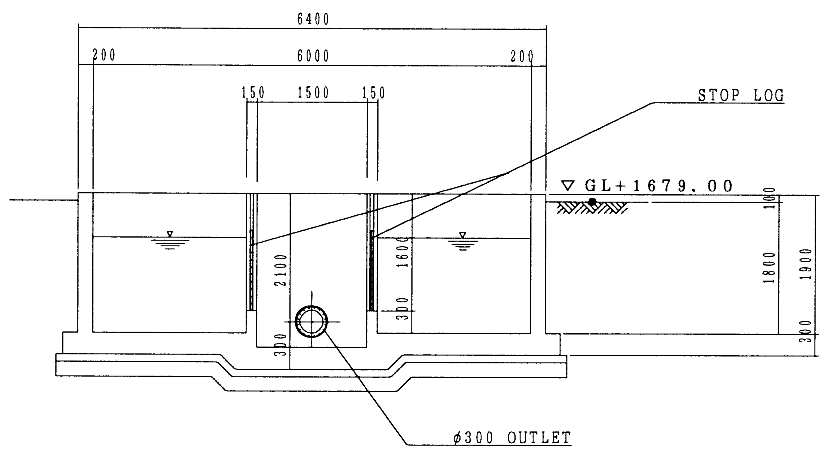


SECTION A-A

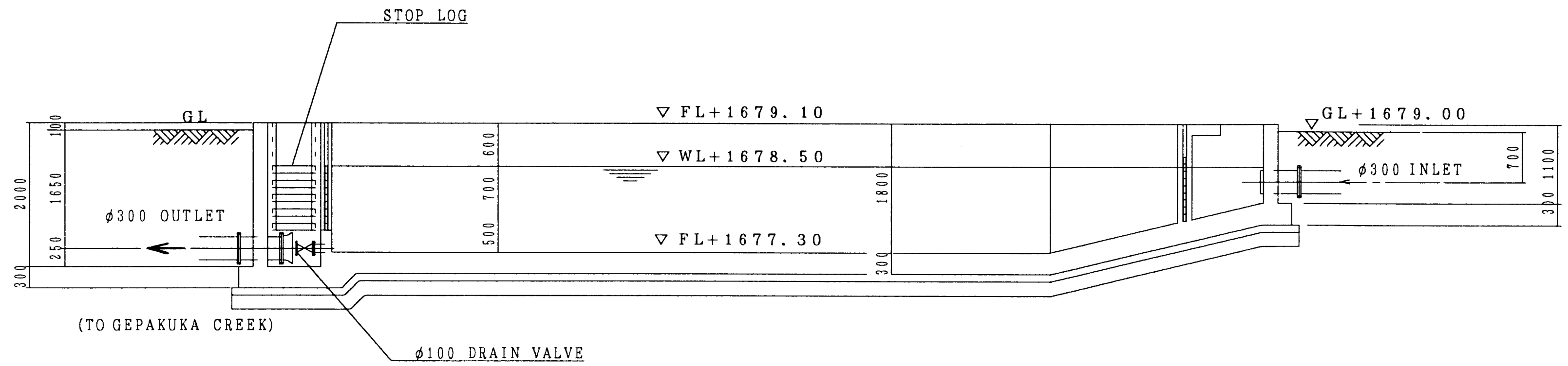
PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Goroka	Title Proposed WTP – Chemical Room	
Date Jan. 2001	Scale 1/100	Draw. No. II – 10
JAPAN INTERNATIONAL COOPERATION AGENCY		



PLAN

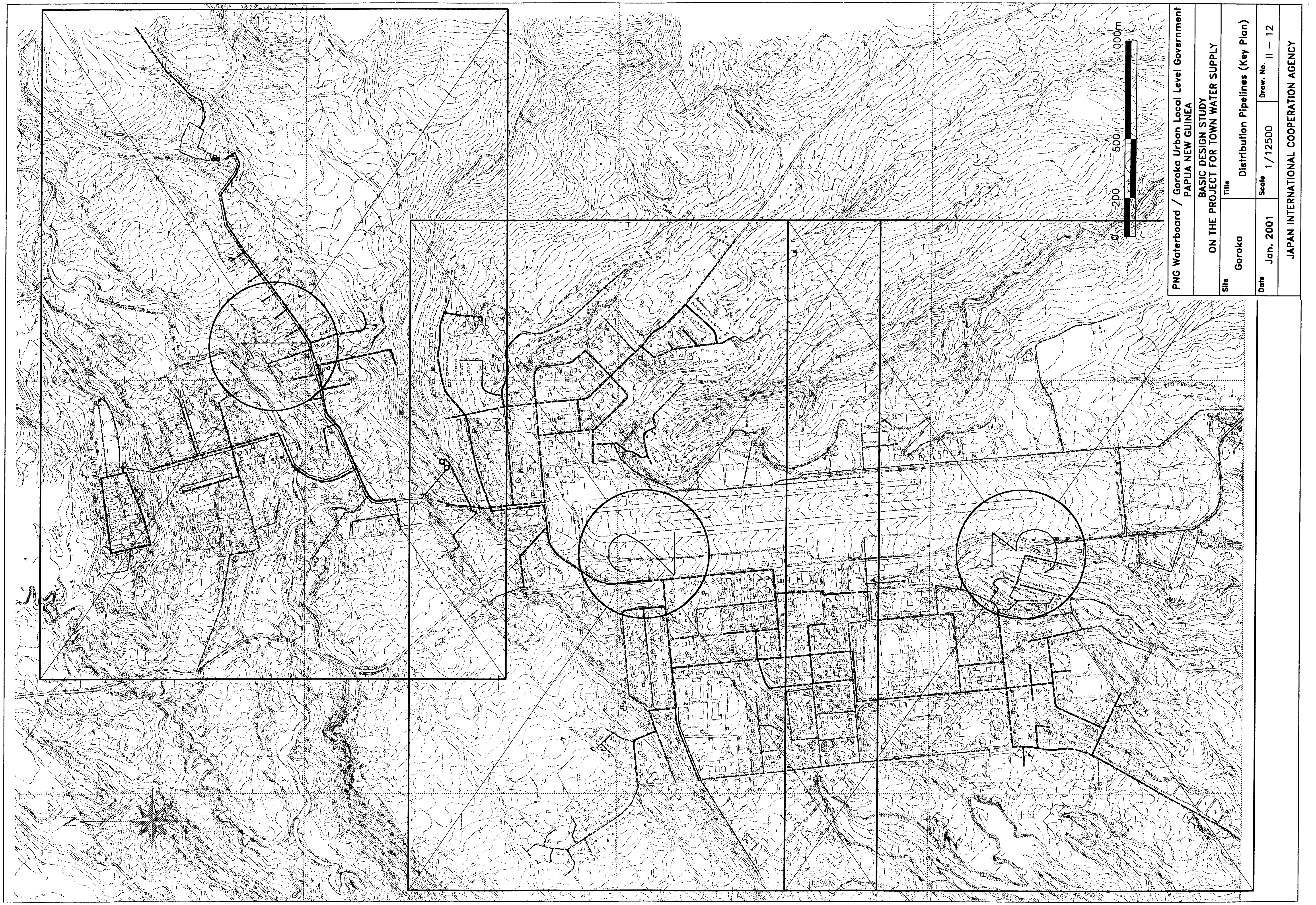


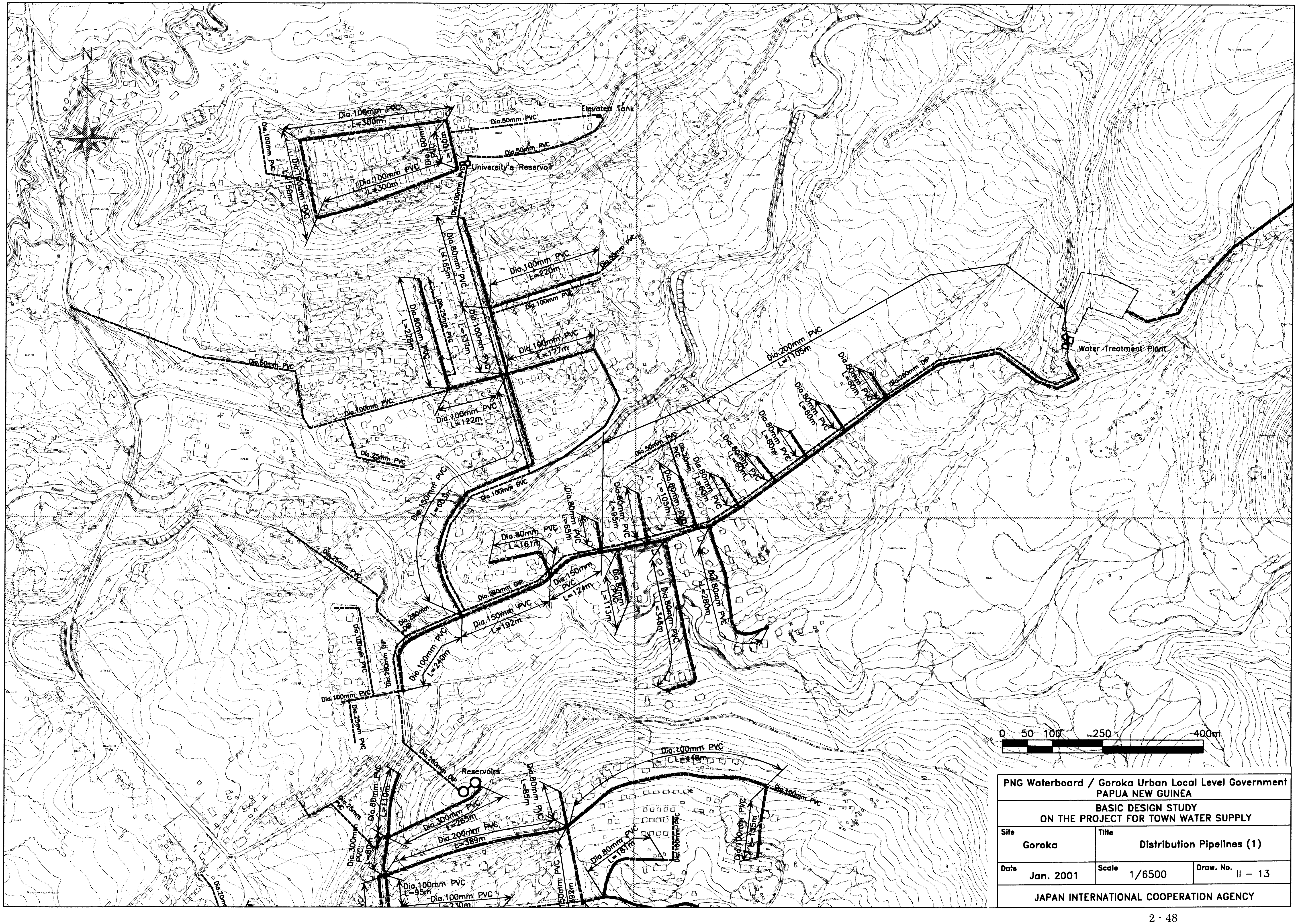
SECTION B-B



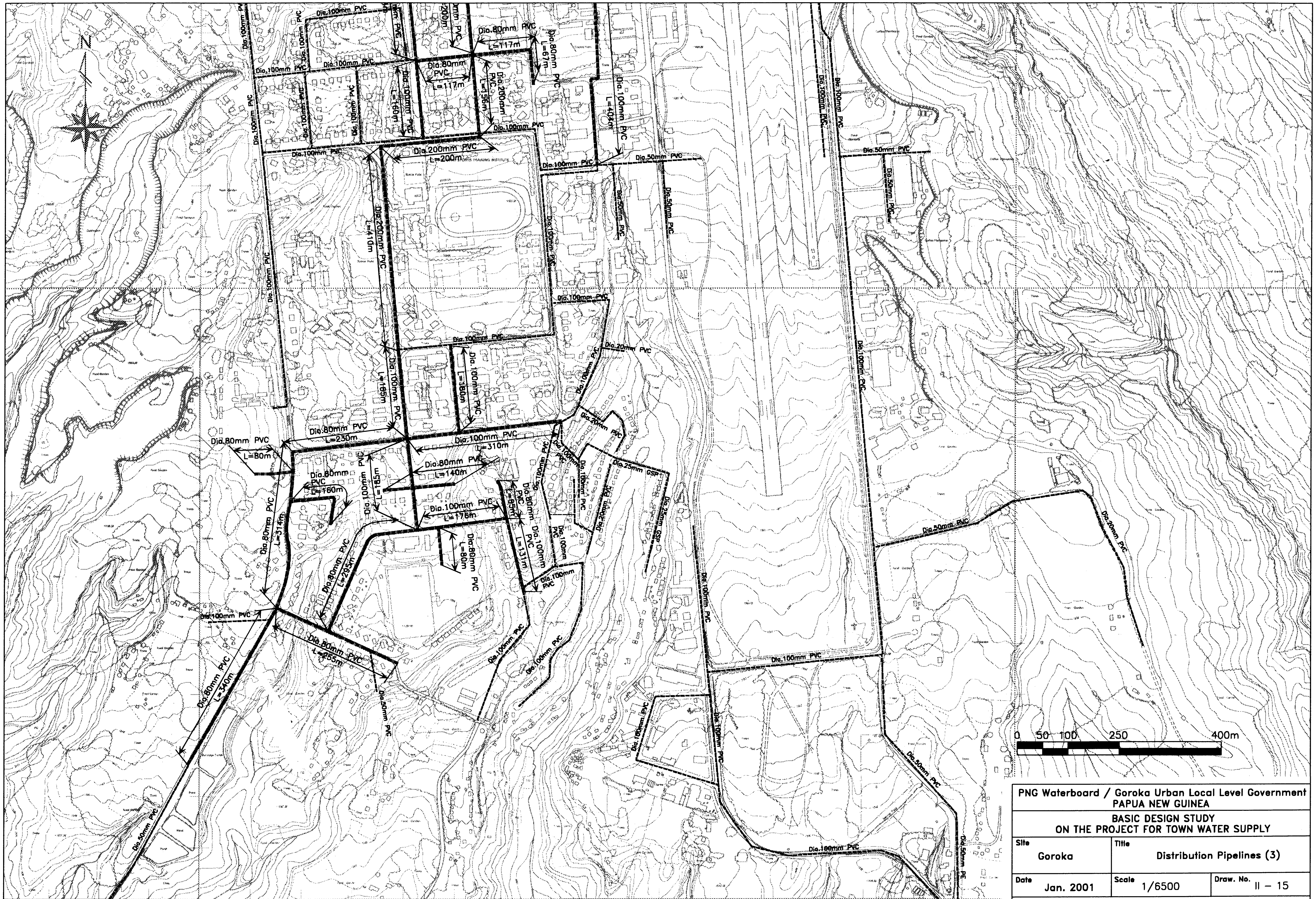
SECTION A-A

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site Goroka	Title Proposed WTP – Sludge Sedimentation Lagoon	
Date Jan. 2001	Scale 1/100	Draw. No. II – 11
JAPAN INTERNATIONAL COOPERATION AGENCY		


PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY
Site
Goroka
Title
Distribution Pipelines (Key Plan)
Date
Jan. 2001
Scale
1/12500
Draw. No.
II – 12
JAPAN INTERNATIONAL COOPERATION AGENCY
0
200
500
1000m
N


N
Elevated Tank
University's Reservoir
Water Treatment Plant
Reservoirs
Dia.100mm PVC
L=300m
Dia.50mm PVC
Dia.200mm PVC
L=1105m
Dia.250mm DIP
Dia.150mm PVC
L=192m
Dia.300mm PVC
L=265m
Dia.200mm PVC
L=389m
Dia.100mm PVC
L=220m
L=177m
L=122m
L=240m
L=230m
L=95m
Dia.80mm PVC
L=161m
Dia.25mm PVC
0 50 100 250 400m
PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY
Site
Goroka
Title
Distribution Pipelines (1)
Date
Jan. 2001
Scale
1/6500
Draw. No.
II – 13
JAPAN INTERNATIONAL COOPERATION AGENCY


N
Reservoirs
0 50 100 250 400m
PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA
BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY
Site
Goroka
Title
Distribution Pipelines (2)
Date
Jan. 2001
Scale
1/6500
Draw. No.
II – 14
JAPAN INTERNATIONAL COOPERATION AGENCY

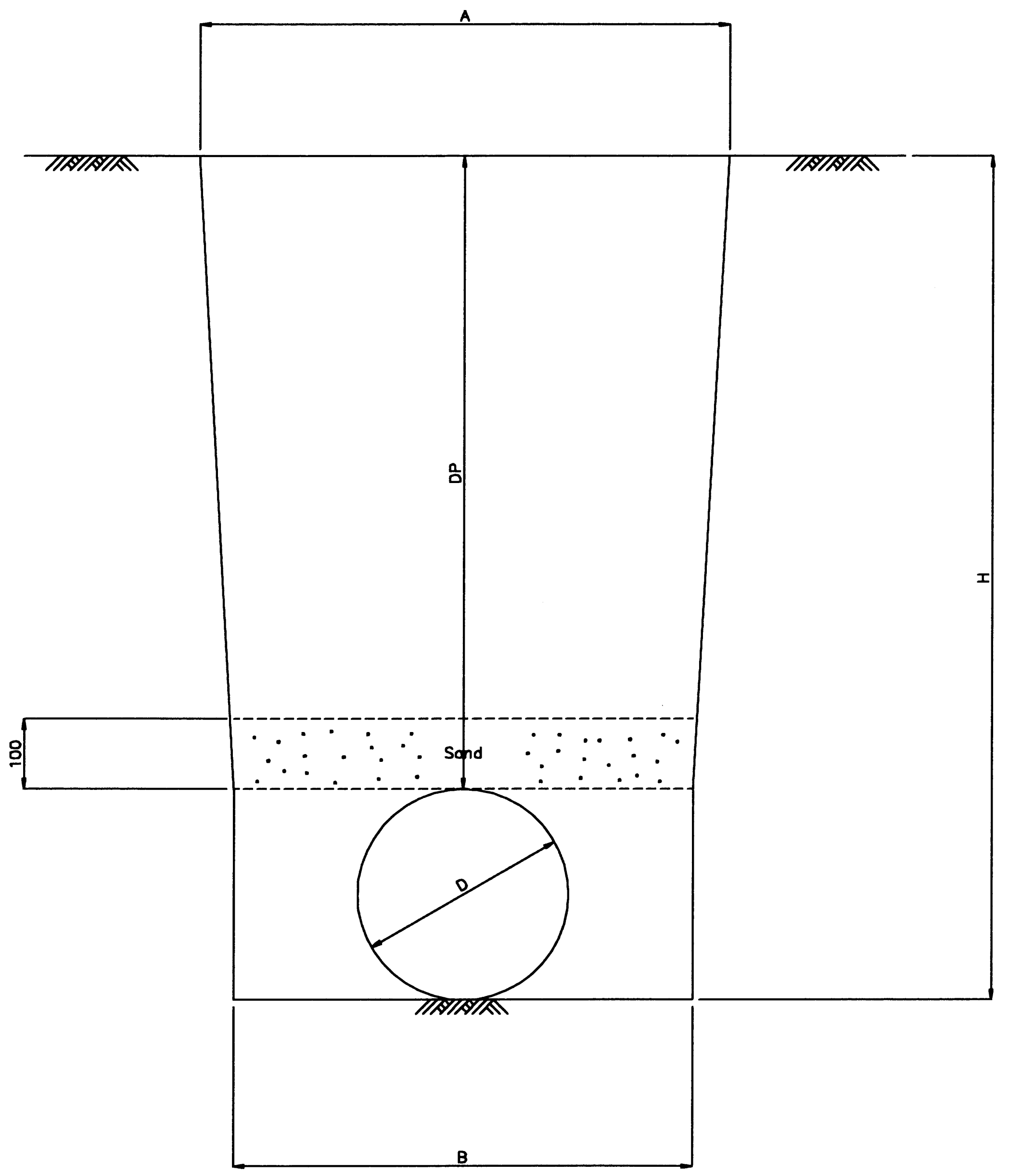


PNG Waterboard / Goroka Urban Local Level Government
PAPUA NEW GUINEA

BASIC DESIGN STUDY
ON THE PROJECT FOR TOWN WATER SUPPLY

Site	Title	
Goroka	Distribution Pipelines (3)	
Date: Jan. 2001	Scale: 1/6500	Draw. No.: II – 15

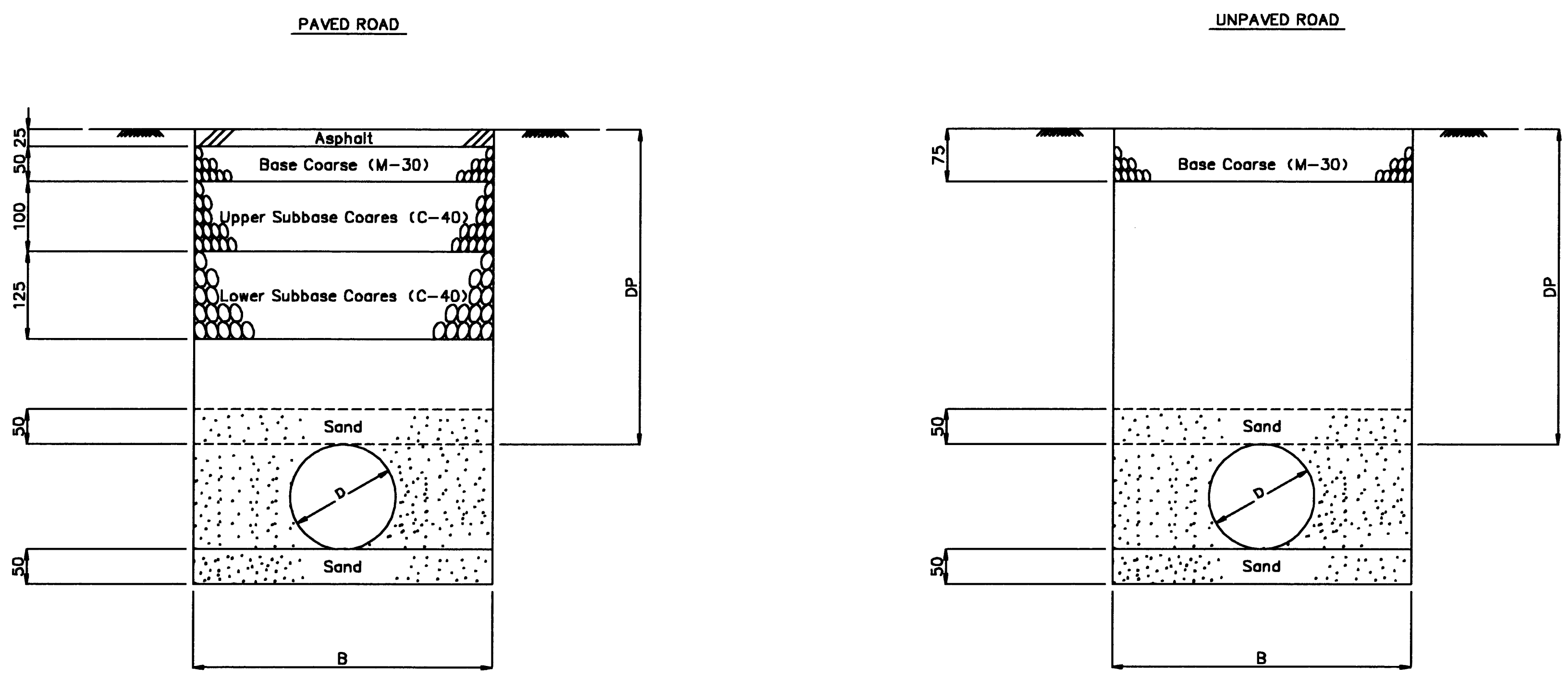
JAPAN INTERNATIONAL COOPERATION AGENCY



D (mm)	A (m)	B (m)
200	0.65	0.55
300	0.75	0.65

"DP"and "H" will be adjusted to the existing ground condition.

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Common	Title: Trench Work Standard (Intake / Transmission Line)	
Date: Jan. 2001	Scale: 1/10	Draw. No. III – 1
JAPAN INTERNATIONAL COOPERATION AGENCY		



D (mm)	B (m)	DP (m)	D (m)	L (m)
50	0.50	1.20	0.30	0.50
75	0.60	〃	〃	〃
100	0.65	〃	〃	〃
125	0.70	〃	〃	〃
150	0.70	〃	〃	〃
200	0.75	〃	〃	〃
250	0.80	〃	〃	〃
300	0.85	〃	〃	〃

PNG Waterboard / Goroka Urban Local Level Government PAPUA NEW GUINEA		
BASIC DESIGN STUDY ON THE PROJECT FOR TOWN WATER SUPPLY		
Site: Common	Title: Trench Work Standard (Distribution Line)	
Date: Jan. 2001	Scale: 1/10	Draw. No. III – 2
JAPAN INTERNATIONAL COOPERATION AGENCY		

Chapter 3 *Implementation Plan*

CHAPTER 3 IMPLEMENTATION PLAN

3-1 Implementation Plan

3-1-1 Implementation Concept

(1) Basic Conditions for Implementation

Project components are summarized in Table 3-1.

Table 3-1 Scope of Works and Project Components

A) Lorengau

Scope of works	Facility	Items to be conducted
Gov. of Japan	Intake facility	Repair of intake weir and installation of a staff for flow measurement
	Raw water transmission facility	Replacement of raw water transmission mains and relocation of the pumping station
	Treatment facility	Procurement of water quality analysis equipment
	Distribution facility	Construction of reservoir tanks and replacement deteriorated distribution pipelines
	House connection	Procurement of connection pipes and water meters
Gov. of PNG	Treatment facility	Repair of equipment of the existing treatment plant
	House connection	Connection of service pipes with water meters to households

B) Goroka

Scope of works	Facility	Items to be conducted
Gov. of Japan	Intake facility	Replacement of intake gate
	Raw water transmission facility	Installation of corrugated pipes, procurement of portable sand pump for the diurnal pond, and replacement raw water transmission pipes
	Treatment facility	Repair of the existing treatment plant, construction of new treatment plant, and procurement of water quality analysis equipment
	Water transmission facility	Replacement of water transmission mains

B) Goroka (continued)

Scope of works	Facility	Items to be conducted
Gov. of Japan	Distribution facility	Replacement of a drain valve of the existing reservoir tank and deteriorated distribution pipelines, and improvement of low water pressure in particular areas
	House connection	Reconnection of service pipes and procurement of water meters
Gov. of PNG	Intake facility	Repair of collapsed part of the intake weir
	Raw water transmission facility	Repair of collapsed stone walls along the raw water transmission channel
	House connection	Installation of water meters

Restoration of service connection is required where distribution pipes are replaced. In construction, special care shall be taken for selection of the construction method and scheduling, in order to minimize period of water suspension.

(2) Local contractors

Local contractors are available in Port Moresby and Lae, which have experienced in water supply projects, bridge construction, road construction, etc., and worked as the subcontractors of the past Japan's grant aid projects and ADB projects. Taking into account of these experience, these contractors are capable of working as the subcontractors under the Japanese contractor for the project.

Although construction machinery is unavailable in the project sites, they are available in Lae where is the proposed import port and the place to supply the construction materials.

Consequently, a Japanese contractor is to direct the local subcontractors in the project.

(3) Dispatch of engineers

A Japanese contractor has to execute technical transfer for maintenance of facilities to PNG Water Board and G.U.L.L.G staff in the form of QJT (On-the-Job Training) during the construction period. Technical transfer shall focus on following items:

- Operation and maintenance of the water treatment plant (Coagulation-sedimentation tank, filtration tank and chemical dosing equipment)
- Operation of the leakage detection equipment (ultrasonic flow meter)

(4) Executing organizations of PNG side

Department of National Planning and Monitoring (DNPM), PNG Water Board, and G.U.L.L.G are to be executing agencies of the Project. DNPM takes responsibility for the implementation of the Project, and the PNG Water Board and G.U.L.L.G are in charge of the implementation at each site. The conceptual structure for the project implementation is shown in Fig. 3-1.

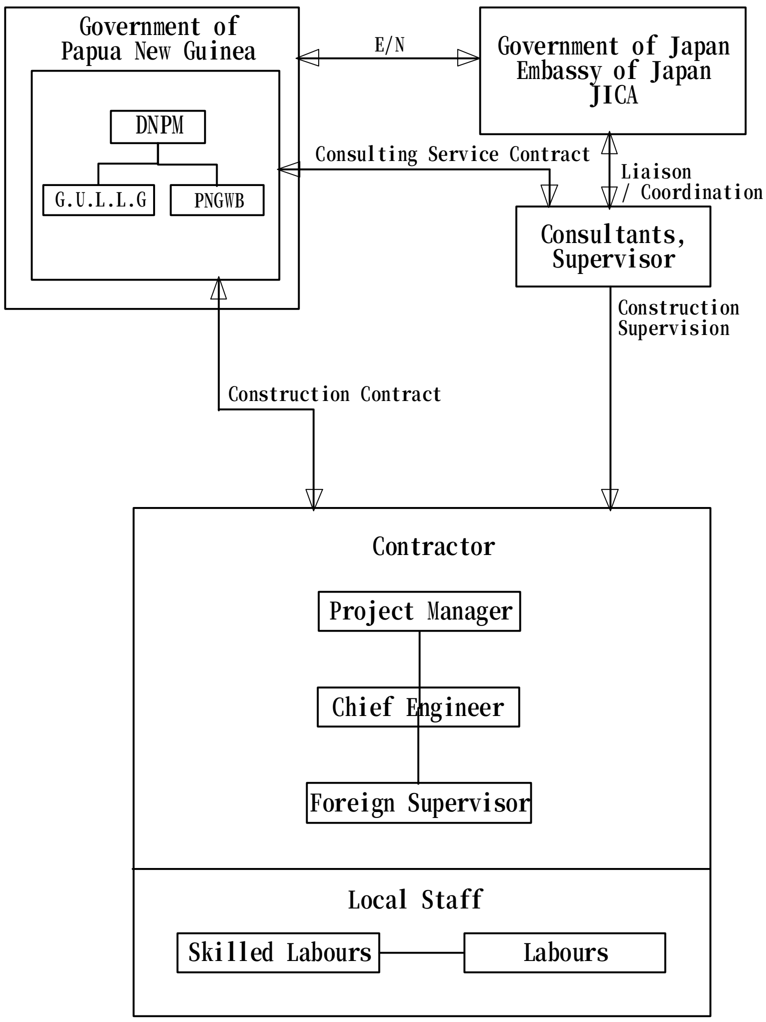


Fig. 3-1 Conceptual Structure for the Project Implementation

3-1-2 Implementation Conditions

(1) Natural Condition on Construction

Climate

○ Lorengau

The climate is characterized by constant high temperature and high humidity.

The annual average precipitation for the 1973〜1998 period is approx. 3,240 mm and the precipitation is high throughout the year. The monthly average temperature fluctuates from 27 to 28 degrees C.

○ Goroka

The average annual precipitation is approx. 1,867 mm and the monthly average precipitation fluctuates from 54 mm in July to249 mm in February. The wet season is generally from October to April while the dry season is from May to September.

The monthly average temperature fluctuates from 19 to 20 degrees C.

(2) Related laws and regulations

Water quality standards for drinking water are prescribed in the design manual issued by PNG Water Board. Standard for designing structures and other water facilities are in general to follow the Australian Standards (AS).

3-1-3 Scope of Works

Table 3-2 Scoke of Works

Work Item	PNG	Japan
Land acquisition	○	
Grass-cutting in the water treatment plant	○	
Construction of fence encircling the completed facilities and its gate	○	
Coordination during water cutoff	○	
Installation of water meters	○	
Information on buried facilities and attendance to excavation work	○	
Coordination during connection work between the existing pipes and	○	
Free water supply to pipe-flushing (washing)	○	
Electrical work up to incoming panel (included)	○	
Trial excavation		○
Construction (schedule, preparation of materials and construction work)		○
Pipe-flushing work of distribution pipes (not including service pipes)		○
Water-pressure tests of distribution pipes (not including service pipes)		○
Chlorination of distribution pipes (not including service pipes)		○
Leak-detection tests of tanks		○

3-1-4 Consultant Supervision

(1) Detail Design

In the detailed design study, following works will be carried out:

- In the field study, followings are conducted; site reconnaissance of the pipeline routes, investigation of underground installations and other obstacles (pole, overhead wire, etc.), investigation of existing pipes, etc., investigation of positions for the connection restoration of existing water supply pipes and branch pipes, topographic survey, trial pit investigation.
- Basic design should be reviewed on the basis of the field study.
- Comparison on construction method, structural planning and temporary planning are carried out so as to decide implementation plan.
- The structural calculation as well as temporary calculation, etc. are carried out.
- Drawings are prepared, such as location map, plans, longitudinal section drawings, detail drawings (plan, longitudinal, cross section, etc.) and structural drawings.
- Calculation sheets are made on all that are necessary for construction.
- Basic conditions, the comparison examinations, etc. are confirmed. Validity of the design plan, consistency of the drawings and the calculation sheets are probed so as to examine the content of the design.
- Cost estimation of the basic design is reviewed on the basis of the decided scale of facilities and quantities.
- Tender document is prepared in accordance with the guideline of JICA (Japan International Cooperation Agency).
- For the selection of the contractor, the consultants will assist the implementing organizations of PNG in line with the tendering procedures stipulated in the guideline of JICA.

(2) Construction Supervision

Following the detail design, the construction supervision will be undertaken. Major items of the construction supervision services are summarized below:

- Close coordination with parties concerned for completing the construction work as scheduled in the implementation program of the Project
- Precise and timely advises to the contractor and the executing agency to construct the facilities consistent to design drawing / contract document
- Proper transfer of knowledge to the staff of G.U.L.L.G and PNG Water Board on construction methods and techniques to maximize the expected effects of the Grant Aid Project in the form of on-the-job training

- Adequate advice and guidance on operation and maintenance of the constructed facilities to facilitate the proper operation of the Project
- During the pipe laying works in the service area, it is important to minimize interference to the residents, such as suspension of water supply, by cooperation with G.U.L.L.G and PNG Water Board.
- In order to achieve project objectives from the early stage, the consultants would pay attention to the progress of TWB portion, construction of distribution pipelines, from the preparatory to construction stages. The consultants will assist its designing and planning to coordinate whole progress of the Project.
- Operation and Maintenance (O&M) manual for equipment and pipelines is to be prepared by the consultants during the construction period. Each manual for equipment or facility would be made by the manufactures. And the consultants will combine the manuals into a comprehensive O&M manual. It will be used for training in commissioning. Necessary modifications shall be made, if any.

The above supervision works include the following duties and responsibilities:

- Supervision of construction program and quality control, such as approval and inspection of construction materials and works
- Inspection and approval of dimensions, and numbers of the constructed works and facilities
- Change order to the contraction as required
- Preparation of reports and papers required as specified by JICA

The above consulting services will be required from the commencement of the construction to the completion of the all construction works. Throughout the construction period, a resident engineer will be assigned who coordinates the construction works. The resident engineer will be a civil engineer. Experts in several disciplines will be dispatched to the site in addition to the resident engineers for smooth implementation of the work.

3-1-5 Procurement Plan

(1) Labor

Concerning procurement of labors, local staff for labor control will be employed under the Japanese engineers. Local foremen will be positioned under them. Technical transfer will be conducted throughout the construction period in the form of OJT (On the Job Training). Common labors are also to be procured locally.

(2) Construction materials

Equipment for the water treatment plant and facilities are the main equipment of the Project. Therefore, they will be procured in Japan. Although straight PVC popes are manufactured in PNG, they are inferior in quality, so that the PVC pipes will be procured in Australia where the materials are stably available in good quality.

1) Cement

Normal Portland cement, PNG product

2) Aggregate

Lorengau

There is no crusher plant in Lorengau, so that concrete aggregates are transported from Lae by sea to Lorengau.

Goroka

There is no crusher plant in Goroka, so that coarse and fine aggregates are purchased and transport from Lae.

3) Reinforcement and ordinary/special structural steels

Reinforcement are available in the market. Mill sheets of sufficient strength can also be issued.

4) Form and construction wood materials

Plywood for concrete forms is also available in the market.

5) Fuels

Gasoline and gas oil are also available in the market.

6) Ready-mixed concrete plant

There is no ready-mixed concrete plant in Lorengau and Goroka. A mobile mixer is used in Lorengau. For Goroka, a concrete batching plant is provided at the site because water treatment plant construction work requires high quality concrete in large quantity and in a stable and continuous supply.

(3) Construction machinery

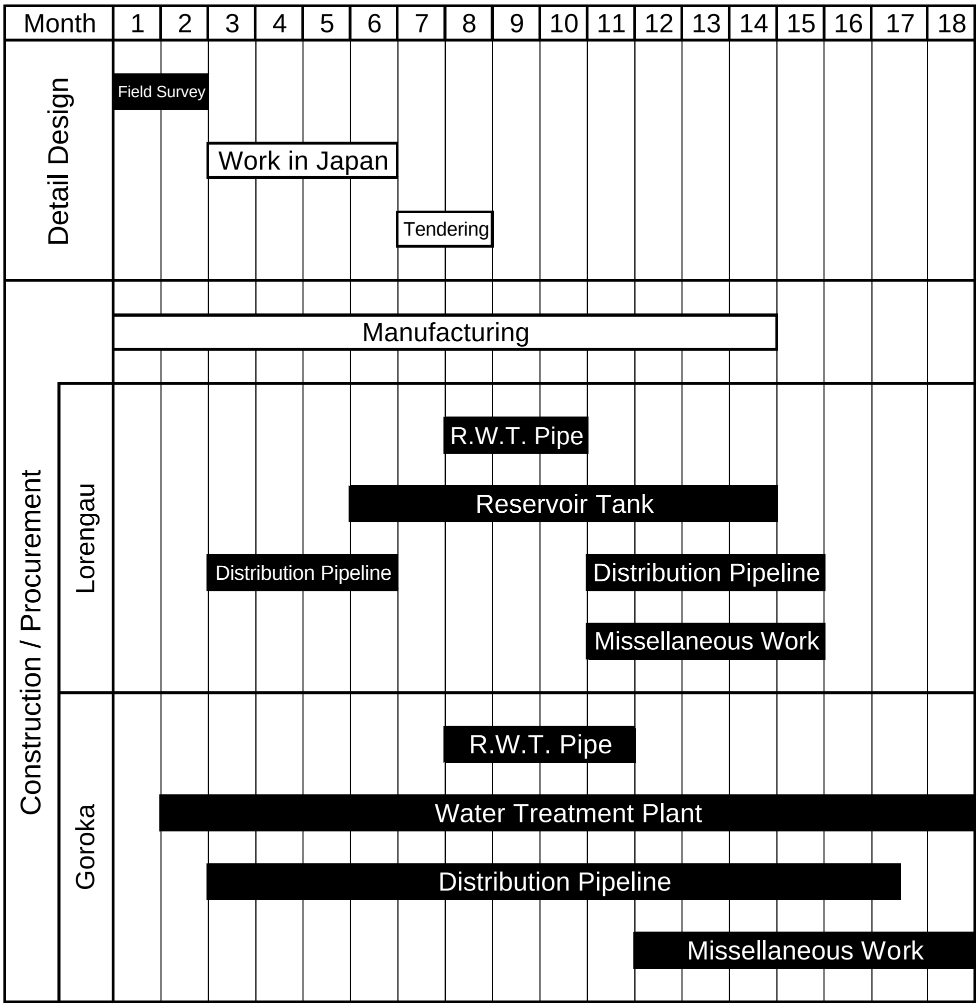
There are construction machinery leasing companies in Port Moresby and Lae, which have a relatively large number of construction machinery. Therefore, construction machinery is to be leased in Lae and transported to the Project site.

Table 3-3 Items and the scope of procurement

Item	Specifications	Procuring country		
		PNG	Japan	Third country
Labor				
Special workers		○		
General workers		○		
Construction materials				
Cement		○		
Gravel / sand		○		
Wood panels for concrete form		○		
Re-bar		○		
Corrugated pipe			○	
Concrete products		○		
Fuels		○		
Water treatment plant	Mechanical and Electrical		○	
Transmission pumps			○	
Distribution reservoir	Steel tank		○	
PVC pipes				○
Galvanized steel pipes			○	
Equipment supplied				
Water meter with cock		○		
Connection pipe	Polyethylene pipe	○		
Water quality analysis equipment			○	
Portable sand pump	with generator	○		
Flow meter	Ultra-sonic flow meter		○	

3-1-6 Implementation Schedule

The implementation schedule is shown in Fig. 3-2.



Note R.W.T. Pipe: Raw Water Transmission Pipe

Fig. 3-2 Implementation schedule

3-1-7 Obligations of Recipient Country

On condition that Grant Aid of Japan is extended to PNG for implementation of the Project, necessary undertakings of the Government of PNG are items described in the Scope of Works of 4-1-3 and necessary measures prescribed in the Minute of Discussion.

3-2 Operation and Maintenance Costs

(1) Maintenance system

Lorengau

Facilities constructed by the Project are to be transferred to the PNG Water Board from Manus Province. PNG Water Board will establish a Lorengau Office and take charge of operation and maintenance of the Lorengau water supply system. The draft organization chart of the Lorengau Office is proposed as shown below.

The Office is headed by the district manager and consists of three divisions; Operation Division in charge of operation and maintenance of the water treatment plant and pumping station, Plumbing Division in charge of repair and maintenance of the pipeline, and Administration Division in charge of collection of water charges.

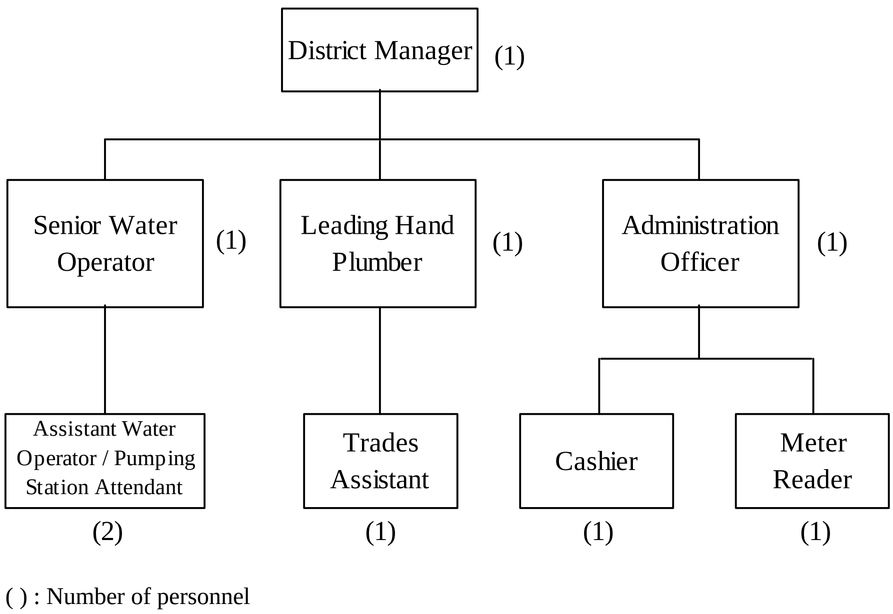


Fig. 3-3 Organization chart of the Lorengau office（draft）

Goroka

The G.U.L.L.G has employed sufficient personnel for operation and maintenance of the water supply facility since the reorganization in 1998. Facilities constructed by the Project will be operated and maintained by the existing system.

The Manager of Technical & Engineering will take charge of execution of the leakage control program.

(2) Maintenance costs

Projection of revenue and expenditure after the Project is shown in Table 3-4. The record of the revenue from water charge in Popondetta was referred to for the projection of Lorengau, while the current water tariff was referred to for the projection of Goroka. As for the accounted-for water, unaccounted-for water is considered to be equal to the leakage volume. The projection assumes that the administration loss could be almost neglected, namely, the percentage of accounted-for water to be 75%, since penal regulations are strictly enforced against nonpayment and arrears.

Expenditures were calculated on the basis of annual expenditures of both towns for 1999. The personnel expense of Lorengau was calculated, referring to the record of the Water Board. Taking into reference of the past financial data, Quarterly Economic Bulletin issued by the Bank of Papua New Guinea, a inflation rate of 10.0%/year and increase rate of salary of 4.1%/year are applied.

Comparing the revenues and expenditures, it is possible that the necessary expenses can be covered while securing profits without raising water charge.

Table 3-4 Projection of revenue and expenditure after the Project

[unit: Kina]

	Lorengau		Goroka	
Revenue	1999	2003	1999	2003
Water charge	Nil	339,950	600,000	1,081,345
Others	Nil		1,000	
Total	---	339,950	601,000	1,081,345
Expenditure	1999	2003	1999	2003
[1] Personnel expenses	16,800	88,689	75,628	88,815
[2] Repair	21,700	21,962	22,500	92,238
[3] Electricity	40,000	36,139	8,500	12,445
[4] Fuel, insurance, etc.,	3,000	4,392	2,500	3,660
[5] Office supplies	500	732	Nil	Nil
[6] Chemical	Nil	63,989	60,000	325,235
[7] Land rent	Nil	Nil	50,000	73,205
[8] Depreciation	Nil	109,808	Nil	461,192
Total	82,000	325,711	219,128	1,056,790
Current balance	▲82,000	14,239	381,872	24,555

Chapter 4 *Project Evaluation and Recommendations*

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATIONS

4-1 Project Effect

(1) Improvement of living standard

At present, domestic water demand of 165 L/c/d is not satisfied in the Project areas. After the Project, the water demand will be satisfied with sufficient water pressure (10 - 50 m) for 24 hours continuously. Owing to that, residents in the Project areas will obtain safe and sufficient water and, thereby, will enjoy comfortable living conditions.

Table 4-1 Improvement by the Project

	Lorengau		Goroka	
Index	Current Status	Target	Current Status	Target
Domestic water demand	20 - 70 L/c/d	165 L/c/d	44 - 112 L/c/d	165 L/c/d
Water supply hours	9 hr	24 hr	18 hr	24 hr
Residual pressure	0.1 m or less	10 m	0.1 m or less	10 m
Number of water meters	0 pcs	912 pcs	260 pcs	1,460 pcs

(2) Improvement of hygienic conditions

In Lorengau and Goroka, number of patients infected by skin disease (Lorengau: 167 persons/1000 persons, Goroka: 152 persons/1000persons), diarrhea (Lorengau: 48 persons/1000 persons, Goroka: 66 persons/1000persons) ranks second after malaria[#1)] among diseases ascribable to lack of water volume and poor water quality. It is known that improvement of the water supply conditions will contribute to decrease the rate of infections. The rate of decrease is reported at 40 to 50 %[#2)].

By implementing this Project, enough volume of water and disinfected safe water will be supplied. And it is expected that rate of both skin diseases and diarrhea will decrease.

[#1)] National Health Plan 2001 – 2010, Health Vision 2010, Provincial and District Health Profiles.
[#2)] Report of WHO environment and health committee, "Our earth, Our health", 1993

(3) Contribution to BHN

Designing facilities of the Project was conducted, taking into consideration the water supply to the vicinity islands of Lorengau and neighboring villages of Goroka. Those islands and villages are interspersed around the project areas. The residents are forced to depend on Lorengau and Goroka for potable water.

The Project will improve water for those residents both in quality and quantity and will contribute the satisfaction of Basic Human Needs (BHN) of the people in islands and villages as well as the people in the project areas. Number of beneficiaries is estimated approx. 2,500 in Lorengau and approx. 12,000 in Goroka, approx. 14,500 in total.

4-2 Recommendation

The followings are recommended in order to sustain stable water supply service with sufficient volume and safe quality and to maintain the water supply facilities properly.

(1) Establishment of water charge collection system

At present, there are no water charge collection system in Lorengau. In Goroka, the flat rate tariff system is applied except for come commercial users. So, understandings for water charge by the consumers are insufficient, and therefore, consciousness of saving water is hardly obtained. While, revenues from water charge becomes low, and eventually, necessary maintenance costs cannot be covered.

In the Project, water meters are proposed to be provided under the Japan's Grant Aid and to be installed by the PNG's implementation agencies, so that water charge collection system can be realized by using water meters based on the principle of beneficiaries to pay. Major subjects for it are as follows:

- to install the water meters to all customers
- to conduct a n enlightenment for customers to understand the water charge system and be aware of willingness to pay.
- to realize the transfer of the Lorengau water supply system from Manus province to PNG Water Board.
- to establish a water charge collecting system for surrounding villages of Goroka in collaboration with the provincial government as well as village authorities.

(2) Implementation of ceaseless leakage control

At present, the existing water distribution pipes in both Lorengau and Goroka is so deteriorated that leakage ratios are estimated at about 60% and 46% respectively. In the Project, the leakage ratio is targeted to be 25% by replacement of the old pipes. In consideration that PNG Water Board intends to achieve the UFW ratio (physical loss and administration loss) of 20% in future, leakage control shall be continued even after the Project, so as to achieve soundness of financial status through reducing the leakage.

In the Project, a portable ultrasonic flow meter is proposed for management of flow rate by distribution blocks. After that, priority areas, which would be detected of high leakage ratio, will be repaired, etc. And small leakage will be tackled in the following stages. As for leakage control of Lorengau, it is proposed to be conducted on the technical initiative of PNG Water Board headquarter, taking into account of small scale of the service area.

