3-2 Operation and Maintenance Plan

(1) Organizations

The facilities to be provided by the Project shall be managed under control of TWB. O&M works also shall be carried out by TWB. To promote the leakage control program, another working team is to be organized within TWB in addition to the existing team.

(2) Operation and Maintenance Cost

Revenue and expenditure of fiscal year 2002/03 are forecast for Nuku'alofa water scheme as a status after the Project (refer to Table 3-3 for revenue and Table 3-4 for expenditure). Revenue is forecast on assumption that the water tariff would be kept as the same as the present tariff and the rate of accounted-for water be increased from the current 47% to 66.3% as a effect of the Project and TWB's leakage control. As for expenditure, that is forecast based on the annual expense of Nuku'alofa water scheme in 1998/99. Taking into reference of the past data such as TWB's financial report and inflation data, 8.0% is applied for annual increase rate of salary and 3.5% is for that of the other expenses.

Comparing the revenue and expenditure of year 2002/03, it is concluded that TWB can cover the necessary expenses for Operation and Maintenance of the facilities and keep a proper profit for management.

Table 3-3 Projection of Annual Revenue for Nuku'alofa Water Scheme after the Project

AFW Forecast	[A] Present Status 1998/99	[B] After Project 2002/03
1. Anuual Water Production	2,540,120 m³	2,382,720 m³
2. Rate of AFW*	47.0%	66.3%
3. AFW Volume (1×2)	1,193,856 m³	1,579,743 m³
Revenue Forecast		
4. Water Sales	T$ 1,344,933	T$ 1,777,126
5. Other Revenues	T$ 103,236	T$ 103,236
6. Total Revenue (4+5)	T$ 1,448,169	T$ 1,880,362

(Notes)
*AFW: Accounted-for Water
[A] : Present status of Nuku'alofa water scheme
[B] : Estimated status after the Project
[B1] = 6,528 m³/day x 365 days
[B2] = 47% + 19.3% (Leakage ratio would be reduced by 19%, from the current 34.3% to 15%)
[B3] = [B1] x [B2]
[B4] = [A4] + {([B3] - [A3]) x 0.00112 T$/litre} (same tariff would be applied as the present tariff)
[B5] = [A5] (assumed at the same level as the present status)

Table 3-4 Projection of Annual Expense for Nuku'alofa Water Scheme after the Project

	Present Status	After Project (2002/03)		
	[A] 1998/99	[B] 1999 Price	[C] Annual Inflation Rate	[D] 2003 Price
1. BOARD EXPENSES				
1-1 Board expenses	71,103	71,103	3.5%	81,592
Sub Total	71,103	71,103		81,592
2. CORPORATE SERVICE				
2-1 Salaries and wages	102,256	102,256	8.0%	139,118
2-2 Other expenses	132,735	132,735	3.5%	152,316
Sub Total	234,991	234,991		291,434
3. FINANCIAL SERVICES				
3-1 Salaries and wages	121,821	121,821	8.0%	165,736
3-2 Other expenses	57,261	57,261	3.5%	65,708
Sub Total	179,082	179,082		231,444
4. CREDIT AND STOCK CONTROL				
4-1 Salaries and wages	27,374	27,374	8.0%	37,242
4-2 Other expenses	2,529	2,529	3.5%	2,902
Sub Total	29,903	29,903		40,144
5. ENGINEERING SERVICES				
5-1 Salaries and wages	55,615	55,615	8.0%	75,664
5-3 Other expenses	22,600	22,600	3.5%	25,934
Sub Total	78,215	78,215		101,598
6. PRODUCTION SERVICES				
6-1 Salaries and wages	55,162	55,162	8.0%	75,047
6-2 Intake pump electricity	42,844	40,464	3.5%	46,433
6-3 Intake pump fuel	133,318	125,911	3.5%	144,486
6-4 Repair and maintenance	19,133	19,133	3.5%	21,956
6-5 Other expenses	35,772	35,772	3.5%	41,049
Sub Total	286,229	276,442		328,971
7. DISTRIBUTION AND CUSTOMER SERVICES				
7-1 Salaries and wages	58,280	58,280	8.0%	79,289
7-2 Repair and maintenance for pipes	10,133	60,000	3.5%	68,851
7-3 Maintenance cost for new vehicles	0	19,000	3.5%	21,803
7-4 Depreciation	58,160	329,080	3.5%	377,627
7-5 Other expenses	9,382	9,382	3.5%	10,766
Sub Total	135,955	475,742		558,336
8. WATER QUALITY				
8-1 Salaries and wages	14,107	14,107	8.0%	19,192
8-2 Chemical cost	9,762	12,086	3.5%	13,869
8-3 Dosing pump electricity	0	473	3.5%	543
8-4 Other expenses	6,612	6,612	3.5%	7,587
Sub Total	30,481	33,278		41,191
9. SPECIAL EXPENSES				
9-1 Special expenses	3,702	3,702	3.5%	4,248
Sub Total	3,702	3,702		4,248
Grand Total	1,049,659	1,382,458		1,678,958