- to control flow rate by distribution blocks by means of flow measurement using the proposed ultrasonic flow meter
- to repair and replace the pipes in the priority areas
- to conduct further leakage control

(3) Strengthening the waterworks management and organizations

It is essential to keep soundness of the managerial bases of waterworks in order to realize sustainability of the water supply systems. For that, it is required to keep the suitable engineering levels as well as to stabilize revenue from water charge, so as to achieve more efficient management body.

- to aim the efficient management body in order to increase rate of accounted-for water
- to keep and improve the engineering levels by means of OJT throughout the construction period and use of the National Training Center.
- to strengthen the financial status
- to manage the information systematically, including drawings and the technical managerial data

(4) Implementation of water quality control

To supply safe water steadily is a principal role for waterworks. It is therefore necessary to be thorough about water quality control from the water source to tap ends. For this purpose, water quality test kits are to be provided under the Project, so that water quality control is expected to be conducted by the PNG's implementation agency.

From the viewpoint of preventing pollution of water source, enlightenment to inhabitants nearby the water source is important as well as patrol around water source.

- to patrol the water source in order to prevent or detect pollutions
- to conduct enlightenment to inhabitants nearby the water source through public activities
- to carry out water quality control of raw water, treated water and service water.

(5) Water resources development for future demand

Although the Lorengau River has been concluded to be enough intake volume for the time being, the expected minimum flow rate of 25 L/s is incapable of future increase of water demand. Therefore, it is recommended to study on the other water sources to prepare for the future demand. The following water sources are supporsed.

- Lihai River

The Lihai River runs in the west of the Lorengau River and has a wide catchment area covered by forest. Rich water flow and good water quality was observed in the field survey of the basic design study. However, existence of a deep valley may requires water transmission by pump, etc.

- Small rivers / creeks

In developing towards the east of the Lorengau River, small rivers and creeks are proposed as water sources, since there is no rivers which have wide catchment areas. Taking into account of the rich annual rainfall of Lorengau (3,240 mm) and the present status of the catchment areas covered by forest, intake volume is expected to be some hundreds cubic meters per day.

- Groundwater

Groundwater would be applicable for small water supply system, although there is no practical study on ground water use in Lorengau.

Appendix 1 ***Member List***

Appendix 1 Member List

Member list of the Basic Design Study Team

1.	Mr. Kaoru IWASAKI	Team Leader	Resident Representative, JICA PNG Office
2.	Mr. Kenichiro KOBAYASHI	Coordinator	Grant Aid Management Department
3.	Mr. Toshifumi OKAGA	Water Supply Planner 1	Pacific Consultants International
4.	Mr. Shunichi NAKATAKE	Water Supply Planner 2	Pacific Consultants International
5.	Dr. Sotoyuki HAYAKASHI	Water Works Management Planner	Pacific Consultants International
6.	Mr. Hiroyuki SHIRAIWA	Hydrologic Planner	Pacific Consultants International
7,	Mr. Yarai SATOH	Water Treatment Facility Planner	Pacific Consultants International
8.	Mr. Naoto TOHDA	Procurement / Cost Estimator 1	Pacific Consultants International
9.	Mr. Takayuki ARAKI	Procurement / Cost Estimator 2	Pacific Consultants International

Member list of the Explanation Team for the Basic Design

1.	Mr. Kaoru IWASAKI	Team Leader	Resident Representative, JICA PNG Office
2.	Mr. Toshifumi OKAGA	Water Supply Planner 1	Pacific Consultants International
3.	Mr. Naoto TOHDA	Procurement / Cost Estimator 1	Pacific Consultants International

Appendix 2 *Schedule and Itinerary*

Appendix 2 Schedule and Itinerary

Schedule of the Basic Design Study

Date	Activities	Accommodation
2 Aug (Wed)	8:25 Arrival at Port Moresby (PX 091) (Mr. Okaga, Mr. Nakatake, Dr. Hayakashi, Mr. Shiraiwa, Mr. Satoh, Mr. Toda) 11:00 Meeting with JICA Office 14:00 Meeting with PNG Waterboard	Port Moresby
3 Aug (Thu)	Port Moresby 8:00 – (PX 160) – 8:50 Goroka (Mr. Okaga, Mr. Nakatake, Dr. Hayakashi, Mr. Shiraiwa, Mr. Satoh, Mr. Toda) Meeting with Goroka Urban Local Level Government	Goroka
4 Aug to 5 Aug	Site Survey	Goroka
6 Aug (Sun)	Goroka 9:15 – (PX 161) – 10:05 Port Moresby (Mr. Okaga, Dr. Hayakashi, Mr. Shiraiwa, Mr. Satoh)	Port Moresby
7 Aug (Mon)	8:25 Arrival at Port Moresby (Mr. Kobayashi, Mr. Araki) 10:30 Meeting with JICA Office 11:30 Courtesy call to EOJ 13:30 Courtesy call on Department of National Planning & Monitoring 15:00 Courtesy call on PNG Waterboard	Port Moresby
8 Aug (Tue)	14:00 Meeting with PNG Waterboard	Port Moresby
9 Aug (Wed)	Port Moresby 7:45 – (PX 226) – 10:00 Lorengau (Mr. Kobayashi, Mr. Okaga, Dr. Hayakashi, Mr. Shiraiwa, Mr. Satoh, Mr. Araki)	Lorengau
9 Aug to 12 Aug	Meeting with PNG Waterboard and Manus Provincial Government, and Site survey	Lorengau
13 Aug	Lorengau 10:25 – (PX 220) – 11:15 Kavieng 11:40 (PX 271) – 13:10 Port Moresby (Mr. Kobayashi, Mr. Okaga, Dr. Hayakashi, Mr. Araki)	Port Moresby
14 Aug (Mon)	Port Moresby 8:40 – (PX 160) – 9:30 Goroka (Mr. Iwasaki, Mr. Kobayashi, Mr. Okaga, Dr. Hayakashi, Mr. Araki)	Goroka
14 Aug (Mon) to 16 Aug (Wed)	Meeting with Goroka Urban Local Level Government, and Site survey	Goroka
17 Aug (Thu)	Goroka 9:15 – (PX 161) – 10:05 Port Moresby (Mr. Iwasaki, Mr. Kobayashi, Mr. Okaga, Mr. Toda) 11:00 Meeting with PNG Waterboard 14:30 Joint Meeting on Signing of Minutes of Discussion	Port Moresby
18 Aug (Fri)	10:00 Signing of the M/D 14:00 Report of the Study Result at EOJ 15:00 Report of the Study Result at JICA Office	Port Moresby
19 Aug (Sat)	Leaving Port Moresby for Cairns, 11:30 – (PX 090) (Mr. Kobayashi) Port Moresby 8:40 – (PX 160) – 9:30 Goroka (Mr. Okaga)	Goroka / Lorengau
19 Aug (Sat) to 31 Aug (Thu)	Site Survey (Consultant Members)	Goroka / Lorengau
1 Sep (Fri)	14:00 Report of the Study Result at EOJ 15:00 Report of the Study Result at JICA Office (Consultant Members)	Port Moresby
2 Sep (Sat) to 3 Sep (Sun)	Inner Meeting	Port Moresby
4 Sep (Mon)	Leaving Port Moresby for Cairns, 11:30 – (PX 090) Consultant Members	

Itinerary of the Basic Design Study

<table>
<tr><th rowspan="2">No</th><th colspan="2" rowspan="2">Date</th><th colspan="8">Activities</th></tr>
<tr><th>Iwasaki / Kobayashi</th><th>Okaga</th><th>Shiraiwa</th><th>Satoh</th><th>Hayakashi</th><th>Araki</th><th>Toda</th><th>Nakatake</th></tr>
<tr><td>1</td><td>1 Aug</td><td>Tue</td><td rowspan="5"></td><td colspan="4">Tokyo to Cairns</td><td rowspan="5"></td><td colspan="2">Tokyo to Cairns</td></tr>
<tr><td>2</td><td>2 Aug</td><td>Wed</td><td colspan="4">Cairns to Port Moresby (POM)</td><td colspan="2">Cairns to POM</td></tr>
<tr><td>3</td><td>3 Aug</td><td>Thu</td><td colspan="4">POM to Goroka (GRK)</td><td colspan="2">POM to GRK</td></tr>
<tr><td>4</td><td>4 Aug</td><td>Fri</td><td colspan="4" rowspan="2">GRK</td><td colspan="2" rowspan="13">GRK</td></tr>
<tr><td>5</td><td>5 Aug</td><td>Sat</td></tr>
<tr><td>6</td><td>6 Aug</td><td>Sun</td><td>Tokyo to Cairns</td><td colspan="4">GRK to POM</td><td>Tokyo to Cairns</td></tr>
<tr><td>7</td><td>7 Aug</td><td>Mon</td><td colspan="6">Cairns to POM (Kobayashi, Araki)
Meeting with JICA, Courtesy Call to Embassy of Japan</td></tr>
<tr><td>8</td><td>8 Aug</td><td>Tue</td><td colspan="6">PNG Water Board</td></tr>
<tr><td>9</td><td>9 Aug</td><td>Wed</td><td colspan="6">POM to Lorengau (LRG)</td></tr>
<tr><td>10</td><td>10 Aug</td><td>Thu</td><td colspan="6" rowspan="3">LRG</td></tr>
<tr><td>11</td><td>11 Aug</td><td>Fri</td></tr>
<tr><td>12</td><td>12 Aug</td><td>Sat</td></tr>
<tr><td>13</td><td>13 Aug</td><td>Sun</td><td colspan="2">LRG to POM</td><td colspan="2" rowspan="5">LRG</td><td colspan="2">LRG to POM</td></tr>
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<tr><td>15</td><td>15 Aug</td><td>Tue</td><td colspan="2" rowspan="2">GRK</td><td colspan="2" rowspan="12">GRK</td></tr>
<tr><td>16</td><td>16 Aug</td><td>Wed</td></tr>
<tr><td>17</td><td>17 Aug</td><td>Thu</td><td colspan="2">GRK to POM</td><td>GRK to POM</td><td rowspan="10">GRK</td></tr>
<tr><td>18</td><td>18 Aug</td><td>Fri</td><td colspan="2">Minutes of Discussion (M/D)</td><td rowspan="7">LRG</td><td>LRG to POM</td><td>M/D</td></tr>
<tr><td>19</td><td>19 Aug</td><td>Sat</td><td>POM to Cairns</td><td>POM to GRK</td><td rowspan="3">POM</td><td>POM</td></tr>
<tr><td>20</td><td>20 Aug</td><td>Sun</td><td>Cairns to Tokyo</td><td rowspan="7">GRK</td><td>POM to LRG</td></tr>
<tr><td>21</td><td>21 Aug</td><td>Mon</td><td rowspan="15"></td><td rowspan="4">LRG</td></tr>
<tr><td>22</td><td>22 Aug</td><td>Tue</td><td>POM to Cairns, Cairns to Tokyo</td></tr>
<tr><td>23</td><td>23 Aug</td><td>Wed</td><td rowspan="13"></td></tr>
<tr><td>24</td><td>24 Aug</td><td>Thu</td></tr>
<tr><td>25</td><td>25 Aug</td><td>Fri</td><td>LRG to POM</td><td>LRG to POM</td></tr>
<tr><td>26</td><td>26 Aug</td><td>Sat</td><td rowspan="3">POM</td><td rowspan="2">POM</td></tr>
<tr><td>27</td><td>27 Aug</td><td>Sun</td><td>GRK to POM</td><td colspan="2">GRK to POM</td><td>GRK to POM</td></tr>
<tr><td>28</td><td>28 Aug</td><td>Mon</td><td rowspan="4">POM</td><td colspan="4" rowspan="4">POM</td></tr>
<tr><td>29</td><td>29 Aug</td><td>Tue</td><td>POM to Cairns</td></tr>
<tr><td>30</td><td>30 Aug</td><td>Wed</td><td>Cairns to Tokyo</td></tr>
<tr><td>31</td><td>31 Aug</td><td>Thu</td><td rowspan="5"></td></tr>
<tr><td>32</td><td>1 Sep</td><td>Fri</td><td>JICA/ EOJ</td><td colspan="4">JICA/ EOJ</td></tr>
<tr><td>33</td><td>2 Sep</td><td>Sat</td><td rowspan="2">POM</td><td colspan="4" rowspan="2">POM</td></tr>
<tr><td>34</td><td>3 Sep</td><td>Sun</td></tr>
<tr><td>35</td><td>4 Sep</td><td>Mon</td><td>POM to Cairns, Cairns to Tokyo</td><td colspan="4">POM to Cairns,
Cairns to Tokyo</td></tr>
</table>

Schedule of Explanation of the Draft Final Report

Date	Day	Activities	Accommodation
1 Nov	Wed	Tokyo to Cairns	
2 Nov	Thu	Cairns to Port Moresby 10:00 JICA PNG Office 11:00 Embassy of Japan 14:00 PNG Department of National Planning and Monitoring 14:30 PNG Water Board	Port Moresby
3 Nov	Fri	PNG Water Board, Explanation on Draft Report	Port Moresby
4 Nov	Sat	Inner Meeting	Port Moresby
5 Nov	Sun	Port Moresby to Goroka	Goroka
6 Nov	Mon	9:00 Goroka, Explanation on Draft Report	Goroka
7 Nov	Tue	9:00 Discussion on Draft Report 13:00 Supplemental Site Survey Goroka to Port Moresby	Port Moresby
8 Nov	Wed	10:00 Meeting with PNG Water Board for Discussing Draft Report 14:00 Joint Meeting on Minutes of Discussion	Port Moresby
9 Nov	Thu	9:00 PNG Water Board Signing of Minutes of Discussion 11:00 Report to Embassy of Japan	Port Moresby
10 Nov	Fri	Travel, Port Moresby to Cairns, Cairns to Tokyo	

Itinerary of Explanation of the Draft Final Report

No	Date		Activities		
			Iwasaki	Okaga	Toda
1	1 Nov	Wed		Tokyo to Cairns	
2	2 Nov	Thu		Cairns to Port Moresby (POM) Courtesy Call to JICA/ Embassy of Japan/ PNG Department of National Planning and Monitoring/ PNG Water Board	
3	3 Nov	Fri	Explanation of Draft Report		
4	4 Nov	Sat	Inner Meeting		
5	5 Nov	Sun		POM to Goroka (GRK)	
6	6 Nov	Mon		Meeting with GRK	
7	7 Nov	Tue		Discussion on Draft Report Supplemental Site Survey GRK to POM	
8	8 Nov	Wed	Meeting with PNG Water Board Discussion on Draft Report Joint Meeting on Minutes of Discussion		
9	9 Nov	Thu	Signing of M/D Report to Embassy of Japan		
10	10 Nov	Fri		POM to Cairns, Cairns to Tokyo	

Appendix 3 ***List of Officers Concerned***

Appendix 3 List of Officers Concerned

<u>Officers Concerned of Japan</u>

1. Embassy of Japan, PNG Office

Tatsuo TANAKA	Ambassador
Yuji OKADA	First Secretary
Ichiro SHIMIZU	First Secretary

2. JICA PNG Office

Kaoru IWASAKI	Resident Representative
Akihiko HOSHINO	Assistant Resident Representative
Mr. Tony Ombo	Programme Officer

<u>Officers Concerned of Papua New Guinea</u>

1. Department of National Planning & Monitoring

Mr. Camillus Midire	Secretary
Mr. Paul Enny	Acting First Assistant Secretary, Foreign Aid Management Division
Mr. Noel Geti	Senior Advisor – Japan ODA/JBIC Desk

2. PNG Waterboard

Mr. Brian Amini	Managing Director
Mr. Amo Mark	Director of Engineering
Mr. Jiamsa Yagas	Executive Engineer
Mr. Sibona Vavia	Principle Engineer, Planning
Mr. Benny B. Bobola	Graduate Engineer

3. Manus Provincial Government

Mr. Job Pomat	Deputy Governor
Mr. James Pokris	Acting Assistant Administrator
Mr. Kanawi Sindol	Executive Research Officer
Mr. Soni Poli	Engineering Works Coordinator
Mr. Bill Marcus	Technical Service

4. Others (Lorengau)

Mr. Noah Posakei	Land Owner

5. Goroka Urban Local Level Government

Mr. Michael Gotaha	Mayor
Mr. Yaunggao Uyassi	Town Manager
Mr. Hanold Aboni	Deputy Town Manager
Mr. Robert Yamnaki	Town Engineer
Mr. Nelson Sabumei	Works Manager
Mr. Cliffson Isaiah	Acting Financial Controller

6. Eastern Highland Provincial Government

Mr. Charles K. Goto	Deputy Provincial Administrator

Appendix 4 *Minutes of Discussions / Technical Notes*

Minutes of Discussions

February 11, 2000

MINUTES OF DISCUSSIONS
PREPARATORY STUDY
ON
THE PROJECT FOR TOWN WATER SUPPLY
IN
PAPUA NEW GUINEA

In response to a request from the Government of Papua New Guinea (hereinafter referred to as "PNG"), the Government of Japan decided to conduct a Preparatory Study on the Project for Town Water Supply (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to PNG the Preparatory Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Kaoru Iwasaki, resident representative, JICA PNG Office, and is scheduled to stay in the country from January 31 to March 4.

The Team held discussions with the officials concerned of the Government of PNG and conducted a field survey at the study areas.

As a result of discussions and field survey, both parties confirmed the main items described on the attached sheets. Subject to the decision by the Government of Japan, JICA will conduct a Basic Design Study on the Project.

Port Moresby, February 11, 2000

岩崎 薫

Mr. Kaoru Iwasaki
Leader
Preparatory Study Team
Japan International Cooperation Agency

Mr. Camillus Midire
Secretary
Department of National Planning & Monitoring

Mr. Patrick Amini OBE
Managing Director
PNG Waterboard

Mr. Yaunggao Uyassi
Town Manager
Goroka Urban Local Level Government

ATTACHMENT

1. Objectiveof the Project

The objective of the Project is to improve the water supply services in Lorengau and Goroka town in order to make safe and stable water supply for the residents.

2. Projectsites

The sites of the Projectare Lorengau and Goroka town.

3. Responsible and ImplementingAgency

3-1. The Responsible Agency

Departmentof NationalPlanning & Monitoring

3-2. The ImplementingAgency

(1) Lorengau

PNG Waterboardin cooperationwith Manus ProvincialGovernment

(2) Goroka

Goroka Urban LocalLevelGovernment

4. Items requested by the Governmentof PNG

After discussions with the Team, the items described in Annex-1 were finally requested by PNG side. JICA will assess the appropriateness of the request and will report the findings to the Governmentof Japan.

5. Japan's Grant Aid Scheme

5-1 PNG side understands the Japan's Grant Aid Scheme explained by the Team, as described in Annex-2.

5-2 PNG side will take the necessary measures, as described in Annex-3, for smooth implementation of the Project, as a conditionfor the Japanese Grant Aid to be implemented.

6. Schedule of the Study

If the Project is found feasible as a result of the Preparatory Study, JICA will send the Basic Design Study Teamaround July.

Annex-1

1. Lorengau
   - To upgrade the intake facilities
   - To upgrade the pump house
     - shelter
     - pumps
     - switchboard
   - To construct a new tank
   - To upgrade pipelines
     - from intake facility to pump house
     - from pump house to storage tank
     - from storage tank to post office
     - ward 1, 2, 3, 4, 5, 6, 7 and Kolwin
   - To install about 500 water meters
   - To install Hydraulic rams at Tamat and Section 42

2. Goroka
   - To rehabilitate the intake facilities
     - river bank protection of intake
     - open channel
     - diurnal pond
   - To replace existing steel and asbestos pipes with dia. 200 mm from diurnal pond to overflow pipe
   - To replace all asbestos pipes
     - from overflow pipe to the treatment plant
     - from water treatment plant to reservoirs
     - Goroka town reticulation system
   - To install at least one water meter in each of the 10 villages
   - To rehabilitate the 2 existing reservoirs at Mt. Kiss
     - repainting 2 reservoirs
     - replacement of the valves
   - To construct a new reservoir at Mt. Kiss
   - To rehabilitate existing water treatment plant
     - installation of meter
     - replacement of filter media
     - construction of a new chemical feeding facility
     - provision of water quality test kits to be used for raw water analysis
   - To construct a new treatment plant next to the existing plant
   - To construct a sludge treatment facility

Annex-2 Japan's Grant Aid System

1. Grant Aid Procedures

1) Japan's Grant Aid Program is executed through the following procedures.

· Application	(Request made by the recipient country)
· Study	(Basic Design Study conducted by JICA)
· Appraisal & Approval	(Appraisal by the Government of Japan and Approval by the Cabinet)
· Determination of Implementation	(Exchange of Notes between the Governments of Japan and the recipient country)

2) Firstly, the application or request for a Grant Aid project submitted by a recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to determine whether or not it is eligible for Grant Aid. If the request is deemed appropriate, the Government of Japan assigns JICA (Japan International Cooperation Agency) to conduct a study on the request.

Secondly, JICA conducts the study (Basic Design Study) using (a) Japanese consulting firm(s).

Thirdly, the Government of Japan appraises the project to see whether or not it is suitable for Japan's Grant Aid Program, based on the Basic Design Study Report prepared by JICA, and the results are then submitted to the Cabinet for an approval.

Fourthly, the project, once approved by the Cabinet, becomes official with the Exchange of Notes signed by the Governments of Japan and the recipient country.

Finally, for the implementation of the project, JICA assists the recipient country in such matters as preparing tenders, contract and so on.

2. Basic Design Study

1) Contents of the study

The aim of the Basic Design Study (hereafter referred to as "the Study") conducted by JICA on a requested project (hereafter referred to as "the Project") is to provide a basic document necessary for the appraisal of the Project by the Government of Japan. The contents of the Study are as follows:

a) Confirmation of the background, objectives, and benefits of the Project and also institutional capacity of agencies concerned of the recipient country necessary for the Project's implementation.

b) Evaluation of the appropriateness of the Project to be implemented under the Grant Aid Scheme from a technical, social and economic point of view.

c) Confirmation of items agreed on by both parties concerning the basic concept of the Project.

d) Preparation of a basic design of the Project.

e) Estimation of costs of the Project.

The contents of the original request are not necessarily approved in their initial form as the contents of the Grant Aid project. The Basic Design of the Project is confirmed considering the guidelines of the Japan's Grant Aid Scheme.

The Government of Japan requests the Government of the recipient country to take whatever measures are necessary to ensure its self-reliance in the implementation of the Project. Such measures must be guaranteed even though they may fall outside of the jurisdiction of the organization in the recipient country actually implementing the Project. Therefore, the implementation of the Project is confirmed by all relevant organizations of the recipient country through the Minutes of Discussions.

2) Selection of Consultants

For smooth implementation of the Study, JICA uses (a) registered consultant firm(s). JICA select

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(a) firm(s) based on proposals submitted by interested firms. The firm(s) selected carry (ies) out a Basic Design Study and write(s) a report, based upon terms of reference set by JICA.

The consultant firm(s) used for the Study is (are) recommended by JICA to the recipient country to also work on the Project's implementation after the Exchange of Notes, in order to maintain technical consistency and also to avoid any undue delay in implementation should the selection process be repeated.

3. Japan's Grant Aid Scheme

1) What is Grant Aid?

The Grant Aid Program provides a recipient country with non-reimbursable funds to procure the facilities, equipment and services (engineering services and transportation of the products, etc.) for economic and social development of the country under principles in accordance with the relevant laws and regulations of Japan. Grant Aid is not supplied through the donation of materials as such.

2) Exchange of Notes (E/N)

Japan's Grant Aid is extended in accordance with the Notes exchanged by the two Governments concerned, in which the objectives of the Project, period of execution, conditions and amount of the Grant Aid, etc., are confirmed.

3) Period

"The period of the Grant Aid" means the one fiscal year which the Cabinet approves the Project for. Within the fiscal year, all procedures such as exchanging of the Notes, concluding contracts with (a) consultant firm(s) and (a) contractor(s) and final payment to them must be completed.

However, in case of delays in delivery, installation or construction due to unforeseen factors such as weather, the period of the Grant Aid can be further extended for a maximum of one fiscal year at most by mutual agreement between the two Governments.

4) Purchase of the Products and or Services

Under the Grant Aid, in principle, Japanese products and services including transport or those of the recipient country are to be purchased.

When the two Governments deem it necessary, the Grant Aid may be used for the purchase of the products or services of a third country.

However, the prime contractors, namely, consulting, constructing and procurement firms, are limited to "Japanese nationals". (The term "Japanese nationals" means persons of Japanese nationality or Japanese corporations controlled by persons of Japanese nationality)

5) Necessity of "Verification"

The Government of recipient country or its designated authority will conclude contracts denominated in Japanese yen with Japanese nationals. Those contracts shall be verified by the Government of Japan. This "Verification" is deemed necessary to secure accountability to Japanese taxpayers.

6) Undertakings required of the Government of the Recipient Country

(As described in Annex-3)

7) Proper Use

The recipient country is required to maintain and use the facilities constructed and the equipment purchased under the Grant Aid properly and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those covered by the Grant Aid.

8) Re-export

The products purchased under the Grant Aid should not be re-exported from the recipient country.

9) Banking Arrangements(B/A)

a) The Government of the recipient country or its designated authority should open an account in the name of the Government of the recipient country in a bank in Japan (hereinafter referred to as "the Bank"). The Government of Japan will execute the Grant Aid by making payments in Japanese yen to cover the obligations incurred by the Government of the recipient country or its designated authority under the Verified Contracts.

b) The payments will be made when payment requests are presented by the Bank to the Government of Japan under an authorization to pay issued by the Government of the recipient country or its designated authority.

Annex-3 Necessary Measures to be taken by the PNG Side

Following necessary measures should be taken by the PNG Side on condition that the Grant Aid by the Government of Japan is extended to the Project.

1. To provide data and information necessary for the Project
2. To prepare the land for the Project and secure the legal rights to build facilities.
3. To provide proper access road to the Project area, if necessary.
4. To remove existing facilities, if necessary.
5. To bear commissions to the Japanese bank for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.
6. To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation and prompt internal transportation therein of the materials and equipment for the Project purchased under the Grant Aid.
7. To provide warehouse for storage of spare parts and other equipment procured by the Project.
8. To undertake incidental outdoor works such as security of the sites, fencing, gates and exterior lighting around.
9. To exempt Japanese juridical and physical nationals engaged in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in PNG with respect to the supply of the products and services under the verified contracts.
10. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into PNG and stay therein for the performance of their work in accordance with the relevant laws and regulations of PNG.
11. To provide necessary permissions, licenses and other authorizations for implementing the Project, if necessary.
12. To maintain and use properly and effectively the facilities constructed and the equipment provided under the Project.
13. To bear all the expenses, other than those to be borne by the Japan's Grant Aid within the scope of the Project.
14. To assign the necessary staff and secure the necessary budget for operation and maintenance of the equipment purchased under the Grant Aid.

Minutes of Discussions

August 18, 2000

MINUTES OF DISCUSSIONS
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR TOWN WATER SUPPLY
IN
PAPUA NEW GUINEA

Based on the results of the Preparatory Study, the Government of Japan decided to conduct a Basic Design Study on the Project for Town Water Supply (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (hereinafter referred to as "JICA").

JICA sent to Papua New Guinea (hereinafter referred to as "PNG") the Basic Design Study Team (hereinafter referred to as "the Team"), which is headed by Mr. Kaoru Iwasaki, Resident Representative, JICA PNG Office, and is scheduled to stay in the country from August 2 to September 2.

The Team held discussions with the officials concerned of the Government of PNG and conducted field surveys at the study areas.

In the course of discussions and field surveys, both parties confirmed the main items described on the attached sheets. The Team will proceed to further work and prepare the Basic Design Study Report.

Port Moresby, August 18, 2000

Mr. Iwasaki, Kaoru
Leader
Basic Design Study Team
Japan International Cooperation Agency

Mr. Camillus Midire
Secretary
Department of National Planning & Monitoring

Mr. Patrick Amini OBE
Managing Director
PNG Waterboard

Mr. Yaunggao Uyassi
Town Manager
Goroka Urban Local Level Government

ATTACHMENT

1.Objective of the Project

The objective of the Project is to improve the water supply services in Lorengau and Goroka towns in order to realize sufficient water supply for the end users.

2.Project sites

The sites of the Project are Lorengau and Goroka towns.

3.Responsible and Implementing Agency

3-1.The Responsible Agency

Department of National Planning & Monitoring

3-2.The Implementing Agency

(1) Lorengau

PNG Waterboard in cooperation with Manus Provincial Government

(2) Goroka

Goroka Urban Local Level Government

4.Items requested by the Government of PNG

After discussions with the Team, the items described in Annex-1 were finally requested by PNG side. JICA will assess the appropriateness of the request and will recommend to the Government of Japan for approval.

5.Japan's Grant Aid Scheme

5-1 PNG side understood the Japan's Grant Aid Scheme as explained by the Team and described in Annex-2 of the Minutes of Discussions signed by both sides on February 11, 2000.

5-2 PNG side will take the necessary measures, as described in Annex-2, for smooth implementation of the Project, under conditions for the Japan's Grant Aid to be implemented.

6. Schedule of the Study

6-1 The consultants will proceed the further studies in PNG until September 2, 2000.

6-2 JICA will prepare the draft report in English and dispatch a mission in order to explain its contents in (or around) November 2000.

6-3 In case that the contents of the report is accepted in principle by the Government of PNG, JICA will complete the final report and send it to the Government of PNG by January 2001.

7. Other relevant issues

7-1 General

(1) Both sides agreed that the scope of the Project is to improve the present water supply system from the viewpoint of urgent necessity.

(2) Both sides agreed that target year of the Project is to be the year 2003 when the Project is scheduled to be completed.

(3) Both sides agreed, in order for maintaining quality water supply, appropriate level of water analysis equipment and personnel(s) are required at the water treatment plants in Lorengau and Goroka.

(4) For the sake of the technology transfer on sustainable operation and maintenance of the water supply systems in Lorengau and Goroka, the PNG side pointed out the need for dispatch of JICA volunteer(s) as well as technical training of the Project's counterpart personnel(s) in Japan. They also understood that any official requests on technical cooperation should be submitted through diplomatic channels such as the Embassy of Japan and / or the JICA Office.

(5) Both sides agreed that existing pipes to be replaced under the Project will remain at the existing position.

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7-2 Lorengau

(1) Both sides agreed that unit water demand for domestic use of 165 L/c/d is employed in the Project.

(2) The Team pointed out that the transfer of Lorengau water supply system from Manus Provincial Government to PNG Waterboard is a matter of critical importance for the sustainable operation of the system. The Manus Provincial Government gave assurances to transfer the water supply system to PNG Waterboard (Annex-3). PNG Waterboard secured the tentative schedule and the necessary budget for the transfer (Annex-4).

(3) PNG Waterboard will take all responsibility for the operation of the existing water treatment plant. In this context, PNG Waterboard requested the provision of repair parts, which are identified through the test run, to Japan side.

(4) Both sides agreed that PNG Waterboard should take the following land preparation measures:
   (a) To clear, level and reclaim the land for the new pump house.
   (b) To secure the space for pipe laying works.

(5) Both sides agreed that service connections would be the responsibility of the PNG side. Department of National Planning & Monitoring have agreed to make necessary budget provision.

7-3 Goroka

(1) Both sides agreed that following units of water demand for domestic use are employed in the Project.

- urban area: 165 L/c/d
- rural area: 40 L/c/d

(2) Both sides agreed that Goroka Urban Local Level Government should take the following land preparation measures:
   (a) To clear, level and reclaim the land for the new water treatment facilities and the sludge sedimentation ponds.
   (b) To prepare a communication road between the existing and the new water treatment facilities.
   (c) To secure the space for pipe laying works.

(3) Both sides confirmed that people's awareness of appropriate water use, especially for people living in rural areas, is indispensable for sustainable management of the water supply system.

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Annex-1 List of Requested Items

1. Lorengau
   - To reconstruct the inlet structure
   - To rehabilitate the water level gauge at intake
   - To construct a new pump house including mechanical and electrical equipment
   - To replace the existing reservoir tank
   - To replace pipelines
     - from intake facility to pump house
     - from pump house to reservoir tank
     - from reservoir tank to post office
     - ward 4,5,6,7
   - To supply water meters for domestic and commercial uses
   - To supply water quality analysis equipment for daily test
   - To supply repair parts of the existing water treatment plant

2. Goroka
   - To rehabilitate the intake facilities
     - open channel
     - water flow control gate
     - provision of sand removal equipment
   - To replace existing pipes from the diurnal pond to the water treatment plant
   - To replace all asbestos cement pipes for transmission and distribution
   - To supply at least one water meter in each of the 10 villages
   - To replace the valve of the existing reservoir at Mt. Kiss
   - To rehabilitate the existing water treatment plant
     - rehabilitation of back wash system
     - installation of meters
     - replacement of filter media
     - construction of a new chemical feeding facility
     - provision of water quality analysis equipment for daily test
   - To construct new treatment facilities attached to the existing plant
   - To construct sludge sedimentation ponds
   - To supply water meters for domestic and commercial uses
   - To supply flow meters for leakage control

Annex-2 Necessary Measures to be taken by the PNG Side

Following necessary measures should be taken by the PNG side on condition that the Grant Aid by the Government of Japan is extended to the Project:

1. To provide data and information necessary for the Project.

2. To prepare the land for the Project and secure the legal rights to build facilities.

3. To provide proper access road to the Project area, if necessary.

4. To remove existing facilities.

5. To bear commissions to the Japanese bank for its banking services based upon the Banking Arrangement, namely the advising commission of the "Authorization to Pay" and payment commission.

6. To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation and prompt internal transportation therein of the materials and equipment for the Project purchased under the Grant Aid.

7. To provide warehouse for storage of spare parts and other equipment procured by the Project.

8. To undertake incidental outdoor works such as security of the sites, fencing, gates and exterior lighting around.

9. To exempt Japanese juridical and physical nationals engaged in the Project from customs duties, internal taxes (such as VAT) and other fiscal levies which may be imposed in PNG with respect to the supply of the products and services under the verified contracts.

10. To accord Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into PNG and stay therein for the performance of their work in accordance with the relevant laws and regulations of PNG.

11. To provide necessary permissions, licenses and other authorizations for implementing the Project, if necessary.

12. To maintain and use properly and effectively the facilities constructed and the equipment provided under the Project.

13. To bear all the expenses, other than those to be borne by the Japan's Grant Aid within the scope of the Project.

14. To assign the necessary staff and secure the necessary budget for operation and maintenance of the equipment purchased under the Grant Aid.

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Annex-3

MANUS PROVINCIAL GOVERNMENT
OFFICE OF THE GOVERNOR

P O Box 37
LORENGAU
Manus Province 641
Papua New Guinea
Telephone: (675) 4709 212
Facsimile: (675) 4709 214

Date 14th August 2000
File:
A/Offr:
Designation:

Mr Patrick Amini, OBE
Managing Director
PNG Waterboard
P O Box 2779
BOROKO

Dear Mr Amini

SUBJECT LORENGAU WATER SUPPLY UPGRADING UNDER JICA GRANT AID

I am pleased to note that the above project is being undertaken with the kind assistance of the Japanese Government. A clean, reliable and safe water supply system has always been lacking in Lorengau and this project is a welcome initiative.

I am also pleased that PNG Waterboard is involved in facilitating the project during the preparatory stages. PNG Waterboard is technically, the most appropriate authority to undertake this project from inception to completion and it is only right that it continues to manage the future operation and maintenance of the system once it is completed.

In my capacity as acting Governor of Manus Province, I hereby give my assurance that the Manus Provincial Government will transfer the Lorengau Water Supply system upon completion of the proposed upgrading works under JICA assistance.

I will instruct my officers in the Provincial Administration to work closely with the JICA Study Team and your officers to ensure the success of this project.

Yours sincerely

JOB POMAT MPA
Acting Governor

cc Provincial Administrator
Deputy Administrator – ETS

PNG Waterboard

PNG WATERBOARD

Annex·

LORENGAU WATER SUPPLY – PROPOSED UPGRADING

UNDER JICA GRANT AID ASSISTANCE.

TRANSFER OF WATER SUPPLY SYSTEM TO PNG WATERBOARD.

1. During Initial discussions with the JICA Basic Study Team on the above project, the issue of possible transfer of control over Lorengau water supply system from Manus Provincial Government to PNG Waterboard was raised as a critical matter.

2. JICA have proposed transfer during the early stages of project preparation and/or implementation, while PNGWB would prefer to take-over the system after the improvements have been completed through Japanese Grant Aid assistance.

3. This early take-over proposed by the JICA team is to ensure that PNG Waterboard as implementing agency has full control over the project, during implementation of the project as well as future operation and maintenance.

4. PNG Waterboard's position is as follows:

- The original take-over of Lorengau Water Supply was planned for 1993, along with Kavieng water supply; however, due to lack of funding to undertake upgrading works in Lorengau, the take-over was deferred.
- A water treatment plant (2 ML/d) was constructed in 1995 through National Government funds, in anticipation of the proposed take-over, which did not take place due to reasons stated above. The plant has been sitting idle for about five years, due to lack of O&M funds at the Provincial Government level.
- The Manus Provincial Government has previously given it's assurance to allow PNG Waterboard to proceed with improvements on the water supply system leading to subsequent take-over.
- Subsequently, a request for grant aid was made to the Japanese Government in June 1996,which resulted in a JICA preparatory study in February 2000 followed by the current basic design study.
- The existing water supply system does not guarantee water quality (to required WHO standards), since the water treatment plant is not connected to the system. Even if the plant is connected in the interim, it would be very un-economical as most of the distribution system (built by US-Army during 2nd World War), would be leaking very badly resulting in a high percentage of unaccounted-for-water.
- There are no existing provisions for metering and charging for services, which is a statutory requirement of PNG Waterboard.
- The transfer of the system to Waterboard can only take place after completion of proposed upgrading works on the system. Then only can Waterboard supply good quality water, on a continuous basis and be able to raise revenue based on actual metered usage.
- The Board of Directors of PNG Waterboard, after satisfying itself on all the above requirements as well as the overall financial viability of the Lorengau Water Supply system, will then make recommendations to the Minister to officially declare Lorengau a Waterboard District.

5. The National Water Supply and Sewerage Act 1986, outlines the statutory requirements of PNG Waterboard as a Commercial Statutory Authority and the provisions for declaration of Waterboard Districts. (*copy provided to study team*). The relevant clauses are:

- Part I, Clause 1 - Purpose of the Act – responsibilities of PNGWB
- Part II, Clause 5 - Functions of PNGWB
- Part II, Clause 6 - Objectives – sub-clauses (a) & (b)
  - Commercial & non-commercial activities
- Part VIII, Clause 27 & 28 - Declaration of Water Districts

6. PNGWB as a Commercial Statutory Authority is required to operate commercially. It can only engage in non-commercial activities, where an explicit subsidy provision for operations is made in the National or Provincial budgets.

7. The proposal to take-over Lorengau water supply in it's present condition, would be a non-commercial activity and therefore would not be possible unless there is an explicit subsidy provision. Past experience shows that subsidy provisions for operation and maintenance are not given priority.

8. The proposed schedule of activities leading to transfer would be as follows:

a. Upgrading of Lorengau W/S system, including this basic design study, detail design, tender, construction and commissioning. (JICA Grant Aid as approved by Japanese Government).

b. Prior to commencement of construction, PNGWB in liaison with Manus Provincial Government will address all project land issues.

c. Approximately 12 months prior to completion of construction, PNGWB will make preparations for establishment of District Operations in Lorengau.

- Establishment of office & staff housing
- Recruitment of essential Operations staff
- Installation of meters & customer database preparation
- Office Equipment & Billing System

d. Upon completion of the project, the Board will make recommendation to the Minister for Declaration of Lorengau Township as a PNG Waterboard District.

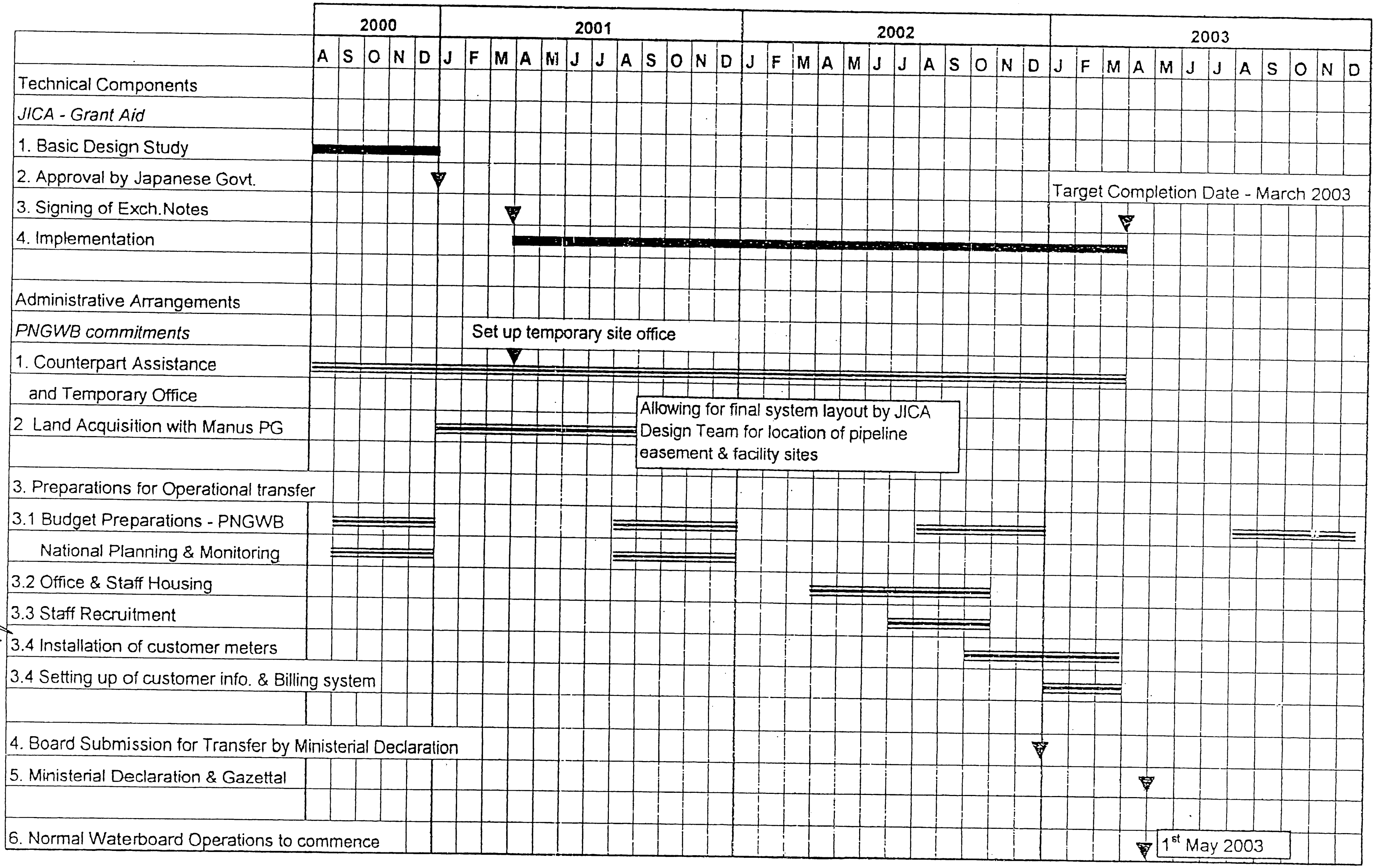
e. Ministerial Declaration by notice in the National Gazette will formalise Waterboard's take-over. The date of the Declaration will be the formal date of transfer of the system to PNGWB. Normal operations will commence thence.

9. The attached schedule outlines the proposed program from present to 2003.

PNG Waterboard – 17th August 2000.

LORENGAU WATER SUPPLY UPGRADING UNDER JICA GRANT AID

Tentative schedule of activities leading to take-over by PNG Waterboard



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Minutes of Discussions

November 9, 2000

MINUTES OF DISCUSSIONS
ON
BASIC DESIGN STUDY
ON
THE PROJECT FOR TOWN WATER SUPPLY
IN
PAPUA NEW GUINEA
EXPLANATION ON DRAFT REPORT

In August 2000, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Basic Design Study Team on the Project for Town Water Supply (hereinafter referred to as "the Project") to Papua New Guinea (hereinafter referred to as "PNG"), and through discussion, field survey, and technical examination of the results in Japan, JICA prepared a draft report of the study.

In order to explain and to consult PNG on the components of the draft report, JICA sent to PNG the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Kaoru Iwasaki, Resident Representative, JICA PNG Office, from November 2 to November 10, 2000.

As a result of discussions, both parties confirmed the main items described in the attached sheets.

Port Moresby, November 9, 2000

岩崎 薫

Mr. Iwasaki, Kaoru
Leader
Basic Design Study Team

Mr. Camillus Midire
Secretary
Department of National Planning & Monitoring

Mr. Patrick K. Amini OBE
Managing Director
PNG Waterboard

Mr. Yaunggao Uyassi
Town Manager
Goroka Urban Local Level Government

ATTACHMENT

1. Components of the Draft Report

The Government of PNG agreed and accepted in principle the components of the draft report explained by the Team.

2. Japan's Grant Aid Scheme

PNG side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of PNG as explained by the Team and described in Annex-2 of the Minutes of Discussions signed by both parties on February 11, 2000 and Annex-2 of the Minutes of Discussions signed by both parties on August 18, 2000.

3. Schedule of the Study

JICA will complete the final report in accordance with the confirmed items and send it to the Government of PNG by January 2001.

4. Other Relevant Issues

4-1 Common Items

(1) The PNG government shall provide tight security in and around the construction camps and plant yards and during transportation of material and equipment.

(2) The both parties agreed on the followings:

a. The water meters to be procured under the Japanese Grant Aid shall be completely installed by the PNG's Implementing Agencies within the period of the Project.
b. The PNG's Implementing Agencies shall use properly the installed water meters and, thereby, collect water-charge and, at the same time, shall endeavor to strengthen its financial status.
c. The PNG's Implementing Agencies asserted that they will carry out an awareness campaign for minimizing wasteful water among the local inhabitants in close collaboration with related organizations and establish a water-charge-collecting system acceptable to the consumers.

(3) The PNG's Implementing Agencies pledged to plan for minimizing water leakage, in order to maintain water leakage ratio of less than 25% to be achieved by the Project.

(4) JICA Study Team explained that technical transfer scheme of JICA would be applicable through a due course of procedures, for the sake of sustainable operation and maintenance of the water supply systems in Lorengau and Goroka.

4-2 Lorengau

JICA Study Team confirmed the following affirmations of PNG Waterboard:

(1) Both the facilities built in the Project and the managerial rights of the facilities would be transferred to PNG Waterboard within two months after the Project's completion.

(2) Expenses necessary for the transfer would be covered by both an equity contribution of the Government of PNG and PNG Waterboard. The necessary budget would be arranged on basis of a transfer program to be worked out by PNG Waterboard.

(3) PNG side secured the implementation schedule and budget preparations shown in the Annex-4 of the Minutes of Discussions signed by both parties on August 18, 2000.

4-3 Goroka

JICA Study Team confirmed the following affirmations of Goroka Urban Local Level Government (GULLG):

(1) The water supply volume to the villages should be maintained as the same as present. Water distribution adjustment among the villages and water-charge collection work would be carried out by GULLG, by utilizing the water meters and valves which would be installed under the Project, at the entrances of villages in the distribution pipes. GULLG would make a plan to enhance awareness of the village people for paying water-charge.

(2) GULLG secured the tentative implementation schedule as ANNEX-1.

Annex-1

Implementation Schedule of GULLG for Town Water Supply Project supported by GOJ

	Month commences upon E/N																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
A. Japanese Grant Aid																											
A-1 Signing of E/N (1)	▼																										
A-2 Detailed design		━	━	━	━	━	━																				
A-3 Signing of E/N (2)					▼																						
A-4 Tendering									▼																		
A-5 Procurement & construction										━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━	━
A-6 Hand over of equipment procured under the Project															▼												
B. Activities of GULLG																											
B-1 Budget preparation - GULLG									━	━	━	━									━	━	━	━			
B-2 Land acquisition for raw water transmission pipe	━	━	━	━	━																						
B-3 Construction of access road to new WTP site				━	━	━																					
B-4 Land preparation for new WTP site								━	━																		
B-5 Primary power supply																				━							
B-6 Fencing																										━	━
B-7 Rehabilitation of intake & transmission facilities													━	━	━												
B-8 Designing of installation of water meters																━	━										
B-9 Installation of water meters																		━	━	━	━	━	━	━			
B-10 Setting up of customer info. & billing system	━	━	━	━	━	━	━	━	━	━	━	━	━	━													

Technical Notes

August 25, 2000

TECHNICAL NOTES
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR TOWN WATER SUPPLY
IN
PAPUA NEW GUINEA (GOROKA)

Based on the Minutes of Discussions signed on August 18, 2000, the consultant members of the Basic Design Study Team (hereinafter referred to as "the consultant") carried out technical study of the project for town water supply in Papua new guinea (hereinafter referred to as "the project") until August 25, 2000.

The consultant held discussion with the official concerned of Goroka Urban Local Level Government (herein after referred to as "Goroka") and conducted field surveys at the study areas.

In the course of study, both parties confirmed the main technical items described on the attached sheets.

Goroka, August 25,2000

Mr. Okaga, Toshifumi
Project Manager
Pacific Consultants International

Mr. Yaunggao Uyassi
Town manager
Goroka Urban Local Level Government

ATTACHMENT

1. Population and Population Served

(1) Population

Population forecast in 2003 is estimated based on number of household at the present (year 2000) that counted by the field survey and census in 1990.

Census data in 1990

Population growth rate: 2.3%

Family size: 6.7 persons/family

Population of Goroka town in 2003 is to be 23,587. (Refer to ANNEX I)

(2) Water service area

The water service area is whole Goroka town administrated by Goroka Urban Local Level Government.

(3) Rate of population served

Rate of population served as same as existing rate is 100% of the town population.

2. Water Demand

(1) Unit water demand

Unit water demand is determined by Design Manual (PNG Water Board) and comparing with surrounding country in South Pacific Ocean as follows: (Refer to ANNEX II)

Water uses	Unit water demand	
Residential (Town)	165	L/c/d
Residential (Village)	40	L/c/d
School (Pupil)	70	L/c/d
School (Teacher)	165	L/c/d
Hospital	500	L/bed/d
Hotel	400	L/room/d
Restaurant	2,500	L/res./d
Commercial	1,500	L/shop/d
Office	1,000	L/off./d

(2) Water demand forecast

The water demand in 2003 is estimated based on residential and others use(hospital, schools, commercial and offices) in Goroka town. The surrounding 10 villages of the town where is existing water service area will be considered water demand based on existing public taps.

Water uses	Unit water demand (UI		Q'ty	Water demand		Rate	Rate
Residential (Town)	165	L/c/d	23,587	3,892	m3/d	-	67%
Residential (Village)	40	L/c/d	12,235	489	m3/d	-	8%
Subtotalotal			35,822	4,381	m3/d	-	75%
Others	33% % of domestic			1,427	m3/d	33%	25%
Total				5,809	m3/d		100%

3. Design Water Capacity

(1) Design conditions

The design conditions are determined by Design Manual (PNG Water Boar).

(a)	Treatment plant use (TPU)		10 %
(b)	Rate of leakage		25 %
(c)	Day peak factor	Domestic	1.2
(d)	Day peak factor	Others	1.1
(e)	Hour peak factor		1.8

(2) Design water capacity

Based on the water demand in 2003 and design condition, design water capacity is calculated as follows: (unit in m3/d)

	Basic Data	Daily Ave.	Daily Maximum	Hourly Maximum
Domestic	4,381	4,381	5,258	7,886
Others	1,427	1,427	1,570	2,569
Subtotal	5,809	5,809	6,828	10,455
TPU	0.10	645	759	1,162
Loss	0.25	1,936	2,276	3,485
Total		8,390	**9,862**	15,102
(Total) - (TPU)		7,745	**9,103**	**13,941**

The design capacity for facilities is shown below.

(Unit in m3/d)

(a) From intake to water treatment plan	10,000
(b) Transmission main and reservoir ta	9,300
(c) Outlet of reservoir	14,100

4. Facility Plan

(1) Intake facility (Refer to Annex III)

a. Intake (from intake to flow adjustment gate)

- The existing flow adjustment sluice gate installed after the control works will be replaced with the same size of steel sluice gate.

b. Intake channel (after flow adjustment gate until end of diurnal pond)

- About 230m of open channel will be converted to box culvert with the size of 1000×1000 mm.

c. Intake pipe (after the diurnal pond until connection to transmission pipe)

- The steel pipe with the diameter of 300mm and length of roughly 270m, will be installed as stand-by of the existing 500mm steel pipe presently on duty.

(2) Water treatment facility

a. Determination for capacity of the existing plant

The capacity of the existing water treatment plant is summarized as the following table.

	System	No. 1	No.2
Coagulo-sedimentation basin	Shape	Inverted pyramid	Column (upper part) Inverted corn (lower part)
	Surface area	93.6 m^2	70.1 m^2
	Effective volume	181 m^3	230 m^3
	Surface load[1)]	12 mm/min	45 mm/min
	Water capacity[1)]	1,600 m^3/d	4,524 m^3/d
		Total 6,204 m^3/d	
Filtration basin	Shape	Rectangle	Circle
	Surface area	14 m^2	39.9 m^2
	Filtration media	Sand and gravel	Sand and gravel
	Filtration rate[2)]	120 m^3/d	120 m^3/d
	Water capacity[2)]	1,680 m^3/d	4,788 m^3/d
		Total 6,468 m^3/d	

Note 1) Figures are estimated from the experiment by the study team.

2) Figures are estimated from the design manual and the actual measurement by the study team.

From the table, 6,500 m^3 /d is adopted as the designed water volume of the existing treatment plant.

(3) Improvement of the existing plant

As a result of the site survey, existing plant will be improved as follow:

	Result of the check	Improvement
Coagulo-sedimentation	Due to over-load operation and low turbidity, the function of the equipment is low. Refer to attached the report	- The system shall be request to operate depending on raw water quality. - The raw water flow should be controlled under the design water capacity.
Filter	No.1: filter media is broken by long operation No.2: filter media is soiled due to unsatisfactory backwash. Many leakage from grand due to overage pump	- Replace of filter sand and pump
Chemical dosing equipment	Insufficiency of dosing capacity and overage pump	- Replace of the chemical dosing equipment such as solution tank and pump.
Disinfection	Overage pump and no solution tank	Replace of the chemical dosing equipment such as solution tank and pump.
Pipeline	Good	
Water quality analysis equipment	- comparator is Already broken body. - No equipment to take necessaries daily maintenance	Water quality analysis equipment is required

Valves	Result of the check	Improvement (Replace)
Raw water valve	No operation	2 sets of 200mm sluice valve
No.1 sedimentation inlet valve	Leakage water	1 set of 200mm sluice
No.2 sedimentation inlet valve	No operation	1 set of 200mm sluice valve
No.1 filtered water valve	No operation	1 set of 200mm sluice valve
No.2 filter drain valve	No operation	2 sets of 300mm butterfly
No.2 filtered water valve	No operation	1 set of 250mm butterfly

(Refer to ANNEX IV)

(4) Expansion of the Plant

According to design capacity and existing plant capacity mentioned above, new plant for expansion is required. The design conditions for new plant is shown as below.

a. Design water capacity: 3,500m3/d

b. Design concept

- To design new receiving and mixing tank, horizontal type sedimentation and self wash system rapid sand filter
- To design the capacity of mixing well, chemical dosing equipment, disinfection

equipment and backwash system is combined with capacity of existing plant replaced in this project. Total design capacity is to be 10,000m3/d.

- To propose the system of energy-saving to utilize gravity.

c. The government already prepares necessary land for new plant construction.

c. To design flow measurement equipment as follows:

- For raw water flow at plant inlet
- For treated water flow at filter outlet
- For transmission flow at clear water tank outlet
- For distribution flow at reservoir tank outlet

(5) Reservoir, transmission main and distribution network

a. Reservoir

One (1) drain valve of the existing reservoir at Mt. Kiss will be replaced.

b. Transmission main

All asbestos cement pipes (ACP) of the transmission main will be replaced. Below table shows the diameter and length of existing pipes for transmission and AC pipes to be replaced as the scope of the project.

	Diameter	Length (m)			Replace
		CIP	ACP	PVC	
Transmission main	300 mm	2,475			
	200 mm		2,376		O
	100 mm			1,347	
	Subtotal	**2,475**	**2,376**	**1,347**	
Total				**6,198**	

Note CIP : Cast iron pipe
ACP : Asbestos cement pipe
PVC : Polyvinyl chloride pipe

c. Distribution network

Below table shows the diameter and length of existing pipes for distribution. All ACP of the distribution network will be replaced with Polyvinyl chloride pipes (PVC). The pipeline in low water pressure area will be considered.

	Diameter	Length (m)			Replace
		ACP	PVC	GSP	
Distribution network	150 mm	12,210			○
	100 mm	12,849			○
	80 mm	244			○
	150 mm		348		
	100 mm		18,876		
	80 mm		52		
	50 mm		4,316		
	25 mm		2,444		
	20 mm		1,045		
	25 mm			629	
	20 mm			182	
	Subtotal	**25,303**	**27,082**	**811**	
Total				**53,196**	

Note ACP : Asbestos cement pipe
PVC : Polyvinyl chloride pipe
GSP : Galvanized steel pipe

d. Fire hydrant

Existing fire hydrants on the ACP will be removed. New fire hydrants will be designed with the 100-meter interval along the pipeline in principle, with taking their present location in consideration.

e. Stop valve

Existing stop valves on the ACP will be removed. New stop valves will be designed at down flow of connection of the distribution network, based on the result of the study.

f. Air valve

Air valves will be designed at convex points of the distribution network based on the result of the study. It is noted that fire hydrants can be utilized as air valves.

g. Wash out valve

Wash out valves will be designed at concave points of the distribution network adjacent to discharge points such as river, based on the result of the study. It is noted that fire hydrants can be utilized as wash out valves.

5. Provision of Equipment

Gorolka Urban Local Level Government requested to supply following equipment.

(1) Flow meter

Purpose: for the leakage control

Request: 1(one) Ultra-sonic flow meter

(2) Water quality analysis equipment

Purpose: for the daily maintenance at the Water Treatment Plant in order to supply water being subject to the water quality standard. The analysis for monthly or yearly maintenance should be entrusted to the research institute.

Request: 1 (one) Jar-tester and portable water quality analysis kit (pH, turbidity, alkalinity, coliform, residual chlorine)

(3) Water meter with stop cock

Purpose: for the stepwise transition from the flat rate system to the meter system with the object of the financial strengthening in compliance with the intention of the Goroka Urban Level Local Government. The Government intends to install meter to consumers having willingness to pay.

Request: reticulation water meter for Goroka town which is determined in consideration of residents' willingness to pay and governmental budget of installation.

Quantity: 1,200 pieces

Request: 10(ten) bulk water meter for villages

(4) Portable sand-pump with the power source of generator

Purpose: for dredging sediments in diurnal pond

Request: 1(one) Portable sand-pump with the power source of generator

Summery of Population and Household

Area		Year 2000		Year 2003 (*1)	
		Population	House hold	Population	House hold
Rorengau (*2)		5,298	1,090	5,672	1,167
Goroka (*3)	Town	22,032	3,684	23,587	3,944
	Village	11,428	3,590	12,235	3,843
	Sub Total	33,460	7,274	35,822	7,788
Total		38,758	10,958	41,494	11,732

Source:
(*1) According to census data in 1990, poopulation forecast in 2003 is estimated based on population gı
rate with 2.3% every year
(*2) National population census, July 2000
(*3) Counting check conducted by the Study Team in August 2000

Name of village	Year 2000			2003
	Public Tap	No of pupil per 1tap	Consumers	Consumers
Okiufa	87	14	1,224	1,310
Segu	79	6	436	467
Faniufa	79	4	350	375
Kami	8	119	954	1,021
Kama,Sipiga	348	8	2,913	3,119
Asaroufa	185	16	2,921	3,127
Kafana, Fimito	50	26	1,277	1,367
Lapegu	10	54	535	573
Komiufa	39	21	818	876
Total	885		11,428	12,235

Water Demand

(1) Water demand in 2000

Water uses	Unit water demand		Q'ty	Water demand(2000		Rate(*1)	Rate
Residential (Town)	165	L/c/d	22,032	3,635	m3/d	-	67%
Residential (Village)	40	L/c/d	11,428	457	m3/d	-	8%
Subtotal			33,460	4,092	m3/d	-	75%
Others							
School (Pupil)	70	L/c/d	5,208	365	m3/d	9%	7%
School (Teacher)	165	L/c/d	317	52	m3/d	1%	1%
Hospital	500	L/bed/d	369	185	m3/d	5%	3%
Hotel	400	L/room/d	412	165	m3/d	4%	3%
Restaurant	2,500	L/res./d	32	80	m3/d	2%	1%
Commercial	1,500	L/shop/d	190	285	m3/d	7%	5%
Office	1,000	L/off./d	202	202	m3/d	5%	4%
Subtotal				1,333	m3/d		25%
Total			**73,650**	**5,426**	**m3/d**	**33%**	**100%**

Rate(*1) The figure is shown ratio of others uses comparing with domestic use.

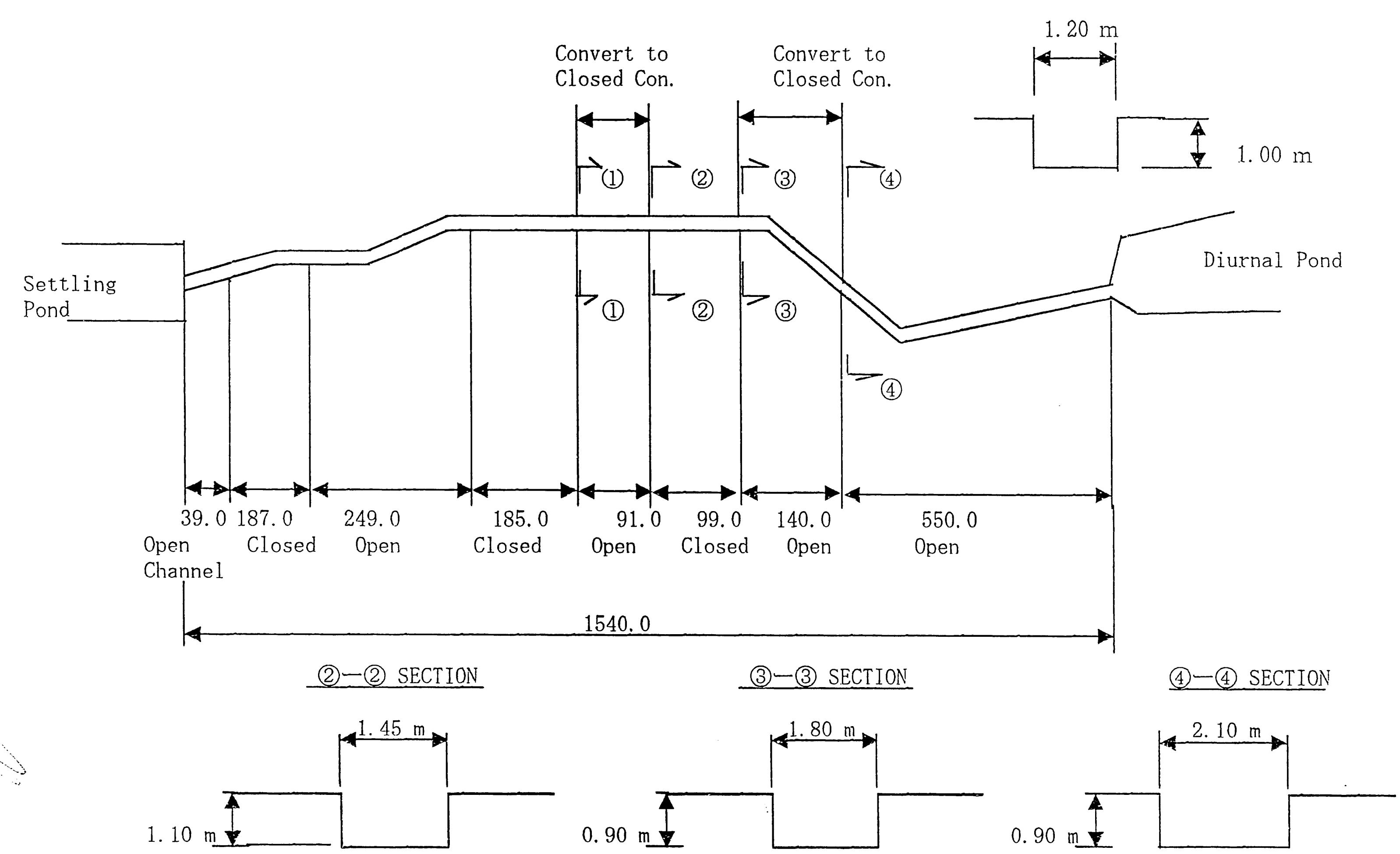
(*2) **Day pupil: 30 L/c/d (70%), Boading pupil: 165 L/c/d (30%)**

(2) Water demand in 2003

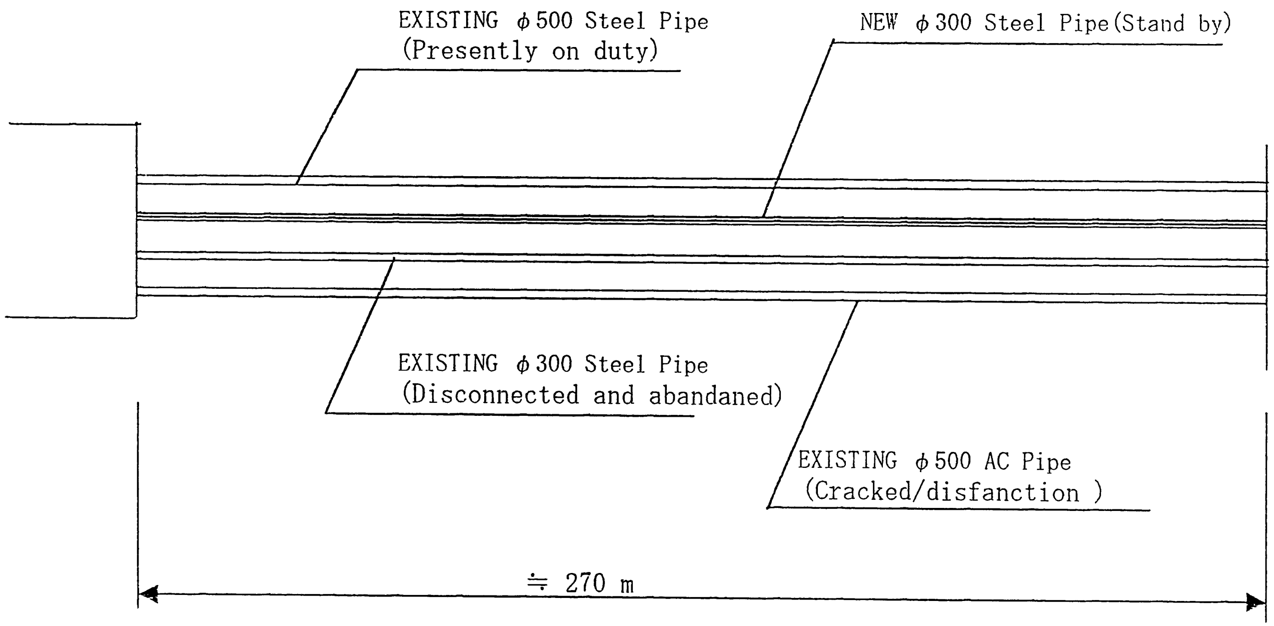
Water uses	Unit water demand (Ul		Q'ty	Water demand		Rate	Rate
Residential (Town)	165	L/c/d	23,587	3,892	m3/d	-	67%
Residential (Village)	40	L/c/d	12,235	489	m3/d	-	8%
Subtotalotal			35,822	4,381	m3/d	-	75%
Others	33% % of domestic			1,427	m3/d	33%	25%
Total				**5,809**	**m3/d**		**100%**

ANNEX III

INTAKE CHANNEL



INTAKE PIPE


EXISTING φ500 Steel Pipe
(Presently on duty)
NEW φ300 Steel Pipe(Stand by)
EXISTING φ300 Steel Pipe
(Disconnected and abandaned)
EXISTING φ500 AC Pipe
(Cracked/disfanction)
≒ 270 m

Check List for the Water Treatment Plant

(1) General

Item	Specification	Result of the survey	Comment
Process	Mixing → coagulo-sedimentation → filter→disinfection	- Effectiveness of chemical mixing is not enough for coagulation. - -In case of low turbidity (less than 10 degree), function of coagulo-sedimentation will be low. - The operation of the facility can not manage efficiently due to no measurement equipment on the system except No.1 treated water pipeline. - Waste water from the plant drain out to river directly.	- Mixing tank is required to make satisfied floc. - The system shall be request to operate depending on raw water quality. - Flow meters, which consist of indicator and recorder, are required on the raw water and treated water pipeline. - Wastewater should be treated environmental aspect.
Treatment capacity	Current treatment capacity with 12,414m3/d was estimated by the result of site measurement test.	Due to over-load operation, the function of each facility is still low. Following items are pointed out. - Flocs in the sedimentation tank carry over to filter. - Interval of the backwash is short. - Capacity of the chemical dosing equipment is short by normal operation capacity.	- The raw water flow should be controlled under the design water capacity. The design water capacity is to be 6.500m3/d.
Arrangement of the plant	The space for the pipeline in the plant is tight.	There is no space to construct expansion facility in future, if any plane.	New land for expansion is already prepared
Operation and maintenance	The rate of chemical dosing for coagulation is not constant dosing.	There is no test equipment for water quality analysis.	Water quality analysis equipment is required such as jar-tester for the daily maintenance.

(2) Facility

	Specification	Result of the check	comment
Coagulo-sedimentation	No.1: Slurry-blanket type No.2: High rate coagulo-sedimentation	Due to over-load operation and low turbidity, the function of the equipment is low.	- The system shall be request to operate depending on raw water quality. - The raw water flow should be controlled under the design water capacity.
Filter	Rapid sand filter	No.1: filter media is broken by long operation No.2: filter media is soiled due to unsatisfactory backwash. Many leakage from grand due to overage pump	- Replace of filter sand and pump
Chemical dosing equipment	Double head diaphragm pump	Insufficiency of dosing capacity and overage pump	- Replace of the chemical dosing equipment such as solution tank and pump.
Disinfection	Diaphragm pump	Overage pump and no solution tank	Replace of the chemical dosing equipment such as solution tank and pump.
Pipeline and valves	Pipe: steel and cast iron Valve: cast iron, sluice and butterfly valve	Pipe: good Valve: leakage water and fault (refer to the valve check list)	Valves: Replace of fault valve
Water quality analysis equipment	Residual chlorine and pH comparator	- comparator is Already broken body. - No equipment to take necessaries daily maintenance	Water quality analysis equipment is required

(3) Check list of valves

Raw water valve	2 sets of 200mm sluice valve	No operation	Replace
No.1 sedimentation inlet valve	1 set of 200mm sluice	Leakage water	Replace
No.2 sedimentation inlet valve	1 set of 200mm sluice valve	No operation	Replace
No.1 filtered water valve	1 set of 200mm sluice valve	No operation	Replace
No.2 filter drain valve	2 sets of 300mm butterfly	No operation	Replace
No.2 filtered water valve	1 set of 250mm butterfly	No operation	Replace

Goroka Urban Local Level Government

SERVING THE TOWN OF GOROKA

P.O. Box 309, GOROKA, Eastern Highlands Province 441, Papua New Guinea
Telephone: (675) 732 1999 Facsimile: (675) 732 1818

Basic Design Study Team
Japan International Corporation Agency

In Reply Please Quote:
Actioning Officer: R. Yamnaki
Designation: T/Engineer
Date: 25.08.2000

ATTENTION: MR. OKAGA TOSHIFUMI

Dear Sir

WATER METER INSTALLATION - FINANCIAL BACKUP

This is in reference to our verbal discussion today (25/08/2000) between the staff of Goroka Urban Local Level Government (GULLG) and the PCI team.

Our estimated number of water meters to install during one year is 1200 meters. The estimated installation costs will be K79,200. This cost is for the materials only as labour will be utilised within the GULLG organisation.

We are certain that the installation cost will be obtained from:

(a) Internal Revenue by means of

- Water Charges
- Land Rates etc.

(b) National and Provincial Government Grants

We hope that this information is sufficient to assist you in your planning purposes.

Thankyou.

Yours Sincerely
GOROKA URBAN LOCAL LEVEL GOVERNMENT

....
YAUNGGAO UYASSI
TOWN ENGINEER

Technical Notes

August 30, 2000

TECHNICAL NOTES
THE BASIC DESIGN STUDY
ON
THE PROJECT FOR TOWN WATER SUPPLY
IN
PAPUA NEW GUINEA (LORENGAU)

Based on the Minutes of Discussions signed on August 18, 2000, the consultant members of the Basic Design Study Team (hereinafter referred to as "the Consultant") carried out technical study of the project for town water supply in Papua New Guinea (hereinafter referred to as "the Project") until August 30, 2000.

The Consultant held discussion with the officials concerned of PNG Waterboard in cooperation with Manus Provincial Government (herein after referred to as "Lorengau") and conducted field surveys at the study areas.

In the course of study, both parties confirmed the main technical items described on the attached sheets.

Port Moresby, August 30,2000

Mr. Okaga, Toshifumi
Project Manager
Pacific Consultants International

Mr. Patrick Amini OBE
Managing Director
PNG Waterboard

ATTACHMENT

1. Population and Population Served

(1) Population

Population of Lorengau and population connected to public water supply have been counted through the field survey. Taking 2.3 % as the annual population growth rate, the result of census in 1990, population served in 2003 has been forecast (**ANNEX I**).

	Year 2000	Year 2003
Population of Lorengau town	5,298	5,672
Population served	4,055	4,341
Rate of population served	76.5%	76.5%

(2) Water service area

The water service area of the Project is to be the existing water service area.

2. Water Demand

(1) Unit water demand

The following unit water demand has been determined, referring to Design Manual (PNG Waterboard) as well as data of neighboring countries in South Pacific Ocean.

Water use	Unit water demand
Residential	165 L/c/d
School (pupil)	70 L/c/d
School (teacher)	165 L/c/d
Hospital	500 L/bed/d
Hotel	400 L/room/d
Restaurant	2,500 L/restaurant/d
Commercial	1,500 L/shop/d
Office	1,000 L/office/d

(2) Water demand forecast

The water demand forecast in 2003 is summarized in table below. Water demand forecast by water use categories, residential, hospital, schools, commercial and offices, is given in **ANNEX II**.

Water use	Unit demand	Q'ty	Water demand	Rate
Domestic (Town)	165 L/c/d	4,341	716 m^3/d	62%
Domestic (Islands)	40 L/c/d	l.s.	100 m^3/d	9%
Total domestic		4,341	816 m^3/d	70%
Others	42 % of domestic		344 m^3/d	30%
Grand total			1,160 m^3/d	100%

3. Design Water Capacity

(1) Design conditions

The design conditions are determined as follows:

(a)	Treatment Plant Use (TPU)	10%
(b)	Leakage ratio	25%
(c)	Day peak factor (Domestic)	1.2
(d)	Day peak factor (Others)	1.1
(e)	Hour peak factor (Domestic)	1.8
(f)	Hour peak factor (Others)	1.6

(2) Design water capacity

Based on the water demand in 2003 and design conditions, design water capacity is calculated as follows:

	Base Data	Daily average	Daily Maximum	Hourly Peak
Domestic	816 m^3/d	816 m^3/d	980 m^3/d	61 m^3/hr
Others	344 m^3/d	344 m^3/d	378 m^3/d	23 m^3/hr
Subtotal		1,160 m^3/d	1,358 m^3/d	84 m^3/hr
TPU	10 %	129 m^3/d	151 m^3/d	9 m^3/hr
Loss	25 %	387 m^3/d	453 m^3/d	28 m^3/hr
Total		1,676 m^3/d	1,961 m^3/d	122 m^3/hr
(Total) - (TPU)		1,547 m^3/d	1,810 m^3/d	112 m^3/hr

4. Facility Plan

(1) Intake facility

a. Available discharge

Available discharge from the Lorengau River for water supply is evaluated as 22 to 25 l/s for a drought of about once every 10 years. If water demand were increased in the future, water sources in other river basins will be required due to limited water resources of the Lorengau River.

b. Facility plan

- Construction of a new intake structure with screen (manual operation)
- Prevention of leakage from the weir
- Installation of a water level gauge

(2) Intake Transmission Facility

- Replacement of the pipes including six(6) aqueducts along the existing alignments
- Provision of a new pump house at a ground elevation of 25 to 30 m above mean sea level

(3) Water treatment facility

Through the test operation of the existing water treatment facility, the following was identified to be malfunctioning:

- Piping system and dosing system of chlorinator
- Filtered water collection equipment
  (Outflow of filter media to clean water chamber and through under drainage has been observed)

Repair of the above will be borne by PNG Waterboard.

(4) Distribution Reservoir

The existing distribution reservoir tank is superannuated so that new tanks will be constructed in the water treatment plant site. The capacity of the tank will be approx. 1,600 m^3, taking the calculation basis as below:

[A] Production capacity	Day peak production	2,000 m^3
[B] Base capacity	12 hours of [A]	1,000 m^3
[C] Capacity for emergency case	[C1]+[C2]+[C3]	584 m^3
[C1] Intake stop due to high turbidity	5 hours of [A]	417 m^3
[C2] Electric power down	2 hours of [A]	167 m^3
[C3] Fire fighting	to be included in [B]	NIL
[D] Total capacity	[B]+[C]	1,584 m^3

Considering the available space in the site, two tanks may be constructed, one in the vacant space at the primary stage, and the other in the location of the existing tank after demolishing the tank

(5) Distribution Pipes

a. Replacement of existing pipes

All the existing galvanized steel pipes (GSP) in the distribution network will be replaced with the polyvinyl chloride pipes (PVC). Galvanized steel pipes (GSP) will be employed for the pipes to be installed above ground, pipe bridges, creek crossings and etc. Standards of pipe materials will be compatible with Australian Standard (AS).

b. Restructuring of the reticulation

Pipelines in the private lands and difficult accessibility will be relocated to new routes, along the public road in principle.

Partially unbalanced water pressure in the reticulation will be improved by means of enlarging the diameter or looping the networks.

c. Pipe diameters

Suitable pipe diameters will be designed through the network analysis on the following conditions, for this purpose, pressure control valve may be installed in the pipeline:

Minimum dynamic pressure head :	10m
Maximum static pressure head :	70m

In the case that diameters of the existing PVC pipes are identified to be small as a result of the network analysis, new PVC pipes will be laid in parallel with the existing pipes and connected at an interval, so as to be capable of the calculated capacity, since the existing PVC pipes seems to be physically in good condition.

d. Fire hydrant

New fire hydrants will be installed at approximately 100-meter interval along the pipeline. Spring hydrant (underground type) will be employed, in conformity with the PNG Waterboard Design Manual.

e. Stop valve

Stop valves will be installed at down flow of every connection of main pipes and at certain intervals.

f. Air valve

Air valves will be installed at convex points of the pipeline.

g. Wash out valve

Wash out valves will be installed at concave points of the distribution network adjacent to discharge points such as river, drainage channel and etc. It is noted that fire hydrants can be utilized as wash out valves.

h. Restoration of pavement

Road pavement demolished in the construction works will be restored under the Project.

5. Provision of Equipment

PNG Waterboard requested the JICA Study Team to supply the following equipment:

(1) Water quality analysis equipment

Purpose: for the daily maintenance at the water treatment plant in order to supply water being subject to the water quality standard. The analysis for monthly or yearly maintenance should be entrusted to the research institute.

Request: 1 (one) Jar-tester and portable water quality analysis kit (pH, turbidity, alkalinity, coliform, residual chlorine)

(2) Water meter with stop cock

Purpose: to establish a water charge collection system for sustainable management of the waterworks.

Request: Water meter for Lorengau town which is determined in consideration of residents' willingness to pay and governmental budget of installation.

Quantity: approx. 1000 pieces

Population of Lorengau Town

Ward No.	No. of Households (2000)	Populatin (2000)	Popuration forecast (2003)
1	143	690	739
2	161	785	840
3	191	940	1006
4	125	605	648
5	156	748	801
6	130	630	674
7	184	900	964
Town Total	1,090	5,298	5,672

Note:
Annual population growth rate : 2.3%/annum

Consumers' Number (Augst 2000)

Ward No.	Dwellings		School		Hospital	Hotel	Restaurant	Market/shop	Office	Zone
	No. of households	Population	Teachers	Pupils	Beds	Rooms	Nos.	Nos.	Nos.	
1	103	515	16	500					8	East
2	150	650	10	200	100		1		6	East
3	101	505	10	200					5	East
4	91	455							2	East
5	129	645			10	28	3	10	26	West
6	120	600	10	200			1		6	West
7	137	685	30	962					8	West
Town Total	831	4,055	76	2,062	110	28	5	10	61	

Population Served

Ward No.	Populatin served (2000)	Popuration forecast (2003)
1	515	551
2	650	696
3	505	541
4	455	487
5	645	691
6	600	642
7	685	733
Town Total	4,055	4,341

Note:
Annual population growth rate : 2.3%/annum

Water Demand

(1) Water demand in 2000

Water uses	Unit water demand		Q'ty	Water demand(2000		Rate(*1)	Rate
Residential (Town)	165	L/c/d	4,055	669	m3/d	-	61%
Residential (Island) *:	-	L/c/d	l.s.	100	m3/d	-	9%
Subtotal			4,055	769	m3/d	-	70%
Others							
School (Pupil)	70	L/c/d	2,062	144	m3/d	19%	13%
School (Teacher)	165	L/c/d	150	25	m3/d	3%	2%
Hospital	500	L/bed/d	110	55	m3/d	7%	5%
Hotel	400	L/room/d	28	11	m3/d	1%	1%
Restaurant	2,500	L/res./d	5	13	m3/d	2%	1%
Commercial	1,500	L/shop/d	10	15	m3/d	2%	1%
Office	1,000	L/off./d	61	61	m3/d	8%	6%
Subtotal				324	m3/d		30%
Total				**1,093**	**m3/d**	**42%**	**100%**

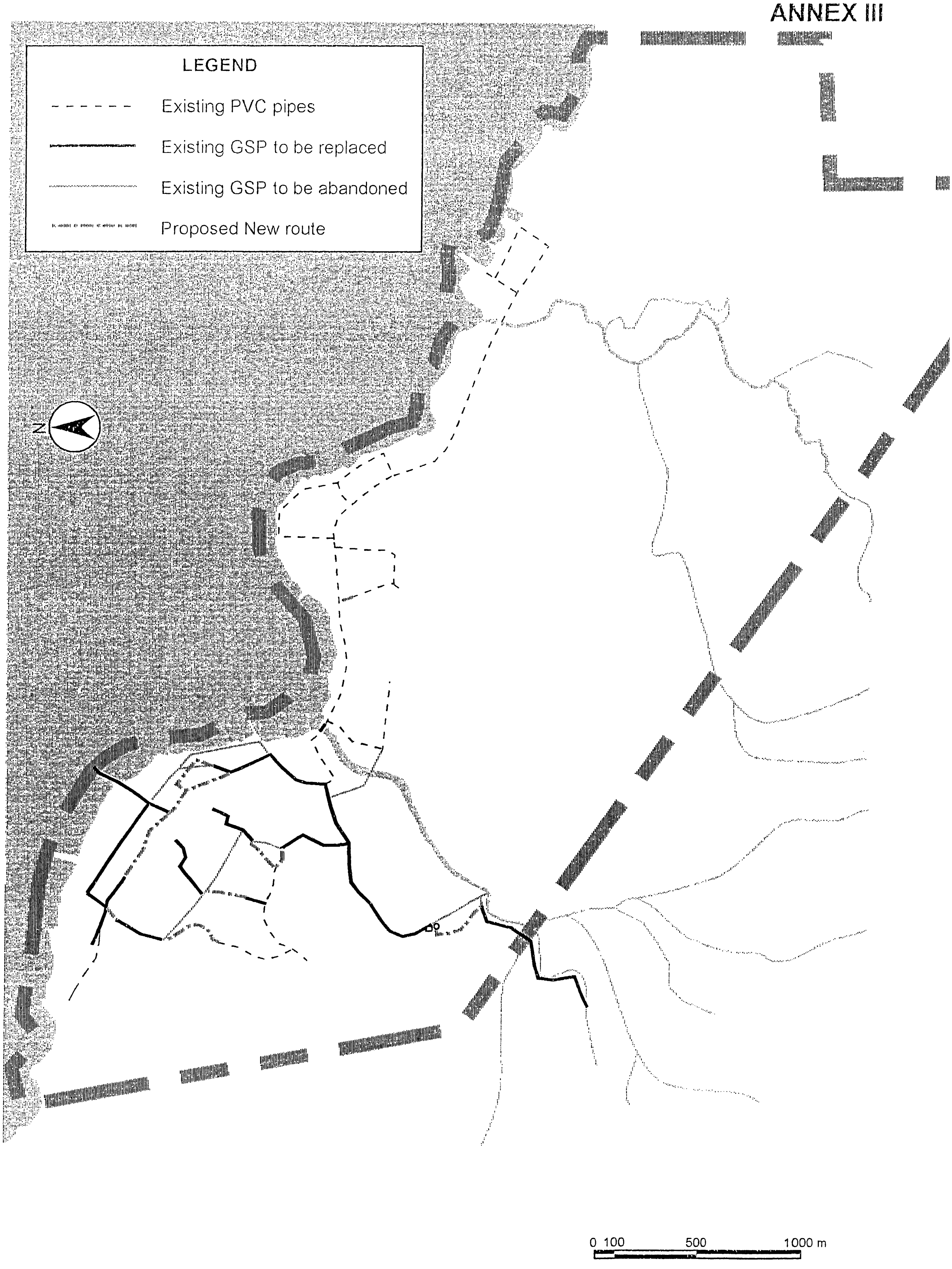
Rate(*1) The figure is shown ratio of others uses comparing with domestic use.

(*2) Day pupil: 30 L/c/d (70%), Boading pupil: 165 L/c/d (30%)

(*3) Source: PNG Water Boad (water demand by past record)

(2) Water demand in 2003

Water uses	Unit water demand (UI		Q'ty	Water demand		Rate	Rate
Residential (Town)	165	L/c/d	4,341	716	m3/d	-	62%
Residential (Island)	40	L/c/d	l.s	100	m3/d	-	9%
Subtotal			4,341	816	m3/d	-	70%
Others	42% % of domestic			344	m3/d	42%	30%
Total				**1,160**	**m3/d**		**100%**


LEGEND
Existing PVC pipes
Existing GSP to be replaced
Existing GSP to be abandoned
Proposed New route
N
0 100
500
1000 m

Appendix 5 *Water Quality Analysis Result*

Appendix Water Quality Analysis Result

Lorengau Raw Water

	Raw Water	PNG Raw Water Quality Requirements	Evaluation
Calcium	7.6 mg/L	200 mg/L #1)	OK
Chloride	2.3 mg/L	1000 mg/L #1)	OK
Faecal Coliforms	200 colonies/100mL	20,000 colonies/100mL	OK
Total Coliforms	800 colonies/100mL	20,000 colonies/100mL	OK
Color	50 units (Hazen)	50 units (Hazen)	OK
Hardness	25mg/L ($CaCO_3$)	600 mg/L ($CaCO_3$) #1)	OK
Iron	0.71 mg/L	1.0 mg/L	OK
Magnesium	1.5 mg/L	150 mg/L #1)	OK
Manganese	0.0035 mg/L	0.5 mg/L	OK
Nitrate	1.4 mg/L	45 mg/L	OK
Nitrite	0.01 mg/L	3 mg/L #2)	OK
pH	7.4 mg/L	8.0 #2)	OK
Total Alkalinity	23 mg/L ($CaCO_3$)	> 20 mg/L #3)	OK
Turbidity	25 NTU	25 NTU #1)	OK
$KmnO_4$ Consumption	2.49 mg/L	10 mg/L #4)	OK

Lorengau Treated Water

	Treated Water	PNG Drinking Water Quality Standards	Evaluation
Calcium	2.8 mg/L	200 mg/L	OK
Chloride	2.7 mg/L	1000 mg/L	OK
Faecal Coliforms	0 colonies/100mL	0 colonies/100mL	OK
Total Coliforms	0 colonies/100mL※	0 colonies/100mL	OK
Color	10 units (Hazen)	50 units (Hazen)	OK
Hardness	9.2 mg/L ($CaCO_3$)	600 mg/L ($CaCO_3$)	OK
Iron	0.71 mg/L	1.0 mg/L	OK
Magnesium	0.6 mg/L	150 mg/L	OK
Manganese	0.0004 mg/L	0.5 mg/L	OK
Nitrate	< 1 mg/L	45 mg/L	OK
Nitrite	0.01 mg/L	3 mg/L #2)	OK
pH	7.4	8.0 #2)	OK
Total Alkalinity	59 mg/L ($CaCO_3$)	> 20 mg/L #3)	OK
Turbidity	2.5 NTU	25 NTU	OK
$KmnO_4$ Consumption	2.07 mg/L	10 mg/L #4)	OK

#1) PNG Drinking Water Quality Standard value
#2) WHO Drinking Water Quality Guideline value
#3) Not regulated (Corrosive at 20mg/L or less)
#4) Japan Water Supply Quality Standard value

※ Due to improper sampling, 10,000 colonies/100mg/L was detected at first. No coliforms were detected by the retest by pack test.

Goroka Raw Water

	Raw Water	PNG Raw Water Quality Requirements	Evaluation
Calcium	4.5 mg/L	200 mg/L #1)	OK
Chloride	< 1 mg/L	1000 mg/L #1)	OK
Faecal Coliforms	0 colonies/100mL	20,000 colonies/100mL	OK
Total Coliforms	0 colonies/100mL	20,000 colonies/100mL	OK
Color	< 5 units (Hazen)	50 units (Hazen)	OK
Hardness	16 mg/L ($CaCO_3$)	600 mg/L ($CaCO_3$) #1)	OK
Iron	0.073 mg/L	1.0 mg/L	OK
Magnesium	1.1 mg/L	150 mg/L #1)	OK
Manganese	0.0004 mg/L	0.5 mg/L	OK
Nitrate	< 1 mg/L	45 mg/L	OK
Nitrite	0.01 mg/L	3 mg/L #2)	OK
pH	7.7 mg/L	8.0 #2)	OK
Total Alkalinity	22 mg/L ($CaCO_3$)	> 20 mg/L #3)	OK
Turbidity	3.0 NTU	25 NTU #1)	OK
$KmnO_4$ Consumption	0.97 mg/L	10 mg/L #4)	OK

Goroka Treated Water

	Treated Water	PNG Drinking Water Quality Standards	Evaluation
Calcium	4.1 mg/L	200 mg/L	OK
Chloride	2.6 mg/L	1000 mg/L	OK
Faecal Coliforms	0 colonies/100mL	0 colonies/100mL	OK
Total Coliforms	0 colonies/100mL	0 colonies/100mL	OK
Color	< 5 units (Hazen)	50 units (Hazen)	OK
Hardness	14 mg/L ($CaCO_3$)	600 mg/L ($CaCO_3$)	OK
Iron	0.087 mg/L	1.0 mg/L	OK
Magnesium	1 mg/L	150 mg/L	OK
Manganese	0.0011 mg/L	0.5 mg/L	OK
Nitrate	< 1 mg/L	45 mg/L	OK
Nitrite	0.01 mg/L	3 mg/L #2)	OK
pH	7.4 mg/L	8.0 #2)	OK
Total Alkalinity	20 mg/L ($CaCO_3$)	> 20 mg/L #3)	OK
Turbidity	1.0 NTU	25 NTU	OK
$KmnO_4$ Consumption	0.94 mg/L	10 mg/L #4)	OK

#1) PNG Drinking Water Quality Standard value
#2) WHO Drinking Water Quality Guideline value
#3) Not regulated (Corrosive at 20mg/L or less)
#4) Japan Water Supply Quality Standard value

Goroka Backwash Water

	Backwash Water	Discharge Water Quality Criteria	Evaluation
BOD_5	3.5 mg/L	160 mg/L #5)	OK
Calcium	4.9 mg/L	200 mg/L #1)	OK
Chloride	< 1 mg/L	1000 mg/L #1)	OK
Faecal Coliforms	0 colonies/100mL	3,000 colonies/cm^3 #5)	OK
Total Coliforms	0 colonies/100mL	3,000 colonies/cm^3 #5)	OK
Dissolved Oxygen	6.9 mg/L	> 5 mg/L #6)	OK
Hardness	17 mg/L ($CaCO_3$)	600 mg/L ($CaCO_3$) #1)	OK
Magnesium	1.1 mg/L	150 mg/L #1)	OK
Nitrate	< 1 mg/L	45 mg/L #1)	OK
Nitrite	0.02 mg/L	3 mg/L #2)	OK
pH	7.4 mg/L	5.8 – 8.6 #5)	OK
Total Alkalinity	24 mg/L ($CaCO_3$)	> 20 mg/L #3)	OK
Total Dissolved Solid (TDS)	81 mg/L	1000 mg/L #2)	OK
Suspended Solid	130 mg/L	200 mg/L #5)	OK

#1) PNG Drinking Water Quality Standard value
#2) WHO Drinking Water Quality Guideline value
#3) Not regulated (Corrosive at 20mg/L or less)
#5) Japanese Water Discharge Regulation value
#6) Japanese Environmental Water Quality Regulation value (River water, category B)

Appendix 6 *Geotechnical Investigation*

GEOTECHNICAL INVESTIGATION

1. Introduction

The geotechnical investigation for the Project was carried out in order to check the stability of main structure of water treatment plant in Goroka.
For the purpose of estimating the bearing capacity of bed-ground for the foundation of the main structure, Standard Penetration Test, Vane Shear Test and sampling of soil were conducted.

2. Site Description

2-1 General

The altitude of the proposed site ranges from 1685 meters to 1695 meters.
It is considered that any likelihood of anticipating groundwater on site is unlikely.
The site is stable with no evidence of land-slip in the vicinity of the proposed site.

2-2 Local Geology

The black/blown top-soil layer is 500 mm thick. Below the top-soil, the soil become rather firm to stiff with a reddish/brown to orange coloration. The soil profile is commonly found on the nearby hills and contains high iron and aluminum oxides.e soil. These soils are derived from original host material (volcanics) by intense lateritic weathering. On a cutting face of road near the site, exposures shows fragments of lower grade metamorphics rock. In one exposure on the road, small round boulders which appears to be in-situ shows sign of exfoliation (onion peeling) which is typical of grained rocks.

3. Site Investigation

Site investigation, they are Standard penetration test (SPT), Vane shear test (VST) and Trial pit excavation for sampling, was commenced on August 28,2000.

The SPT carried out up to 25 m depth and sampled soil from all depth of the borehole.
Trial pit was excavated approximately 5 m due west of the PST site to a depth of 3 m.

The trial pit was to test the first 3 m of the soil profile using a vane shear tester.
In-situ vane shear reading was collected using a 19 mm pilcon vane on the clay soils.
The soil sampled from this pit was provided for laboratory test.

4. Investigation Findings

4-1 Soil Profile / Soil Composition

The soil composition forming the profile encountered during the excavation of the trial pit and the geologic drill hole was found with the soil sampler to be uniform over the proposed site. The soil profile which consist of the reddish brown clayey soil and some fine sandy gravel appears generally uniform and vary marginally over the site.

4-2 Top-soil ; blackish/blown, loose soil

The top-soil consists mostly of expansive black high plasticity clays with varying composition of sandy silt and clays. The villagers to grow crops plow the ground and hence the soil is very loose. The average thickness of the top-soil materials is between 0.3 m and 0.6 m thickness.

4-3 Residual Soils ; clay silt

Residual soils were encountered below the reddish/blown clay and becoming firm to stiff at depth of 2 m to 6 m.
Based on the laboratory test, bulk density of the clayey materials 1.49 kgf/m^3 with liquid limits of up to 75% [Appendix A]. Plasticity index averages 30 whilst the in–situ moisture content of 58% is common for these clayey material.
Summary of laboratory tests is enclosed.
Based on the SPT result, N-value shows 3 to 7 at range 2 m to 6 m depth.
And based on VST result, VS-reading shows 50 kPa to 75 kPa at range 2 m to 4 m depth.

4-4 Bedrock

In this investigation no fresh bedrock was encountered, however it is considered that at depth of between 9-10m, extremely weathered bedrock or band of dense material was encountered. It is considered that the soil has undergone extreme weathering process that all rock fabric has totally disintegrated to form the present clay soil profiles.

4-5 Groundwater

The site is perched on a small hill with no evidence of groundwater noted during the investigation of the test pit and that of the borehole.

No permeability test was carried out, however based on field inspection and typical soil characteristic on site, it is considered soil permeability is generally regarded as poor.

4-6 Laboratory Test

Six(6) representative soil samples were tested. Three(3) samples were from the trial pit (each 1m, 2m, 3m depth) whilst the other three(3) samples were collected from the borehole (each 4.5m,7.5m,11.0m depth).

Summary Report is attached. **[Appendix A.]**

4-7 Site Test

Result of SPT and VST is attached. **[Appendix B.]**

5. Engineering Assessment

5-1 Estimated Bearing Capacity

The elevation of foundation bed of the proposed structure is approx. 1,690 m above from seawater level, whilst of the site test ground is approx. 1,695m .

For studying bearing capacity of bed-ground, the test result and soil samples shall be adopted with the data at 5 m depth.

Bearing capacity of ground shall be estimated by the data of SPT at 5 m depth and laboratory test.