(Notes)

[A] : Annual expense for Nuku'alofa Water Scheme in 1998/99 (Source: TWB Estimates of Revenue and Expenditure 1999-2000)

[B] : Estimated annual expense for Nuku'alofa Water Scheme in 1999 price

[C] : Annual inflation rate 8.0% for "Salaries and wages" on account of TWB's past trend of personnel cost
3.5% for other items with reference to Quarterly Bulletin 1999 (National Reserve Bank of Tonga)

[D] : Estimated annual expense for Nuku'alofa Water Scheme in 2003 price

$[D] = [B] \times (1.0 + [C])^{(2003-1999)}$

As most construction works of the Project are renovation of the existing pipeline, the expenses except the following items are assumed to be the same level as the present status.

[B6-2] = [A6-2] x 85%/90% (rate of operation would become 85% from the present 90%)

[B6-3] = [A6-3] x 85%/90% (rate of operation would become 85% from the present 90%)

[B7-2] = 0.5% x T$12,000,000 (estimated cost for materials and construction)

[B7-3] estimated by TWB

[B7-4] = T$300,000 (estimated for new facilities, life span 40 years) + T$58,160 / 2 (estimated for present PVC pipes)

[B8-2] = 0.7mg-Cl_2/L / 65% x 6,528m^3/d x 365days x 4.71T$/kg x 10^{-3}

[B8-3] = 0.2kW x 24hr x 365 days x 0.27T$/kWh

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATIONS

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATIONS

4-1 Project Effect

Project effects through the implementation are estimated as follows:

(1) Improvement of living conditions

In both eastern and western ends of the distribution network, water pressure is currently so low that residents can not receive water for about three hours a day during peak hours of water consumption. The average water consumption is presently estimated to be 30 ~ 50 l/c/d. By implementation of the Project, it will be possible to supply disinfected water for 24 hours continuously with proper water pressure. The average water supply volume will be increased up to 155 l/c/d. Sanitary and living conditions is expected to be improved consequently.

(2) Sustainable management of waterworks

The leakage ratio of the existing distribution pipes is 34.3 %. The leakage ratio will be reduced to 15 % by replacement of the distribution pipes of approx. 35 km and TWB's leakage control (TWB: Tonga Water Board). In consequence, annual revenue of the Nuku'alofa water scheme is estimated to be T$ 1.88 million. On the other hand, annual expenditure including depreciation cost, repair cost, etc., considering the rate of inflation is estimated at T$ 1.68 million. Accordingly, it is turned out that the expenditure can be covered by the estimated revenue without revision of the current tariff. To secure the budget for repairing and depreciation will contribute to financial soundness of TWB, which will realize sustainable management of the waterworks.

(3) Conservation of groundwater resource

Water demand in 2003 will be covered through water leakage reduction under the Project. Therefore, groundwater will not be newly developed in the Project. So far, tendency of salination is not observed, since the pumping discharge and recharge volume are in balance. However, chloride ion contents slightly increased in the past when groundwater source was newly developed. Further groundwater development might lead to lose the balance of saline water and freshwater. To keep the groundwater source undeveloped, therefore, largely contributes to the environment through groundwater conservation.

4-2 Technical assistance and cooperation with other donors

Support from Australia to Nuku'alofa water supply will be completed in 1999. No succeeding project by the other donor is scheduled as of now.