Estimate

(a) Terzaghi Formula, ultimate bearing capacity ; Q_{d1}

$$Q_{d1} = \alpha \times c \times Nc + \beta \times \gamma 1 \times B \times N\gamma + \gamma 2 \times Df \times Nq$$

c ; adhesive force of soil at the bottom of foundation (tf/m^2)

γ_1 ; unit weight of soil at the bottom of foundation(tf/m^3)

γ_2 ; unit weight of soil at the upper side of foundation(tf/m^3)

α, β ; shape coefficient of foundation(refer to table-A)

Nc, $N\gamma$, N_q ; bearing capacity coefficient(refer to table-B)

Df ; depth from ground surface to foundation bottom (m)

B ; minimum width of foundation (m)

in case rectangle foundation ; shorter side B(m)

longer side L(m)

Table-A Shape Coefficient of foundation

Shape of foundation	Strip	Square	Rectangle	Circle
α	1.0	1.3	$1.0+0.3\times B/L$	1.3
β	0.5	0.4	$0.5-0.3\times B/L$	0.3

Table-B Bearing Capacity Coefficient

ϕ	Nc	$N\gamma$	N_q
0°	5.3	0	3.0
5°	5.3	0	3.4
10°	5.3	0	3.9
15°	6.5	1.2	4.7
20°	7.9	2.0	5.9
25°	9.9	3.3	7.6
28°	11.4	4.4	9.1
32°	20.9	10.6	16.1
36°	42.2	30.5	33.6
>40°	95.7	114.0	83.2

here, $C = qu/2$

qu ; Unconfined Compressive Strength (kgf/cm^2)

$qu = 5N \sim 2.5N$ this adopt ; 4N and N=5

$\therefore C = qu/2 = 4N/2 = 4\times 5/2 = 1.0$ kgf/cm2 = 10 tf/m^2

γ_1 = 1.5 tf/m^3

γ_2 = 1.5 tf/m^3

$\alpha = 1.0+0.3\times B/L$ (here B = 8.5m, L = 31.0m)

$= 1.0+0.3\times 8.5/31.0 = 1.08$

$\beta = 0.5-0.1\times B/L$ (here B = 8.5m, L = 31.0m)

$= 0.5-0.1\times 8.5/31.0 = 0.47$

Nc, = 5.3

$N\gamma$ = 0 } from Table-B, $\phi = 0°$ as for clay soil

N_q = 3.0

Df = 1.5

Result

$Q_{d1} = 1.08\times 10\times 5.3+0.47\times 1.5\times 0+1.5\times 1.5\times 3.0$

$= 57.2 + 0 + 6.8 = 64.0\ tf/m^2$

(b) Tschebotarioff Formula, ultimate bearing capacity ; Q_{d2}

$Q_{d2} = 6.28\ C$

here $C = 10.0\ tf/m^2$

Result

$= 6.28 \times 10.0 = \underline{62.8\ tf/m^2}$

(c) Shield Formula, ultimate bearing capacity; Q_{d3}

$Q_{d3} = (5.14 + 0.66\ B/L)\ C$

here $B = 8.5$ (m), $L = 31.0$ (m), $C = 10.0\ tf/m^2$

Result

$Q_{d3} = (5.14 + 0.66 \times 8.5/31.0) \times 10.0 = \underline{53.2\ tf/m^2}$

(d) Estimate Ultimate Bearing Capacity ; Q_d

Considering from the above 3 case,

$Q_d = (Q_{d1} + Q_{d2} + Q_{d3})/3$

$= (64.0 + 62.8 + 53.2)/3 =$ **60.0 tf/m²**

5-2 Estimated Allowable Bearing Capacity

Allowable Bearing Capacity (Qa) shall be adopted with [F=3] of safety coefficient

$Q_a = Q_d/3.0 = 60.0/3.0 = \underline{\mathbf{20.0\ tf/m^2}}$

JB GEO-SERVICES LIMITED - MATERIALS TESTING LABORATORY

Appendix A

PROJECT: PROPOSED WATER PURIFICATION PLANT - GOROKA

SUMMARY OF LABORATORY TEST RESULTS

Sample No.	Location Depth (m)	Description of Soil	Particle Size Distribution Clay & Silt %	Sand %	Gravel %	Atterberg Limits Liquid Limit %	Plastic Limit %	Plastic Index %	Lin. Shrink. %	Moisture Content %	Specific Gravity (SG)	Unit Weight t/m3
99/245	TP 1 1.0 - 1.45	Silty CLAY, high plasticity, fine to coarse grained sand, trace of gravels, orange/black color	79	18	3	79	44	29	14	49.5		
99/246	TP 1 2.0 - 2.50	Silty CLAY, high plasticity, fine to coarse grained sand, trace of gravels, orange/brown color	80	10	9	73	40	32	15	54	2.6	1.5
99/247	TP 1 3.0 - 3.50	Silty CLAY, high plasticity, fine to coarse grained sand, trace of gravel, orange / brown	76	12	13	76	42	33	15	58		
99/248	BH 1 4.5 -5.0	Silty CLAY, high plasticity, fine to coarse grained sand, trace of gravel, orange / brown	75	13	7	75	42	30	13	57		
99/249	BH 1 7.5 - 8.0	Silty CLAY, high plasticity, fine to coarse grained sand, trace of gravel, orange / brown	78	15	10						2.6	1.49
99/250	BH 1 11.0 11.5	Silty CLAY, high plasticity, fine to coarse grained sand, trace of gravel, orange / brown	77	18	5	77	41	28	14	50		
2000-307 (DOW)	TP 1 1.3m	Silty CLAY, high plasticity,trace fine sand, brown(chocolate)	84	16	0	100	56	44	21.3	65.6		
2000-308 (DOW)	TP 1 3.0m	Sandy CLAY, fine to coarse sand high plasticity, brown (chocolate)	54	46	0	83	56	27	12.5	51	2.3	

Comments: DOW : Dept Work Lab.

Report No:

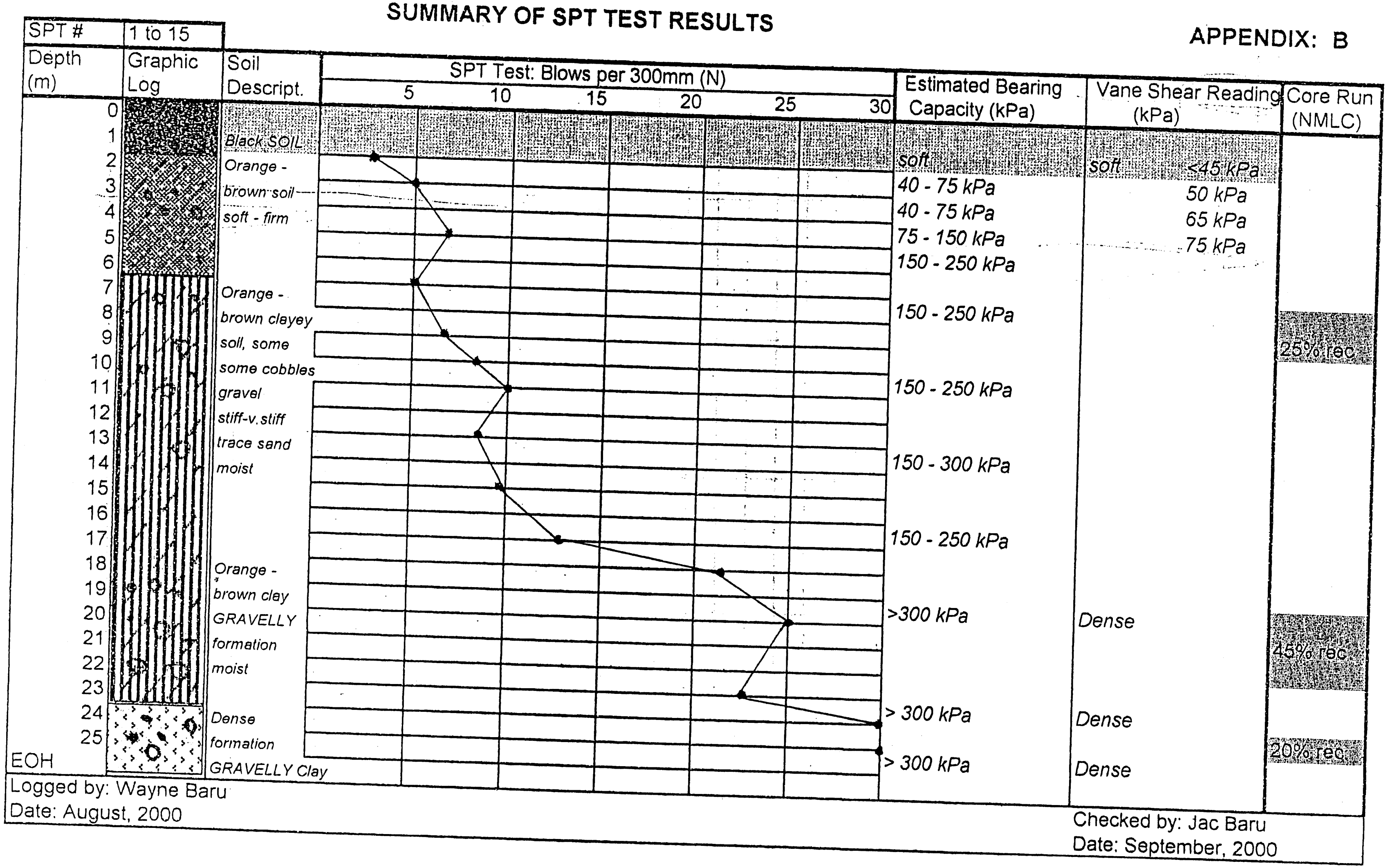
Date: Aug. 2000

Checked By: [signature]

PROPOSED WATER PURIFICATION PLANT - GOROKA TOWN WATER SUPPLY
GOROKA, EHP

SUMMARY OF SPT TEST RESULTS

APPENDIX: B



Appendix 7 *Result of Site Investigation (Water Treatment Plant)*

Result of the Site Investigation

I. Lorengau Water Treatment Plant

II. Goroka Water Treatment Plant

5.1 Result for the Site Investigations

I. Lorengau Water Treatment Plant

(1)The plant flow : 20,000 (m^3/d)

(2) Confirmation for the capacity of the basin

The capacity of each basin was confirmed by the dimensional check and the detention time as follows:

Facility	Dimensions (m) (L x W x D)	No.	Capacity (m^3)	Detention Time (min.)	Evaluation	
					Design	Check
Receiving well	1.3 x 1.3 x 3	1	5.07	3.6	≧1.5	OK
Mixing basin	1.3 x 1.3 x 2.7	1	4.56	3.3	1.5～5	OK
Coagulation basin	2.3 x .3 x 2	2	42.3	30.4	20～40	OK
Sedimentation basin	2.3 x 8 x 2.7	2	99.36	71.5	≧60	OK
Filter	3.3 φ	2	8.55	117m/d	≦150	OK

(3) Result of the check of the equipment

Equipment	Equip. No.	Specification	Visual	Operation			Check
				Start	Stop	Rise Temp.	
Soda ash dosing	TK300	2200 L, Polyethylene	OK	OK	OK	—	OK
	P330	750 ml/min., 0.37kW	OK	OK	OK	OK	OK
	P340	ditto	OK	OK	OK	OK	OK
	ME360	0.75 kW	OK	OK	OK	OK	OK
Alum dosing	TK400	2200 L、Polyethylene	OK	OK	OK	—	OK
	P430	600ml/min 0.37kW	OK	OK	OK	OK	OK
	P440	Ditto	OK	OK	OK	OK	OK
	ME460	0.75 kW	OK	OK	OK	OK	OK
Polymer dosing	TK500	2200 L, Polyethylene	OK	OK	OK	—	OK
	P530	75 ml/min., 0.15kW	OK	OK	OK	OK	OK
	ME560	0.5 kW	OK	OK	OK	OK	OK
chlorinator	ME603	Chlorinator	OK	OK	OK	—	OK
	ME604	ditto	OK	OK	OK	—	OK
Clean water pump	P151	125/100mm Dia. 99m3/hr. x 13.6mH, 7.5kW	OK	OK	OK	OK	OK
	P152	ditto	OK	OK	OK	OK	OK
Back-wash pump	P160	150 /125 mm Dia. 225m3/hr.x8.8mH,11kW	OK	OK	OK	OK	OK
Pump for domestic use	P170	25mm Dia., 1.5kW	OK	OK	OK	OK	OK
Control panel		Self-standing steel made	OK	OK	OK	—	OK

(4) Check for the fabrication

Equipment	Material	Visual		Water leakage	Life *1		Check
		scratch	Deformation		Regulation (Year)	Actual (Year)	
Receiving well	Steel	O	O	O	45	5	O
Coagulo-sedimentation	Steel	O	O	O	45	5	O
Filter	Steel	O	O	O	45	5	O
Clear water tank	Steel	O	O	O	45	5	O
Reservoir tank	Steel	×	×	×	45	50	×
Control house	Concrete block	O	O	—	40	5	O
Intake pump house	Concrete block	×	×	—	40	40	×

*1: The life of the equipment is based on the regulation of the public works of Japan.

(5) Performance check for the water treatment system

System	Performance	Check
Chemical Mixing	To mix equally	O
Coagulation	To make optimum floc	O
Sedimentation	To have an effective settle of the floc	O
Filtration	To be fund sand in the treated water channel	△

△ : The functions of the filter will be recovered by the rehabilitation of the water collecting system.

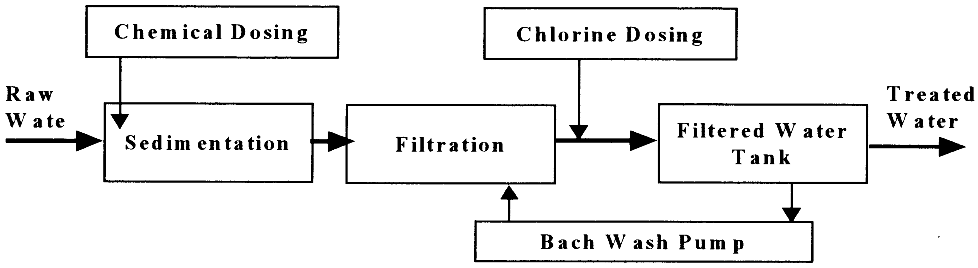
II. Goroka Water Treatment Plant

1. Raw water quality

According to the result of the water analysis in August 2000, all of the parameters satisfied figure of WHO's guideline. However, in general, it is assumed that color and turbidity will increase due to muddy of river water in raining season. Although raw water quality satisfied the drinking water standard, some nitrite was detected in the raw water and treated water.

2. Process flow

The process of the existing plant consists of clarifier and filtration for turbidity-removal. The chemical dosing equipment has on the plant in order to accelerate flocculation. The chemical for the coagulation is using solid Alum. The organic matter and bacteria in the raw water was disinfected by chlorine. The process of the plant is shown as below.



Process Flow of the Water Treatment System

3.Confirmation of the Equipment Capacity

(1) Outline of the existing plant

① Clarifire

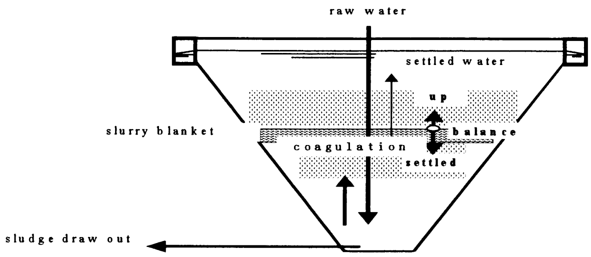
Specification	Line No.1	Line No.2
Shape	Rectangular	Cylinder
Surface area	93.6m^2	70.1 m^2
Depth	3.17m	4.52m
Capacity	181m^3	230 m^3

② Filter

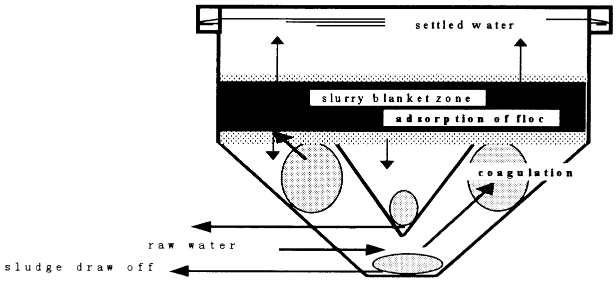
Specification	Line No.1	Line No.2
Shape	Rectangular	Cylinder
Surface area	14 m^2	39.9 m^2
Filter media	Sand + Gravel	Sand + Gravel
Wash system	Wash water	Wash water + Air score

Comparing with Line No.1 and No.2, the efficiency of both filters is almost same. However, each clarifire is differed from the performance. Following table and figures is shown the comparative between Line No.1 and Line No.2.

Line	No.1	No.2
Type	Slurry-blanket	High-rate sedimentation
System	In order to make floc, the raw water will flow slowly with the progress of up-word because of the structure of inverted triangle shape. (Refer to the drawings)	Floc will be made in the lower part of tank. Then the solid-liquid separator will appear in the top parts of the tank. (Refer to the drawings)
Efficiency	From result of the site experiment, the optimum surface load is 12mm/min.	From result of the site experiment, the optimum surface load is 45 mm/min.



N0.1 Coagulo-Sedimentation Tank



No. 2 Coagulo-Sedimentation Tank

These existing clarifires can get more effective function to make optimum slurry-blanket zone. However, it has restrictions of the raw water quality such as high turbidity to maintain slurry-blanket zone. From result of this experience data, the optimum turbidity is assumed more than 10mg/l as kaolin turbidity. According to the record of the water quality in 1999, annual variation of the turbidity is shown as below:

High turbidity (<10)	From January to March, September (13days)、October(8 days),November (13days), total 125
Low turbidity (> 10)	Total day is 240 days excepting mentioned above.

From the water quality recorded by the water works, existing clarifire cannot be impossible to operate by slurry-blanket system during 240 days due to low turbidity.

At present, the existing clarifires are running under over load operations. More 2 times water flow is flowing into clarifire. Therefore, the function of the clarifire will be reduced. And the flocs carry over at the weir of the clarifire and flow into the filter. Consequently, the filter is required frequent washing subject to block of the filter media.

(2) Plant flow

Based on the site investigation, each technical data of the facility is confirmed as follows:

	Design	No.1	NO.2	Total
Clarifire	Surface area (m2)	93.6	70.1	
	Surface load (mm/min.)	12	45	
	Design flow (m3/d)	1,600	4,524	6,204
Filter	Filtration area (m2)	14	39.9	
	Filter late (m3/d)	120	120	
	Design flow (m3/d)	1,680	4,788	6,468

According to the above data, plant flow is assumed to be 6,500 m3/d.

4. Result of the check of the facility

(1) Civil structure

System	Facility	Check item				Result
		Visual check			Life*1 (60 years)	
		Deformation	Crack	Water leakage		
Clarifire	No.1clarifire (Inside)	N/D*2	N/D	N/D	40years	○
	(Outside)	N/D	N/D	N/D	40	○
Filter	No. 1Filter (Inside)	N/D	N/D	N/D	40	○
	(Outside)	N/D	N/D	N/D	40	○
Pipe support		N/D	N/D	N/D	40	○
Chemical house		N/D	N/D	—	40	△
Work shop		N/D	N/D	N/D	40	○

Note: *1: Based on the regulation of the Public works in Japan, the life of the civil structure is 60 years.

*2: Not Detected

(2) Steel fabrications

System	Facility	Check item				Result
		Visual check			Life (45 years)	
		Deformation	Crack	Water leakage		
Clarifire	No.1clarifire (Inside)	N/D	N/D	N/D	12years	○
	(Outside)	N/D	N/D	N/D	12	○
Filter	No. 1Filter (Inside)	Detected	N/D	N/D	12	○
	(Outside)	Detected	N/D	N/D	12	○
Clear water tank		N/D	N/D	N/D	12	○

(3) Mechanical equipment

System	Equipment	Check item					Result
		Visual	Performance			Life	
		Defor*1	Noize*2	Operation*3	Capa.	15years	
Chemical dosing	Alum pump	Detected	N/D	No	No	40	×
	Soda pump	Detected	N/D	No	No	40	×
Chlorinator	Tank	Detected	N/D	—	No	12	×
	Dosing pump	N/D	N/D	Good	No	12	×
Pump	No. 1Filter	Detected	Detected	No	Yes	40	×
	No. 2Filter	N/D	N/D	Good	Yes	12	○

Main point of the check

*1 : Deformation、clack、painting conditions

*2 : Noise for motor

*3 : Temperature rise, operational function when equipment start and stop

(4) Valves

As a result of the site investigation, following valves is out of repair and can not be operated.

Location	Specification and q'ty of the valve	Visual	Performance		Life (40 years)
			Open & close	Leakage	
Raw water	200mm, sluice 2 sets	Rusted	×	×	40 years
No.1 clarifire inlet	200mm ,sluice 1 set	Rusted	○	×	40
No.2 clarifire inlet	200mm ,sluice 1 set	○	×	○	12
No.1 Filter inlet	200mm ,sluice 1 set	○	×	○	40
No.2 Filter drain	300mm,butterfly 2 sets	Rusted	×	×	12
No.2 Clean water	250mm,butterfly 1 set	○	×	○	12

Remark: ○: Not detected, ×detected

(5) Connection pipe in the plant

Location	Specification	Visual	Leakage	Life 25 years	Check
Raw water	300mm ACP 200mm, SP	x	x	40 years	×
No.1clarifire inlet	200mm , SP	○	○	40	○
No.2clarifire inlet	200mm , SP	○	○	12	○
No.1 filtered water	200mm SP	○	○	12	○
No.2 filtered water	300mm, SP	○	○	40	○

Remark: ○: Not detected, ×detected

5. Result of the experiment

5-1 Coagulation and settling tests

Test 1 Flow variation and Settling efficiency

Line no.1 clarifire

The varied inlet flow and the shape of the floc were confirmed through the site experiment as follows.

Experiment data

Water flow (m^3/d)	2,000	1,500	1,000
turbidity (Degr.)	3	3	3
Conditions of the floc	Defective floc and carrying-over of the floc	Good floc with 1 to 2mm size	Good floc with 1 to 2mm size
Settling effect	wrong	good	good

The most effective settling was arisen to be flow rate with 1,500 to 2,000m3/d by the evaluation result of the mentioned above data. And arising of slurry zone could not found due to low turbidity in the raw water.

Line no.2 clarifire

Due to damage of the flow meter, the inlet flow was measured by differential water level between over flow trough and clarifire. After completion of the experiment, the most effective condition of the clarifire was to be 7.5 cm of deferential water level, and floc size was 2 to 3 mm of diameter. From water level, the water flow is obtain as follow:

$V=0.6x(2gh)^{1/2}$

Where:

V : water flow through orifice of the trough

g : $9.8m/sec^{2}$

h : differential water level between over flow trough and clarifire

$V=0.6x(2x9.8x0.075)^{1/2}=0.441m/sec.$

Then:

Q= A x V

Where:

Q : water flow

A : area of the orifice, $(0.7x10^{-3} m^2)$ x22 holes x 8 troughs

$Q=0.1243\ m/sec.x3600x24x0.7x10^{-3} m^2=4,737 m^3/d$

Test No.2 Settling velocity

Alum was dosed 30 mg/l into the sample water in the measuring flask. Then, settling velocity was measured through visual count. Raw water conditions are shown as below:

Water temperature: 24℃

Turbidity: 2 deg.

PH before alum dosing: 7.0 to 7.1

PH after alum dosing: 6.0

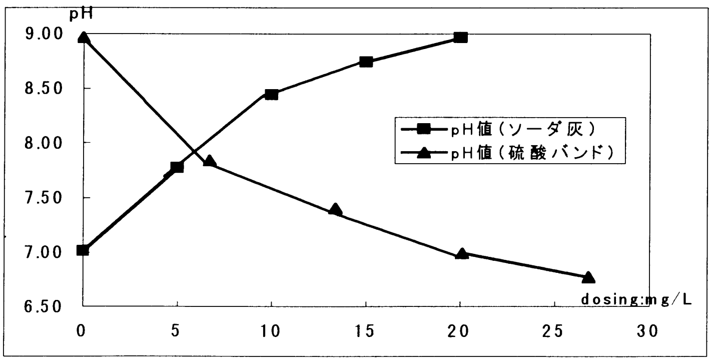
Relation between floc size and settling velocity

Floc size	No floc	ϕ 1～2mm	ϕ 2 to 3mm
Settling velocity	Not applicable	12 mm/min.	45 mm/分

According to the result of the experiment、the coagulation function of the N0.1 clarifire differed from No.2 such as floc size. No. 2 clarifire is most efficiency due to making of the big size floc of what has high rate velocity (2 to 3mm). The comparison between No.1 and No.2 clarifire is shown as follows:

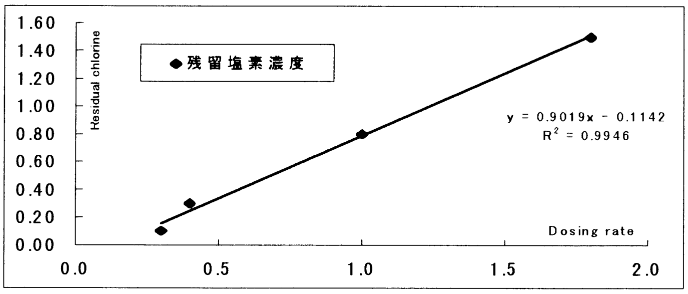
	No.1	No.2
Coagulation efficiency as floc size (mm)	2	4
Settling velocity (mm/min.)	12	45
Surface load (mm/min.)	Less than 12	Less than 45

Since the raw water pH value rapidly reduced after dosing of the Alum. In order to make good floc, it shall be controlled pH value in the raw water by dosing alkalinity such as soda ash. From the result of the experiment, when alkalinity in the raw water was 23.5 mg/l, pH value of the water after dosing of Alum was decrease. The test of the pH control is shown as following graph.



5.2 Test of the chlorine demand

The test result of the chlorine demand of the raw water is shown as following graph.



As for the treated water, the chlorine demand was tested also and test data has been gave as same as treated water test data.

The entire test mentioned above was carried out under the following water quality conditions.

Sampling date：August 21,2000		weather：rain, cloudy later	
Parameter	Drinking standard	Raw water	Treated water
Manganese (mg/L)	Less than 0.05	0.056	≦0.005
Total iron	Less than 0.3	1.75	0.14
Calcium･magnesium (hardness) (mg/L)	Less than 300	16	18.8
Organic matter (KmnO4) (mg/L)	Less than 10	14.1	3.2
pH	5.8～8.6	6.9	7.0
Color (deg.)	Less than 5	8	7
Turbidity (deg.)	Less than 2	6.4	0.8
Total alkalinity (mg/L)	-	24	24.0
Nitrate nitrogen (mg/L)	-	≦0.05	≦0.05

Appendix 8 *Leakage Control*

Appendix Leakage Control

1. Objective

This section describes the current status of the leakage in the existing distribution and service pipes as well as the basic data for improvement of the pipelines, so as to give a guideline for the leakage control activities to be conducted by the PNG's executing agencies.

2. Leakage Ratio in the Existing Distribution and Service Pipes

Based on the leakage volume which is assumed by hearing to the waterworks staff and observing the actual leakage points, leakage ratios by pipe materials were assumed. From the leakage ratios and the surface area ratio of the distribution pipe as well as ratio of number of the service connection, leakage ratio of the whole pipelines was calculated.

2.1 Leakage Ratio by Pipe Materials (Table 1)

(1) Lorengau

Leakage Ratios by Pipe Materials (Lorengau)

		Length /connections	Leakage ratio by pipe material
Distribution Pipe	Steel Pipe	5,743 m	80%
	PVC Pipe	7,699 m	15%
Service Pipe	Connected to steel pipe	342 points	20%
	Connected to PVC pipe	458 points	15%

Number of service connections is assumed by proportion of the length of the material to be connected.

A. Distribution Pipes (Steel Pipe)

Six leakage points were observed in approx. 1.5 km of the existing steel pipe. The leakage seems to occur due to deterioration of the distribution pipes which are embedded about 40 years ago. The observed leakage was spouting out from about dia. 3 mm spot. The leakage volume per spot was estimated at 25 L/hr from hydraulic calculation. The observed leakage ratio is assumed to be 20%, taking into account of approx. 1,100 m^3/d of the water flow in the steel pipe. Consequently leakage ratio of the steel pipe is estimated to be approx. 80 %, on assumption that similar leakage conditions exist in approx. 6km of the total length other than the observed part, on account of big amount of leakage suspected by hearing the local staff and observing wet surface soil.

B. Distribution Pipes (PVC Pipe)

PVC distribution pipes used for dia. 50mm to 200mm, total length of approx. 7.7 km, are installed after year 1980. The leakage ratio for PVC pipes is estimated to be 15%, considering that major repair works were not required in 1999 and that the pipes are still within the durable life.

C. Service Pipes

According to the recorded, repair works for leakage from the service pipes was 100 times for the service pipes connected to steel pipes, and 10 times for that to PVC. The service pipes connected to steel pipes were installed at the same years with the steel distribution pipes. Therefore, most pipes are considered to be overage already. Leakage observed occurs at the connection of steel pipes without surface coat. The leakage volume was about 0.8 L/min. Considering many complaints are raised by the residents living in the old pipes, the rest about 200 connections of old service pipes are assumed to be the same condition. Accordingly, total leakage ratio in the old service pipe is estimated to be 20%. As for leakage from the service pipes connected to PVC distribution pipes, the leakage ratio is estimated to be around 15% on account that the pipes are not old and the used material is mostly the galvanized steel pipe, which is anti corrosive.

(2) Goroka

Leakage Ratios by Pipe Materials (Goroka)

		Length /connections	Leakage ratio by pipe material
Distribution Pipe	AC Pipe	29,026m	40%
	Ductile Iron Pipe	2,475m	15%
	PVC Pipe	27,081m	15%
	Steel Pipe	811m	15%
Service Pipe	Connected to AC pipe	1,879 points	15%
	Connected to PVC/Steel pipe	1,804 points	15%

Number of service connections is assumed by proportion of the length of the material to be connected.

A. Asbestos Cement Pipe (AC Pipe)

Most distribution pipes are the AC pipes. The AC pipes were installed in early 1960's, that has past the durable life of 25 years regulated in the Japanese Public Utilities Law. Nevertheless, the pipes are barely used in the present low pressure, although as much as 39 times in 2000 of repair works were reported to the town manager of Goroka. Most leakages occurs from cracks which varies the shapes and sizes. Average leakage volume is estimated to be 1.8 m^3/hr per crack, assuming the typical shape of 0.1 mm width, 5 cm length and 15 m pressure head. Total leakage volume of the 40 points repaired amounts to 1,684 m^3/d, or 25% of leakage ratio in the whole AC pipes. Major leakage from the AC pipes are considered to be thoroughly repaired, taking into account that the AC pipes is used for main distribution pipes and that big leakage happens in accidental case. And minor leakage is assumed to be around 15%. Therefore, leakage ratio of the AC pipes amounts to 40%.

B. Ductile Iron Pipe / PVC Pipe / Steel Pipe

In Goroka, 4 plumbers are in charge of patrol and repair for maintenance of the pipes. Leakage ratio from the ductile iron pipes, PVC pipes as well as steel pipes that were installed in rather recent years is estimated to be 15%, which is average leakage ratio in the durable life.

C. Service Pipe

Leakage ratio from the service pipes are estimated to be 15%, considering the year of installation and hearing to the local staff.

2.2 Leakage Ratio of the Existing Distribution and Service Pipes

(1) Leakage Ratio of the Distribution Pipe (Table 2-1, Table 3-1)

Leakage ratio of the whole distribution pipes was calculated by using the following calculation, taking the weighted average of the above leakage ratio by pipe material and proportion of surface areas of the pipes.

[Leakage Ratio of the Distribution Pipe]

= Σ ([Leakage ratio by material] ×[Proportion of surface areas])

= Σ ([Leakage ratio by material] × (π ×[Diameter] ×[Length]) /[Total surface area])

Lorengau : 42.7%

Goroka : 31.4%

(2) Leakage Ratio in the Service Pipe (Table 2-2, Table 3-2)

Leakage ratio of the service pipes are calculated by the following formula, taking the weighted average of the number of service connections by materials to be connected.

[Leakage ratio of service pipe]

= Σ ([Leakage ratio by pipe material] ×[Proportion of No.of service connections])

= Σ ([Leakage ratio by pipe material] × ([No. of connections])／[Total No. of connections])

Lorengau : 17.1%

Goroka : 15.0%

(3) Whole Leakage Ratio of the Distribution and Service Pipe

The whole leakage ratio was calculated by totaling the above results.

Lorengau : 59.2%

Goroka : 46.4%

2.2 Leakage Ratio after the Project

(1) Leakage ratio by pipe material after replacement of the pipes (Table2-3, Table3-3)

-1 Diameters/Length/Standard pressure are set by hydraulic analysis.

-2 Leakage ratio for the new pipes is to be 10%.

-3 Leakage ratio in the existing distribution Pipe is calculated by the following Leakage calculation formula (Practical Leakage Survey, Japan Water Research Center).

[Leakage Ratio(L1)]

=[Present Leakage Ratio(L0)]

× ([Proposed standard pressure(P1)]/[Present standard pressure(P0)]) exp(1.15)

(Leakage ratio in the pressure improved is calculated)

(2) Total Leakage of Distribution Pipe

Total leakage ratio is calculated in proportion to the surface areas of pipes.

Lorengau : 14.2%

Goroka : 11.3%

(3) Leakage Ratio of the Service Pipes (Table2-4, Table3-4)

Number of service connections in 2003 is calculated in proportion to the length by materials. On assumption that the leakage ratio of the replaced service pipe is to be 10%, leakage ratio of the service pipes is calculated by weighted average of the leakage ratio and number of connections.

Lorengau : 10.9%
Goroka : 13.9%

(4) Whole Leakage Ratio

Whole leakage ratio is calculated by totaling the above results.

Lorengau : 25.2%
Goroka : 25.1%

Therefore, the target leakage ratio in the Project is to be 25%.

Table1 Leakage Ratio by Pipe Materials

Table 1-1 Lorengau

Points	g	h (m)	V (m/sec)	d (mm)	A(m2)	Observed leakage volume			Distribution volume by pipe materials Q (m3/d)	Leakage ratio by pipe materials		
						Leakage volume per leakage Q (L/hr.)	Number of leakage N	Leakage volume Σ Q(m3/d)		Observation	Estimation	Total
PVC	9.8	10	0	0	0	0	0	0	900	0%	15%	15%
Steel Pipe	9.8	10	58.8	3	7.065E-06	25	6	215	1,100	20%	60%	80%
S.P.(Steel)			per one leakage		20 L/hr	20	100	48	855	6%	14%	20%
S.P.(PVC)			per one leakage		20 L/hr	20	10	5	1,145	0%	15%	15%

Number of leakage (N) : Observed for steel pipes. Record of repair works for S.P. in 1999

S.P. : Service Pipe

表1-2 Goroka

Points	g	h (m)	V (m/sec)	d (mm)	A(m2)	Observed leakage volume			Distribution volume by pipe materials Q (m3/d)	Leakage ratio by pipe materials		
						Leakage volume per leakage Q (L/hr.)	Number of leakage N	Leakage volume Σ Q(m3/d)		Observation	Estimation	Total
ACP		15	99.96		0.000005	1,799	39	1,684	6,750	25%	15%	40%
Others		0	0	0	0	0	0	0	5,750	0%	15%	15%
S.P.(ACP)			per one leakage		20 L/hr	20	30	14	6,377	0%	15%	15%
S.P.(Others)			per one leakage		20 L/hr	20	30	14	6,123	0%	15%	15%

Number of leakage（N) : Record of repair works in 1999 by hearing GULLG

Leakage point in ACP : Typical shape of crack 0.1mm width and 5cm length is assumed

g: 9.8m/sec^2
V=0.6x(2gh)^1/2
Q=AxV

Q: Leakage volume
h: Dynamic head
V: Velocity through the hole

A: Area of the hole
N: No. of the holes

Table 2 Leakage Ratio of Lorengau

Table 2-1 Leakage from the existing distribution pipes

Type of Material	Diameter (mm)	Length (m)	Standard pressure head	Leakage ratio by material(	Surface area of pipe(m2)	Total (%)
Steel pipe	200	1,338	10	80%	841	14.8%
Steel pipe	100	868	10	80%	273	4.8%
Steel pipe	80	2,737	10	80%	688	12.2%
Steel pipe	50	800	10	80%	126	2.2%
PVC	200	524	10	15%	329	1.1%
PVC	150	1,078	10	15%	508	1.7%
PVC	100	4,699	10	15%	1,476	4.9%
PVC	80	734	10	15%	184	0.6%
PVC	50	664	10	15%	104	0.3%
					Weighted Average	42.7%

Table 2-2 Leakage from the existing service pipes

	Number of connectio	Leakage Ratio	Total
S.P. from GSP	342	20%	8.6%
S.P. from PVC	458	15%	8.6%
		Weighted Average	17.1%

Number of connection: in proportion to the length of distribution pipes to be connected

Whole Leakage Ratio	59.8%

Table 2-3 Leakage from the proposed distribution pipes

Type of Material	Diameter (mm)	Length (m)	Standard pressure head	Leakage ratio by material(	Surface area of pipe(m2)	Total (%)
PVC/GSP(nev	200	1,338	15	10%	841	1.7%
PVC/GSP(nev	100	1,875	15	10%	589	1.2%
PVC/GSP(nev	80	3,184	15	10%	800	1.7%
PVC/GSP(nev	50	0	15	10%	0	0.0%
PVC(existing)	200	524	15	24%	329	1.6%
PVC(existing)	150	1,078	15	24%	508	2.5%
PVC(existing)	100	4,699	10	15%	1,476	4.6%
PVC(existing)	80	734	10	15%	184	0.6%
PVC(existing)	50	664	10	15%	104	0.3%
					Weighted Average	14.2%

Leakage Ratio after replacement

1)New 10% as target

2)Existing Leakage calculation formula (Practical leakage survey, Japan Water Reserch Center)

Leakage Ratio(L1)＝Existing leakage ratio(L0)

×(Proposed pressure(P1)／Present standard pressure(P0)) exp(1.15)

Table 2-4 Leakage from the service pipes after replacement

	Number of connectio	Leakage Ratio	Total
S.P. from PVC	397	10%	5.0%
S.P. from PVC	478	10%	6.0%
		Weighted Average	10.9%

Number of connection: in proportion to the length of distribution pipes to be connected

Whole Leakage Ratio	25.2%

Table 3 Leakage Ratio of Goroka

Table 3-1 Leakage from the existing distribution pipes

Type of Material	Diameter (mm)	Length (m)	Standard pressure head	Leakage ratio by material(	Surface area of pipe(m2)	Total (%)
ACP	300	0	15	40%	0	0.0%
ACP	250	0	15	40%	0	0.0%
ACP	200	2,376	15	40%	1,493	2.8%
ACP	150	12,210	15	40%	5,754	10.9%
ACP	100	14,196	15	40%	4,460	8.4%
ACP	80	244	15	40%	61	0.1%
DIP	300	2,475	15	40%	2,333	4.4%
PVC	150	348	15	15%	164	0.1%
PVC	100	18,876	15	15%	5,930	4.2%
PVC	80	52	15	15%	13	0.0%
PVC	50	4,316	15	15%	678	0.5%
PVC	25	2,444	15	15%	192	0.1%
PVC	20	1,045	15	15%	66	0.0%
GSP	25	629	15	15%	49	0.0%
GSP	20	182	15	15%	11	0.0%
					Weighted Average	31.4%

Table 3-2 Leakage from the existing service pipes

	Number of connectio	Leakage Ratio	Total
S.P. from ACP	1879	15%	7.7%
S.P. from PVC/GSP	1804	15%	7.3%
		Weighted Average	15.0%

Number of connection: in proportion to the length of distribution pipes to be connected

Whole Leakage Ratio	46.4%

Table 3-3 Leakage from the proposed distribution pipes

Type of Material	Diameter (mm)	Length (m)	Standard pressure head	Leakage ratio by material(	Surface area of pipe(m2)	Total (%)
PVC(new)	300	270	15	10%	254	0.1%
PVC(new)	250	880	15	10%	691	0.4%
PVC(new)	200	3,134	15	10%	1,969	1.2%
PVC(new)	150	2,080	15	10%	980	0.6%
PVC(new)	100	6,517	15	10%	2,047	1.2%
PVC(new)	80	6,382	15	10%	1,604	0.9%
DIP(existing)	300	2,475	15	10%	2,333	1.4%
PVC(existing)	150	348	15	15%	164	0.1%
PVC(existing)	100	18,876	15	15%	5,930	5.2%
PVC(existing)	80	52	15	15%	13	0.0%
PVC(existing)	50	4,316	15	15%	678	0.6%
PVC(existing)	25	2,444	15	15%	192	0.2%
PVC(existing)	20	1,045	15	15%	66	0.1%
GSP (existing	25	629	15	15%	49	0.0%
GSP (existing	20	182	15	15%	11	0.0%
					Weighted Average	11.3%

Leakage Ratio after replacement

1) New — 10% as target

2) Existing — Leakage calculation formula (Practical leakage survey, Japan Water Reserch Center)

Leakage Ratio(L1) = Existing leakage ratio(L0)

× (Proposed pressure(P1) ／ Present standard pressure(P0)) exp(1.15)

Table 3-4 Leakage from the service pipes after replacement

	Number of connectio	Leakage Ratio	Total
S.P. from PVC(new)	1611	10%	4.4%
S.P. from PVC(existing	2331	15%	9.5%
		Weighted Average	13.9%

Number of connection: in proportion to the length of distribution pipes to be connected

Whole Leakage Ratio	25.1%

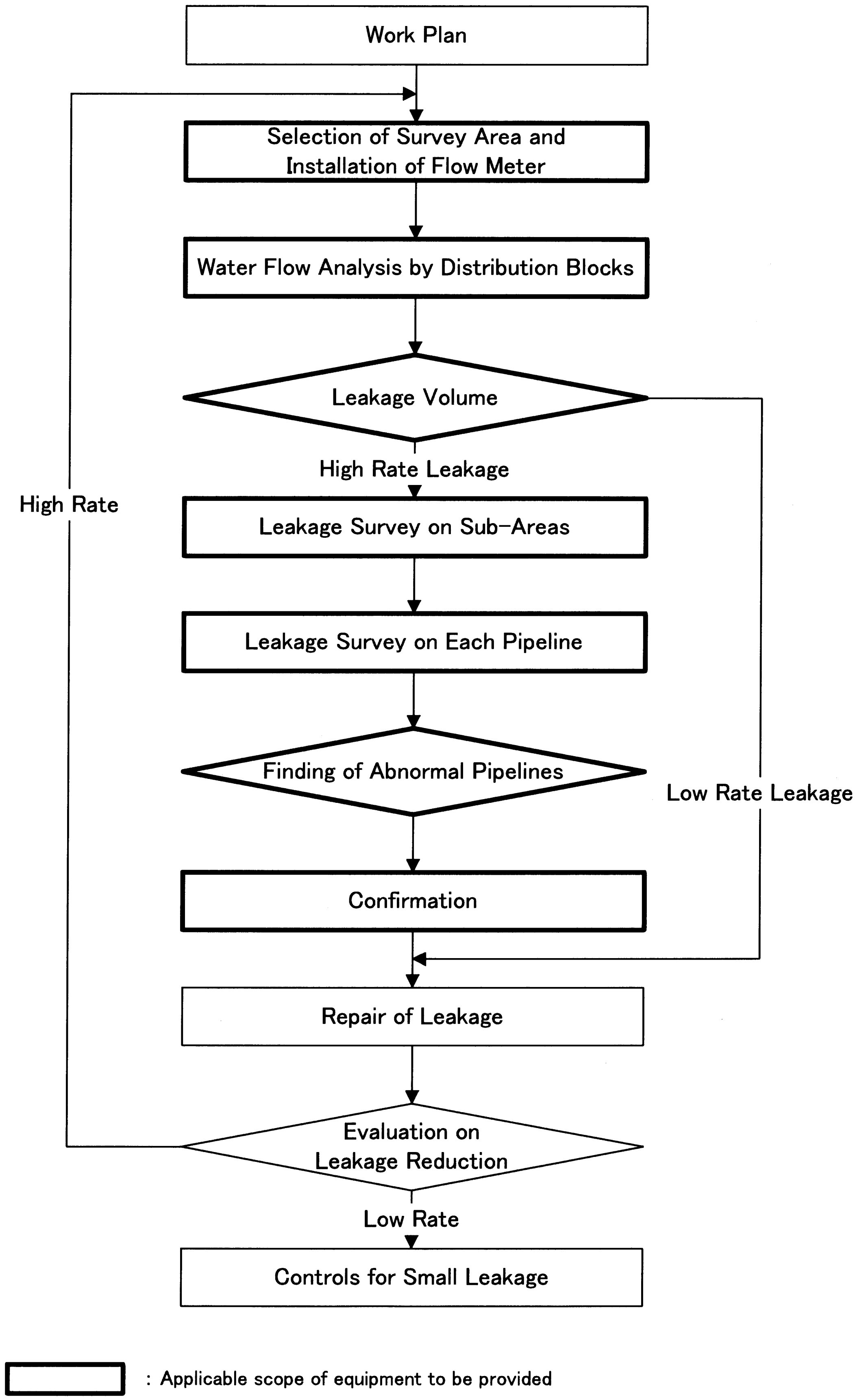
3. Recommended Leakage Control after the Project

Leakage ratio is targeted to be 25% in the Project, by replacement of the distribution pipes. It is recommended that the leakage control will continue after the Project, in order to reduce the leakage ratio furthermore that contributes to soundness of the financial status through improvement of the accounted-for water.

As the leakage control equipment, water meters and portable flow meter (ultrasonic type) for Goroka are to be provided under the Project. Water meters are necessary not only for sustaining the water charge collection system, but also for obtaining the base data on actual leakage status by water balance analysis. The ultrasonic flow meter is applicable in maintenance for calibration of the installed water meter, alternative use of the malfunctioned water meter, leakage survey, verification of the hydraulic analysis result, and etc.

The flowchart of the leakage reduction plan and the applicable scope of the equipment to be provided under the Project are shown in the following page. In the Project, PNG's implementation agencies are responsible for installing the water meters and water flow control by the distribution blocks. Thereafter, priority areas which will be identified by the surveys are to be repaired and replaced. Controls for small leakage will be conducted furthermore,.

Flowchart of the Leakage Reduction Plan



Appendix 9 ***Population and Water Demand***

Population and Water Demand

1. Population

2. Water Demand

5.2 Population and Water Demand

1. Population

(1) Summery

① Population and Household

Area		Year 2000		Year 2003 (*1)	
		Population	House hold	Population	House hold
Lorengau (*2)		5,298	1,090	5,672	1,167
Goroka (*3)	Town	22,032	3,684	23,587	3,944
	Village	12,235	3,843	12,235	3,843
	Sub Total	34,267	7,527	35,822	7,787
Total		39,565	11,211	41,494	11,731

Source:
(*1) According to census data in 1990, population forecast in 2003 is estimated based on population growth rate with 2.3% every year
(*2) National population census, July 2000
(*3) Counting check conducted by the Study Team in August 2000

②Consumers in 2000

	Residence	School		Hospital	Hotel	Restaurant	Market /shop	Office	Others
	Population	Teachers	Pupils	Beds	Rooms	Nos.	Nos.	Nos.	Nos.
Goroka	22,032	317	5,208	369	412	34	190	200	2
Village	12,235								
Lorengau	4,055	76	2,062	110	28	5	10	61	
Island	2,500								
Total	40,822	393	7,270	479	440	39	200	261	2

(2) Lorengau

① Population and Population Served in 2000 and 2003

Year	2000		2003		Population served	
Ward	Population (A)	Household (B)	Population (C)	Household (D)	2000	2003
1	690	143	739	153	515	551
2	785	161	840	172	650	696
3	940	191	1,006	204	505	541
4	605	125	648	134	455	487
5	748	156	801	167	645	691
6	630	130	674	139	600	642
7	900	184	964	197	685	733
Total	5,298	1,090	5,672	1,167	4,055	4,341
Rate of population served					77%	77%

Note :
Source: (A) and (B) , Population census in July 2000
(C): Population growth rate is 2.3% based on population census in 1990
(D) =(C)/((A)/(B))
Population served in 2003 is the same rate as present conditions in year 2000.

② Consumers by Ward (August 2000)

Ward No.	Dwellings		School		Hospital	Hotel	Restaurant	Market /shop	Office	Zone
	No. of households	Population	Teachers	Pupils	Beds	Rooms	Nos.	Nos.	Nos.	
1	103	515	16	500					8	East
2	150	650	10	200	100		1		6	East
3	101	505	10	200					5	East
4	91	455							2	East
5	129	645			10	28	3	10	26	West
6	120	600	10	200			1		6	West
7	137	685	30	962					8	West
Total	831	4,055	76	2,062	110	28	5	10	61	

Source :Census data in 2000 and count survey

(3) Goroka

① Consumers in Town

Block No.	Dwellings			School		Hospital	Hotel	Restaurant	Market /shop	Office	Others	
Block No.	Individual	Flat/ Duplex	Dormitory	Teachers	Pupils	Beds	Rooms	Nos.	Nos.	Nos.	Nos.	Zone
1	13									1		East
2	3						220			66		East
3	1							3	14	16		East
4								3	4	3		East
5	1							3	13	16		East
6	20	12						1	5	1		East
7	37	12								1		East
8	9	2						2	6			East
9-520/521	29	27	298	99	1,493	2			1			North
9-522	6								1	2		North
9-523	78	12	126	30	196	1		1	7	7		North
10	48	23				5				8	2	North
11	26	30										North
12	9	18						3	6	16		South West
13	6	12						3	14			West
14	6	12		8	164			1	8			West
15	40	33										West
16	26	12								1		West
17	6	14		4	37					4		West
18	62	58	87	11	88	360				2		West
19	62	37		53	1,200				1	1		South West
20	15	108					108	1		4		South West
21	10	43							10	4		South West
22	22	16							3	1		South West
23	21	6							1			South West
25	7	14								1		West
26	12	7										West
27	11	16										West
28	22											West
29	19											West
30	32						8					East
32	35	10										West
33	45	21										East
34									5			East
35	21											West
36	55		24				39					East
37	19	18	21	28			12			7		West
38	20	10										West
39	29	16										East
40	30											West
41	10	12										West
42	7	18										West
43	21	16										West
50	57	9		5	48				1	1		North
51	21	4										North

52	13											North
53	20	14							11	2		East
54	2	21							1			East
55	10	8						1	4			East
61	77	36							4			South West
62	18	2							4			South West
63	14											South West
64	24		8					1	2			South West
65	3							2	4			South West
66	22								2			South West
67	6											South West
68	52	6						2	1			South West
69	46	5							5			South West
70	81							1	5			South West
71	3	4						2	20			South West
72	36								3			South West
73	32								2			East
74	108	19							1	1		North
76	12	10								5		North
78	38											East
79	14											East
80	29	4							1	1		East
81									3	1		West
82	3	4								5		East
83	6	4						1	3	12		East
84	12											East
86	98								2	1		South West
87	7	4				1						South West
88	74	14		21	500					1		West
89	74											East
90	28			34	1,098				1			East
91	10											East
92	14											East
93	12											East
94	8											East
95	9											East
96	10											East
97	3								1			South West
98	52	10								1		West
99	5											West
101	7											East
102	30	25						1		4		North
104	7	5						1	3			East
105	4	11		12	130					2		West
106	14							1				East
107	3	6							2			South West
115	25	12										South West
116	6			6	24		25					North
117	14	5		6	230							North
124	3	6							5	1		East
Town Total	2,227	893	564	317	5,208	369	412	34	190	200	2	

count survey in August 2000

size	6.7	6.7	2
Population	14,921	5,983	1,128
Total	**22,032**		

② Consumers in Village

Name of village	Year 2000			
	Public Tap	Family per 1tap	Consumers per 1tap	Consumers
Okiufa	87	2	6.7	1,310
Segu	79	1	6.7	467
Faniufa	79	1	6.7	375
Kami	8	19	6.7	1,021
kama, Sipiga	348	1	6.7	3,119
Asaroufa	185	3	6.7	3,127
Kafana, Fimito	50	4	6.7	1,367
Lapegu	10	9	6.7	573
Komiufa	39	3	6.7	876
Total population served	885			**12,235**
Total population				23,214
Rate of population served				48%

Source: Population census in July 2000
Population served: Information from Goroka town office

③ Population forecast in 2003 and water demand

Block No.	Population estimated (2000)	Population forecast (2003)	Estimated water demand								
			2000 (A)								2003
			Domestic water demand (m3/day)	School (m3/day)	Hospital (m3/day)	Hotel (m3/day)	Restaurant (m3/day)	Market/shop (m3/day)	Office (m3/day)	Total (m3/day)	(A)*(1+0.023)^3
1	87	93	15.3	0	0	0	0	0	1	16.3	17.5
2	20	22	3.6	0	0	88	0	0	66	157.6	168.7
3	7	7	1.2	0	0	0	7.5	21	16	45.7	48.9
4	0	0	0	0	0	0	7.5	6	3	16.5	17.7
5	7	7	1.2	0	0	0	7.5	19.5	16	44.2	47.3
6	214	230	38	0	0	0	2.5	7.5	1	49	52.5
7	328	351	57.9	0	0	0	0	0	1	58.9	63.1
8	74	79	13	0	0	0	5	9	0	27	28.9
9-520/521	971	1040	171.6	114.4	1	0	0	1.5	0	288.5	308.9
9-522	40	43	7.1	0	0	0	0	1.5	2	10.6	11.3
9-523	855	915	151	16.7	0.5	0	2.5	10.5	7	188.2	201.5
10	476	509	84	0	2.5	0	0	0	8	94.5	101.2
11	375	402	66.3	0	0	0	0	0	0	66.3	71.0
12	181	194	32	0	0	0	7.5	9	16	64.5	69.1
13	121	129	21.3	0	0	0	7.5	21	0	49.8	53.3
14	121	129	21.3	12.3	0	0	2.5	12	0	48.1	51.5
15	489	524	86.5	0	0	0	0	0	0	86.5	92.6
16	255	273	45	0	0	0	0	0	1	46	49.2
17	134	143	23.6	3	0	0	0	0	4	30.6	32.8
18	978	1047	172.8	7.3	180	0	0	0	2	362.1	387.7
19	663	710	117.2	89.3	0	0	0	1.5	1	209	223.8
20	824	882	145.5	0	0	43.2	2.5	0	4	195.2	209.0
21	355	380	62.7	0	0	0	0	15	4	81.7	87.5
22	255	273	45	0	0	0	0	4.5	1	50.5	54.1
23	181	194	32	0	0	0	0	1.5	0	33.5	35.9
25	141	151	24.9	0	0	0	0	0	1	25.9	27.7
26	127	136	22.4	0	0	0	0	0	0	22.4	24.0
27	181	194	32	0	0	0	0	0	0	32	34.3
28	147	158	26.1	0	0	0	0	0	0	26.1	27.9
29	127	136	22.4	0	0	0	0	0	0	22.4	24.0
30	214	230	38	0	0	3.2	0	0	0	41.2	44.1
32	302	323	53.3	0	0	0	0	0	0	53.3	57.1
33	442	473	78	0	0	0	0	0	0	78	83.5
34	0	0	0	0	0	0	0	7.5	0	7.5	8.0
35	141	151	24.9	0	0	0	0	0	0	24.9	26.7
36	417	446	73.6	0	0	15.6	0	0	0	89.2	95.5
37	290	310	51.2	2.8	0	4.8	0	0	7	65.8	70.4
38	201	215	35.5	0	0	0	0	0	0	35.5	38.0
39	302	323	53.3	0	0	0	0	0	0	53.3	57.1
40	201	215	35.5	0	0	0	0	0	0	35.5	38.0
41	147	158	26.1	0	0	0	0	0	0	26.1	27.9
42	168	179	29.5	0	0	0	0	0	0	29.5	31.6

43	248	265	43.7	0	0	0	0	0	0	43.7	46.8
50	442	473	78	3.9	0	0	0	1.5	1	84.4	90.4
51	168	179	29.5	0	0	0	0	0	0	29.5	31.6
52	87	93	15.3	0	0	0	0	0	0	15.3	16.4
53	228	244	40.3	0	0	0	0	16.5	2	58.8	63.0
54	154	165	27.2	0	0	0	0	1.5	0	28.7	30.7
55	121	129	21.3	0	0	0	2.5	6	0	29.8	31.9
61	757	811	133.8	0	0	0	0	6	0	139.8	149.7
62	134	143	23.6	0	0	0	0	6	0	29.6	31.7
63	94	100	16.5	0	0	0	0	0	0	16.5	17.7
64	177	189	31.2	0	0	0	2.5	3	0	36.7	39.3
65	20	22	3.6	0	0	0	5	6	0	14.6	15.6
66	147	158	26.1	0	0	0	0	3	0	29.1	31.2
67	40	43	7.1	0	0	0	0	0	0	7.1	7.6
68	389	416	68.6	0	0	0	5	1.5	0	75.1	80.4
69	342	366	60.4	0	0	0	0	7.5	0	67.9	72.7
70	543	581	95.9	0	0	0	2.5	7.5	0	105.9	113.4
71	47	50	8.3	0	0	0	5	30	0	43.3	46.4
72	241	258	42.6	0	0	0	0	4.5	0	47.1	50.4
73	214	230	38	0	0	0	0	3	0	41	43.9
74	851	911	150.3	0	0	0	0	1.5	1	152.8	163.6
76	147	158	26.1	0	0	0	0	0	5	31.1	33.3
78	255	273	45	0	0	0	0	0	0	45	48.2
79	94	100	16.5	0	0	0	0	0	0	16.5	17.7
80	221	237	39.1	0	0	0	0	1.5	1	41.6	44.5
81	0	0	0	0	0	0	0	4.5	1	5.5	5.9
82	47	50	8.3	0	0	0	0	0	5	13.3	14.2
83	67	72	11.9	0	0	0	2.5	4.5	12	30.9	33.1
84	80	86	14.2	0	0	0	0	0	0	14.2	15.2
86	657	703	116	0	0	0	0	3	1	120	128.5
87	74	79	13	0	0.5	0	0	0	0	13.5	14.5
88	590	631	104.1	37.1	0	0	0	0	1	142.2	152.2
89	496	531	87.6	0	0	0	0	0	0	87.6	93.8
90	188	201	33.2	80.3	0	0	0	1.5	0	115	123.1
91	67	72	11.9	0	0	0	0	0	0	11.9	12.7
92	94	100	16.5	0	0	0	0	0	0	16.5	17.7
93	80	86	14.2	0	0	0	0	0	0	14.2	15.2
94	54	57	9.4	0	0	0	0	0	0	9.4	10.1
95	60	65	10.7	0	0	0	0	0	0	10.7	11.5
96	67	72	11.9	0	0	0	0	0	0	11.9	12.7
97	20	22	3.6	0	0	0	0	1.5	0	5.1	5.5
98	415	445	73.4	0	0	0	0	0	1	74.4	79.7
99	34	36	5.9	0	0	0	0	0	0	5.9	6.3
101	47	50	8.3	0	0	0	0	0	0	8.3	8.9
102	369	395	65.2	0	0	0	2.5	0	4	71.7	76.8
104	80	86	14.2	0	0	0	2.5	4.5	0	21.2	22.7
105	101	108	17.8	10.3	0	0	0	0	2	30.1	32.2
106	94	100	16.5	0	0	0	2.5	0	0	19	20.3
107	60	65	10.7	0	0	0	0	3	0	13.7	14.7
115	248	265	43.7	0	0	0	0	0	0	43.7	46.8
116	40	43	7.1	2.3	0	10	0	0	0	19.4	20.8
117	127	136	22.4	16.7	0	0	0	0	0	39.1	41.9
124	60	65	10.7	0	0	0	0	7.5	1	19.2	20.6
Town Total	22,032	23,589	3,635	417	185	165	80	285	202	4,969	5320

2. Water Demand

(1) Lorengau

① Water demand in 2000

Water uses	Unit water demand		Q'ty	Water demand(200		Rate(*1)	Rate
Residential (Town)	165	L/c/d	4,055	669	m3/d	-	62%
Residential (Isrand)			L.S.	100	m3/d	-	9%
Others							
School (Pupil)	70	L/c/d	2,062	144	m3/d	19%	13%
School (Teacher)	165	L/c/d	76	13	m3/d	2%	1%
Hospital	500	L/bed/d	110	55	m3/d	7%	5%
Hotel	400	L/room/d	28	11	m3/d	1%	1%
Restaurant	2,500	L/res./d	5	13	m3/d	2%	1%
Commercial	1,500	L/shop/d	10	15	m3/d	2%	1%
Office	1,000	L/off./d	61	61	m3/d	8%	6%
Subtotal				312	m3/d		29%
Total				**1,081**	**m3/d**	**41%**	

Rate(*1) The figure is shown ratio of others uses comparing with domestic use.

(*2) Day pupil: 30 L/c/d (70%), Boading pupil: 165 L/c/d (30%)

② Water demand in 2003

Water uses	Unit water demand (U		Q'ty	Water demand		Rate	Rate
Residential (Town)	165	L/c/d	4,341	716	m3/d	-	62%
Residential (Village)	40	L/c/d		100	m3/d	-	9%
Subtotalotal			4,341	816	m3/d	-	71%
Others	41% % of domestic			331	m3/d	41%	29%
Total				1,147	m3/d		100%

(2) Goroka

① Water Demand in 2000年

Water uses	使用原単位		Q'ty	Water demand(200		Rate(*1)	Rate
Residential (Town)	165	L/c/d	22,032	3,635	m3/d	-	67%
Residential (Village)	40	L/c/d	12,235	489	m3/d	-	9%
Subtotal			34,267	4,125	m3/d	-	76%
Others							
School (Pupil)	70	L/c/d	5,208	365	m3/d	9%	7%
School (Teacher)	165	L/c/d	317	52	m3/d	1%	1%
Hospital	500	L/bed/d	369	185	m3/d	4%	3%
Hotel	400	L/room/d	412	165	m3/d	4%	3%
Restaurant	2,500	L/res./d	32	80	m3/d	2%	1%
Commercial	1,500	L/shop/d	190	285	m3/d	7%	5%
Office	1,000	L/off./d	202	202	m3/d	5%	4%
Subtotal				1,333	m3/d		24%
Total			**75,264**	**5,458**	**m3/d**	**33%**	**100%**

Rate(*1) The figure is shown ratio of others uses comparing with domestic use.

(*2) Day pupil: 30 L/c/d (70%), Boading pupil: 165 L/c/d (30%)

② Water demand in 2003

Water uses	Unit water demand (U		Q'ty	Water demand		Rate	Rate
Residential (Town)	165	L/c/d	23,589	3,892	m3/d	-	67%
Residential (Village)	40	L/c/d	12,235	489	m3/d	-	8%
Subtotalotal			35,824	4,382	m3/d	-	75%
Others	33% % of domestic			1,427	m3/d	33%	25%
Total				5,809	m3/d		100%

Appendix 10 ***Design Water Flow***

(1) Lorengau

① Design criteria

(a)	Treatment plant use (TPU)		10 %
(b)	Rate of leakage		25 %
(c)	Day peak factor	Domestic	1.2
(d)	Day peak factor	Others	1.1
(e)	Hour peak factor	Domestic	1.8
(e)	Hour peak factor	Others	1.6

② Calculation of design water flow Unit in m3/d

	Basic Data	Daily Ave.	Daily Maximum	Hourly Maximum
Domestic (1)	816	816	980	1,469
Others (2)	331	331	364	529
Subtotal (3)= (1)+(2)	**1,147**	1,147	1,343	1,999
Loss (4)=(3)x0.25/(1-0.25)	0.25	382	448	666
Subtotal (4)= (3)+(4)	-	**1,529**	**1,791**	**111**
TPU (5)=(3)x0.1	0.10	-	134	-
Total (6)=(4)+(5)	-	-	**1,925**	-

(2) Goroka

① Design criteria

(a)	Treatment plant use (TPU)		10 %
(b)	Rate of leakage		25 %
(c)	Day peak factor	Domestic	1.2
(d)	Day peak factor	Others	1.1
(e)	Hour peak factor	Domestic	1.8
(e)	Hour peak factor	Others	1.6

② Calculation of design water flow

Unit in m3/d

	Basic Data	Daily Ave.	Daily Maximum	Hourly Maximum
Domestic (1)	4,382	4,382	5,258	7,887
Others (2)	1,427	1,427	1,570	2,284
Subtotal (3)= (1)+(2)	**5,809**	5,809	6,828	10,171
Loss (4)=(3)x0.25/(1-0.25)	0.25	1,936	2,276	3,390
Total (5)=(3)+(4)		**7,745**	**9,104**	**565**
TPU (4)=(3)x0.1	0.10	-	683	-
Total		-	**9,787**	-

Appendix 11 *Design Calculation for Water Treatment Plant for Goroka*

I. Head Loss Calculation for the Water Treatment Plant

II. Water Flow Calculation for the Water Treatment Plant

III. Calculation of Chemical Dosing Equipment

HYDRAULIC CALCULATIONS

I. Head Loss Calculation for the Water Treatment Plant

Hydraulic Calculations

I. Head Loss Calculation for the Water Treatment Plant

1. Basic Conditions

① Plant flow Q=10, 000 m^3/日

Distribution of the water flow

Line No.1 Q_1=	1,700	[m^3/d]	=	0.02	[m^3/s]	(Existing)
Line No.2 Q_2=	4,800	[m^3/d]	=	0.056	[m3/s]	(Existing)
Line No.3 Q_3=	3,500	[m^3/d]	=	0.041	[m^3/s]	(Expansion)

② Basic water levels

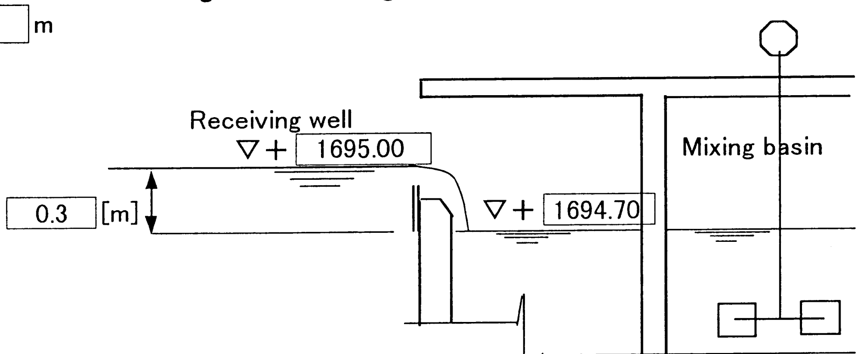
New receiving well	WL	+	1,695.00	[m]
Existing No.1 sedimentation	WL	+	1,685.65	[m]
Existing No.2 sedimentation	WL	+	1,685.60	[m]
Existing No.2 filter trough	EL	+	1,683.40	[m]

2. From receiving well to eachFacilitie (Line No.1,2and 3)

(1) Head loss of Mixing ba:: Δh_1

(Differential head between Receiving well and Mixing basin)

where: Δh_1= 0.3 m



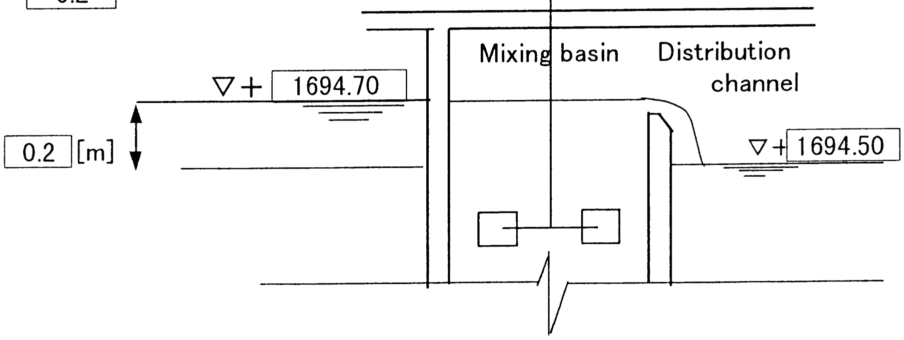
The required water level of mixing basin (Mix. L) is then:

Max.L − Δh_1= 1,695.00 − 0.3 = 1694.700 m

(2) Head loss of the Discharge channel Δh_2

(Differential head between Mixing basin and Distribution channel)

where: Δh_2= 0.2 m



The required water level of distribution channel (Dis.L) is then:

$$\text{Dis..L} - \Delta h_1 = 1{,}694.70 - 0.2 = \boxed{1694.50}\ [m]$$

(3) Head loss of sedimentation basin: Δh_3

(Differential head between Distribution channel and Sedimentation basin)

① No.1 sedimentation

The head loss can be obtained from the Williams and Hazen empirical formula:

$$\Delta h_3 = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

where:

C : roughness coefficient of the pipe wall C= 110 (steel pipe)

D : internal pipe size D= 0.2 [m]

L : pipe length L= 145 [m]

therefor:

$$= 10.666 \times 110^{-1.85} \times 0.2^{-4.87} \times 0.02^{1.85} \times 145$$

$$= 0.472\ [m] \rightarrow \boxed{0.5}\ [m]$$

Water level of No. 1 Sedimentation

$$WL+\ 1{,}685.65 < 1{,}694.50 - 0.5 = WL+ \boxed{1{,}694.00}\ [m]$$

② No.2 sedimentation

The head loss can be obtained from the Williams and Hazen empirical formula:

$$\Delta h_3 = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

where:

$$= 10.666 \times 110^{-1.85} \times 0.2^{-4.87} \times 0.056^{1.85} \times 150$$

$$= 3.28\ [m] \rightarrow \boxed{3.5}\ [m]$$

Water level= $WL+\ 1{,}685.60 < 1{,}694.50 - 3.5 = WL+ \boxed{1{,}691.00}\ [m]$

Therefor, the water level with 1,691m is accepted.

③ No.3 sedimentation

The head loss can be obtained from the Williams and Hazen empirical formula:

where:

$$\Delta h_3 = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

$$= 10.666 \times 110^{-1.85} \times 0.2^{-4.87} \times 0.041^{1.85} \times 10$$

$$= 0.123\ [m] \rightarrow \boxed{0.5}\ [m]$$

Water level $= +\ 1{,}694.50 - 0.5 = WL+ \boxed{1{,}694.00}\ [m]$

where:

L : pipe length

$L_1 =$ 145 [m]

$L_2 =$ 150 [m]

$L_3 =$ 10 [m]

3. Line No. 3 Treatment Plant

(1) Required head loss in the valve with 200mm: Δh_4

$$\Delta h_4 = (fbv + fi + of) \times \frac{V^2}{2g} = (0.30 + 0.30 + 1.00) \times \frac{0.653^2}{2g} = 0.035 \text{ [m]}$$

$\rightarrow$ 0.05 [m]

with:

fbv :	loss coefficient of valves	0.3
fi :	loss coefficient of pipe inlet	0.30
fo :	loss coefficient of pipe outlet	1.00

V : velocity in the pipe $\dfrac{0.041 \times 4}{0.2^2 \times \pi \times 2} = 0.653$ [m/sec]

(2) Required head loss in the flocculation basin: Δh_5

where:

required G-value: 50 1/sec. (10 < G < 75)

$$\Delta h_5 = \frac{G^2 V \mu}{\rho Q g} = \frac{50^2 \times 73.5 \times 10^{-3}}{10^3 \times 0.041 \times 9.8} = 0.46 \text{ [m]} \rightarrow 0.5 \text{ [m]}$$

with:

V :	Volume of the flocculation basin	73.5	[m^3]	
μ :	Viscosity coefficient of the water	0.001	[kg/m·s]	as 20°C
ρ :	density of the water	1.00	[kg/m^3]	as 20°C
Q :	water flow	0.04	[m^3/S]	

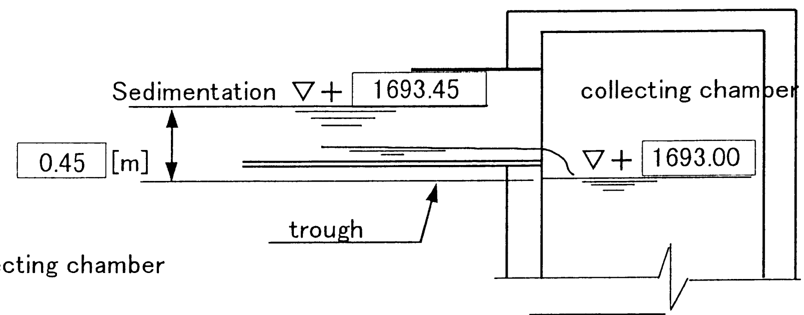
Water level of the sedimentation:

water level $- \Delta h_4 - \Delta h_5 =$ 1694.00 $-$ 0.05 $-$ 0.5 $= +$ 1693.45 [m]

(3) Required head loss in sedimentation basin: Δh_6

where:

$\Delta h_6 =$ 0.45 [m]



water level of the collecting chamber

sedimentation water level · $\Delta h_7 - \Delta h_6 =$ 1693.45 $-$ 0.45 $=$ 1693.000 [m]

(4) Required loss head from collection chamber to filter inlet channel

The head loss can be obtained from the Williams and Hazen empirical formula:

$$\Delta h_7 = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

where:

$$= 10.666 \times 110^{-1.85} \times 0.2^{-4.87} \times 0.041^{1.85} \times 40$$

$$= 0.492 \ [m] \rightarrow \boxed{0.5} \ [m]$$

water level of filter inlet $= + \ 1{,}693.00 - 0.5 = WL + \boxed{1{,}692.50}$ [m]

where:

C	roughness coefficient of the pipe wall	C=	110	
D	internal pipe size	D=	0.2	[m]
L	pipe length	L=	40	[m]

(5) Required head loss from filter inlet and filter bed

① Inlet filter valve $\Delta h_{①}$

$$\Delta h_{①} = (fo + fbv) \times \frac{V^2}{2g} = (1.0 + 0.6) \times \frac{0.74^2}{2g}$$

$$= 0.045 \rightarrow \boxed{0.05} \ [m]$$

with:

fo	head loss coefficient of the outlet connection	1.0	[-]
fbv	head loss coefficient of the valves	0.6	[-]

$$V : \text{velocity} \frac{4 \times Q_0}{\pi \times D^2} = \frac{4 \times 0.0058}{\pi \times 0.1^2} = 0.74 \ [m/s]$$

② Distribution channel $\Delta h_{②}$

$$\Delta h_{②} = \boxed{0.25} \ [m]$$

$$\Delta h_8 = \Delta h_{①} + \Delta h_{②} = 0.05 + 0.25 = 0.3 \ [m] \rightarrow \boxed{0.5} \ [m]$$

HWL of the filter bed

$+ \ 1{,}692.50 - 0.5 = \boxed{HWL + \ 1{,}692.00}$ [m]

③ Filter including initial loss

where:

ha= $\boxed{2.0}$ [m]

LWL of the filter bed

$+ \ 1{,}692.00 - 2.0 = \boxed{LWL + \ 1{,}690.00}$ [m]

(6) Required head loss during filtration: Δh_9

① Filter media (sand): Δhs
The filter resistance of the clean filter media is :

$$\Delta hs = \frac{F \mu LvL}{\rho g \phi^2 D^2} \times \frac{(1-\varepsilon)^2}{\varepsilon^3}$$

where:

・empirical coefficeint by Levis formula	F	:	144			
・filtration rate	LV	:	130	[m/d]=	0.0015	[m/s]
・layer depth	L	:	0.7	[m]		
・acceleration gravity	g	:	9.8	[m/s²]		
・size of the sand	D	:	6.50E−04	[m]		
・rate of media space	ε	:	0.45	[−]		
・media coefficient	ϕ	:	0.8	[−]		
・viscosity coefficient (at 20°C)	μ	:	1.0E−03	[kg/(m・s)]		
・density	ρ	:	1000	[kg/m³]		

then:

$$\Delta hs = \frac{144 \times 1.0E{-}03 \times 0.0015 \times 0.7}{1000 \times 9.8 \times 0.8^2 \times 6.50E{-}04^2} \times \frac{(1- 0.45)^2}{0.45^3}$$

$\Delta hs =$ 0.190 [m]

② supporting gravel Δhg
The filter resistance by the clean filter media is :

$$\Delta hg = \frac{F \mu Lv}{\rho g \phi^2} \times \xi \times \frac{(1-\varepsilon)^2}{\varepsilon^3}$$

・empirical coefficeint by Levis formula	F	:	144			
・filtration rate	LV	:	130	[m/d]=	0.0015	[m/s]
・layer depth	L	:	0.05	[m]		
・acceleration gravity	g	:	9.8	[m/s²]		
・gravel size (1st)	D_1	:	2.00E−03	[m]		
・gravel size (2nd)	D_2	:	4.00E−03	[m]		
・gravel size (3rd)	D_3	:	6.00E−03	[m]		
・gravel size (4th)	D_4	:	1.30E−02	[m]		
・rate of media space	ε	:	0.4	[−]		
・media coefficient	ϕ	:	0.7	[−]		
・viscosity coefficient (at 20°C)	μ	:	1.0E−03	[kg/(m・s)]		
・density	ρ	:	1000	[kg/m³]		

then:

$$\xi = \left[\frac{1}{d_1^2} + \frac{1}{d_2^2} + \frac{1}{d_3^2} + \frac{1}{d_4^2} \right] \times L$$

$$\xi = \left[\frac{1}{2.00E{-}03^2} + \frac{1}{4.00E{-}03^2} + \frac{1}{6.00E{-}03^2} + \frac{1}{1.30E{-}02^2} \right] \times 0.05 = 1.7E{+}04$$

therefore:

$$\Delta hg = \frac{144 \times 1.0E-03 \times 0.0015}{1000 \times 9.8 \times 0.7^2} \times 1.7E+04 \times \frac{(1- 0.4)^2}{0.4^3}$$

$\Delta hg =$ 0.004 [m]

③ under collecting device $\Delta hc =$ 5.6 [mm] → 0.006 [m]

④ treated water pipe: Δhp

$$\Delta hp = (fi + fo + fL \frac{L}{D}) \times \frac{V^2}{2g} = (0.5 + 1 + 0.022 \frac{3.0}{0.3}) \times \frac{0.08^2}{2g}$$

$= $ 0.001 [m]

with:

fi	: head loss coefficient of the inflow	0.50	[-]
fo	: head loss coefficient of the outflow	1.00	[-]
fL	: head loss coefficient of the friction (0. 020 + 0. 0005/ D)	0.022	[-]
D	: pipe size	0.300	[m]

$$V : \text{velocity} \quad \frac{4 \times Q_0}{\pi \times D^2} = \frac{4 \times 0.0058}{\pi \times 0.3^2} = 0.08 \quad [m/sec]$$

Therefore, initial filter resistance of the filter isobtained as follows:

$\Delta h_9 = \Delta hs + \Delta hg + \Delta hc + \Delta hp$

$= 0.190 + 0.004 + 0.006 + 0.001 =$ 0.20 [m]

(7) Required head loss during washing process Δh_9

① filter media (sand) Δhs

$$\Delta hs = \frac{L}{\rho_F} (1 - \varepsilon)(\rho_S - \rho_F)$$

where:

・layer depth	L	:	0.7	[m]
・rate of media space	ε	:	0.48	[−]
・specific gravity of the water	ρ_F	:	1000	[kg/m3]
・specific gravity of the sand	ρ_S	:	2630	[kg/m3]

$$\Delta hs = \frac{0.7}{1000} (1- 0.48)(2630 - 1000)$$

$=$ 0.593 [m]

② supporting gravel Δhg

The resistance of the gravel zone is obtained from following formula:

$$\Delta hg = \frac{F \mu u}{\rho g \phi^2} \times \xi \times \frac{(1-\varepsilon)^2}{\varepsilon^3}$$

with:

・empirical coefficient by Levis formula	F	:	144			
・filtration rate	u	:	0.6	[m/分]=	0.01	[m/s]
・layer depth	L	:	0.05	[m]		
・acceleration gravity	g	:	9.8	[m/s^2]		
・gravel size (1st)	D_1	:	2.00E-03	[m]		
・gravel size (2nd)	D_2	:	4.00E-03	[m]		
・gravel size (3rd)	D_3	:	6.00E-03	[m]		
・gravel size (4th)	D_4	:	1.30E-02	[m]		
・rate of media space	ε	:	0.4	[−]		
・media coefficient	ϕ	:	0.7	[−]		
・:viscosity coefficient (at 20℃)	μ	:	1.0E-03	[kg/(m・s)]		
・density	ρ	:	1000	[kg/m^3]		

where:

$$\xi = \left[\frac{1}{d_1^2} + \frac{1}{d_2^2} + \frac{1}{d_3^2} + \frac{1}{d_4^2} \right] \times L$$

$$\xi = \left[\frac{1}{2.00E{-}03^{\,2}} + \frac{1}{4.00E{-}03^{\,2}} + \frac{1}{6.00E{-}03^{\,2}} + \frac{1}{1.30E{-}02^{\,2}} \right] \times 0.05$$

$$= 1.7E{+}04$$

then:

$$\Delta hg = \frac{144 \times 1.0E{-}03 \times 0.01}{1000 \times 9.8 \times 0.7^{2}} \times 1.7E{+}04 \times \frac{(1 - 0.4)^2}{0.4^{3}}$$

$$\Delta hg = \boxed{0.029}\ [m]$$

③ under collecting device: $\Delta hc = \boxed{0.2}$ [m]

④ treated water pipe Δhp

where:

$$\Delta hp = (fi + fo + fL\frac{L}{D}) \times \frac{V^2}{2g} = (0.1 + 1.0 + 0.022\frac{3.0}{0.3}) \times \frac{0.54^{2}}{2g}$$

$$= \boxed{0.020}\ [m]$$

with:

fi	:	head loss coefficient of the inflow	0.10	[-]
fo	:	head loss coefficient of the outflow	1.00	[-]
fL	:	head loss coefficient of the friction (0.020 + 0.0005/D)	0.022	[-]
D	:	pipe size	0.300	[m]

$$V : \text{velocity} \quad \frac{4 \times Qb}{\pi \times D^2} = \frac{4 \times \boxed{0.0384}}{\pi \times 0.3^{2}} = 0.54 \quad [m/秒]$$

⑤ treated water valve Δhv

$$\Delta hv = (fi + fo + fbv) \times \frac{V^2}{2g} = (0.1 + 1 + 0.5) \times \frac{0.78^{2}}{2g} \boxed{=0.05m}$$

where:

fi : head loss coefficient of the inflow 0.1

fo : head loss coefficient of the outflow 1

fbv : head loss coefficient of the valve 0.5

D : valve size 0.25 [m]

V : velocity $\dfrac{4x \quad Qb}{\pi \times D^2} = \dfrac{4\times 0.038}{\pi \times 0.25^2} = 0.78$ [m/S]

Qb : wash water flow 1.6 × 2.4 × 0.6 ／ 60 = 0.038 [m^3/sec./bed]

Therefore, required head loss during washing ($\Delta h10$) is:

$\Delta h_{10} = \Delta hs + \Delta hg + \Delta hc + \Delta hp + \Delta hv$

= 0.593 + 0.029 + 0.200 + 0.020 + 0.050 = 0.892 [m] → [1.0] [m]

op elevation of the drainage trough in the filter be

+ 1690.000 − 1.000 = EL+ [1689.000] [m]

(8) Required overflow head from the treated water channel Δh_{11}

where:

Δh_{11} = [0.2] [m]

treated water tank HWL + 1690.000 − 0.2 = HWL+ [1689.800] [m]

Then effective water depth is 2.5m.

treated water tank LWL + 1689.800 − 2.5 = LWL+ [1687.300] [m]

(9) Required head loss of pipe between treated water tank and Line No.2 existing filtei Δh_{12}

The head loss is obtained by Hazen-Willamus formula:

$\Delta h_{12} = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$

where:

C :	roughness coefficient of the pipe wall	C=	110	
D :	inside pipe dia	D=	0.3	[m]
Q :	flow rate	Q=	0.139	[m^3/sec]
L :	pipe length	L=	150	[m]

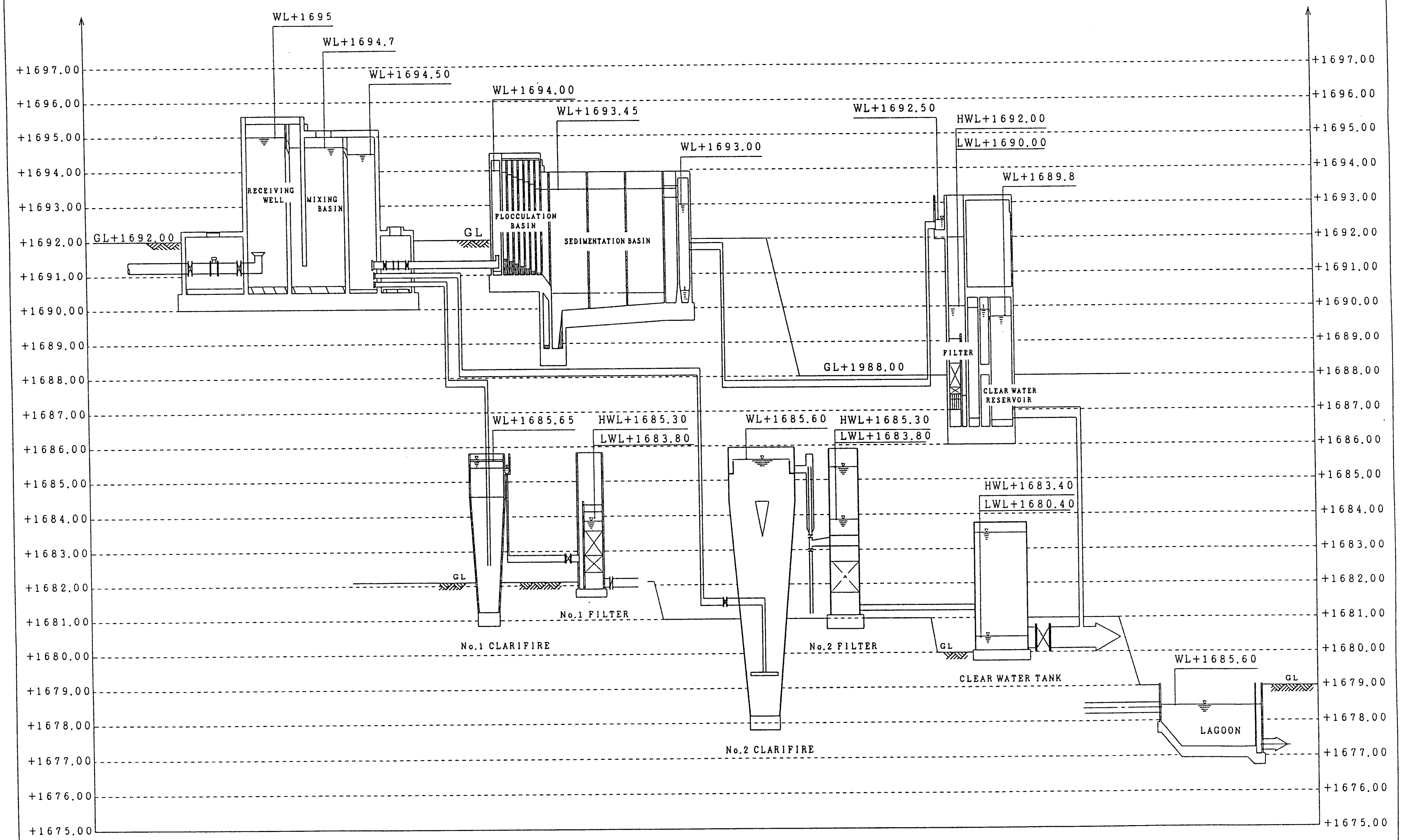
$= 10.666 \times 110^{-1.85} \times 0.3^{-4.87} \times 0.139^{1.85} \times 150$

= 2.447 [m] → [2.5] [m]

[LWL of treated water tanl] − [top elevation of the drainage trough in No.2 filter bed]

= 1687.30 − 1683.40 = 3.9 [m] > [2.5] [m]

Where, required head of the back wash water is to be 1.4m.


WL+1695
WL+1694.7
WL+1694.50
WL+1694.00
WL+1693.45
WL+1693.00
WL+1692.50
HWL+1692.00
LWL+1690.00
WL+1689.8
RECEIVING WELL
MIXING BASIN
FLOCCULATION BASIN
SEDIMENTATION BASIN
GL+1692.00
GL
GL+1988.00
FILTER
CLEAR WATER RESERVOIR
WL+1685.65
HWL+1685.30
LWL+1683.80
WL+1685.60
HWL+1685.30
LWL+1683.80
HWL+1683.40
LWL+1680.40
No.1 FILTER
No.1 CLARIFIRE
No.2 FILTER
No.2 CLARIFIRE
CLEAR WATER TANK
WL+1685.60
LAGOON
+1697.00
+1696.00
+1695.00
+1694.00
+1693.00
+1692.00
+1691.00
+1690.00
+1689.00
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+1676.00
+1675.00

図 2　　水位高低図

II. Water Flow Calculation for the Water Treatment Plant

II. Water flow Calculation for the Water Treatment Plant

1. Receiving Well

(1) Design conditions

Plant flow (Q)	: 10,000 m3/d = 6.94m3/min.
No. of basin	: 1tank
Detention time (t)	: more than 1.5 min. (based on the guideline of water supply design, Japan)

(2) Required capacity : V_o

When the detention time is 5 minutes, the required capacity of the basin is obtain as follows:

V_0 = Q x t = 6.94 x 5 = 34.7m3

$V_0 = Q \times t$

(3) Determination of the dimension

When width (B) of the basin is 2.8m and depth (H) is 4.3m, length (L) of the basin is:

$$L = \frac{V_0}{B \times H} = \frac{34.7}{2.8 \times 4.3} = 2.88 \rightarrow 2.8 \ [m]$$

(4) Available capacity: V

$$V = B \times L \times H = 2.8 \times 2.8 \times 4.3 = 33.7 \ [m^3]$$

(5) Confirmation of the available detention time: T

$$T = \frac{V}{Q} = \frac{33.7}{6.94} = 4.9 \ [min.] > 1.5 \ [min.]$$

(6) Design

Shape	rectangular
Dimension	2.8 [mW] × 2.8 [mL] × 4.3 [mH]
No. of basin	1 unit
Detention time	4.9 [min.]

2 Rapid Mixing Basin

(1) Basic conditions

Plant flow (Q)	: 10,000 m3/d = 6.94m3/min.
No. of basin	: 1tank
Detention time (t)	: more than 1 to 5 min. (based on the guideline of water supply design, Japan)

(2)When the detention time is 5 minutes, the required capacity of the basin is obtained as follows:

$$V_0 = Q \times t = 6.94 \times 4 = 27.8 \ [m^3]$$

(3) Determination of the dimension

When width of the basin will be 2.8m and depth in 4.0m, length of the basin is:

$$L = \frac{V_0}{B \times H} = \frac{27.8}{2.8 \times 4} = 2.48 \rightarrow 2.8 \ [m]$$

(4) Available capacity: V

$$V = B \times L \times H = 2.8 \times 2.8 \times 4 = 31.4 \ [m^3]$$

(5) Available detention time: T

$$T = \frac{V}{Q} = \frac{31.4}{6.94} = 4.5 \ [分]$$

(6) Design

Shape	rectangular
Dimension	2.8 [mW] × 2.8 [mL] ×4.0 [mH]
No. of basin	1 tank

3. Flocculation Basin

(1) Basic conditions

Plant flow (Q)	: 10,000 m3/d = 6.94m3/min. = 0.041 m3/sec.
No. of basin	: 1tank
Detention time (t)	: more than 20 to 40 min. (based on the guideline of water supply design, Japan)

(2) Required capacity: V_o

When the detention time (t) is 30 minutes, the required capacity of the basin is obtained as follows:

$$V_0 = Q \times t = 2.43 \times 30 = 72.9 \ [m^3]$$

(3) Determination of the dimension

When width (B) of the basin is 3.5 m and depth (H) is 2.5m, length of the basin is:

$$L = \frac{V_0}{B \times H} = \frac{72.9 \times 2}{3.5 \times 2.5} = 4.17 \rightarrow 4.2 \ [m]$$

(4) Available capacity: V

$$V = B \times L \times H = 3.5 \times 4.2 \times 2.5 \times 2 = 73.5 \ [m^3]$$

(5) Confirmation of the detention time: T

$$T = \frac{V}{Q} = \frac{73.5}{2.43} = 30.2 \ [min.]$$

(6) Required head loss for G-value

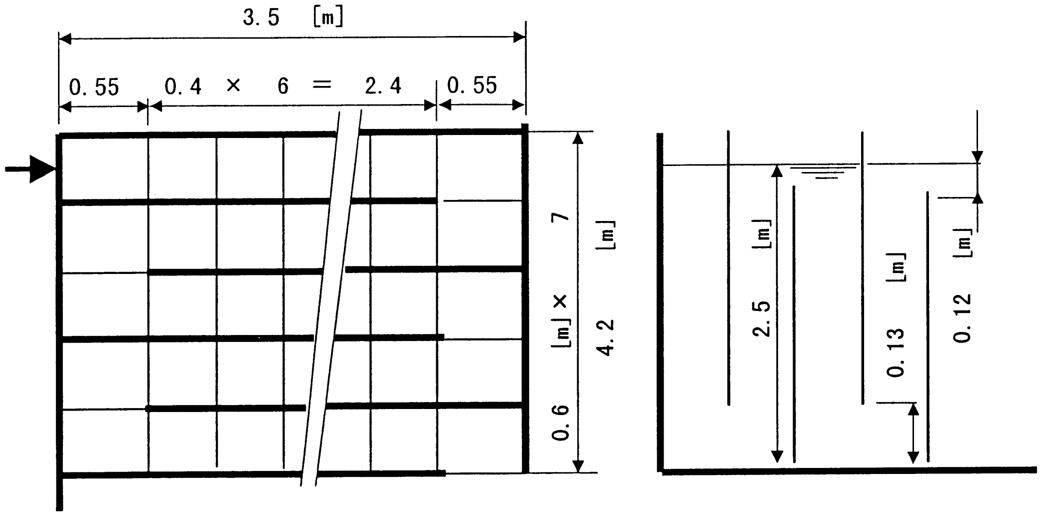
Where, required G-value for flocculation is 50 S^{-1}

(The available G-value (G) is from 10 to 75 based on Camp empirical formula.)

$$H = \frac{G^2 \cdot V \cdot \mu}{\rho \cdot Q \cdot g} = \frac{50^2 \times 73.5 \times 10^{-3}}{10^3 \times 0.041 \times 10} = 0.5 \quad m$$

μ : Viscosity coefficient 10^{-3} [kg/(m・s)]
g : acceleration gravity 9.8 [m/(sec.^{2})]

(7) Required head loss for the flocculation



① Required head loss through the bottom bend Δh_1

$$\Delta h_1 = f \frac{v_1^2}{2g} \times \text{No. of bend}$$

where:

f : head loss coefficient $f = 3 \sim 4.5$

$$v_1 : \frac{0.041}{2 \times 0.6 \times 0.13} = 0.263$$

(available velocity is [m/sec] $0.3 > v > 0.15$ [m/sec])

then:

$$= 4 \times \frac{0.26^2}{2 \times 10} \times 28 = \boxed{0.392} \text{ [m]}$$

② Required head loss through weir: Δh_2

$$\Delta h_2 = \frac{v_2^2}{2g} \times \text{No. of weir}$$

where:

$$v_2 : \frac{0.041}{2 \times 0.6 \times 0.12} = \boxed{0.285} \text{ [m]}$$

(available velocity is [m/sec] $0.3 > v > 0.15$ [m/sec])

③ Required head loss through open channel: Δh_3

$$\Delta h_3 = \frac{L}{C^2 R} v_3^{\,2}$$

where:

R : hydraulic radius

$$\frac{0.55 \times 0.6}{2 \times (0.55 + 0.6)} = 0.143 \quad [m]$$

C : coefficient given by empirical Chezy formula

$$v_3 : \frac{0.041}{2 \times 0.55 \times 0.6} = 0.062 \quad [m/sec.]$$

then:

$$= \frac{0.281^2}{2 \times 9.8} \times 28 = 0.113 \quad [m]$$

Required head loss Δh_2) is calculated as follows :

$$= \frac{2.5 \times 6 \times 7 + 2.4 \times 7}{31^2 \times 0.143} \times 0.061^2 = \boxed{0.003} \; [m]$$

Based on each head loss to be obtained above calculation, total head loss is:

$$\Sigma \Delta h = 0.392 + 0.113 + 0.003 = \boxed{0.508} \; [m] > 0.5 \; [m]$$

(8) Design

Shape	rectangular
Dimension	3.5 [mW] × 4.2 [mL] × 2.5 [mH]
No. of basin	2 [tanks]
Detention time	30.2 [min.]

4. Chemical Sedimentation

(1) Basic conditions

Plant flow	Q=	3,500	[m^3/d]	= 2.43	[m^3/min.]
No. of basin	n=	2	[tanks]		
Surface load	E=	20	[mm/min.]		

(where, the available surface load is from 15 to 30 mm/min. based on the guideline for water supply design, Japan.

Velocity in the basin v= 0.4 [m/min.]

(2) Required settling area

$$A_0 = \frac{Q}{SL \times 10^{-3}} = \frac{2.43}{20 \times 10^{-3}} = 121.5 \quad [m^2]$$

(3) Determination of the dimension

When width of the basin (B) is 3.5 m and settling area (A_0) is 121.5m^2, length of the basin (L) is:

$$L = \frac{A_0}{B \times n} = \frac{121.5}{3.5 \times 2} = 17.4 \quad [m] \rightarrow 18.9 \quad [m]$$

(4) Available capacity

When the available depth of the basin (H) is 3.5m, the available capacity is:

$$V = B \times L \times H \times n = 3.5 \times 18.9 \times 3.5 \times 2 = 463.05 \quad [m^3]$$

(5) Confirmation of the detention time : T

$$T = \frac{V}{Q} = \frac{463}{2.43} = 191 \quad [min.]$$

(6) Available settling area : A

$$A = B \times L \times n = 3.5 \times 18.9 \times 2.0 = 132.3 \quad [m^2]$$

(7) Confirmation of the surface load : E

$$E = \frac{Q}{A \times 10^{-3}} = \frac{2.43}{132.3 \times 10^{-3}} = 18.4 \quad [mm/min.]$$

(8) Confirmation of the velocity in the basin: VH

$$VH = \frac{Q}{B \times H \times n} = \frac{2.43}{3.5 \times 3.5 \times 2} = 0.099 \quad [m/min.] \leqq 0.4 \ m/min.$$

(9) Design

Shape	rectangular
Dimension	3.5 [mB] × 18.9 [mL] × 3.5 [mH]
No. of basin	2 [tanks]
Detention time	191 [min.]
Surface load	18.4 [mm／min.]