4-3 Recommendations

Followings are recommended for TWB to execute stable water supply both in quantity and quality, and to operate the facilities properly:

(1) Monitoring of water source

Groundwater resource is under control of the Ministry of Land, Survey and Natural Resource (MLSNR). At present, the Ministry conducts the monitoring of the groundwater level as well as groundwater quality. It is necessary to continue the groundwater monitoring in order to prevent salination of groundwater. Particularly, it is important to investigate and monitor carefully in future development of water source. Therefore, it is recommended for TWB to set up a practical groundwater monitoring system by cooperation with MLSNR.

There is a possibility that in the waste disposal field of the city, sewage from rainfall and waste might permeates into the ground to contaminate the groundwater. Besides the monitoring of groundwater quality, periodical measurement of property and quantity of the leachate are required. To perform the leachate measurement, it is necessary to cooperate with the Ministry of Health.

(2) Promotion of leakage control program

Leakage control program of this Project includes the leakage reduction of polyvinyl chloride (PVC) pipelines to be conducted by the TWB. According to the TWB's implementation schedule, the leakage ratio of PVC pipelines will be reduced from 26.3 % to 20 % by the year 2003. In order to achieve the Project effect, execution of the leakage control program is necessary. In addition, continuous leakage control activities are necessary to keep the leakage ratio at small level, since the leakage ratio increases with lapse of the years by nature.

(3) Improvement of accounted-for water

The Project will increase accounted-for water from 47 % to 66.3 % by reduction of leakage ratio. Yet, administrative loss is about 19 %. Training of water meter readers and replacement of malfunctioned water meters are recommended for reduction of administrative loss so as to increase the water sales furthermore.

(1) Countermeasure against oil leakage from intake pump facilities

In order to prevent groundwater pollution by spilt oil from diesel engines of intake facilities, TWB changes the flooring types of some intake pump houses to the one that prevents oil from permeating into the ground and also build the intake houses that isolate the intake pump and the engine. So far groundwater pollution is not observed. But it is necessary to take such countermeasures to prevent accidental groundwater pollution by oil spilling.

APPENDIX 1 LIST OF SURVEY TEAM

Appendix 1 Member List

Member List of the Basic Design Study Team

1.	Mr. Yoshiki Omura	Team Leader	Water Supply Development Specialist, Institute for International Cooperation, JICA
2.	Mr. Tsutomu Tanaka	Project Coordinator	Fourth Project Management Division, Grant Aid Management Department, JICA
3.	Mr. Toshifumi Okaga	Water Supply Planner	Pacific Consultants International
4.	Mr. Hideki Yamazaki	Pipeline Planner	Hokkaido Engineering Consultants
5.	Mr. Shunichi Nakatake	Water Supply Facilities Planner	Pacific Consultants International
6.	Mr. Ko Umezawa	Leakage Control Expert	Hokkaido Engineering Consultants
7.	Mr. Yusuke Oshika	Hydrogeologist	Pacific Consultants International
8.	Mr. Naoto Tohda	Procurement /Cost Estimator	Pacific Consultants International

Member of the Explanation Team for the Draft Basic Design

1.	Mr. Noriaki Niwa	Team Leader	Deputy Resident Representative, Australia Office, JICA
2.	Mr. Toshifumi Okaga	Water Supply Planner	Pacific Consultants International
3.	Mr. Hideki Yamazaki	Pipeline Planner	Hokkaido Engineering Consultants
4.	Mr. Naoto Tohda	Procurement /Cost Estimator	Pacific Consultants International