5. Rapid Sand Filter

(1) Basic conditions

Plant flow	Q= 3,500 [m^3/d] = 2.43 [m^3/min.]	
Filtration rate	LV=120～150 [m/d]	
Filter media	silica sand	layer 0.7 [m]
Washing system	surface and back wash water	
Required velocity:		
surface wash	qa= 0.2 [m^3/min./m^2]	
Back wash	qb= 0.6 [m^3/min./m^2]	
Required period		
surface wash	Ta= 6 [min.]	
Back wash	Tb= 6 [min.]	
drain	Td= 20 [min.]	

(2) Required area of filter bed

When filtration rate is 120 m/d, required filter area is:

$$A_0 = \frac{Q}{LV} = \frac{3,500}{120} = 29.2 \quad [m^2]$$

(3) Determination of the dimension of filter bed

Shape	rectangular	
No. of bed	n = 8 [beds]	(including 1set of stand-by bed)
	n' = 8 [beds]	
Dimension	width (B) : 1.6 [m] × length L : 2.4 [m]	

(4) Available filter area :A

$A = B \times L = 1.6 \times 2.4 = 3.84 \quad [m^2/bed]$

(5) Confirmation of the filtration rate: LV

$$LV = \frac{Q}{A \times n'} = \frac{3,500}{3.84 \times 8} = 114 \quad [m/d]$$

(6) Required surface wash water flow: Qs

$\Sigma Qs = A \times qa \times Ta = 3.84 \times 0.2 \times 6 = \boxed{4.6} \quad [m^3]$

where: Qa: unit washing water flow : 0.2 $m^3/min.\cdot m^2$

Ta: period of washing (min.)

(7) Total back wash-water flow (Qb)

$\Sigma Qb = A \times qb \times Tb = 3.84 \times 0.6 \times 6 = \boxed{13.8} \quad [m^3]$

where: Qa: unit washing water flow : 0.6 $m^3/min.\cdot m^2$

Ta: period of washing (min)

(8) Total drainage water before washing: Qd

$Qd = A \times LV \times T_1 = 3.84 \times 114 \times 20 / 24 / 60 = \boxed{6.1} \quad [m^3]$

(9) Remaining water after washing : Qr

$Qr = B' \times L \times H = 2.4 \times 2.4 \times 3 = \boxed{17.3} \quad [m^3]$

(10) Total discharge water flow through washing:

$\Sigma Q = Qs + Qb + Qd + Qr = 4.6 + 13.8 + 6.1 + 17.3 = \boxed{41.8} \quad [m^3]$

(11) Design

Shape	rectangular
Dimension	1.6 [m] × 2.4 [m]
No. of bed	8 [bed] (including 1 bed of stand-by)
Filter area	3.84 [m²/bed]
Filtrate	114 [m/d]
Discharge water for washing	41.8 [m³/池]

7. Sludge Lagoon

(1) Basic conditions

Plant flow	Q 1 = 1,700	$[m^3/d]$	= 1	$[m^3/min.]$
	Q 2 = 4,800	$[m^3/d]$	= 3	$[m^3/min.]$
	Q 3 = 3,500	$[m^3/d]$	= 2	$[m^3/min.]$
	合計 10,000	$[m^3/d]$		
No. of filter bed for washing	n = 2	[tank]		
Average turbidity	Tu = 5	[mg/L]		
Alum dosing rate	α = 20	[mg/L]		
concentration of the sludge	Cs = 3	[kg/m3]		
Settling rate	E = 10	[mm/min.]		

(2) Dry sludge volume

W1= 1,700 × (5 ×1.0 + 0 × 20) × 1 ／1000 = 16.5 [kg・DS/d]
W2= 4,800 × (5 ×1.0 + 0 × 20) × 1 ／1000 = 46.5 [kg・DS/d]
W3= 3,500 × (5 ×1.0 + 0 × 20) × 1 ／1000 = 33.9 [kg・DS/d]

(3) Waste water flow

V1= 16.5 ÷ 3 = 7 $[m^3/d]$
V2= 46.5 ÷ 3 = 18.6 $[m^3/d]$
V3= 33.9 ÷ 3 = 13.6 $[m^3/d]$

(4) Required area of solid-liquid separator :A

where, it is treated 4times every day of waste water with max.18.6m3/d. A treated period every time takes 15min.

$$A = \frac{18.6}{4 \times 15 \times 10 \times 10-3} = 31 \quad [m^2]$$

(5) Determination of the dimension

where, width of the basin is 3m, required length (L) is:

$$L = \frac{31}{3} = 11 \quad [m]$$

(6) Surface area of the lagoon : A

$$A = 3 \times 11 = 31.9 \quad [m^2]$$

(7) Design

Shape	:rectangular
Dimension	:3 [mB] × 11 [mL]
No. of basin	:2 [tanks]
Surface area of the basin	:31.9 $[m^2]$

III. Calculation of Chemical Dosing Equipment

III Calculation of Chemical Dosing Equipment

1. Basic design conditions

(1) Plant flow:

Line No. 1 treatment plant (existing)	1,700 m^3/d
Line No.2 treatment plant (existing)	4,800 m^3/d
Line No.3 treatment plant (expansion)	3,500 m^3/d
Total plant flow	10,000 m^3/d (6.94 $m^3/min.$)

(2) Water quality

Turbidity as kaolin test:

Max.	Average	Min.
10 mg/l	5mg/l	3mg/l

(3) Chemical

Dosing purpose	Chemical
Coagulation	Solid Alum
pH control	Soda ash
Disinfecting	Hipo-chlorine calcium (65% cl_2)

(4) Dosing rate

The dosing rate has been determined by site experiments as follows:

Unit in mg/l

Chemical	Max.	Average	Min.
Alum	30	20	10
Soda ash	8	5.5	3
Hipo-chlorine	2	1	-

2. Calculation of dosing capacity

(1) Alum

The dosing capacity in kg/d (q_1) is:

$q_1 = Q \times \alpha \times 10^{-3}$

where:

Q: plant flow (m^3/d)

α: dosing rate (mg/l)

then:

Max.	Average	Min.
12.5	8.33	4.16

The dosing capacity in volumetric unit (q_2)is calculated as follows:

$q_2 = Q \times \alpha \times 100/C \times 1/r \times 10^{-3}$

where:

C: solution concentration (10%)

r: specific gravity (1.05 at 10% solution)

therefore:

	Max.	Average	Min.
Unit in l/d	2,857	1,905	952
Unit in l/hr.	119	79.4	39.6

(2) Soda ash

The dosing capacity in kg/d (q_1) is :

$q_1 = Q \times \alpha \times 10^{-3}$

where:

Q: plant flow (m^3/d)

α: dosing rate (mg/l)

then:

Max.	Average	Min.
80	55	30

The dosing capacity in volumetric unit (q_2)is calculated as follows:

$q_2 = Q \times \alpha \times 100/C \times 1/r \times 10^{-3}$

where:

C: solution concentration (5 %)

r: specific gravity (1.05 at 5% solution)

therefore:

	Max.	Average	Min.
Unit in l/d	1,524	1,048	571
Unit in l/hr.	63.5	47.67	23.8

(3) Hipo-chlorine

The dosing capacity in kg/d (q_1) is :

$q_1 = Q \times \alpha \times 10^{-3}$

where:

Q: plant flow (m3/d)

α: dosing rate (mg/l)

then:

Max.	Average	Min.
30.8	15.4	–

The dosing capacity in volumetric unit (q_2)is calculated as follows:

$q_2 = Q \times \alpha \times 100/C \times 1/r \times 10^{-3}$

where:

C: solution concentration (3%)

r: specific gravity (1at 3% solution)

therefore:

	Max.	Average	Min.
Unit in l/d	667	333	–
Unit in l/hr.	27.8	13.9	–

3. Equipment capacity

(1) Alum

① Solution tank capacity

The capacity is calculated using the average dosing capacity and detention for 1 day. The capacity is to be 1,905 liter. The tank made from polyethylene will prepare 2 tanks and each capacity has 2,000 liter. The tank is required the baskets for solid Alum with dimension in 450mm diameter and 500mm depth.

② Dosing pump

The dosing pumps will operate by means of 3 stages-step control with plant flow. The capacity of a pump (q_3: l/min.) will be determined as bellow:

q_3 = 119 l/hr. x 3,500/10,000 x 1/60 = 0.694 l/min.

Quantities of the pump are 4 sets including 1set of stand bay.

③ Storage space

Storage period: 1month

Where:

200 kg/d x 30 days = 6,000 kg

6,000 kg/25 kg/1bag = 240 bags

dimension of a bag: 0.45 x 0.65 x 0.12 (thickness)

loading limit: max. 10 bags

therefore:

(240/10) x 0.45 x 0.65 = 7 (m^2)

(2) Soda ash

① Solution tank capacity

The capacity is calculated using the average dosing capacity and detention for 1 day. The capacity is to be 1,048 liter. The tank made from polyethylene will prepare 2 tanks and each capacity has 2,000 liter. The concentrate of the Soda ash is adjusted the solution with 3 % in the tanks.

② Dosing pump

The dosing pumps will operate by means of 3 stages-step control with plant flow. The capacity of a pump (q_3: l/min.) will be determined as bellow:

q_3 = 63.5 l/hr. x 3,500/10,000 x 1/60 =0.37 l/min.

Quantities of the pump are 4 sets including 1set of stand bay.

③ Storage space

Storage period: 1month

Where:

55 kg/d x 30 days = 1,650 kg

1,650 kg/25 kg/1bag = 66 bags

Dimension of a bag: 0.45 x 0.65 x 0.12 (thickness)

Loading height: 10 bags

therefore:

(66/10) x 0.45 x 0.65 = 2.34 (m2)

(3) Hipo-chlorine

① Solution tank capacity

The capacity is calculated using the average dosing capacity and detention for 1 day. The capacity is to be 667 liter. The tank made from polyethylene will prepare 2 tanks and each capacity has 1,000 liter. The concentrate of the Hypo-chlorine is adjusted solution with 3% in the tanks.

② Dosing pump

The dosing pumps will operate by means of 3 stages-step control with plant flow. The capacity of a pump (q_3: l/min.) will be determined as bellow:

q_3 = 27.8 l/hr. x 3,500/10,000 x 1/60 =0.162 l/min.

Quantities of the pump are 4 sets including 1set of stand bay.

③ Storage space

Storage period: 1month

Where:

15.4 kg/d x 30 days = 462 kg

462 kg/25 kg/1can = 19 cans

dimension of a can: 0.6mΦ x 0.7 m(high)

Loading height: 3 cans

therefore:

$(19/3) \times 0.3^2 \times 3.14 = 1.96\ (m^2)$

4. Equipment Specifications (Preliminary Design)

(1) Alum

① Dissolution tank

Type	: cylindrical tank
Capacity	: 2 m^3
Dimension	:Φ1,400mm x 1,545mH
Materials	: polyethylene
No. of set	: 2 set including 1set of stand-by
Accessory	: stirrer with approx. 0.75 kW motor

② Dosing pump

Type	: diaphragm chemical pump
Capacity	: 0.694 l/min.
Motor output	: AC240V, 3fhase, 50Hz, approx. 0.2kW
No. of set	: 4 sets including 1set of stand-by

(2) Soda ash

① Dissolution tank

Type	: cylindrical tank
Capacity	: 2 m^3
Dimension	:Φ1,400mm x 1,545mH
Materials	: polyethylene
No. of set	: 2 set including 1set of stand-by
Accessory	: stirrer with approx. 0.75 kW motor

② Dosing pump

Type : diaphragm chemical pump
Capacity : 0.37 l/min.
Motor output : AC240V, 3fhase, 50Hz, approx. 0.2kW
No. of set : 4 sets including 1set of stand-by

(3) Soda ash

① Dissolution tank

Type : cylindrical tank
Capacity : 1 m^3
Dimension : Φ 1,060mm x 1,250 mH
Materials : polyethylene
No. of set : 2 set including 1set of stand-by
Accessory : stirrer with approx. 0.4 kW motor

② Dosing pump

Type : diaphragm chemical pump
Capacity : 0.162 l/min.
Motor output : AC240V, 3fhase, 50Hz, approx. 0.2kW
No. of set : 4 sets including 1set of stand-by

5. Production Makers

The design specification is based on the equipment of following production makers
Suidou Kiko Kaisha, Ltd
Ebara corporation
Hitach Plant Engineering & Construction Co., Ltd

Appendix 12 *Hydraulic Analysis of Distribution Networks*

Hydraulic Analysis of Distribution Networks

For the peak hours' supply at the daily maximum demand for the year 2003, the hydraulic analysis of the distribution networks was carried out. The conditions for the analysis were the following:

- Hydraulic formula : Hazen Williams Formula
- Coefficient of velocity : C=110
- Minimum dynamic water pressure : 10m
- Maximum dynamic water pressure : 50m
- Maximum static water pressure : 70m

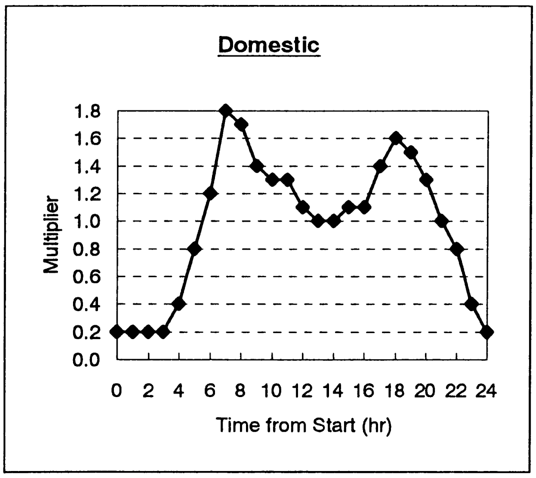
As a result of the hydraulic analysis, the pipeline network which assures appropriate water supply was established. For the sake of keeping the dynamic water pressure below 50m, pressure control valves (pressure reducing valves) were proposed at the strategic points.

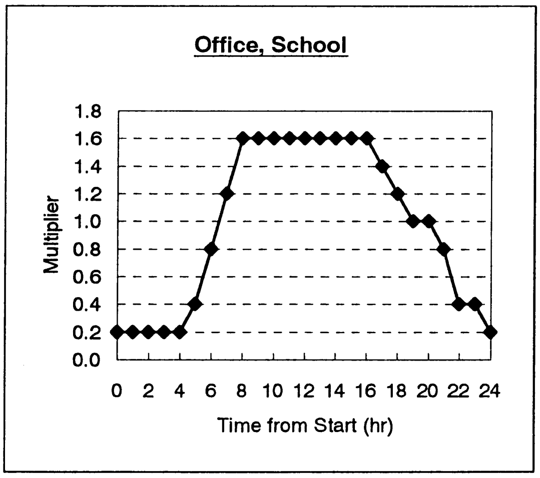
The hydraulic analysis results are given in the following pages.

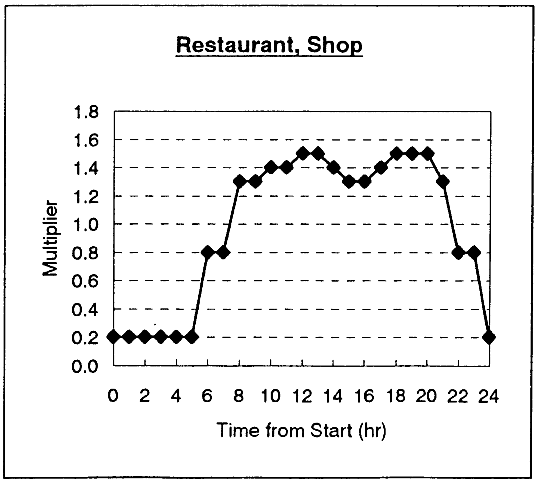
- Water demand patterns (4 types)
- Lorengau Skelton of the networks (Nos. of pipelines and junctions for the year 2003)
- Lorengau Junction data for the peak hour supply
- Lorengau Pipeline data for the peak hour supply
- Goroka Skelton of the networks (Nos. of pipelines and junctions for the year 2003)
- Goroka Junction data for the peak hour supply
- Goroka Pipeline data for the peak hour supply

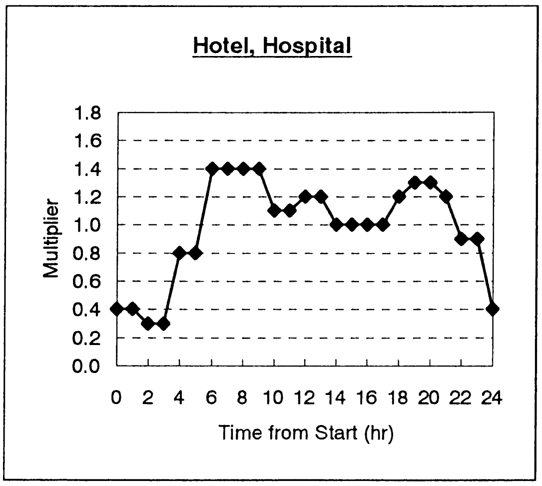
Demand Patterns

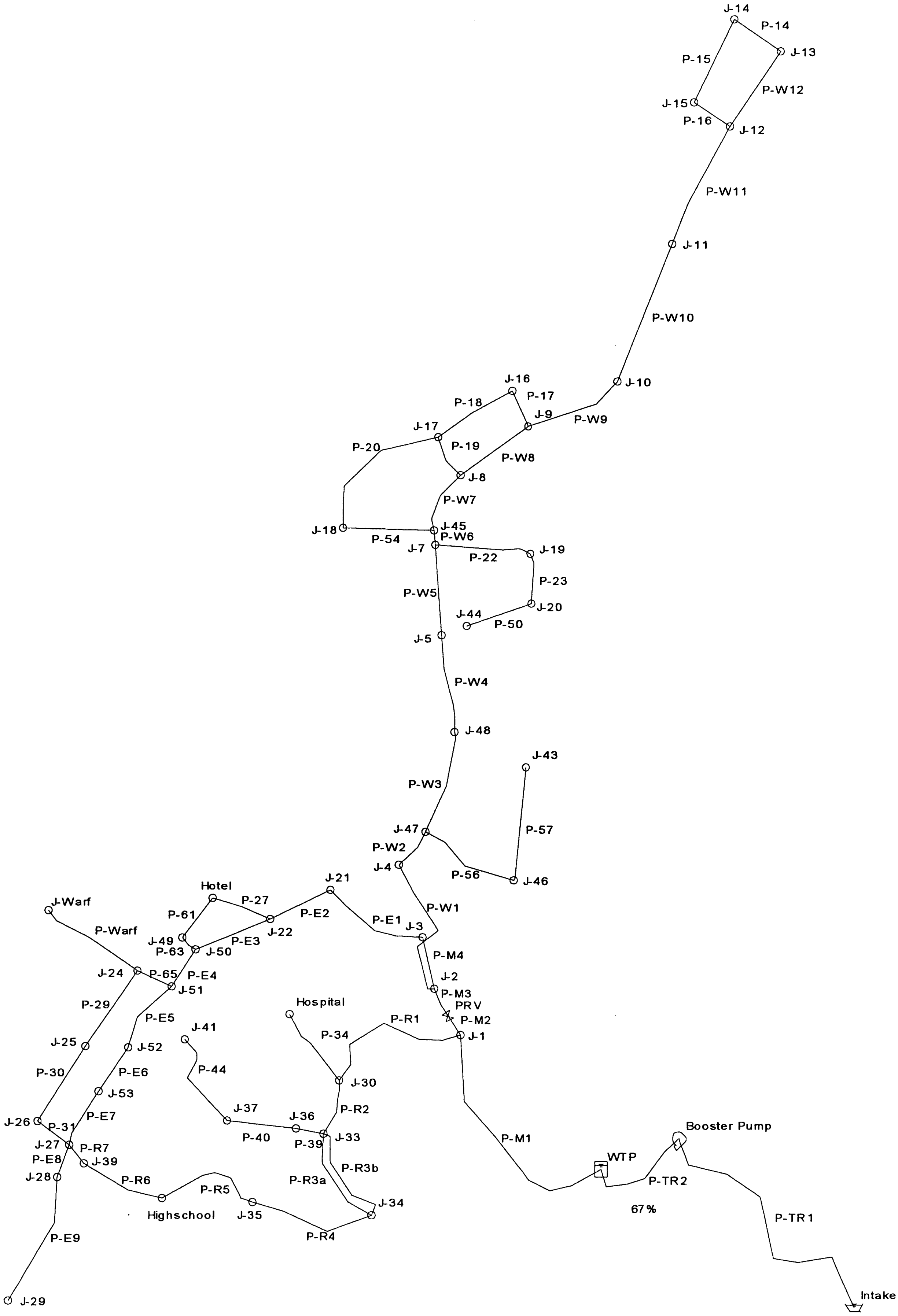
Time from start (hr)	Multiplier			
	Domestic	Office, School	Restaurant, Shop	Hotel, Hospital
0	0.2	0.2	0.2	0.4
1	0.2	0.2	0.2	0.4
2	0.2	0.2	0.2	0.3
3	0.2	0.2	0.2	0.3
4	0.4	0.2	0.2	0.8
5	0.8	0.4	0.2	0.8
6	1.2	0.8	0.8	1.4
7	1.8	1.2	0.8	1.4
8	1.7	1.6	1.3	1.4
9	1.4	1.6	1.3	1.4
10	1.3	1.6	1.4	1.1
11	1.3	1.6	1.4	1.1
12	1.1	1.6	1.5	1.2
13	1.0	1.6	1.5	1.2
14	1.0	1.6	1.4	1.0
15	1.1	1.6	1.3	1.0
16	1.1	1.6	1.3	1.0
17	1.4	1.4	1.4	1.0
18	1.6	1.2	1.5	1.2
19	1.5	1.0	1.5	1.3
20	1.3	1.0	1.5	1.3
21	1.0	0.8	1.3	1.2
22	0.8	0.4	0.8	0.9
23	0.4	0.4	0.8	0.9
24	0.2	0.2	0.2	0.4










J-14
P-14
J-13
P-15
P-W12
J-15
P-16
J-12
P-W11
J-11
P-W10
J-10
J-16
P-17
P-18
J-9
P-W9
J-17
P-20
P-19
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P-W7
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P-23
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J-20
P-50
J-5
P-W4
J-48
J-43
P-W3
P-57
J-47
P-W2
J-4
P-56
J-46
Hotel
J-21
J-Warf
P-27
P-61
P-E2
P-W1
P-Warf
J-22
P-E1
J-49
J-3
P-63
J-50
P-E3
P-M4
J-24
P-65
P-E4
J-2
J-51
P-M3
P-29
Hospital
PRV
P-E5
P-R1
P-M2
J-41
J-1
J-25
J-52
P-34
P-44
P-30
P-E6
J-30
J-53
J-37
P-R2
J-26
P-E7
J-36
Booster Pump
P-31
J-33
J-27
P-R7
P-40
P-39
P-M1
P-E8
J-39
P-R3b
WTP
J-28
P-R6
P-R3a
P-TR2
P-R5
J-34
67%
Highschool
J-35
P-TR1
P-R4
P-E9
Intake
J-29

Networks Calculation at Peak Hour (LORENGAU, Year 2003)

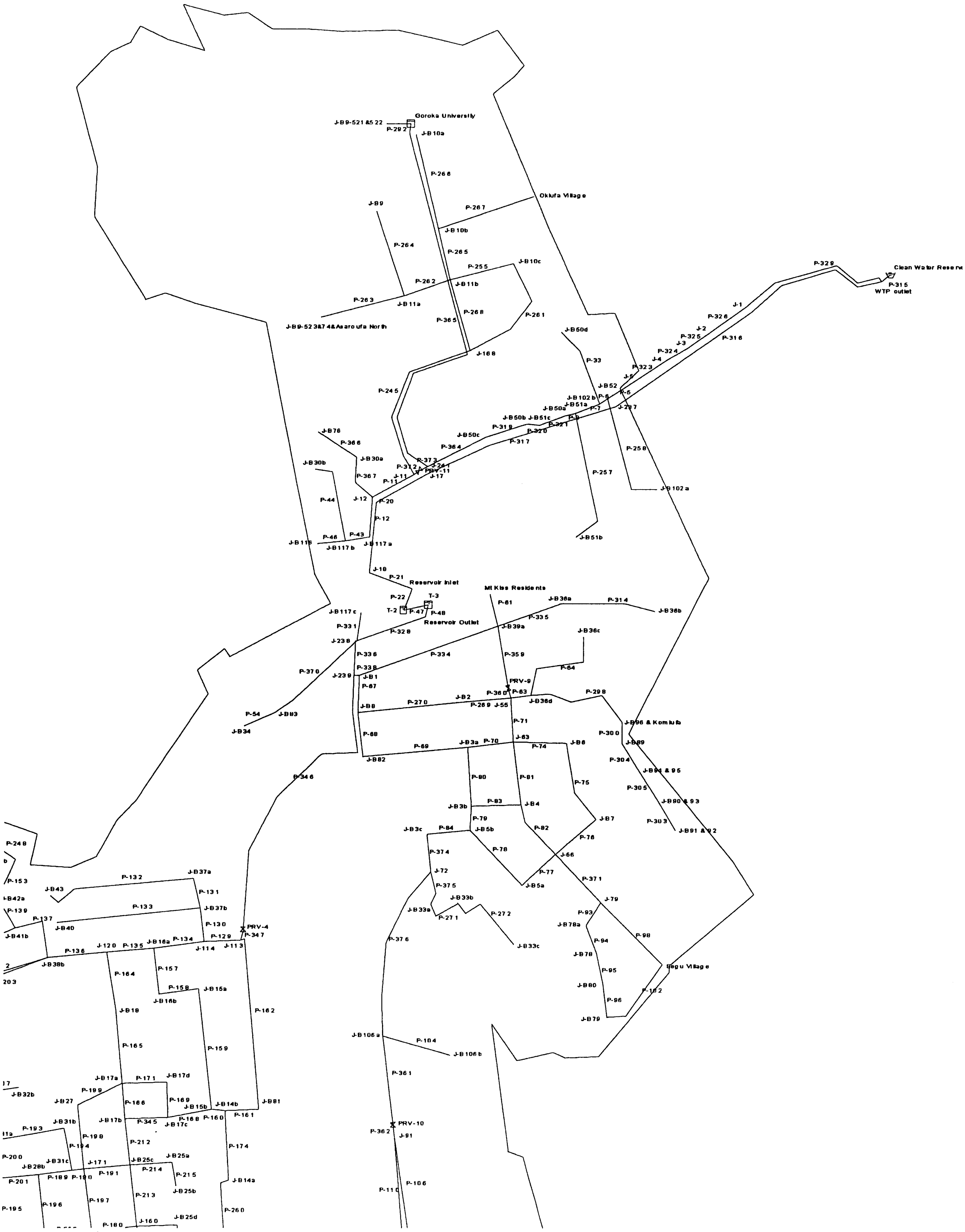
Junction Report

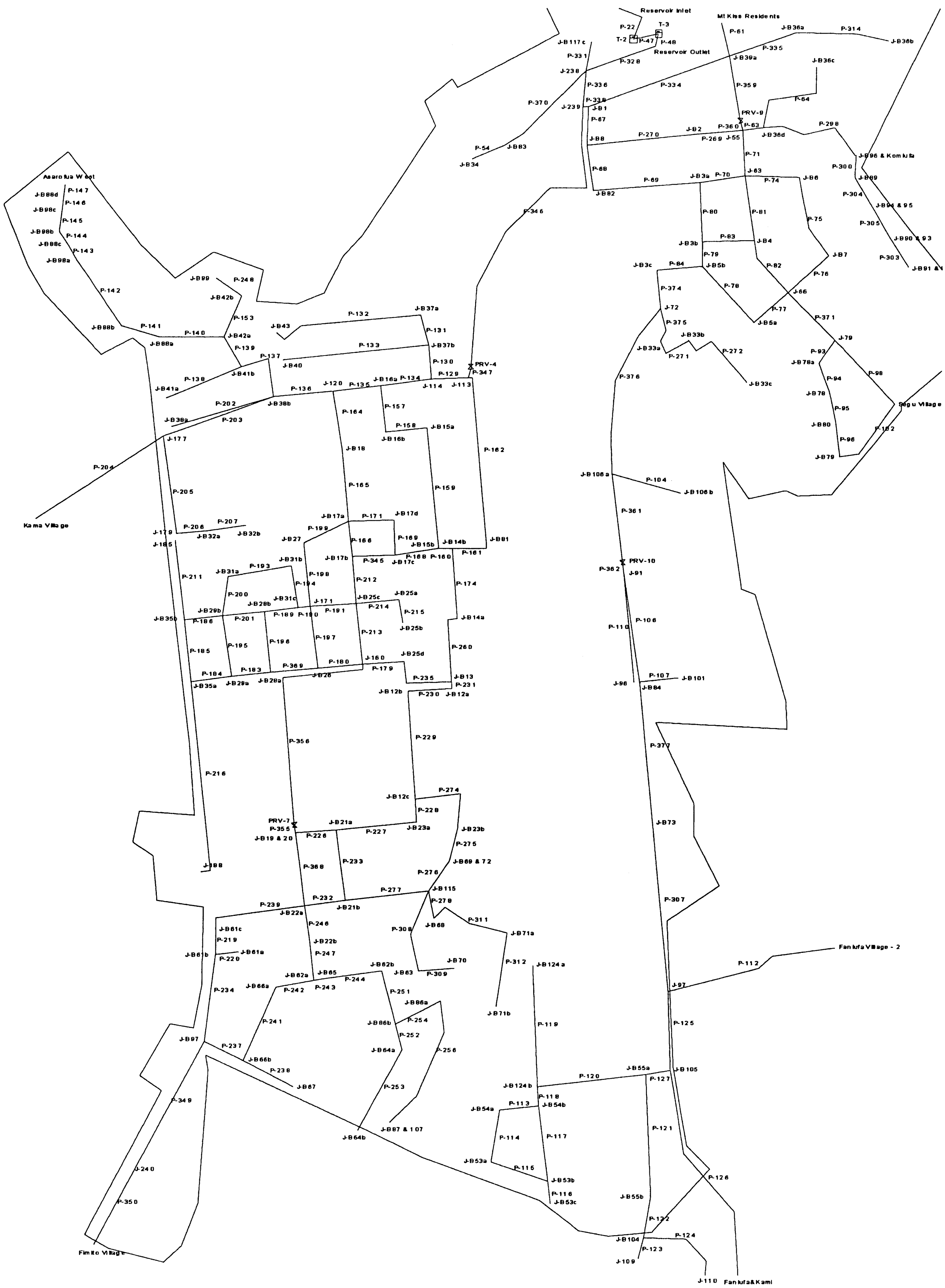
Node	Hydraulic Grade (+m)	Elevation (+m)	Pressure Head (m)	Base Demand (l/s)	Peak Hour Demand (l/s)	Zone
J-1	65.51	55.00	10.51	0.20	0.28	Ward-5
J-2	49.74	16.00	33.74	0.30	0.46	Ward-5
J-4	49.03	3.00	46.03	0.32	0.50	Ward-4
J-5	46.29	6.00	40.29	0.46	0.69	Ward-3
J-7	45.29	5.00	40.29	0.47	0.66	Ward-3
J-8	43.08	3.00	40.08	0.49	0.74	Ward-2
J-9	42.40	3.00	39.40	0.45	0.66	Ward-2
J-10	41.16	3.00	38.16	0.41	0.60	Ward-1
J-11	39.88	3.00	36.88	0.41	0.60	Ward-1
J-12	39.13	3.00	36.13	0.42	0.61	Ward-1
J-13	39.07	3.00	36.07	0.42	0.61	Ward-1
J-14	39.06	3.00	36.06	0.41	0.60	Ward-1
J-15	39.08	3.00	36.08	0.42	0.61	Ward-1
J-16	42.47	3.00	39.47	0.41	0.63	Ward-2
J-17	42.82	3.00	39.82	0.43	0.66	Ward-2
J-18	43.59	3.00	40.59	0.43	0.66	Ward-2
J-19	45.00	11.00	34.00	0.36	0.57	Ward-3
J-20	44.93	22.00	22.93	0.36	0.57	Ward-3
J-21	46.50	3.00	43.50	0.32	0.50	Ward-5
J-22	45.42	3.00	42.42	0.62	0.78	Ward-5
Hotel	45.13	3.00	42.13	0.44	0.55	Ward-5
J-24	44.80	3.00	41.80	0.43	0.65	Ward-6
J-25	44.79	3.00	41.79	0.34	0.54	Ward-6
J-26	44.83	3.00	41.83	0.53	0.74	Ward-7
J-27	44.96	3.00	41.96	0.30	0.46	Ward-7
J-28	44.83	3.00	41.83	0.43	0.59	Ward-7
J-29	44.56	3.00	41.56	0.82	1.36	Ward-7
J-30	65.13	40.00	25.13	0.32	0.50	Ward-5
Hospital	64.77	23.00	41.77	0.73	0.97	Ward-5
J-33	64.72	45.00	19.72	0.18	0.26	Ward-7
J-34	63.87	55.00	8.87	0.23	0.35	Ward-7
J-35	59.96	43.00	16.96	0.18	0.26	Ward-7
J-36	64.60	40.00	24.60	0.18	0.26	Ward-7
J-37	64.27	20.00	44.27	0.35	0.57	Ward-6
Highschool	50.82	20.00	30.82	0.68	0.89	Ward-7
J-39	46.23	10.00	36.23	0.17	0.25	Ward-7
J-41	64.17	20.00	44.17	0.28	0.44	Ward-6
J-Warf	44.80	3.00	41.80	0.05	0.05	Ward-6
J-43	45.21	18.00	27.21	0.27	0.45	Ward-4
J-44	44.91	20.00	24.91	0.36	0.57	Ward-3
J-45	44.60	3.00	41.60	0.42	0.64	Ward-2
J-46	46.08	15.00	31.08	0.27	0.45	Ward-4
J-47	48.97	3.00	45.97	0.32	0.50	Ward-4
J-48	47.53	3.00	44.53	0.35	0.53	Ward-4
J-49	45.06	3.00	42.06	0.25	0.32	Ward-5
J-50	45.06	4.50	40.56	0.48	0.63	Ward-5
J-51	44.89	5.00	39.89	0.48	0.69	Ward-6
J-52	44.88	5.00	39.88	0.45	0.67	Ward-6
J-53	44.89	5.00	39.89	0.50	0.70	Ward-7
J-3	48.66	15.00	33.66	0.32	0.50	Ward-5

Networks Calculation at Peak Hour (LORENGAU, Year 2003)

Pipe Report

Pipe	Start	End	Length (m)	Dia. (mm)	Material	C	Q (l/s)	V (m/s)	I (m/km)	Headloss (m)	Start Hydraulic Grade (m)	End Hydraulic Grade (m)
P-M1	WTP	J-1	703	200	PVC	110	28.30	0.90	6.14	4.31	69.82	65.51
P-R1	J-1	J-30	485	200	PVC	110	9.29	0.30	0.78	0.38	65.51	65.13
P-M2	J-1	PRV	50	200	PVC	110	18.73	0.60	2.86	0.14	65.51	65.36
P-M4	J-2	J-3	139	100	PVC	110	5.18	0.66	7.75	1.08	49.74	48.66
P-W2	J-4	J-47	44	200	PVC	110	12.59	0.40	1.37	0.06	49.03	48.97
P-W1	J-4	J-2	480	200	PVC	110	-13.09	0.42	1.47	0.71	49.03	49.74
P-22	J-7	J-19	290	100	PVC	110	1.70	0.22	0.99	0.29	45.29	45.00
P-W6	J-7	J-45	44	100	PVC	110	7.60	0.97	15.77	0.69	45.29	44.60
P-W5	J-7	J-5	276	150	PVC	110	-9.97	0.56	3.62	1.00	45.29	46.29
P-W8	J-8	J-9	251	100	PVC	110	2.94	0.37	2.72	0.68	43.08	42.40
P-W9	J-9	J-10	310	100	PVC	110	3.62	0.46	4.00	1.24	42.40	41.16
P-17	J-9	J-16	118	100	PVC	110	-1.34	0.17	0.64	0.07	42.40	42.47
P-W10	J-10	J-11	447	100	PVC	110	3.02	0.38	2.86	1.28	41.16	39.88
P-W11	J-11	J-12	392	100	PVC	110	2.42	0.31	1.90	0.75	39.88	39.13
P-W12	J-12	J-13	272	100	PVC	110	0.80	0.10	0.24	0.07	39.13	39.07
P-14	J-13	J-14	171	100	PVC	110	0.19	0.02	0.02	0.00	39.07	39.06
P-15	J-14	J-15	275	100	PVC	110	-0.41	0.05	0.07	0.02	39.06	39.08
P-16	J-15	J-12	130	100	PVC	110	-1.02	0.13	0.38	0.05	39.08	39.13
P-18	J-16	J-17	263	100	PVC	110	-1.97	0.25	1.30	0.34	42.47	42.82
P-19	J-17	J-8	136	80	PVC	110	-1.37	0.27	1.96	0.27	42.82	43.08
P-20	J-17	J-18	457	80	PVC	110	-1.26	0.25	1.68	0.77	42.82	43.59
P-54	J-18	J-45	277	80	PVC	110	-1.92	0.38	3.66	1.01	43.59	44.60
P-23	J-19	J-20	155	100	PVC	110	1.14	0.14	0.47	0.07	45.00	44.93
P-50	J-20	J-44	206	100	PVC	110	0.57	0.07	0.13	0.03	44.93	44.91
P-E2	J-21	J-22	208	100	PVC	110	4.18	0.53	5.23	1.09	46.50	45.42
P-E1	J-21	J-3	335	100	PVC	110	-4.68	0.60	6.43	2.15	46.50	48.66
P-27	J-22	Hotel	188	80	PVC	110	1.19	0.24	1.51	0.28	45.42	45.13
P-61	Hotel	J-49	146	80	PVC	110	0.64	0.13	0.48	0.07	45.13	45.06
P-29	J-24	J-25	265	80	PVC	110	0.19	0.04	0.05	0.01	44.80	44.79
P-Warf	J-24	J-Warf	331	80	PVC	110	0.05	0.01	0.00	0.00	44.80	44.80
P-30	J-25	J-26	250	80	PVC	110	-0.35	0.07	0.16	0.04	44.79	44.83
P-31	J-26	J-27	103	80	PVC	110	-1.09	0.22	1.28	0.13	44.83	44.96
P-E8	J-27	J-28	104	100	PVC	110	1.95	0.25	1.28	0.13	44.96	44.83
P-R7	J-27	J-39	70	80	PVC	110	-4.55	0.91	18.09	1.27	44.96	46.23
P-E9	J-28	J-29	402	100	PVC	110	1.36	0.17	0.66	0.26	44.83	44.56
P-34	J-30	Hospital	346	80	PVC	110	0.97	0.19	1.04	0.36	65.13	64.77
P-R2	J-30	J-33	178	150	PVC	110	7.83	0.44	2.31	0.41	65.13	64.72
P-R3a	J-33	J-34	274	100	PVC	110	3.15	0.40	3.09	0.85	64.72	63.87
P-39	J-33	J-36	68	80	PVC	110	1.27	0.25	1.70	0.12	64.72	64.60
P-R3b	J-33	J-34	274	100	PVC	110	3.15	0.40	3.09	0.85	64.72	63.87
P-R4	J-34	J-35	390	100	PVC	110	5.95	0.76	10.02	3.91	63.87	59.96
P-R5	J-35	School	334	80	PVC	110	5.69	1.13	27.36	9.14	59.96	50.82
P-44	J-37	J-41	400	80	PVC	110	0.44	0.09	0.24	0.10	64.27	64.17
P-40	J-37	J-36	300	80	PVC	110	-1.01	0.20	1.11	0.33	64.27	64.60
P-R6	School	J-39	230	80	PVC	110	4.80	0.95	19.97	4.59	50.82	46.23
P-TR2	Pump	WTP	350	200	PVC	110	26.76	0.85	5.54	1.94	71.76	69.82
P-TR1	Intake	Pump	950	200	PVC	110	26.76	0.85	5.54	5.26	35.00	29.74
P-57	J-43	J-46	345	50	PVC	110	-0.45	0.23	2.51	0.87	45.21	46.08
P-W7	J-45	J-8	205	100	PVC	110	5.05	0.64	7.39	1.52	44.60	43.08
P-W3	J-47	J-48	322	150	PVC	110	11.19	0.63	4.48	1.44	48.97	47.53
P-56	J-47	J-46	319	50	PVC	110	0.91	0.46	9.05	2.89	48.97	46.08
P-W4	J-48	J-5	302	150	PVC	110	10.66	0.60	4.09	1.24	47.53	46.29
P-63	J-49	J-50	58	80	PVC	110	0.32	0.06	0.13	0.01	45.06	45.06
P-65	J-50	J-51	139	100	PVC	110	1.91	0.24	1.22	0.17	45.06	44.89
P-E3	J-50	J-22	224	100	PVC	110	-2.22	0.28	1.62	0.36	45.06	45.42
P-E4	J-51	J-24	95	80	PVC	110	0.89	0.18	0.88	0.08	44.89	44.80
P-E5	J-51	J-52	210	100	PVC	110	0.32	0.04	0.05	0.01	44.89	44.88
P-E6	J-52	J-53	160	100	PVC	110	-0.35	0.04	0.05	0.01	44.88	44.89
P-E7	J-53	J-27	186	100	PVC	110	-1.05	0.13	0.40	0.07	44.89	44.96
P-M3	PRV	J-2	100	200	PVC	110	18.73	0.60	2.86	0.29	50.02	49.74


Goroka University
Okiufa Village
Clean Water Reserve
WTP outlet
Reservoir Inlet
Reservoir Outlet
Mt Kiss Residents
Segu Village
PRV-4
PRV-9
PRV-10
PRV-11



Reservoir Inlet
Mt Kiss Residents
Reservoir Outlet
T-2
T-3
P-22
P-47
P-48
PRV-9
PRV-4
PRV-10
PRV-7
Kama Village
Sogu Village
Fanlufa Village - 2
Fimito Village
Fanlufa&Kami

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Junction Report

Node	Hydraulic Grade (+m)	Elevation (+m)	Pressure Head (m)	Base Demand (l/s)	Peak Hour Demand (l/s)	Zone
J-1	1,676.11	1,649.00	27.11	0.15	0.27	North
J-2	1,675.11	1,645.00	30.11	0.15	0.27	North
J-3	1,674.51	1,640.00	34.51	0.15	0.27	North
J-4	1,674.04	1,637.00	37.04	0.15	0.27	North
J-5	1,673.25	1,655.00	18.25	0.15	0.27	North
J-B102b	1,672.61	1,636.00	36.61	0.14	0.23	North
J-B52	1,672.42	1,634.00	38.42	0.28	0.45	North
J-B51a	1,671.97	1,647.00	24.97	0.17	0.27	North
J-B50a	1,671.80	1,645.00	26.80	0.35	0.56	North
J-B51c	1,671.36	1,642.00	29.36	0.19	0.30	North
J-12	1,654.26	1,615.00	39.26	0.00	0.00	North
J-B117a	1,654.14	1,615.00	39.14	0.28	0.38	North
J-11	1,654.68	1,631.00	23.68	0.00	0.00	North
Reservoir Inlet	1,663.55	1,650.00	13.55	0.00	0.00	West
J-B50b	1,671.19	1,641.00	30.19	0.35	0.56	North
J-B50c	1,668.53	1,639.00	29.53	0.39	0.62	North
J-17	1,667.61	1,631.00	36.61	0.00	0.00	North
J-18	1,664.63	1,615.00	49.63	0.00	0.00	North
J-B102a	1,671.59	1,650.00	21.59	1.18	1.82	North
J-B50d	1,672.30	1,615.00	57.30	0.46	0.69	North
J-B51b	1,671.93	1,650.00	21.93	0.19	0.30	North
J-B76	1,654.14	1,610.00	44.14	0.56	0.86	North
J-B117b	1,654.08	1,605.00	49.08	0.33	0.47	North
J-B30b	1,654.05	1,605.00	49.05	0.37	0.59	North
J-B116	1,654.08	1,605.00	49.08	0.35	0.49	North
Reservoir Outlet	1,661.58	1,650.00	11.58	0.00	0.00	East
J-B83	1,656.90	1,615.00	41.90	0.55	0.70	East
J-B34	1,656.88	1,616.00	40.88	0.13	0.11	East
J-B1	1,657.49	1,624.00	33.49	0.29	0.46	East
J-B36b	1,653.80	1,640.00	13.80	0.65	0.97	East
J-B39a	1,654.03	1,625.00	29.03	0.80	1.28	East
Mt Kiss Residents	1,654.03	1,645.00	9.03	0.18	0.29	East
J-55	1,644.25	1,609.00	35.25	0.00	0.00	East
J-B36d	1,643.02	1,605.00	38.02	0.02	0.04	East
J-B36c	1,642.80	1,620.00	22.80	0.55	0.87	East
J-B91 & 92	1,635.94	1,580.00	55.94	0.54	0.86	East
J-B8	1,656.91	1,620.00	36.91	0.48	0.59	East
J-B82	1,656.85	1,614.40	42.45	0.24	0.35	East
J-B3a	1,656.82	1,609.00	47.82	0.30	0.30	East
J-63	1,642.39	1,605.00	37.39	0.00	0.00	East
J-B6	1,641.24	1,605.00	36.24	0.89	1.29	East
J-B7	1,640.61	1,600.00	40.61	1.08	1.72	East
J-66	1,638.56	1,600.00	38.56	0.00	0.00	East
J-B5a	1,638.54	1,600.00	38.54	0.37	0.36	East
J-B5b	1,632.43	1,602.00	30.43	0.37	0.36	East
J-B3b	1,634.88	1,604.10	30.78	0.30	0.30	East
J-B4	1,640.35	1,604.00	36.35	0.28	0.25	East
J-B3c	1,628.12	1,605.00	23.12	0.17	0.15	East
J-72	1,624.45	1,602.00	22.45	0.00	0.00	East
J-B33a	1,624.30	1,585.00	39.30	0.14	0.20	East
J-B33c	1,624.07	1,575.00	49.07	0.65	1.05	East
J-79	1,637.48	1,593.00	44.48	0.00	0.00	East
J-B78a	1,637.05	1,594.00	43.05	0.40	0.64	East
J-B78	1,636.77	1,592.00	44.77	0.44	0.71	East
J-B80	1,636.65	1,590.00	46.65	0.76	1.19	East

Networks Calculation at Peak Hour (GOROKA, Year 2003)
Junction Report

Node	Hydraulic Grade (+m)	Elevation (+m)	Pressure Head (m)	Base Demand (l/s)	Peak Hour Demand (l/s)	Zone
J-B79	1,636.65	1,590.00	46.65	0.31	0.49	East
Segu Village	1,636.71	1,590.00	46.71	1.90	2.91	East
J-B106a	1,612.76	1,590.00	22.76	0.14	0.22	West
J-B106b	1,594.11	1,580.00	14.11	0.21	0.31	West
J-91	1,599.39	1,585.00	14.39	0.00	0.00	West
J-B84	1,592.85	1,578.00	14.85	0.27	0.43	West
J-B101	1,592.85	1,570.00	22.85	0.16	0.26	West
J-96	1,599.39	1,578.00	21.39	0.00	0.00	West
J-97	1,578.78	1,558.00	20.78	0.00	0.00	South East
Faniufa Village - 2	1,574.91	1,558.00	16.91	0.50	0.90	South East
J-B54b	1,575.28	1,553.00	22.28	0.24	0.38	South East
J-B54a	1,575.24	1,553.00	22.24	0.29	0.45	South East
J-B53a	1,575.23	1,550.00	25.23	0.53	0.72	South East
J-B53b	1,575.23	1,548.00	27.23	0.33	0.43	South East
J-B53c	1,575.23	1,548.00	27.23	0.20	0.32	South East
J-B124b	1,575.36	1,554.00	21.36	0.08	0.12	South East
J-B124a	1,575.35	1,561.00	14.35	0.27	0.33	South East
J-B55a	1,576.03	1,554.00	22.03	0.27	0.38	South East
J-B55b	1,575.93	1,550.00	25.93	0.28	0.39	South East
J-B104	1,575.92	1,548.00	27.92	0.39	0.53	South East
J-109	1,575.92	1,548.00	27.92	0.00	0.00	South East
J-110	1,575.92	1,545.00	30.92	0.00	0.00	South East
J-B105	1,576.32	1,554.00	22.32	0.55	0.78	South East
Faniufa&Kami	1,557.20	1,545.00	12.20	1.22	1.87	South East
J-113	1,629.53	1,600.00	29.53	0.00	0.00	West
J-114	1,625.01	1,597.00	28.01	0.00	0.00	West
J-B37b	1,624.57	1,595.00	29.57	0.58	0.88	West
J-B37a	1,624.45	1,598.00	26.45	0.60	0.91	West
J-B43	1,624.22	1,580.00	44.22	0.81	1.30	West
J-B40	1,624.42	1,585.00	39.42	0.65	1.04	West
J-B16a	1,619.13	1,591.00	28.13	0.26	0.42	West
J-120	1,614.15	1,587.00	27.15	0.00	0.00	West
J-B38b	1,611.95	1,585.00	26.95	0.12	0.19	West
J-B41b	1,607.47	1,577.00	30.47	0.12	0.20	West
J-B41a	1,607.44	1,575.00	32.44	0.36	0.57	West
J-B42a	1,605.40	1,577.00	28.40	0.15	0.24	West
J-B88a	1,602.35	1,574.00	28.35	0.60	0.88	West
J-B88b	1,600.85	1,571.00	29.85	0.60	0.88	West
J-B98a	1,598.43	1,570.00	28.43	0.42	0.68	West
J-B88c	1,597.96	1,570.00	27.96	0.69	1.04	West
J-B98b	1,597.71	1,570.00	27.71	0.47	0.75	West
J-B98c	1,597.41	1,571.00	26.41	0.48	0.76	West
J-B88d	1,597.30	1,572.00	25.30	0.69	1.04	West
Asarofua West	1,597.25	1,572.00	25.25	1.54	2.37	West
J-B42b	1,604.59	1,580.00	24.59	0.40	0.64	West
J-B99	1,604.56	1,580.00	24.56	0.11	0.17	West
J-B16b	1,618.70	1,591.00	27.70	0.59	0.94	West
J-B15a	1,618.49	1,596.00	22.49	0.80	1.28	West
J-B15b	1,618.31	1,587.00	31.31	0.80	1.28	West
J-B14b	1,629.26	1,587.00	42.26	0.34	0.42	West

Networks Calculation at Peak Hour (GOROKA, Year 2003)
Junction Report

Node	Hydraulic Grade (+m)	Elevation (+m)	Pressure Head (m)	Base Demand (l/s)	Peak Hour Demand (l/s)	Zone
J-B81	1,629.30	1,588.00	41.30	0.16	0.15	West
J-B18	1,610.66	1,585.00	25.66	6.40	9.26	West
J-B17a	1,607.50	1,585.00	22.50	0.11	0.17	West
J-B17b	1,606.42	1,586.00	20.42	0.20	0.28	West
J-B17c	1,606.55	1,587.00	19.55	0.12	0.18	West
J-B17d	1,606.93	1,589.00	17.93	0.13	0.20	West
J-B14a	1,629.22	1,588.00	41.22	0.51	0.67	West
J-B13	1,602.63	1,583.00	19.63	0.88	1.05	West
J-B25d	1,602.82	1,583.00	19.82	0.13	0.21	West
J-160	1,602.97	1,580.00	22.97	0.00	0.00	West
J-B26	1,604.39	1,579.00	25.39	0.41	0.66	West
J-B28a	1,604.33	1,573.00	31.33	0.27	0.43	West
J-B29a	1,604.27	1,570.00	34.27	0.21	0.34	West
J-B35a	1,604.22	1,568.00	36.22	0.27	0.43	West
J-B35b	1,604.22	1,570.00	34.22	0.20	0.32	West
J-B29b	1,604.28	1,573.00	31.28	0.20	0.32	West
J-B28b	1,604.34	1,574.00	30.34	0.21	0.34	West
J-B31c	1,604.45	1,583.00	21.45	0.20	0.32	West
J-171	1,604.58	1,583.00	21.58	0.00	0.00	West
J-B25c	1,604.91	1,583.00	21.91	0.08	0.12	West
J-B31a	1,604.30	1,575.00	29.30	0.20	0.32	West
J-B31b	1,604.37	1,589.00	15.37	0.20	0.32	West
J-B27	1,606.02	1,580.00	26.02	0.59	0.94	West
J-B38a	1,611.73	1,577.00	34.73	0.53	0.85	West
J-177	1,604.25	1,577.00	27.25	0.00	0.00	West
Kama Village	1,596.95	1,565.00	31.95	5.52	8.46	West
J-179	1,604.04	1,575.00	29.04	0.00	0.00	West
J-B32a	1,603.97	1,575.00	28.97	0.46	0.73	West
J-B32b	1,603.95	1,575.00	28.95	0.52	0.84	West
J-185	1,604.16	1,575.00	29.16	0.50	0.90	West
J-B25a	1,604.88	1,585.00	19.88	0.14	0.22	West
J-B25b	1,604.88	1,585.00	19.88	0.13	0.21	West
J-188	1,604.07	1,557.00	47.07	0.50	0.90	South West
J-B61c	1,583.20	1,560.00	23.20	0.80	1.28	South West
J-B61b	1,582.01	1,559.00	23.01	0.88	1.34	South West
J-B61a	1,581.89	1,559.00	22.89	0.90	1.43	South West
J-B22a	1,585.44	1,564.00	21.44	0.43	0.66	South West
J-B19 & 20	1,594.78	1,568.00	26.78	7.24	10.61	South West
J-B21a	1,589.32	1,568.00	21.32	0.69	1.00	South West
J-B23a	1,587.10	1,571.00	16.10	0.34	0.53	South West
J-B12c	1,586.56	1,572.00	14.56	0.50	0.66	South West
J-B12b	1,602.60	1,582.00	20.60	0.50	0.66	West
J-B12a	1,602.62	1,583.00	19.62	0.13	0.16	West
J-B21b	1,586.69	1,563.00	23.69	0.79	1.15	South West
J-B97	1,581.47	1,551.00	30.47	0.09	0.13	South West
Fimito Village	1,576.60	1,540.00	36.60	0.80	1.44	South West
J-B66b	1,582.18	1,551.00	31.18	0.29	0.43	South West
J-B67	1,582.17	1,551.00	31.17	0.13	0.21	South West
J-B66a	1,582.28	1,557.00	25.28	0.24	0.38	South West
J-B62a	1,582.39	1,559.00	23.39	0.26	0.37	South West

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Junction Report

Node	Hydraulic Grade (+m)	Elevation (+m)	Pressure Head (m)	Base Demand (l/s)	Peak Hour Demand (l/s)	Zone
J-B65	1,582.16	1,559.00	23.16	0.25	0.26	South West
J-B62b	1,580.79	1,556.00	24.79	0.29	0.43	South West
J-B22b	1,583.79	1,561.00	22.79	0.50	0.76	South West
J-B86b	1,579.69	1,552.00	27.69	1.05	1.69	South West
J-B64a	1,579.67	1,552.00	27.67	0.40	0.57	South West
J-B64b	1,579.65	1,550.00	29.65	0.27	0.43	South West
J-B86a	1,579.54	1,550.00	29.54	1.16	1.80	South West
J-B87 & 107	1,579.45	1,540.00	39.45	0.50	0.76	South West
J-168	1,648.30	1,605.00	43.30	0.00	0.00	North
J-B10c	1,645.60	1,615.00	30.60	0.63	0.97	North
J-B11b	1,645.64	1,615.00	30.64	0.60	0.96	North
J-B11a	1,640.35	1,613.00	27.35	0.62	1.00	North
J-B9-523&74&Asarouf	1,635.04	1,600.00	35.04	6.61	9.63	North
J-B9	1,639.11	1,617.00	22.11	1.56	2.39	North
J-B10b	1,644.24	1,620.00	24.24	0.60	0.93	North
J-B10a	1,644.06	1,625.00	19.06	0.50	0.80	North
Okiufa Village	1,642.80	1,625.00	17.80	2.86	4.38	North
J-B2	1,655.99	1,615.00	40.99	2.67	3.33	East
J-B33b	1,624.16	1,575.00	49.16	0.65	1.05	East
J-B23b	1,585.05	1,570.00	15.05	0.27	0.43	South West
J-B69 & 72	1,584.51	1,568.00	16.51	2.11	3.22	South West
J-B115	1,584.44	1,566.00	18.44	0.81	1.30	South West
J-B68	1,584.26	1,555.00	29.26	1.37	2.11	South West
J-B71b	1,571.62	1,550.00	21.62	0.41	0.41	South West
J-B117c	1,658.88	1,615.00	43.88	0.08	0.13	East
J-B9-521&522	1,661.60	1,660.00	1.60	5.53	7.77	North
WTP outlet	1,679.53	1,660.00	19.53	0.00	0.00	West
J-B96 & Komiufa	1,637.63	1,580.00	57.63	1.00	1.55	East
J-B89	1,636.87	1,580.00	56.87	1.62	2.60	East
J-B90 & 93	1,635.96	1,580.00	55.96	2.27	3.00	East
J-B94 & 95	1,636.36	1,580.00	56.36	0.37	0.59	East
J-B73	1,585.47	1,568.00	17.47	0.76	1.18	South East
J-B63	1,583.67	1,550.00	33.67	0.31	0.49	West
J-B70	1,583.41	1,550.00	33.41	1.94	2.98	West
J-B71a	1,582.86	1,550.00	32.86	0.35	0.36	West
J-B36a	1,653.89	1,625.00	28.89	0.40	0.64	East
J-237	1,672.26	1,636.00	36.26	0.00	0.00	West
J-238	1,658.90	1,615.00	43.90	0.00	0.00	East
J-239	1,657.63	1,624.00	33.63	0.00	0.00	West
J-240	1,580.65	1,540.00	40.65	0.00	0.00	West
J-241	1,664.81	1,631.00	33.81	0.00	0.00	West
J-B30a	1,654.17	1,610.00	44.17	0.39	0.61	West

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Pipe Report

Pipe	Start	End	Length (m)	Dia. (mm)	Material	C	Q (l/s)	V (m/s)	I (m/km)	Headloss (m)	Start Hydraulic Grade (m)	End Hydraulic Grade (m)
P-329	J-1	WTP outlet	392.28	200	PVC	110	-34.22	1.09	8.72	3.42	1676.11	1679.53
P-326	J-2	J-1	116.13	200	PVC	110	-33.95	1.08	8.60	1.00	1675.11	1676.11
P-325	J-3	J-2	71.32	200	PVC	110	-33.68	1.07	8.47	0.60	1674.51	1675.11
P-324	J-4	J-3	55.47	200	PVC	110	-33.41	1.06	8.34	0.46	1674.04	1674.51
P-5	J-5	J-B102b	79.25	200	PVC(new)	110	32.87	1.05	8.10	0.64	1673.25	1672.61
P-323	J-5	J-4	96.93	200	PVC	110	-33.14	1.05	8.22	0.80	1673.25	1674.04
P-6	J-B102b	J-B52	26.52	200	PVC(new)	110	30.82	0.98	7.18	0.19	1672.61	1672.42
P-258	J-B102b	J-B102a	304.8	80	PVC(new)	110	1.82	0.36	3.33	1.02	1672.61	1671.59
P-7	J-B52	J-B51a	66.14	200	PVC(new)	110	29.68	0.94	6.70	0.44	1672.42	1671.97
P-8	J-B51a	J-B50a	27.13	200	PVC(new)	110	29.10	0.93	6.46	0.18	1671.97	1671.80
P-257	J-B51a	J-B51b	350.52	80	PVC(new)	110	0.30	0.06	0.12	0.04	1671.97	1671.93
P-321	J-B50a	J-B51c	69.49	200	PVC	110	28.54	0.91	6.24	0.43	1671.80	1671.36
P-320	J-B51c	J-B50b	28.96	200	PVC	110	28.24	0.90	6.12	0.18	1671.36	1671.19
P-12	J-12	J-B117a	103.33	100	PVC(new)	110	1.93	0.25	1.24	0.13	1654.26	1654.14
P-43	J-B117a	J-B117b	61.87	100	PVC	110	1.54	0.20	0.83	0.05	1654.14	1654.08
P-11	J-11	J-12	117.96	100	PVC(new)	110	3.40	0.43	3.56	0.42	1654.68	1654.26
P-245	J-11	J-168	442.87	150	PVC(new)	110	21.06	1.19	14.43	6.39	1654.68	1648.30
P-372	J-11	PRV-11-Out	17.68	150	PVC	110	-24.46	1.38	19.03	0.34	1654.68	1655.02
P-22	Reservoir Inlet	T-2	58.52	280	DIP	110	85.06	1.38	9.13	0.53	1663.55	1663.02
P-319	J-B50c	J-B50b	111.25	150	PVC	110	-27.68	1.57	23.92	2.66	1668.53	1671.19
P-364	J-B50c	J-241	162.15	150	PVC	110	27.06	1.53	22.94	3.72	1668.53	1664.81
P-20	J-17	J-18	327.05	280	DIP	110	85.06	1.38	9.13	2.99	1667.61	1664.63
P-21	J-18	Reservoir Inlet	117.96	280	DIP	110	85.06	1.38	9.13	1.08	1664.63	1663.55
P-47	T-2	T-3	64.31	280	PVC(new)	110	113.01	1.84	15.45	0.99	1663.02	1662.02
P-48	T-3	Reservoir Outlet	30.78	300	PVC(new)	110	130.80	1.85	14.47	0.45	1662.02	1661.58
P-33	J-B50d	J-B52	211.84	80	PVC(new)	110	-0.69	0.14	0.56	0.12	1672.30	1672.42
P-366	J-B76	J-B30a	117.04	100	PVC	110	-0.86	0.11	0.28	0.03	1654.14	1654.17
P-44	J-B117b	J-B30b	221.59	100	PVC	110	0.59	0.07	0.14	0.03	1654.08	1654.05
P-46	J-B117b	J-B116	71.02	100	PVC	110	0.49	0.06	0.10	0.01	1654.08	1654.08
P-328	Reservoir Outlet	J-238	185.01	300	DIP	110	130.80	1.85	14.47	2.68	1661.58	1658.90
P-54	J-B83	J-B34	86.26	50	PVC(new)	110	0.11	0.06	0.18	0.02	1656.90	1656.88
P-67	J-B1	J-B8	94.18	100	PVC(new)	110	4.57	0.58	6.14	0.58	1657.49	1656.91
P-334	J-B1	J-B39a	372.77	200	PVC(new)	110	35.37	1.13	9.27	3.46	1657.49	1654.03
P-338	J-B1	J-239	11.89	200	PVC	110	-40.40	1.29	11.86	0.14	1657.49	1657.63
P-61	J-B39a	Mt Kiss Residents	85.04	100	PVC(new)	110	0.29	0.04	0.04	0.00	1654.03	1654.03
P-335	J-B39a	J-B36a	163.37	100	PVC	110	1.61	0.20	0.89	0.15	1654.03	1653.89
P-359	J-B39a	PRV-9-In	159.41	150	PVC(new)	110	32.19	1.82	31.62	5.04	1654.03	1648.99
P-63	J-55	J-B36d	51.82	100	PVC(new)	110	9.50	1.21	23.83	1.23	1644.25	1643.02
P-269	J-55	J-B2	117.96	100	PVC	110	0.00	0.00	0.00	0.00	1644.25	1655.99
P-71	J-55	J-63	112.47	150	PVC(new)	110	22.69	1.28	16.56	1.86	1644.25	1642.39
P-64	J-B36d	J-B36c	255.12	80	PVC	110	0.87	0.17	0.85	0.22	1643.02	1642.80
P-298	J-B36d	J-B96 & Komiufa	271.88	100	PVC(new)	110	8.59	1.09	19.79	5.38	1643.02	1637.63
P-68	J-B8	J-B82	112.47	80	PVC(new)	110	0.65	0.13	0.50	0.06	1656.91	1656.85
P-69	J-B82	J-B3a	265.48	80	PVC(new)	110	0.30	0.06	0.12	0.03	1656.85	1656.82
P-70	J-B3a	J-63	114.91	80	PVC(new)	110	0.00	0.00	0.00	0.00	1656.82	1642.39
P-74	J-63	J-B6	135.64	80	PVC(new)	110	3.01	0.60	8.43	1.14	1642.39	1641.24
P-81	J-63	J-B4	160.32	150	PVC(new)	110	19.68	1.11	12.72	2.04	1642.39	1640.35
P-75	J-B6	J-B7	213.06	80	PVC(new)	110	1.72	0.34	3.00	0.64	1641.24	1640.61
P-76	J-B7	J-66	136.25	80	PVC(new)	110	0.00	0.00	0.00	0.00	1640.61	1638.56
P-77	J-66	J-B5a	113.08	80	PVC(new)	110	0.36	0.07	0.17	0.02	1638.56	1638.54
P-371	J-66	J-79	168.86	100	PVC(new)	140	5.95	0.76	6.41	1.08	1638.56	1637.48
P-78	J-B5a	J-B5b	191.72	80	PVC(new)	110	0.00	0.00	0.00	0.00	1638.54	1632.43
P-79	J-B5b	J-B3b	59.13	100	PVC(new)	110	-12.81	1.63	41.43	2.45	1632.43	1634.88

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Pipe Report

Pipe	Start	End	Length (m)	Dia. (mm)	Material	C	Q (l/s)	V (m/s)	I (m/km)	Headloss (m)	Start Hydraulic Grade (m)	End Hydraulic Grade (m)
P-84	J-B5b	J-B3c	109.73	100	PVC(new)	110	12.45	1.58	39.28	4.31	1632.43	1628.12
P-80	J-B3b	J-B3a	148.44	80	PVC(new)	110	0.00	0.00	0.00	0.00	1634.88	1656.82
P-83	J-B3b	J-B4	126.49	100	PVC(new)	110	-13.12	1.67	43.27	5.47	1634.88	1640.35
P-82	J-B4	J-66	159.72	100	PVC(new)	110	6.31	0.80	11.17	1.78	1640.35	1638.56
P-374	J-B3c	J-72	95.4	100	PVC	110	12.30	1.57	38.43	3.67	1628.12	1624.45
P-375	J-72	J-B33a	86.87	100	PVC	110	2.30	0.29	1.73	0.15	1624.45	1624.30
P-376	J-72	J-B106a	446.53	100	PVC	110	10.00	1.27	26.19	11.69	1624.45	1612.76
P-271	J-B33a	J-B33b	96.93	100	PVC(new)	110	2.10	0.27	1.46	0.14	1624.30	1624.16
P-93	J-79	J-B78a	68.88	80	PVC(new)	110	2.56	0.51	6.24	0.43	1637.48	1637.05
P-98	J-79	Segu Village	219.46	100	PVC(new)	110	3.39	0.43	3.54	0.78	1637.48	1636.71
P-94	J-B78a	J-B78	76.5	80	PVC(new)	110	1.92	0.38	3.66	0.28	1637.05	1636.77
P-95	J-B78	J-B80	78.94	80	PVC(new)	110	1.21	0.24	1.56	0.12	1636.77	1636.65
P-96	J-B80	J-B79	82.91	80	PVC(new)	110	0.02	0.00	0.00	0.00	1636.65	1636.65
P-102	J-B79	Segu Village	204.22	80	PVC(new)	110	-0.48	0.09	0.28	0.06	1636.65	1636.71
P-104	J-B106a	J-B106b	175.56	20	PVC	110	0.31	0.98	106.18	18.64	1612.76	1594.11
P-361	J-B106a	PRV-10-In	224.03	100	PVC	110	9.47	1.21	23.69	5.31	1612.76	1607.45
P-106	J-91	J-B84	275.84	100	PVC	110	9.47	1.21	23.69	6.53	1599.39	1592.85
P-110	J-91	J-96	275.23	100	PVC	110	0.00	0.00	0.00	0.00	1599.39	1599.39
P-107	J-B84	J-B101	96.62	100	PVC	110	0.26	0.03	0.03	0.00	1592.85	1592.85
P-377	J-B84	J-B73	358.14	100	PVC	110	8.78	1.12	20.61	7.38	1592.85	1585.47
P-112	J-97	Faniufa Village - 2	434.64	50	PVC	110	0.90	0.46	8.90	3.87	1578.78	1574.91
P-125	J-97	J-B105	196.29	100	PVC	110	6.71	0.85	12.51	2.46	1578.78	1576.32
P-113	J-B54b	J-B54a	96.62	100	PVC	110	1.04	0.13	0.40	0.04	1575.28	1575.24
P-118	J-B54b	J-B124b	46.94	100	PVC	110	-2.30	0.29	1.73	0.08	1575.28	1575.36
P-114	J-B54a	J-B53a	130.45	100	PVC	110	0.59	0.08	0.14	0.02	1575.24	1575.23
P-115	J-B53a	J-B53b	150.88	100	PVC	110	-0.13	0.02	0.01	0.00	1575.23	1575.23
P-116	J-B53b	J-B53c	53.64	100	PVC	110	0.32	0.04	0.05	0.00	1575.23	1575.23
P-117	J-B53b	J-B54b	187.76	100	PVC	110	-0.88	0.11	0.29	0.06	1575.23	1575.28
P-119	J-B124b	J-B124a	304.5	100	PVC	110	0.33	0.04	0.05	0.01	1575.36	1575.35
P-120	J-B124b	J-B55a	274.62	100	PVC	110	-2.75	0.35	2.41	0.66	1575.36	1576.03
P-121	J-B55a	J-B55b	301.75	100	PVC	110	0.92	0.12	0.32	0.10	1576.03	1575.93
P-127	J-B55a	J-B105	59.44	100	PVC	110	-4.05	0.52	4.93	0.29	1576.03	1576.32
P-122	J-B55b	J-B104	103.94	100	PVC	110	0.53	0.07	0.11	0.01	1575.93	1575.92
P-123	J-B104	J-109	51.21	100	PVC	110	0.00	0.00	0.00	0.00	1575.92	1575.92
P-124	J-B104	J-110	212.45	50	PVC	110	0.00	0.00	0.00	0.00	1575.92	1575.92
P-126	J-B105	Faniufa&Kami	553.82	50	PVC	110	1.87	0.95	34.52	19.12	1576.32	1557.20
P-129	J-113	J-114	89.92	200	PVC(new)	110	88.22	2.81	50.30	4.52	1629.53	1625.01
P-130	J-114	J-B37b	86.26	100	PVC(new)	110	4.14	0.53	5.12	0.44	1625.01	1624.57
P-134	J-114	J-B16a	127.71	200	PVC(new)	110	84.09	2.68	46.02	5.88	1625.01	1619.13
P-131	J-B37b	J-B37a	75.29	100	PVC(new)	110	2.21	0.28	1.60	0.12	1624.57	1624.45
P-133	J-B37b	J-B40	363.63	100	PVC	110	1.04	0.13	0.40	0.15	1624.57	1624.42
P-132	J-B37a	J-B43	381.61	100	PVC	110	1.30	0.17	0.60	0.23	1624.45	1624.22
P-135	J-B16a	J-120	118.26	200	PVC(new)	110	80.17	2.55	42.14	4.98	1619.13	1614.15
P-157	J-B16a	J-B16b	115.82	100	PVC	110	3.50	0.45	3.75	0.43	1619.13	1618.70
P-136	J-120	J-B38b	149.66	150	PVC(new)	110	21.28	1.20	14.71	2.20	1614.15	1611.95
P-164	J-120	J-B18	146.61	200	PVC(new)	110	58.89	1.87	23.81	3.49	1614.15	1610.66
P-137	J-B38b	J-B41b	164.59	100	PVC(new)	110	10.21	1.30	27.23	4.48	1611.95	1607.47
P-202	J-B38b	J-B38a	265.79	80	PVC(new)	110	0.85	0.17	0.81	0.22	1611.95	1611.73
P-203	J-B38b	J-177	292.3	100	PVC	110	10.03	1.28	26.33	7.70	1611.95	1604.25
P-138	J-B41b	J-B41a	205.13	100	PVC	110	0.57	0.07	0.13	0.03	1607.47	1607.44
P-139	J-B41b	J-B42a	87.48	100	PVC(new)	110	9.44	1.20	23.57	2.06	1607.47	1605.40
P-140	J-B42a	J-B88a	161.24	100	PVC(new)	110	8.39	1.07	18.94	3.05	1605.40	1602.35
P-153	J-B42a	J-B42b	109.73	50	PVC	110	0.81	0.41	7.39	0.81	1605.40	1604.59
P-141	J-B88a	J-B88b	97.54	100	PVC	110	7.51	0.96	15.43	1.50	1602.35	1600.85
P-142	J-B88b	J-B98a	197.51	100	PVC	110	6.63	0.84	12.25	2.42	1600.85	1598.43
P-143	J-B98a	J-B88c	46.33	100	PVC	110	5.96	0.76	10.05	0.47	1598.43	1597.96
P-144	J-B88c	J-B98b	35.36	100	PVC	110	4.92	0.63	7.05	0.25	1597.96	1597.71

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Pipe Report

Pipe	Start	End	Length (m)	Dia. (mm)	Material	C	Q (l/s)	V (m/s)	I (m/km)	Headloss (m)	Start Hydraulic Grade (m)	End Hydraulic Grade (m)
P-145	J-B98b	J-B98c	57	100	PVC	110	4.17	0.53	5.19	0.30	1597.71	1597.41
P-146	J-B98c	J-B88d	32.92	100	PVC	110	3.41	0.43	3.58	0.12	1597.41	1597.30
P-147	J-B88d	Asarofua West	25.91	100	PVC	110	2.37	0.30	1.83	0.05	1597.30	1597.25
P-248	J-B42b	J-B99	77.72	50	PVC	110	0.17	0.09	0.43	0.03	1604.59	1604.56
P-158	J-B16b	J-B15a	100.89	100	PVC	110	2.56	0.33	2.11	0.21	1618.70	1618.49
P-159	J-B15a	J-B15b	303.58	100	PVC	110	1.28	0.16	0.58	0.18	1618.49	1618.31
P-160	J-B15b	J-B14b	32.61	100	PVC(new)	110	0.00	0.00	0.00	0.00	1618.31	1629.26
P-168	J-B15b	J-B17c	109.73	100	PVC(new)	110	0.00	0.00	0.00	0.00	1618.31	1606.55
P-161	J-B14b	J-B81	103.02	100	PVC(new)	110	-1.09	0.14	0.43	0.04	1629.26	1629.30
P-174	J-B14b	J-B14a	175.26	100	PVC(new)	110	0.67	0.09	0.18	0.03	1629.26	1629.22
P-162	J-B81	J-113	425.5	100	PVC(new)	110	-1.24	0.16	0.55	0.23	1629.30	1629.53
P-165	J-B18	J-B17a	182.27	200	PVC(new)	110	49.63	1.58	17.35	3.16	1610.66	1607.50
P-166	J-B17a	J-B17b	89.61	200	PVC(new)	110	40.64	1.29	11.99	1.07	1607.50	1606.42
P-212	J-B17b	J-B25c	117.65	200	PVC(new)	110	42.25	1.34	12.88	1.52	1606.42	1604.91
P-345	J-B17b	J-B17c	106.98	100	PVC	110	-1.90	0.24	1.21	0.13	1606.42	1606.55
P-169	J-B17c	J-B17d	88.09	80	PVC(new)	110	-2.08	0.41	4.26	0.38	1606.55	1606.93
P-171	J-B17d	J-B17a	112.47	80	PVC(new)	110	-2.28	0.45	5.06	0.57	1606.93	1607.50
P-315	Clean Water Reservoir	WTP outlet	27.43	280	PVC	110	119.28	1.94	17.07	0.47	1680.00	1679.53
P-260	J-B14a	J-B13	177.7	100	PVC(new)	110	0.00	0.00	0.00	0.00	1629.22	1602.63
P-179	J-B25d	J-160	102.72	100	PVC(new)	110	-2.08	0.26	1.43	0.15	1602.82	1602.97
P-235	J-B25d	J-B13	166.73	100	PVC	110	1.87	0.24	1.18	0.20	1602.82	1602.63
P-180	J-160	J-B26	111.56	100	PVC	110	0.00	0.00	0.00	0.00	1602.97	1604.39
P-197	J-B26	J-171	157.28	100	PVC(new)	110	-1.89	0.24	1.20	0.19	1604.39	1604.58
P-369	J-B26	J-B28a	119.18	100	PVC	110	1.23	0.16	0.55	0.07	1604.39	1604.33
P-183	J-B28a	J-B29a	101.19	100	PVC	110	1.22	0.16	0.53	0.05	1604.33	1604.27
P-184	J-B29a	J-B35a	99.97	100	PVC(new)	110	1.22	0.16	0.54	0.05	1604.27	1604.22
P-185	J-B35a	J-B35b	157.28	100	PVC(new)	110	-0.11	0.01	0.01	0.00	1604.22	1604.22
P-216	J-B35a	J-188	506.27	100	PVC	110	0.90	0.11	0.30	0.15	1604.22	1604.07
P-186	J-B35b	J-B29b	96.62	100	PVC	110	-1.33	0.17	0.63	0.06	1604.22	1604.28
P-211	J-B35b	J-185	201.17	100	PVC	110	0.90	0.11	0.30	0.06	1604.22	1604.16
P-195	J-B29b	J-B29a	155.45	100	PVC(new)	110	0.34	0.04	0.05	0.01	1604.28	1604.27
P-200	J-B29b	J-B31a	98.15	100	PVC	110	-0.77	0.10	0.23	0.02	1604.28	1604.30
P-201	J-B29b	J-B28b	107.29	100	PVC	110	-1.22	0.16	0.53	0.06	1604.28	1604.34
P-189	J-B28b	J-B31c	83.82	100	PVC	110	-1.97	0.25	1.30	0.11	1604.34	1604.45
P-196	J-B28b	J-B28a	154.84	100	PVC(new)	110	0.41	0.05	0.07	0.01	1604.34	1604.33
P-190	J-B31c	J-171	32.31	100	PVC	110	-3.70	0.47	4.17	0.13	1604.45	1604.58
P-191	J-171	J-B25c	113.69	80	PVC(new)	110	0.00	0.00	0.00	0.00	1604.58	1604.91
P-198	J-171	J-B27	160.32	100	PVC(new)	110	-5.59	0.71	8.94	1.43	1604.58	1606.02
P-213	J-B25c	J-160	153.92	200	PVC(new)	110	41.70	1.33	12.57	1.94	1604.91	1602.97
P-214	J-B25c	J-B25a	107.29	80	PVC(new)	110	0.43	0.09	0.23	0.03	1604.91	1604.88
P-193	J-B31a	J-B31b	160.32	100	PVC	110	-1.09	0.14	0.44	0.07	1604.30	1604.37
P-194	J-B31b	J-B31c	105.16	100	PVC	110	-1.41	0.18	0.70	0.07	1604.37	1604.45
P-199	J-B27	J-B17a	124.05	100	PVC(new)	110	-6.54	0.83	11.93	1.48	1606.02	1607.50
P-204	J-177	Kama Village	380.09	100	PVC	110	8.46	1.08	19.21	7.30	1604.25	1596.95
P-205	J-177	J-179	246.58	100	PVC	110	1.57	0.20	0.85	0.21	1604.25	1604.04
P-206	J-179	J-B32a	79.55	100	PVC	110	1.57	0.20	0.85	0.07	1604.04	1603.97
P-207	J-B32a	J-B32b	94.79	100	PVC	110	0.84	0.11	0.27	0.03	1603.97	1603.95
P-215	J-B25a	J-B25b	58.52	80	PVC(new)	110	0.21	0.04	0.06	0.00	1604.88	1604.88
P-219	J-B61c	J-B61b	71.63	80	PVC(new)	110	4.34	0.86	16.56	1.19	1583.20	1582.01
P-239	J-B61c	J-B22a	248.41	100	PVC(new)	110	-5.62	0.72	9.01	2.24	1583.20	1585.44
P-220	J-B61b	J-B61a	57	80	PVC(new)	110	1.43	0.28	2.12	0.12	1582.01	1581.89
P-234	J-B61b	J-B97	216.71	80	PVC(new)	110	1.57	0.31	2.51	0.55	1582.01	1581.47
P-232	J-B22a	J-B21b	102.41	100	PVC(new)	110	0.00	0.00	0.00	0.00	1585.44	1586.69
P-246	J-B22a	J-B22b	92.96	100	PVC(new)	110	8.09	1.03	17.71	1.65	1585.44	1583.79
P-226	J-B19 & 20	J-B21a	103.02	100	PVC	110	14.64	1.86	53.01	5.46	1594.78	1589.32

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Pipe Report

Pipe	Start	End	Length (m)	Dia. (mm)	Material	C	Q (l/s)	V (m/s)	I (m/km)	Headloss (m)	Start Hydraulic Grade (m)	End Hydraulic Grade (m)
P-355	J-B19 & 20	PRV-7-Out	21.03	200	PVC	110	-39.62	1.26	11.44	0.24	1594.78	1595.02
P-368	J-B19 & 20	J-B22a	182.27	100	PVC(new)	110	14.37	1.83	51.26	9.34	1594.78	1585.44
P-227	J-B21a	J-B23a	201.17	100	PVC	110	6.27	0.80	11.04	2.22	1589.32	1587.10
P-228	J-B23a	J-B12c	57.91	100	PVC	110	5.74	0.73	9.38	0.54	1587.10	1586.56
P-274	J-B12c	J-B23b	201.47	100	PVC	110	5.08	0.65	7.48	1.51	1586.56	1585.05
P-229	J-B12c	J-B12b	270.36	100	PVC	110	0.00	0.00	0.00	0.00	1586.56	1602.60
P-230	J-B12b	J-B12a	109.42	100	PVC	110	-0.66	0.08	0.17	0.02	1602.60	1602.62
P-231	J-B12a	J-B13	18.29	100	PVC	110	-0.82	0.10	0.26	0.00	1602.62	1602.63
P-233	J-B21b	J-B21a	176.78	100	PVC(new)	110	-7.37	0.94	14.91	2.64	1586.69	1589.32
P-237	J-B97	J-B66b	110.95	80	PVC(new)	110	0.00	0.00	0.00	0.00	1581.47	1582.18
P-349	J-B97	J-240	379.48	80	PVC(new)	110	1.44	0.29	2.15	0.82	1581.47	1580.65
P-238	J-B66b	J-B67	141.12	80	PVC(new)	110	0.21	0.04	0.06	0.01	1582.18	1582.17
P-241	J-B66b	J-B66a	201.47	80	PVC(new)	110	-0.64	0.13	0.47	0.10	1582.18	1582.28
P-242	J-B66a	J-B62a	96.62	80	PVC(new)	110	-1.02	0.20	1.14	0.11	1582.28	1582.39
P-243	J-B62a	J-B65	22.56	100	PVC(new)	110	5.94	0.76	10.00	0.23	1582.39	1582.16
P-244	J-B65	J-B62b	149.35	100	PVC(new)	110	5.68	0.72	9.19	1.37	1582.16	1580.79
P-251	J-B62b	J-B86b	137.46	100	PVC(new)	110	5.25	0.67	7.96	1.09	1580.79	1579.69
P-247	J-B22b	J-B62a	95.4	100	PVC(new)	110	7.33	0.93	14.75	1.41	1583.79	1582.39
P-252	J-B86b	J-B64a	67.67	100	PVC(new)	110	1.00	0.13	0.37	0.03	1579.69	1579.67
P-254	J-B86b	J-B86a	74.98	100	PVC	110	2.56	0.33	2.11	0.16	1579.69	1579.54
P-253	J-B64a	J-B64b	225.86	100	PVC	110	0.43	0.05	0.08	0.02	1579.67	1579.65
P-256	J-B86a	J-B87 & 107	391.36	100	PVC	110	0.76	0.10	0.22	0.09	1579.54	1579.45
P-268	J-168	J-B11b	186.54	150	PVC(new)	110	20.92	1.18	14.24	2.66	1648.30	1645.64
P-255	J-B10c	J-B11b	164.59	100	PVC(new)	110	-0.83	0.11	0.26	0.04	1645.60	1645.64
P-261	J-B10c	J-168	309.98	25	PVC	110	-0.14	0.29	8.71	2.70	1645.60	1648.30
P-262	J-B11b	J-B11a	123.75	100	PVC	110	13.02	1.66	42.70	5.28	1645.64	1640.35
P-265	J-B11b	J-B10b	132.89	100	PVC(new)	110	6.11	0.78	10.52	1.40	1645.64	1644.24
P-263	J-B11a	J-B9-523&74&A saroufa North	217.32	100	PVC	110	9.63	1.23	24.44	5.31	1640.35	1635.04
P-264	J-B11a	J-B9	224.94	80	PVC(new)	110	2.39	0.48	5.52	1.24	1640.35	1639.11
P-266	J-B10b	J-B10a	245.06	80	PVC(new)	110	0.80	0.16	0.72	0.18	1644.24	1644.06
P-267	J-B10b	Okiufa Village	252.68	100	PVC(new)	110	4.38	0.56	5.69	1.44	1644.24	1642.80
P-270	J-B2	J-B8	269.14	100	PVC(new)	110	-3.33	0.42	3.42	0.92	1655.99	1656.91
P-272	J-B33b	J-B33c	211.53	100	PVC	110	1.05	0.13	0.41	0.09	1624.16	1624.07
P-275	J-B23b	J-B69 & 72	85.34	100	PVC	110	4.65	0.59	6.35	0.54	1585.05	1584.51
P-276	J-B69 & 72	J-B115	89.31	100	PVC	110	1.43	0.18	0.71	0.06	1584.51	1584.44
P-277	J-B115	J-B21b	205.74	100	PVC(new)	110	-6.22	0.79	10.89	2.24	1584.44	1586.69
P-278	J-B115	J-B68	71.02	100	PVC	110	2.88	0.37	2.62	0.19	1584.44	1584.26
P-308	J-B115	J-B63	210.31	100	PVC	110	3.47	0.44	3.70	0.78	1584.44	1583.67
P-311	J-B68	J-B71a	211.23	50	alvanized i	110	0.77	0.39	6.61	1.40	1584.26	1582.86
P-292	J-B9-521&522	Goroka University	60.05	100	PVC	110	-7.77	0.99	16.43	0.99	1661.60	1662.59
P-316	WTP outlet	J-237	796.14	280	DIP	110	85.06	1.38	9.13	7.27	1679.53	1672.26
P-300	J-B96 & Komiufa	J-B89	55.78	100	PVC	110	7.05	0.90	13.71	0.76	1637.63	1636.87
P-304	J-B89	J-B94 & 95	86.26	100	PVC	110	4.45	0.57	5.86	0.51	1636.87	1636.36
P-303	J-B90 & 93	J-B91 & 92	87.48	100	PVC	110	0.86	0.11	0.28	0.02	1635.96	1635.94
P-305	J-B94 & 95	J-B90 & 93	89.31	100	PVC	110	3.86	0.49	4.50	0.40	1636.36	1635.96
P-307	J-B73	J-97	423.98	100	PVC	110	7.61	0.97	15.80	6.70	1585.47	1578.78

Networks Calculation at Peak Hour (GOROKA, Year 2003)

Pipe Report

Pipe	Start	End	Length (m)	Dia. (mm)	Material	C	Q (l/s)	V (m/s)	I (m/km)	Headloss (m)	Start Hydraulic Grade (m)	End Hydraulic Grade (m)
P-309	J-B63	J-B70	90.83	100	PVC	110	2.98	0.38	2.79	0.25	1583.67	1583.41
P-312	J-B71a	J-B71b	186.54	25	alvanized i	110	0.41	0.83	60.25	11.24	1582.86	1571.62
P-314	J-B36a	J-B36b	247.19	100	PVC	110	0.97	0.12	0.35	0.09	1653.89	1653.80
P-317	J-237	J-17	508.71	280	DIP	110	85.06	1.38	9.13	4.65	1672.26	1667.61
P-331	J-238	J-B117c	72.54	50	PVC	110	0.13	0.07	0.24	0.02	1658.90	1658.88
P-336	J-238	J-239	89	300	DIP	110	129.86	1.84	14.28	1.27	1658.90	1657.63
P-370	J-238	J-B83	274.62	50	PVC	110	0.81	0.41	7.29	2.00	1658.90	1656.90
P-346	J-239	PRV-4-In	797.97	250	DIP	110	89.46	1.82	17.41	13.89	1657.63	1643.74
P-347	PRV-4-Out	J-113	28.35	250	DIP	110	89.46	1.82	17.41	0.49	1630.03	1629.53
P-350	J-240	Fimito Village	190.8	50	PVC	110	1.44	0.73	21.24	4.05	1580.65	1576.60
P-356	PRV-7-In	J-160	588.26	200	PVC	110	-39.62	1.26	11.44	6.73	1596.24	1602.97
P-360	PRV-9-Out	J-55	24.69	150	PVC(new)	110	32.19	1.82	31.62	0.78	1645.03	1644.25
P-362	PRV-10-Out	J-91	27.43	100	PVC	110	9.47	1.21	23.69	0.65	1600.04	1599.39
P-365	J-241	Goroka University	1023.21	100	PVC	110	2.60	0.33	2.17	2.22	1664.81	1662.59
P-367	J-B30a	J-12	121.62	100	PVC	110	-1.47	0.19	0.76	0.09	1654.17	1654.26
P-373	PRV-11-In	J-241	24.38	150	PVC	110	-24.46	1.38	19.03	0.46	1664.34	1664.81

Appendix 13 *Structural Analysis*

STRUCTURAL ANALYSIS OF THE STEEL RESERVOIR TANK
– LORENGAU –

1. Basic Dimension

1-1 Volume

Effective Volume		800 m^3
Total Volume		800 m^3

1-2 Depth of Water

Effective Depth of Water		4.000 m
Total Depth of Water		4.300 m
Design Depth of Water	HL=	4.200 m

1-3 Inner Diameter

I.D=	16.000 m

1-4 Water Level

H.W.L=	+G.L	4.200 m
L.W.L=	+G.L	0.200 m

2. Design Load

Material Load 60 kgf/m^2

The Load of Roofing Material is considered and averaging inspector for conservatism, inspection tools, snow and wind load.

Unit Weight

Steel Material	
SS400	7.85 tf/m^3
SM490M	7.85 tf/m^3
SUS304	7.93 tf/m^3
SUS316	7.98 tf/m^3
SUS329J_3L	7.80 tf/m^3
SUS329J_4L	7.80 tf/m^3
Reinforcement Concrete	2.50 tf/m^3
Asphalt Concrete	2.10 tf/m^3
Soil	1.80 tf/m^3
Water	1.00 tf/m^3

3. Seismic Condition

3-1 Peculiar Cycle of Reservoir Tank (Full Water) T= 0.04 sec

Inner Diameter 16.000 m

Effective Depth of Water 4.000 m

Design Depth of Water 4.200 m

3-2 Type of Ground Type II

3-3 Design Seismic Coefficient Rank A

3-4 Design Horizontal Seismic Coefficient 0.20

3-5 Design Vertical Seismic Coefficient 0.10

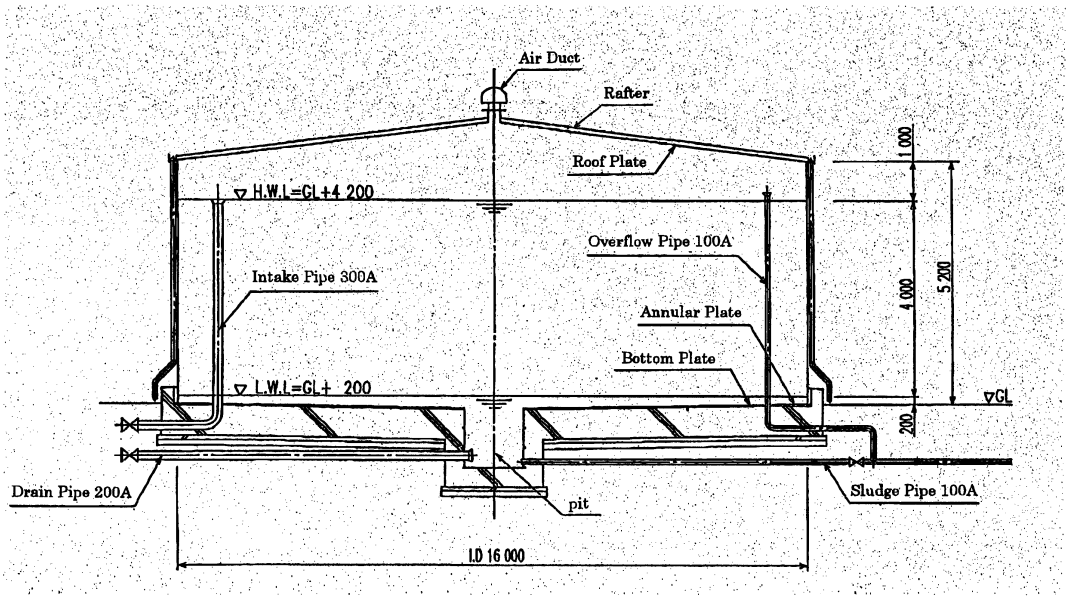
4. Allowable Stress

Material			Yield Point (0.2%Proof Stress) Kgf/cm2	Tensile Compressive Bending Stress Kgf/cm2	Shearing Stress Kgf/cm2	Remark
SS400		t≦16	2500	1500	870	Allowable Stress is 60% of Yield Point
		t>16	2400	1440	830	
Welding	Butt Weld	Shop	t≦16	1350	780	
			t>16	1300	750	
		Site	t≦16	1280	740	
			t>16	1220	710	
	Fillet Weld	Shop	t≦16	780	780	
			t>16	750	750	
		Site	t≦16	740	740	
			t>16	710	710	
SM490M		t≦16	3300	1980	1220	Allowable Stress is 60% of Yield Point
		t>16	3200	1920	1110	
Welding	Butt Weld	Shop	t≦16	1780	1010	
			t>16	1720	1000	
		Site	t≦16	1680	970	
			t>16	1630	940	
	Fillet Weld	Shop	t≦16	1030	1030	
			t>16	1000	1000	
		Site	t≦16	970	970	
			t>16	940	940	
SUS304・SUS316			2100	1260	720	Allowable Stress is 60% of Proof Stress
Welding	Butt Weld	Shop		1130	650	
		Site		1070	610	
	Fillet Weld	Shop		650	650	
		Site		610	610	
SUS329J3L・J4L			4600	2760	1590	Allowable Stress is 60% of Proof Stress
Welding	Butt Weld	Shop		2480	1430	
		Site		2340	1350	
	Fillet Weld	Shop		1430	1430	
		Site		1350	1350	

5. Base Structure

Allowable Stress of Base Material

<table>
<tr><th></th><th>Tensile</th><th>Compressive</th><th>Shearing</th><th>Bond</th><th>Remark</th></tr>
<tr><td>Concrete
Fc=210(kgf/cm2)</td><td></td><td>70</td><td>7.0</td><td rowspan="2">14</td><td rowspan="2"></td></tr>
<tr><td>Reinforcement
Bar
SD295A</td><td>1800</td><td>1800</td><td></td></tr>
</table>



6. Calculation for Roof

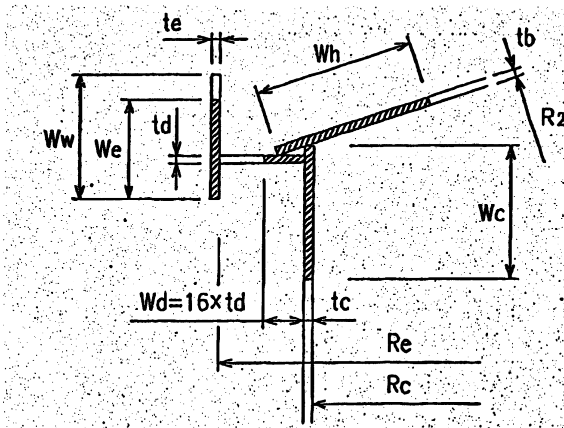
Roof Arrangement Drawing
Examination of Roof
Examination of Rafter
Examination of Support for Roof Material

$A \geqq 4.6 \cdot D \cdot R$

A : Total of Sectional Area

D : Inner Diameter of Reservoir Tank

R : Curvature of Roof



R2 :	18.40	(m)
Rc :	8.00	(m)
Re :	8.206	(m)
tb :	6.00	(mm)
tc :	6.00	(mm)
td :	6.00	(mm)
te :	6.00	(mm)
Ww :	150.00	(mm)

$Wh = 0.67\sqrt{2 \cdot R2 \cdot tb} = 9.96$ (cm) Max. (30cm)

$Wc = 1.34\sqrt{2 \cdot Rc \cdot tc} = 13.13$ (cm)

$Wd = 16 \cdot td = 9.60$ (cm)

$We = 1.34\sqrt{2 \cdot Re \cdot te} = 13.30$ (cm)

$A \geqq 4.6 \times 16 \times 18.4 = 1177.6$ mm2 $= 11.78$ cm2

$A = 0.6 \times 9.96 + 0.6 \times 13.13 + 0.6 \times 9.6 + 0.6 \times 13.3 = 27.59$cm2

27.59 cm2 $\geqq$ 11.78 cm2   O.K

7. Calculation of Side Plate

Arrangement of Side Plate

↓

Examination for Usual

↓

Examination for Seismic

Examination on Stress of Side Plate

$\sigma\phi + \sigma C$ was evaluated by the allowable yield stress as below.

$\sigma\phi + \sigma C <$ Yield stress

where, $\sigma\phi$: The synthesis circumference stress

σC : (Load by roof + Load up to the side plate) / (Cross section of the plate)

Examination on stress of side plate by horizontal seismic force

No	h (m)	t (mm)	σCH (kgf/cm²)	$\sigma\phi H$ (kgf/cm²)	$\sigma\phi 0$ (kgf/cm²)	$\sigma\phi$ (kgf/cm²)	σc (kgf/cm²)	$\sigma\phi+\sigma C$ (kgf/cm²)		Yield stress (kgf/cm²)
3	3.6	6.0	0.18	25.33	78.40	103.73	4.30	108.03	<	2500
2	1.8	6.0	2.81	77.33	313.60	390.93	5.71	396.64	<	2500
1	0.0	6.0	8.62	94.67	548.80	643.47	7.12	650.59	<	2500

Maximum of Wave Height by Shaking of Water Surface is calculated by below.

$$d_{max} = \frac{0.408 \cdot R \cdot \coth(1.84 \cdot HL/R)}{\dfrac{g}{\omega^2 \cdot \theta h \cdot R} - 1}$$

$= 0.83\ \mathrm{m} < 1.0\ \mathrm{m}$ O.K

8. Examination of Annular Plate

- Arrangement of Annular Plate Bottom Plate
- Calculation of Thickness of Plate by Seismic Movement
- Calculation of Thickness of Plate by Seismic Movement Level 2

Stress Valuation at Seismic Movement

$\Delta \sigma BL = \sqrt{(\Delta \sigma B - H)2 + (\Delta \sigma B - V)2}$

$\Delta \sigma BL = 21.53$ kgf/mm2 $<$ $2 \cdot \sigma y = 2 \times 25 = 50$ kgf/mm2

Steel Plate with 6mm thickness is suitable for Annular Plate.