APPENDIX 2 ITINERARY OF STUDY TEAM

Appendix – 2 Itinerary

Itinerary of the Basic Design Study

No	Date		Activities		
			Omura / Tanaka	Okaga / Yamazaki / Oshika	
1	6 June	Sun	From Tokyo to Auckland		
2	7 June	Mon	From Auckland to Tongatapu		
3	8 June	Tue	AM : JICA office, Ministry of Foreign Affairs, Central Planning Department PM : Tonga Water Board(TWB), Explanation of Inception Report		
4	9 June	Wed	Site survey, Discussion on the result of site survey		
5	10 June	Thu	Discussion on result of the site survey		
6	11 June	Fri	Discussion on Minutes of Discussion		
7	12 June	Sat	Inner meeting, Site survey		
8	13 June	Sun	Inner meeting, Data arrangement		
9	14 June	Mon	Signing of Minutes of Discussion		
10	15 June	Tue	From Tongatapu to Nadi	Data collection (TWB)	
11	16 June	Wed	Report to Embassy of Japan and JICA office	Data collection	Umezawa / Toda
12	17 June	Thu	From Nadi to Tokyo	Site survey	From Tokyo to Nadi
13	18 June	Fri		Discussion with TWB	Survey on procurement plan for O&M equipment
14	19 June	Sat		Inner meeting	From Nadi to Tongatapu
15	20 June	Sun		Inner meeting, Site survey	
16	21 June	Mon		Discussion with TWB	
17	22 June	Tue		Site survey	
18	23 June	Wed		Site survey	
19	24 June	Thu		Site survey	
20	25 June	Fri		Site survey	
21	26 June	Sat		Inner meeting	
22	27 June	Sun		Inner meeting, Data arrangement	
23	28 June	Mon		Discussion with TWB	
24	29 June	Tue		Site survey	
25	30 June	Wed		Site survey	
26	1 July	Thu		Site survey	
27	2 July	Fri		Site survey	
28	3 July	Sat		Inner meeting	
29	4 July	Sun		Inner meeting, Data arrangement	
30	5 July	Mon		Discussion with TWB	
31	6 July	Tue		Site survey	
32	7 July	Wed	Nakatake	Site survey	
33	8 July	Thu	Leave from Tokyo	Site survey	
34	9 July	Fri	Arrival at Nadi	Site survey	
35	10 July	Sat	From Nadi to Tongatapu	Inner meeting, Data arrangement	
36	11 July	Sun	Inner meeting		
37	12 July	Mon	Discussion with TWB		
38	13 July	Tue	Site survey		
39	14 July	Wed	Discussion on Technical Notes		
40	15 July	Thu	Discussion on Technical Notes		
41	16 July	Fri	Signing on Technical Notes		
42	17 July	Sat	Inner meeting		
43	18 July	Sun	Inner meeting, Data arrangement		
44	19 July	Mon	Supplemental Study		
45	20 July	Tue	From Tongatapu to Nadi		
46	21 July	Wed	Report to Embassy of Japan and JICA office		
47	22 July	Thu	From Nadi to Tokyo		

Itinerary of Explanation for the Draft Basic Design

No	Date		Activities	
			Niwa	Okaga / Yamazaki / Toda
1	25 Oct	Mon		From Tokyo to Nadi
2	26 Oct	Tue		From Nadi to Tongatapu
3	27 Oct	Wed		AM : JICA office, Ministry of Foreign Affairs, Central Planning Department PM : Tonga Water Board(TWB), Explanation of Draft Basic Design Report
4	28 Oct	Thu	From Nadi to Tongatapu	Discussion on Draft Basic Design Report
5	29 Oct	Fri	Discussion on Minutes of Discussion (M/D)	
6	30 Oct	Sat	Inner Meeting	
7	31 Oct	Sun	Data Arrangement	
8	1 Nov	Mon	Signing of M/D	
9	2 Nov	Tue	Field Survey, Travel (From Tongatapu to Nadi)	
10	3 Nov	Wed	Report to Embassy of Japan and JICA office	
11	4 Nov	Thu	From Nadi to Sidney	From Nadi to Tokyo

APPENDIX 3 LIST OF OFFICERS CONCERNED

Appendix 3 List of Officers Concerned

Officers Concerned of Japan

1. Embassy of Japan , Fiji Office

Mr. Hisato Murayama	Ambassador
Mr. Tsuguyoshi Hada	First Secretary
Mr. Yukifumi Ikki	Second Secretary

2. JICA Fiji Office

Mr. Tadanori Suzuki	Resident Representative
Mr. Kyoji Mizutani	Deputy Resident Representative
Mr. Hiroyuki Sawada	Assistant Resident Representative

3. JICA / JOCV Tonga Office

Mr. Hiroji Yamaguchi	Resident Representative
Ms. Hiroko Oka Tu'umoto'oa	Programme Officer
Mr. Masahiro Ishikawa	Coordinator of JOCV
Ms. Yumi Kimura	Coordinator of JOCV

Officers Concerned of Tonga

1. Tonga Water Board

Mr. Saimone P. Helu	General Manager
Mr. Mosse K. Latu	Chief Administrative Officer
Ms. Lesieli Niu	Chief Engineer
Mr. Malakai J. Vakasiuola	Chief Distribution Officer
Mr. Lisiate Bloonfield	Chief Production Officer
Mr. Harvard Tupouniua	Chief Accountant
Mr. Nafe Tufui	Leakage Control Engineer