STRUCTURAL ANALYSIS OF SEDIMENTATION BASIN – GOROKA –

1. Outline

The sedimentation basin composes the main structure of the proposed treatment plant, and it consist of flocculation basin and inlet/outlet chamber.
Its shape is 8.5 m×28.9 m rectangular and approximately 4.5 m height. The bottom of foundation is 2.5 m depth from the proposed ground level.
The design calculation is given with typical cross-section of the sedimentation basin, then stress of structure and sub-grade reaction has been checked.

2. Design Condition

2-1 Allowable Stress

1) Concrete (Design Strength σ_{28} = 210.0 kgf/cm^2)

a) Allowable Compressive Stress	σca =	70.0 kgf/cm^2
b) Allowable Shearing Stress	τa =	3.6 kgf/cm^2
c) Allowable Punching Shearing Stress	τa =	8.5 kgf/cm^2
d) Allowable Diagonal Tensile Stress	σta =	16.0 kgf/cm^2
(in case with diagonal tension bar)		
e) Allowable Bond Stress		
against Round Bar	τrba =	7.0 kgf/cm^2
against Deformed Bar	τdba =	14.0 kgf/cm^2

2) Reinforcement Bar (Material Specification SD295)

a) Allowable Tensile Stress	σsa =	1800 kgf/cm^2

2-2 Load

1) Unit Weight		
a) Concrete	γc =	2.5 tf/m^3
b) Soil	γc =	1.8 tf/m^3
2) Wind Load	qw =	0.12 tf/m^2
3) Ground Surcharge		
a) Usual	q_1 =	1.0 tf/m^2
b) Seismic	q_2 =	0 tf/m^2
4) Surcharge for Structure	q_3 =	0.1 tf/m^2
5) Impact Coefficient	i =	30 %

2-3 Seismic Coefficient

a) Horizontal Seismic Coefficient	Kh =	0.2
b) Vertical Seismic Coefficient	Kv =	0.1

2-4 Soil Condition

1) Sub-ground

a) Unit Weight $\gamma c =$ 1.5 tf/m^3

b) Angle of Internal friction $\phi =$ 0 °

c) Cohesion $C =$ 1.0 tf/m^3

2) Backfill Soil Material

a) Unit Weight $\gamma c =$ 1.8 tf/m^3

b) Angle of Internal friction $\phi =$ 30 °

c) Cohesion $C =$ 0 tf/m^3

d) Usual Active Coefficient of Earth Pressure ; K_A

$\phi = 30°$, $\alpha = 0°$, $\delta = \phi / 3 = 10°$, $\theta = 0°$

$$K_A = \frac{\cos^2(\phi-\theta)}{\cos^2\theta \cos(\theta+\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\alpha)}{\cos(\theta+\delta)\cos(\theta-\alpha)}}\right]^2}$$

$K_A =$ 0.308

e) Usual Passive Coefficient of Earth Pressure ; K_P

$\phi = 30°$, $\alpha = 0°$, $\delta = \phi / 3 = 10°$, $\theta = 0°$

$$K_P = \frac{\cos^2(30+0)}{\cos^2 0 \cos(0+10)\left[1-\sqrt{\frac{\sin(30-10)\sin(30+0)}{\cos(0+10)\cos(0-0)}}\right]^2}$$

$K_P =$ 2.238

f) Seismic Active Coefficient of Earth Pressure ; K_{EA}

$\phi = 30°$, $\alpha = 0°$, $\theta = 0°$, $\delta_E = 0°$, $\theta_0 = \tan^{-1} Kh = \tan^{-1}(0.2) = 11.3°$

$$K_{EA} = \frac{\cos^2(\phi-\theta_0-\theta)}{\cos\theta_0 \cos^2\theta \cos(\theta+\theta_0+\delta_E)\left[1+\sqrt{\frac{\sin(\phi+\delta_E)\sin(\phi-\alpha-\theta_0)}{\cos(\theta+\theta_0+\delta_E)\cos(\theta-\alpha)}}\right]^2}$$

$K_{EA} =$ 0.473

g) Seismic Passive Coefficient of Earth Pressure ; K_{EP}

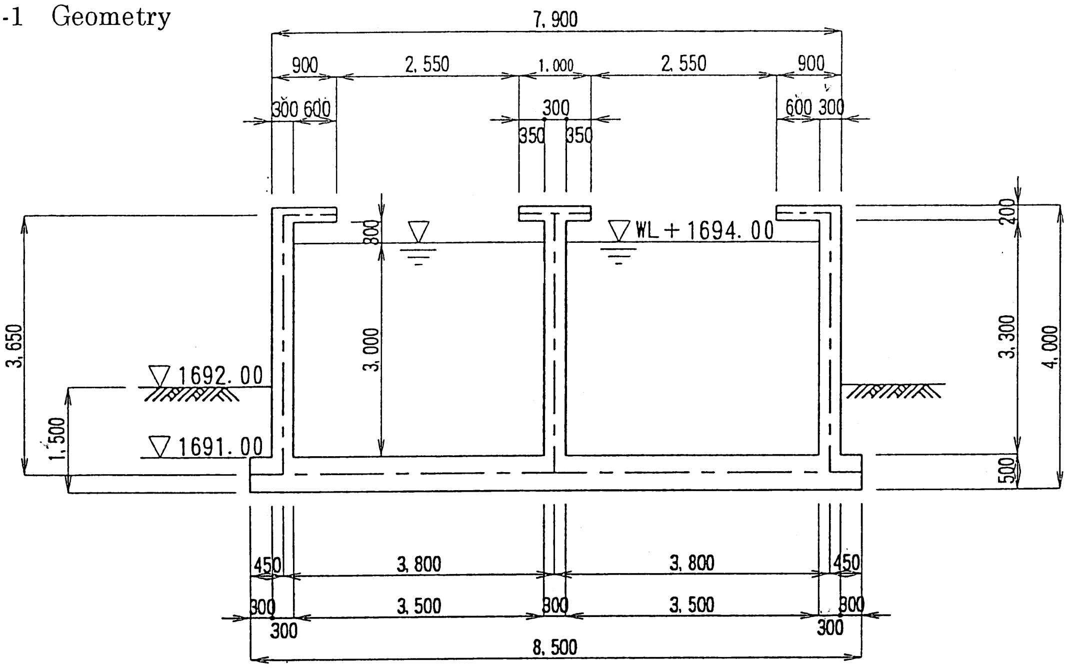
$\phi = 30°$, $\alpha = 0°$, $\theta = 0°$, $\delta_E = 0°$, $\theta_0 = \tan^{-1} Kh = \tan^{-1}(0.2) = 11.3°$

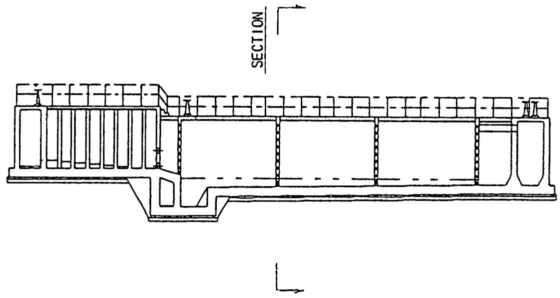
$$K_{EP} = \frac{\cos^2(\phi-\theta_0+\theta)}{\cos\theta_0 \cos^2\theta \cos(\theta-\theta_0+\delta_E)\left[1-\sqrt{\frac{\sin(\phi-\delta_E)\sin(\phi+\alpha-\theta_0)}{\cos(\theta-\theta_0+\delta_E)\cos(\theta-\alpha)}}\right]^2}$$

$K_{EP} =$ 2.692

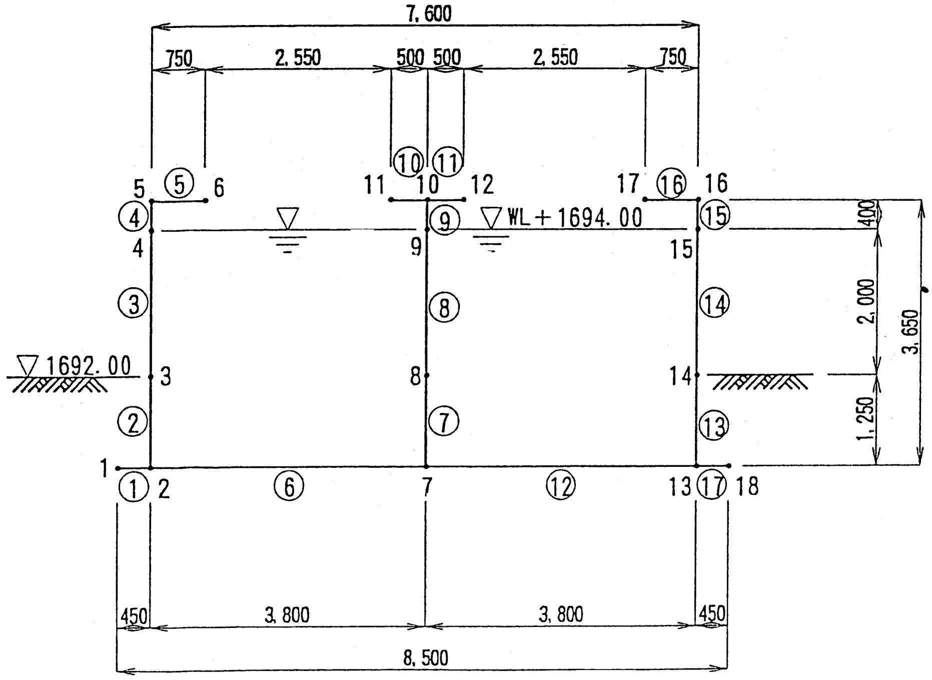
3. Sectional Dsign

3-1 Geometry





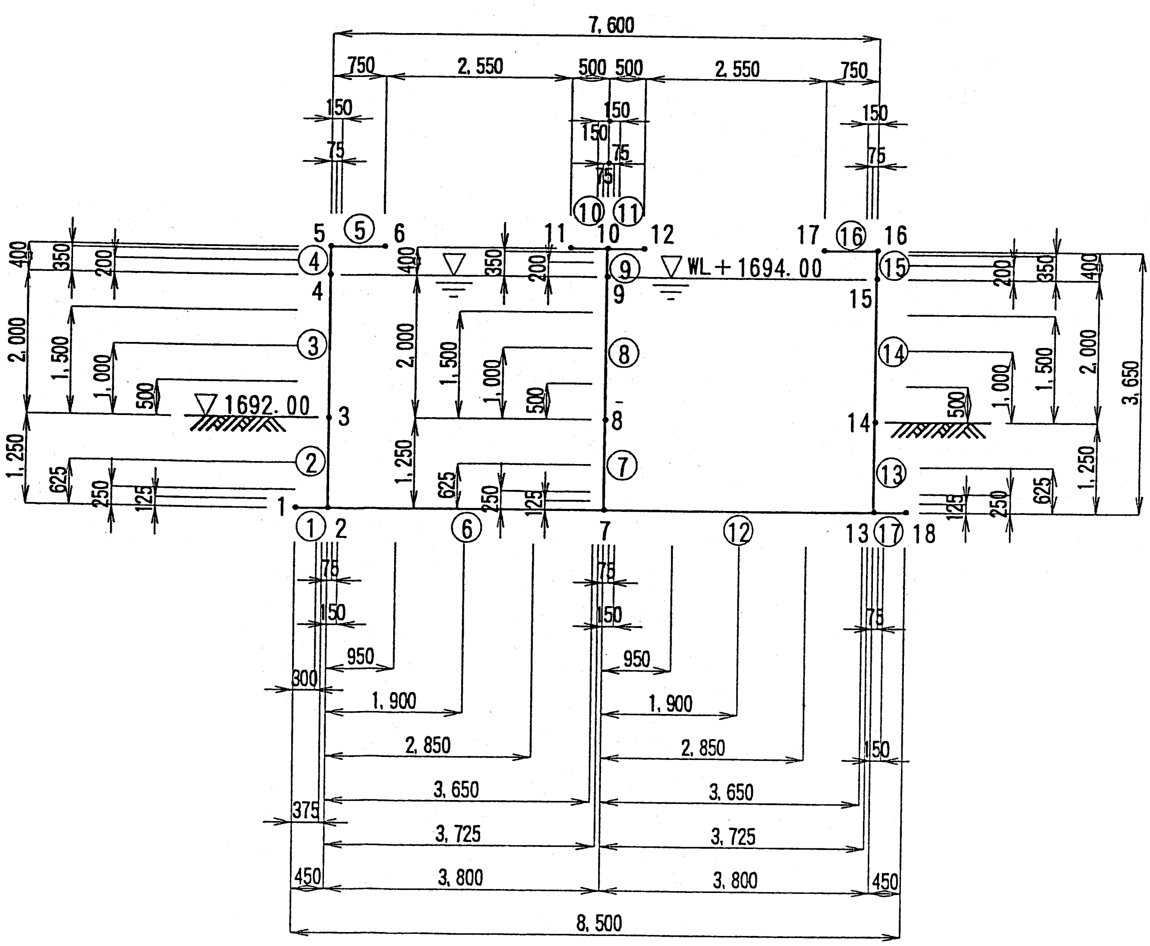
3-2 Calculation Frame



(Coordinates of nodal point)

No	X	Y	No	X	Y
1	0.000	0.000	11	3.750	3.650
2	0.450	0.000	12	4.750	3.650
3	0.450	1.250	13	8.050	0.000
4	0.450	3.250	14	8.050	1.250
5	0.450	3.650	15	8.050	3.250
6	1.200	3.650	16	8.050	3.650
7	4.250	0.000	17	7.300	3.650
8	4.250	1.250	18	8.500	0.000
9	4.250	3.250	19		
10	4.250	3.650	20		

(Attention Point)



3-3 Cross-section Property of Member

Member ①, ⑥, ⑫, ⑰

$A = 0.500 \times 1.000 = 0.500\ m^2$

$I = \frac{1}{12} bH^3 = \frac{1}{12} \times 1.000 \times 0.500^3 = 0.01042\ m^4$

$E = 2.35 \times 10^6 = 2.35 \times 10^6\ tf/m^2$

$W = 0.500 \times 2.50 = 1.250\ tf/m$

$H = W \times 0.200 = 0.250\ tf/m$

Member ②, ③, ④, ⑦, ⑧, ⑨, ⑬, ⑭, ⑮

$A = 0.300 \times 1.000 = 0.300\ m^2$

$I = \frac{1}{12} bH^3 = \frac{1}{12} \times 1.000 \times 0.300^3 = 0.00225\ m^4$

$E = 2.35 \times 10^6 = 2.35 \times 10^6\ tf/m^2$

$W = 0.300 \times 2.50 = 0.750\ tf/m$

$H = W \times 0.200 = 0.150\ tf/m$

Member ⑤, ⑩, ⑪, ⑯

$A = 0.200 \times 1.000 = 0.200\ m^2$

$I = \frac{1}{12} bH^3 = \frac{1}{12} \times 1.000 \times 0.200^3 = 0.000667\ m^4$

$E = 2.35 \times 10^6 = 2.35 \times 10^6\ tf/m^2$

$W = 0.200 \times 2.50 = 0.500\ tf/m$

$H = W \times 0.200 = 0.100\ tf/m$

3-4 Load Calculation and Loading Case

(1) Horizontal Load

1) Horizontal Earth Pressure

Usual

$Ph = (q + \gamma \cdot z) K_A$

$Ph_0 = (1.0 + 1.8 \times 0.000) \times 0.308 = 0.308$ tf/m^2

$Ph_1 = (1.0 + 1.8 \times 1.250) \times 0.308 = 1.001$ tf/m^2

Seismic

$Ph_E = \gamma \cdot z \cdot K_{Ea}$

$Ph_{E0} = 1.8 \times 0.000 \times 0.473 = 0.000$ tf/m^2

$Ph_{E1} = 1.8 \times 1.250 \times 0.473 = 1.064$ tf/m^2

2) Hydraulic Pressure

Hydrostatic Pressure $h = 1694 - 1691 = 3.0$ m

$P_{hw} = 1.0 \times 3.0 = 3.0$ tf/m^2

Dynamic Water Pressure

$$P = \frac{7}{12} Kh \cdot Wo \cdot b \cdot h^2$$

$$= \frac{7}{12} \times 0.2 \times 1.0 \times 1.00 \times 3.00^2 = 1.050 \text{ tf}$$

$$hg = \frac{2}{5} h$$

$$= \frac{2}{5} \times 3.000 = 1.20 \text{ m}$$

$$h = 1.200 + 0.250 = 1.45 \text{ m}$$

(2) Vertical Load

1) Soil Load

$w = 1.0 \times 1.8 \times 1.000 = 1.80$ tf/m

2) Live Load 1.000 tf/m^2

(3) Basic Loading Case

Case-1. Non inner water pressure ＋ Live load

Case-2. Inner water pressure (both side)＋Live load

Case-3. Inner water pressure (single side)＋Live load

Case-4. Non inner water pressure ＋ Seismic load

Case-5. Inner water pressure (both side)＋Seismic load

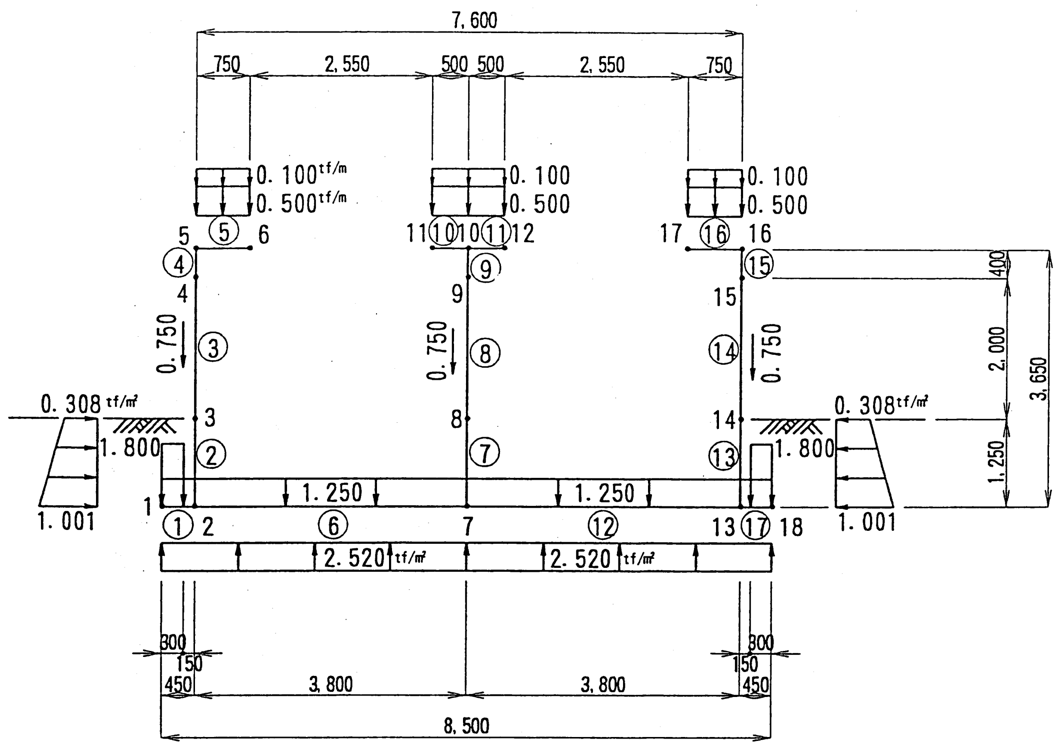
Case-6. Inner water pressure (single side)＋Seismic load

Case-7. { Non inner water pressure ＋ Seismic load }／1.5 (Conversion to usual)

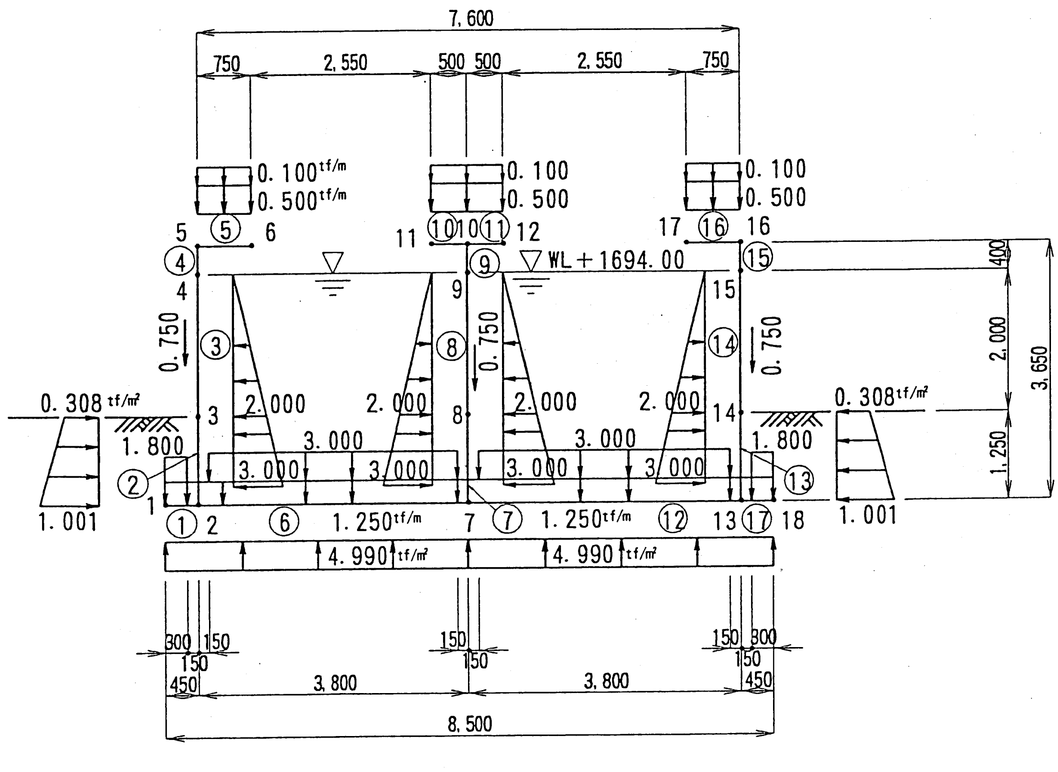
Case-8. { Inner water pressure (both side)＋Seismic load }／1.5 (Conversion to usual)

Case-9. { Inner water pressure (single side)＋Seismic load }／1. (Conversion to usual)

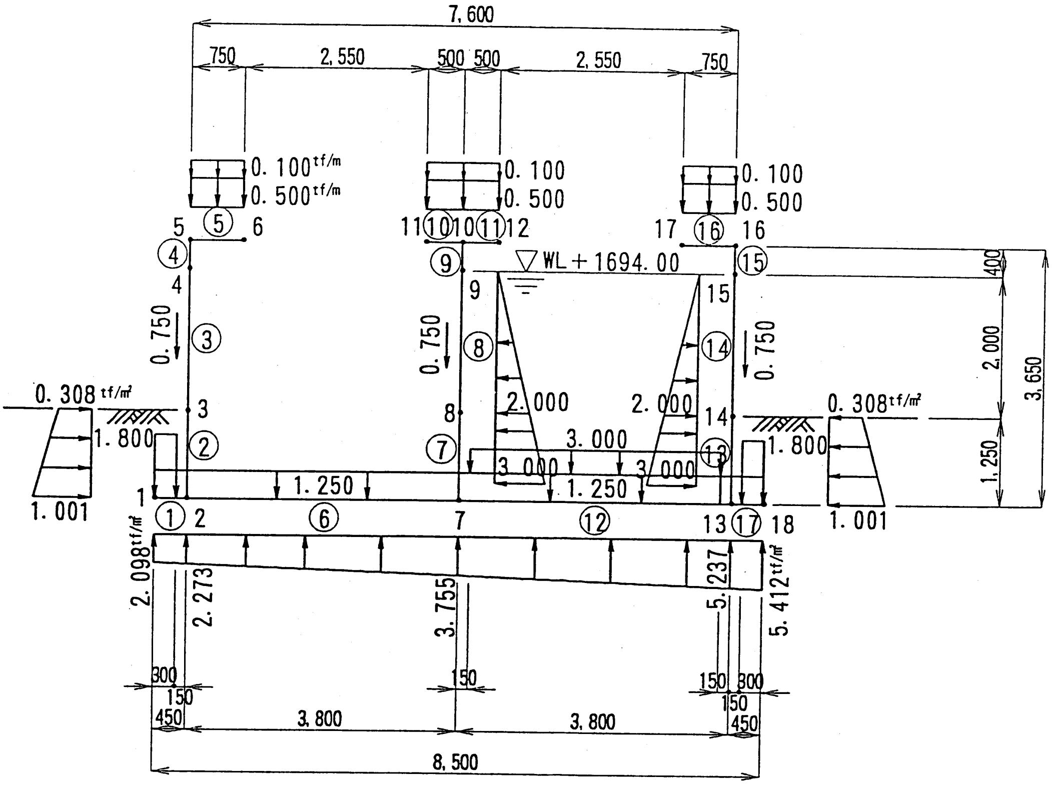
Case-1.　Non inner water pressure ＋ Live load



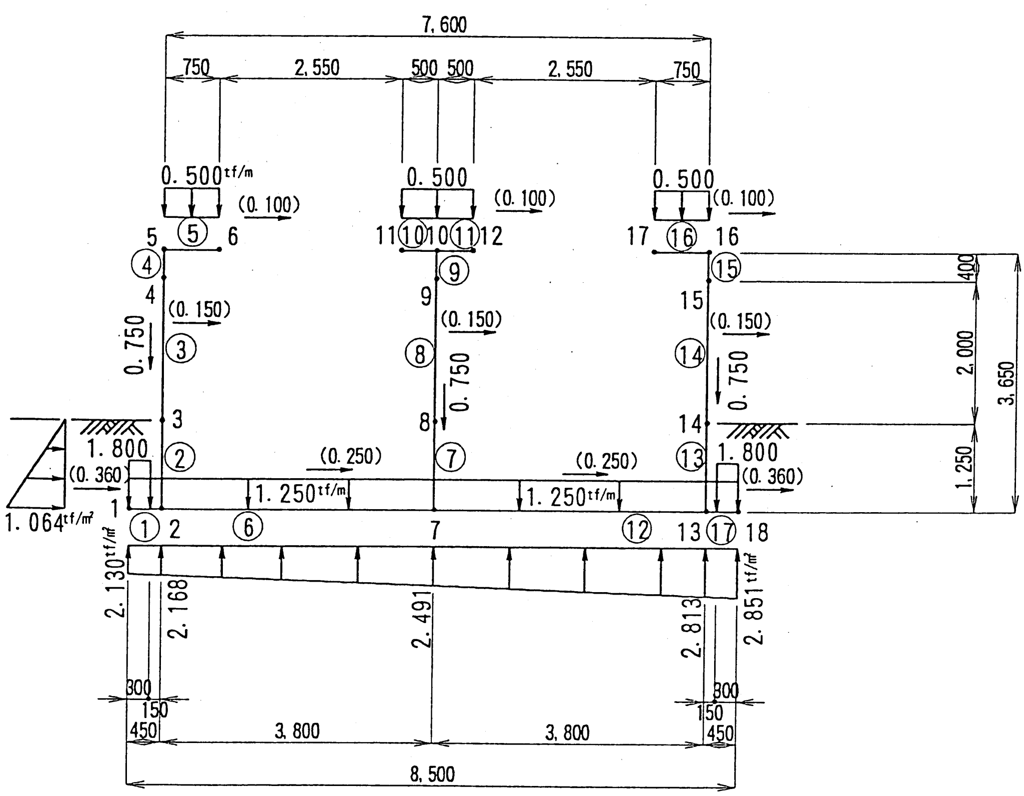
Case-2.　Inner water pressure (both side)＋Live load



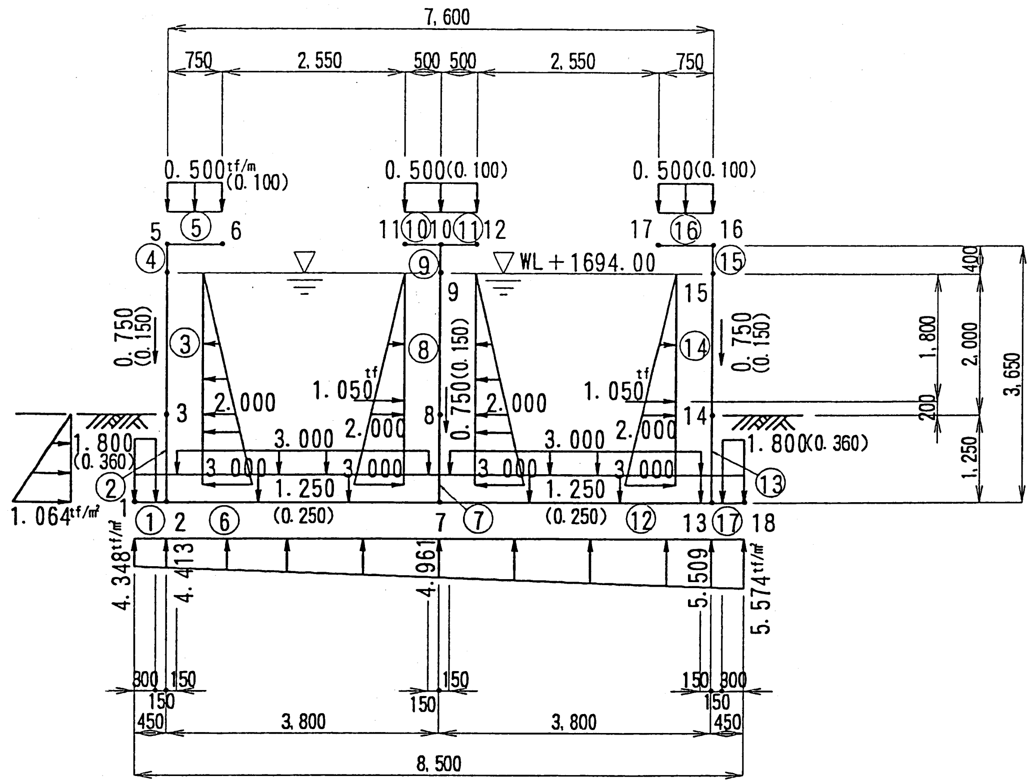
Case-3. Inner water pressure (single side)+Live load



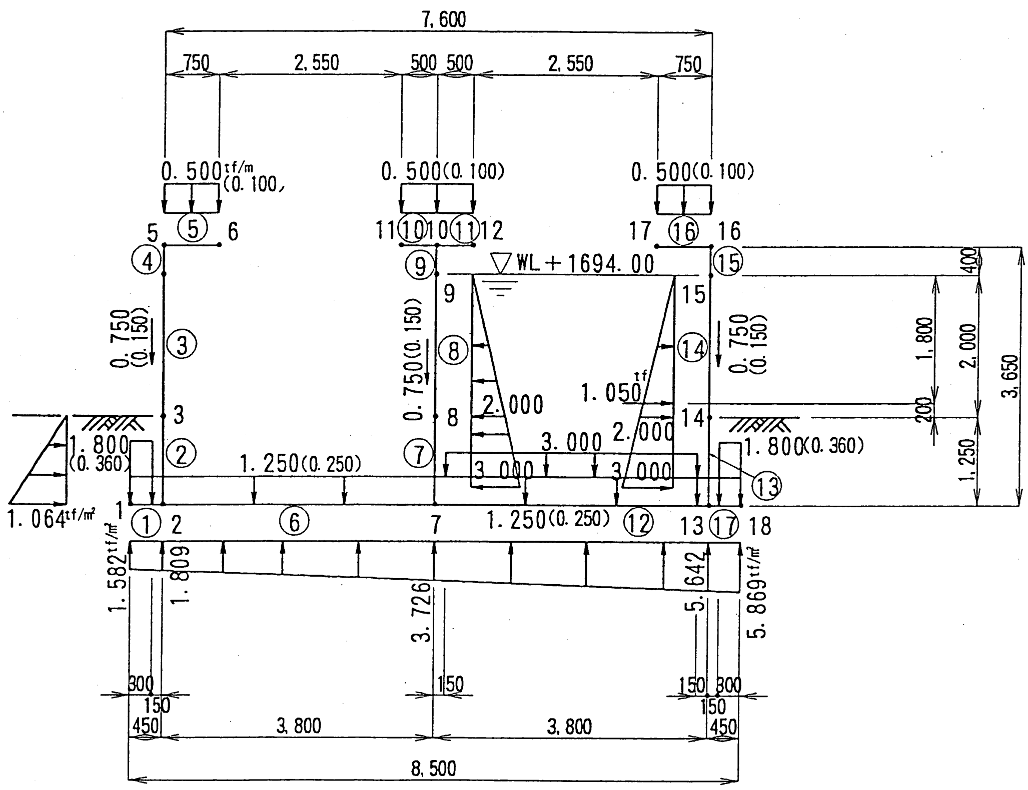
Case-4. Non inner water pressure + Seismic load



Case-5. Inner water pressure (both side)+Seismic load



Case-6. Inner water pressure (single side)+Seismic load



3-5 Calculation and Check of Subgrade Reaction

Case-1. Non inner water pressure ＋ Live load

1) Force, arm length and moment for bottom of base slab

Element/External force	V(tf)	X(m)	Mx (t•m)	H(tf)	Y(m)	Hy (t•m)
0.6×2.5 (Top slab)	1.500	4.250	6.375			
0.75×3.65×3 (Wall)	8.213	4.250	34.905			
1.0×0.3×2 (Backfilling Soil)	1.080	4.250	4.590			
8.500×1.250 (Base Slab)	10.625	4.250	45.156			
Total	21.418		91.026			

2) Arm length to vertical application point

$$x = \frac{Mx}{V} = \frac{91.026}{21.418} = 4.250 \text{ m}$$

3) Length from application point to center of structure

$$d = \frac{Mx + Hy}{V} = \frac{91.026 + 0.000}{21.418} = 4.250$$

4) Eccentricity

$$|e| = \frac{B}{2} - d = \frac{8.5}{2} - 4.250 = \mathbf{0} \text{ m} < \frac{B}{6} = \mathbf{1.417} \text{ m} \quad \text{OK}$$

5) Subgrade reaction

$$q = \frac{V}{A}\left(1 \pm \frac{6e}{B}\right) = \frac{21.418}{8.500}\left(1 \pm \frac{6 \times 0.000}{8.500}\right)$$

$$= 2.52 \text{ tf/m}^2 < Qa = 20.0 \text{ tf/m}^2 \quad \text{OK}$$

Case-2. Inner water pressure (both side)+Live load

1) Force, arm length and moment for bottom of base slab

Element/External force	V(tf)	X(m)	Mx (t·m)	H(tf)	Y(m)	Hy (t·m)
0.6×2.5 (Top slab)	1.500	4.250	6.375			
0.75×3.65×3 (Wall)	8.213	4.250	34.905			
1.0×0.3×2 (Backfilling Soil)	1.080	4.250	4.590			
8.500×1.250 (Base Slab)	10.625	4.250	45.156			
3.000×3.500×2 (Inner Water Pressure)	21.000	4.250	89.250			
Total	42.418		180.276			

2) Arm length to vertical application point

$$x = \frac{Mx}{V} = \frac{180.276}{42.418} = 4.250 \text{ m}$$

3) Length from application point to center of structure

$$d = \frac{Mx + Hy}{V} = \frac{180.276 + 0.000}{42.418} = 4.250$$

4) Eccentricity

$$|e| = \frac{B}{2} - d = \frac{8.5}{2} - 4.250 = \mathbf{0} \text{ m} < \frac{B}{6} = \mathbf{1.417} \text{ m} \quad \text{OK}$$

5) Subgrade reaction

$$q = \frac{V}{A}\left(1 \pm \frac{6e}{B}\right) = \frac{42.418}{8.500}\left(1 \pm \frac{6 \times 0.000}{8.500}\right)$$

$$= 4.99 \text{ tf/m}^2 < Qa = 20.0 \text{ tf/m}^2 \quad \text{OK}$$

Case-3. Inner water pressure (both side)+Live load

1) Force, arm length and moment for bottom of base slab

Element/External force	V(tf)	X(m)	Mx (t·m)	H(tf)	Y(m)	Hy (t·m)
0.6×2.5 (Top slab)	1.500	4.250	6.375			
0.75×3.65×3 (Wall)	8.213	4.250	34.905			
1.0×0.3×2 (Backfilling Soil)	1.080	4.250	4.590			
8.500×1.250 (Base Slab)	10.625	4.250	45.156			
3.000×3.500 (Inner Water Pressure)	10.500	6.150	64.575			
Total	31.918		155.601			

2) Arm length to vertical application point

$$x = \frac{Mx}{V} = \frac{155.601}{31.918} = 4.875 \text{ m}$$

3) Length from application point to center of structure

$$d = \frac{Mx + Hy}{V} = \frac{155.601 + 0.000}{31.918} = 4.875$$

4) Eccentricity

$$|e| = \frac{B}{2} - d = \frac{8.5}{2} - 4.875 = \mathbf{0.625} \text{ m} < \frac{B}{6} = \mathbf{1.417} \text{ m} \quad \text{OK}$$

5) Subgrade reaction

$$q = \frac{V}{A}\left(1 \pm \frac{6e}{B}\right) = \frac{31.918}{8.500}\left(1 \pm \frac{6 \times 0.625}{8.500}\right)$$

$$= 2.098 \text{ tf/m}^2 \quad \text{Or} \quad 5.412 \text{ tf/m}^2 < Qa = 20.0 \text{ tf/m}^2 \quad \text{OK}$$

Case-4. Non inner water pressure + Seismic load

1) Force, arm length and moment for bottom of base slab

Element/External force	V(tf)	X(m)	Mx (t·m)	H(tf)	Y(m)	Hy (t·m)
0.6×2.5 (Top slab)	1.250	4.250	5.313	0.250	3.650	0.913
0.75×3.65×3 (Wall)	8.213	4.250	34.905	1.643	1.825	2.998
1.80×0.3×2 (Backfilling Soil)	1.080	4.250	4.590	0.216	0.750	0.162
8.500×1.250 (Base Slab)	10.625	4.250	45.156	2.125	0.000	0.000
Earth pressure				0.665	0.417	0.277
Total	21.168		89.964	4.899		4.350

2) Arm length to vertical application point

$$x = \frac{Mx}{V} = \frac{89.964}{21.168} = 4.250 \text{ m}$$

3) Arm length to horizontal application point

$$y = \frac{Hy}{H} = \frac{4.350}{4.899} = 0.888 \text{ m}$$

4) Length from application point to center of structure

$$d = \frac{Mx + Hy}{V} = \frac{89.964 + 4.350}{21.168} = 4.455$$

5) Eccentricity

$$|e| = \frac{B}{2} - d = \frac{8.5}{2} - 4.455 = \mathbf{0.205} \ \mathbf{m} < \frac{B}{6} = \mathbf{1.417} \text{ m} \quad \text{OK}$$

6) Subgrade reaction

$$q = \frac{V}{A}\left(1 \pm \frac{6e}{B}\right) = \frac{21.168}{8.500}\left(1 \pm \frac{6 \times 0.205}{8.500}\right)$$

$$= 2.130 \text{ tf/m}^2 \text{ Or } 2.851 \text{ tf/m}^2 < Qa = 20.0 \text{ tf/m}^2 \quad \text{OK}$$

Case−5. Non inner water pressure ＋ Seismic load

1) Force, arm length and moment for bottom of base slab

Element/External force	V(tf)	X(m)	Mx (t・m)	H(tf)	Y(m)	Hy (t・m)
0.6×2.5 (Top slab)	1.250	4.250	5.313	0.250	3.650	0.913
0.75×3.65×3 (Wall)	8.213	4.250	34.905	1.643	1.825	2.998
1.80×0.3×2 (Backfilling Soil)	1.080	4.250	4.590	0.216	0.750	0.162
8.500×1.250 (Base Slab)	10.625	4.250	45.156	2.125	0.000	0.000
3.000×3.500×2 (Inner Water Pressure)	21.000	4.250	89.250			
Earth pressure				0.665	0.417	0.277
Dynamic water pressure 1				1.050	1.450	1.523
Dynamic water pressure 2				1.050	1.450	1.523
Total	42.168	4.250	179.214	6.999		7.396

2) Arm length to vertical application point

$$x = \frac{Mx}{V} = \frac{179.214}{42.168} = 4.250 \text{ m}$$

3) Arm length to horizontal application point

$$y = \frac{Hy}{H} = \frac{7.396}{6.999} = 1.057 \text{ m}$$

4) Length from application point to center of structure

$$d = \frac{Mx + Hy}{V} = \frac{179.214 + 7.396}{42.168} = 4.425$$

5) Eccentricity

$$|e| = \frac{B}{2} - d = \frac{8.5}{2} - 4.425 = \mathbf{0.175} \text{ m} < \frac{B}{6} = \mathbf{1.417} \text{ m} \quad \text{OK}$$

6) Subgrade reaction

$$q = \frac{V}{A}\left(1 \pm \frac{6e}{B}\right) = \frac{42.168}{8.500}\left(1 \pm \frac{6 \times 0.175}{8.500}\right)$$

$$= 4.348 \text{ tf/m}^2 \quad \text{Or} \quad 5.574 \text{ tf/m}^2 < Qa = 20.0 \text{ tf/m}^2 \quad \text{OK}$$

Case-6. Non inner water pressure + Seismic load

1) Force, arm length and moment for bottom of base slab

Element/External force	V(tf)	X(m)	Mx (t·m)	H(tf)	Y(m)	Hy (t·m)
0.6×2.5 (Top slab)	1.250	4.250	5.313	0.250	3.650	0.913
0.75×3.65×3 (Wall)	8.213	4.250	34.905	1.643	1.825	2.998
1.80×0.3×2 (Backfilling Soil)	1.080	4.250	4.590	0.216	0.750	0.162
8.500×1.250 (Base Slab)	10.625	4.250	45.156	2.125	0.000	0.000
3.000×3.500 (Inner Water Pressure)	10.500	6.150	64.575			
Earth pressure				0.665	0.417	0.277
Dynamic water pressure 1				1.050	1.450	1.523
Total	31.668		154.539	5.949		5.873

2) Arm length to vertical application point

$$x = \frac{Mx}{V} = \frac{154.539}{31.668} = 4.880 \text{ m}$$

3) Arm length to horizontal application point

$$y = \frac{Hy}{H} = \frac{5.873}{5.949} = 0.987 \text{ m}$$

4) Length from application point to center of structure

$$d = \frac{Mx + Hy}{V} = \frac{154.539 + 5.873}{31.668} = 5.065$$

5) Eccentricity

$$|e| = \frac{B}{2} - d = \frac{8.5}{2} - 5.065 = \mathbf{0.815} \text{ m} < \frac{B}{6} = \mathbf{1.417} \text{ m} \quad \text{OK}$$

6) Subgrade reaction

$$q = \frac{V}{A}\left(1 \pm \frac{6e}{B}\right) = \frac{31.668}{8.500}\left(1 \pm \frac{6 \times 0.815}{8.500}\right)$$

$$= 1.582 \text{ tf/m}^2 \quad \text{Or} \quad 5.869 \text{ tf/m}^2 < Qa = 20.0 \text{ tf/m}^2 \quad \text{OK}$$

3−6 Moment, Shear force and Axial force of the members

1) Summary of caluculation Result

Culculated by computer with a prpgram of optional shape frame analysis

Member	Attention Point	M(t·m) max	S(tf/m) max	N(tf/m) max	H(thick-ness of member) mm	Case No.	Position	Necessity of Culculation
1−2	2	0.141	0.862	0.000	500	C-2	Bottom slub	
2−3	1	4.567	-3.803	-3.094	466	C-2	Side wall	
2−7	1	-4.777	0.691	3.682	500	C-2	Bottom slub	
2−7	7	5.335	5.002	-0.818	500	C-3	Bottom slub	○
7−8	1	5.063	-4.500	-0.818	666	C-3	Center wall	○
7−13	1	3.605	-3.774	4.810	500	C-8	Bottom slub	
7−13	7	-5.639	-1.078	4.202	500	C-9	Bottom slub	○
13−14	1	-5.006	4.102	-2.012	666	C-9	Side wall	○

3−7 Bar arrangement, Stress caluculation result and Comparison to alowable stress

		Member			
	Unit	2-7	7-8	7-13	13-14
Section width	cm	100.0	100.0	100.0	100.0
Section height	cm	50.0	66.6	50.0	66.6
Max. Moment	t・m	5.34	5.06	5.64	5.06
Max. Shear	ton	0.0	0.82	0.0	2.01
Max. Axial Force	ton	5.00	4.50	1.08	4.10
Bar arrangement		D16-4	D16-4	D16-8	D16-4
		D16-8	D16-4	D16-8	D16-4
Amount of bar	cm^2	23.832	15.888	31.766	15.888
Neutral Axis	cm	11.5	10.9	11.4	11.5
Concrete					
Compressive Stress	kgf/cm^2	25.1	16.2	26.2	16.2
Comparison to σca = 70.0kgf/cm^2		OK	OK	OK	OK
Shear Stress	kgf/cm^2	1.25	0.76	0.27	0.69
Comparison to τa = 3.6kgf/cm^2		OK	OK	OK	OK
Reinforced Bar					
Tensil Stress	kgf/cm^2	933.4	1088.4	988.8	1014
Comparison to σsa = 1800kgf/cm^2		OK	OK	OK	OK

Appendix 14 *Cost Estimation Borne by the Recipient Country*

Appendix 14 Cost Estimation Borne by the Recipient Country

(1) PNG Water Board

[Unit : Kina]

	Year 2001	Year 2002	Year 2003	Total
Government subsidy→Water Board (Consultant supervision, temporary office, personnel costs, installation of water meters)	250,000	825,000	300,000	750,000
Government subsidy → Manus Province (Temporary running cost, land acquisition)	350,000	200,000	200,000	1,375,000
Budget of the Water Board (Expenses of the counterpart)	50,000	50,000	50,000	150,000
Total	650,000	1,075,000	550,000	2,275,000

(2) Goroka Urban Local Level Government

[Unit : Kina]

		Year 2001	Year 2002	Year 2003	Total
A	Government Budget Subsidy	Nil	Nil	Nil	
B	Provincial Government Budget	Nil	Nil	Nil	
C	GULLG Budget				
C-1	Land Acquisition	25,000	Nil	Nil	25,000
C-2	Power Extension	20,000	Nil	Nil	20,000
C-3	Access Road	10,000	Nil	Nil	10,000
C-4	Fencing	Nil	20,000	Nil	20,000
C-5	Personnel	30,000	30,000	30,000	90,000
C-6	Meter Installation	Nil	79,200	Nil	79,200
C-7	Public Information	5,000	5,000	5,000	15,000
C-8	Others	Nil	20,000	Nil	20,000
	Total	90,000	154,200	35,000	279,200

Appendix 15 *Reference*

Appendix 15 Reference

No.	TITLE / CONTENTS	ISSUED BY
1	Papua New Guinea Population Census	M.P.G
2	Education Sector	M.P.G
3	Organization Structure of M.P.G	M.P.G
4	Organization Structure of G.U.L.L.G	G.U.L.L.G
5	Financial Report of Income & Expenditure, 1998	G.U.L.L.G
6	Budget Report, 1999	G.U.L.L.G
7	Budget	G.U.L.L.G
8	Control, Supply & Management of Town Water Rule	G.U.L.L.G
9	Expenditure Transaction Details	M.P.G
10	Typhoid Investigations January 1999 – July 2000	M.P.G
11	Diarrhoea Cases / Diarrhoea Admission January 1999 – July 2000	M.P.G
12	PNG Water Board, Board Paper, Budget 2000	PNG Water Board
13	The economy of Papua New Guinea	AusAID
14	Economic & development policies	Ministry of treasury and corporate affairs
15	Quarterly economic bulletin, march 2000 issue	Bank of Papua New Guinea
16	Medium term development strategy 1997-2002	DNPM
17	Public Investment Program, volume 1	DNPM
18	Public Investment Program, volume 3	DNPM
19	Public Investment Program, supplementary budget – development	DNPM
20	National Health Plan 2001 – 2010, Health vision 2010	Ministry of health
21	Design manual	PNG Water Board
22	Goroka town sewage plan, Scale = 1:4,000	G.U.L.L.G
23	Goroka town water reticulation plan, Scale = 1:4,000	G.U.L.L.G
24	Topographic Survey Drawings (Water Treatment Plant)	G.U.L.L.G

Note) M.P.G: Manus Provincial Government, G.U.L.L.G: Goroka Urban Local Level Government