2. Ministry of Foreign Affairs

Ms. Viela Tupou	Acting Vice Minister
Mr. Tevita Kolokihakaufisi	Desk Officer of Japan, International Cooperation Department

3. Central Planning Department

Mr. Tavita Paula Lavulo	Director General
Ms. Carorine Tupouahi Fusimalohi	Acting Director of Planning
Mr. Tatafu Moeahi	Economist, Desk Officer of Japan
Ms. Lupeolo Ofa	Economist
Mr. Viliami Uava'a	Population Planning Department
Mr. Ofa Fatukala	Councilor

4. Ministry of Works

Hon. Semisi Sesolo Koka	Minister
Mr. Sione M. Taumoepeau	Director of Works

5. Ministry of Lands, Survey and Natural Resources

Mr. Paula Taufa	Director of Environmental Department
Mr. Kelepi Maki	Director of Geology Institute

6. Ministry of Health

Mr. Lelea Tuifupou	Director of Health Department

7. Ministry of Police

Mr. Fateki Tupou	Acting Director of Fire Station

8. AusAID

Mr. Graham White	Team Leader, TWB Institutional Strengthening Programme
Mr. Tony Falkland	Leakage Control Specialist, TWB Institutional Strengthening Programme

APPENDIX 4 MINUTES OF DISCUSSIONS

MINUTES OF DISCUSSIONS
BASIC DESIGN STUDY ON THE PROJECT
FOR NUKU'ALOFA WATER SUPPLY
IN THE KINGDOM OF TONGA

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

JICA sent to the Kingdom of Tonga (hereinafter referred to as "Tonga") the Basic Design Study Team (hereinafter referred to as "the Team"), headed by Mr. Yoshiki Omura, Development Specialist, Institute for International Cooperation, JICA, and is scheduled to stay in the country from 6th June to 14th June 1999.

The team held discussions with the officials concerned of the Government of the Tonga, and conducted field survey at the study area.

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

Nuku'alofa, 14th June, 1999

Mr. Yoshiki Omura
Leader,
Basic Design Study Team,
JICA

Mr. Saimone P. Helu
Manager,
Tonga Water Board
The Kingdom of Tonga

ATTACHMENT

1. Objective of the Project

The objective of the Project is to improve living standards of the Nuku'alofa residents by means of improvement of water supply service.

2. Project Site of Japan's Grant Aid (hereinafter referred as to "the Site")

The project site is located in Nuku'alofa. The location of the project site is shown in ANNEX I.

3. Responsible and Executing Agency on Tonga Side

The Responsible and Implementing Agency for executing of the Project is Tonga Water Board.

4. Items requested for Japan's Grant Aid by the Kingdom of Tonga

The items described in ANNEX-II are requested by Tonga side. JICA will assess the appropriateness of the request and will recommend to the Government of Japan for approval.

5. Japan's Grant Aid System

1) The Government of Tonga has understood the system of Japan's Grant Aid on ANNEX III as explained by the Team.
2) The Government of Tonga will take necessary measures, as described in ANNEX IV for the smooth implementation of the Project on condition that the Japan's Grant Aid is extended to the Project.

6. Schedule of the Study

1) The consultants will proceed to further studies in Tonga until 20th July, 1999.

2) JICA will prepare a draft report in English and dispatch a mission in order to explain its contents in October 1999.

3) In case that the contents of the report is accepted in principle by the Government of Tonga, JICA will complete the final report and send it to the Government of Tonga in January 2000.

7. Other Relevant Issues

Both sides discussed and agreed to the following subjects:

1) The target year of the project is to be the year 2003.

2) The distribution would be of gravity-flow system. The whole service area would be hydraulically divided into two distribution blocks. Both blocks will be supplied from the existing outlet, located at Mataki'eua. The requested elevated tanks shall remain until further consideration at the conclusion of the study.

3) All the existing asbestos cement pipes (ACP) shall be assessed for prioritization for replacement and upgrading.

4) The necessity of the additional wells required shall be reviewed through study on balance of water demand forecast and production capacity of the existing wells with the sustainable use of the very limited water resource and prevention of salinity intrusion.

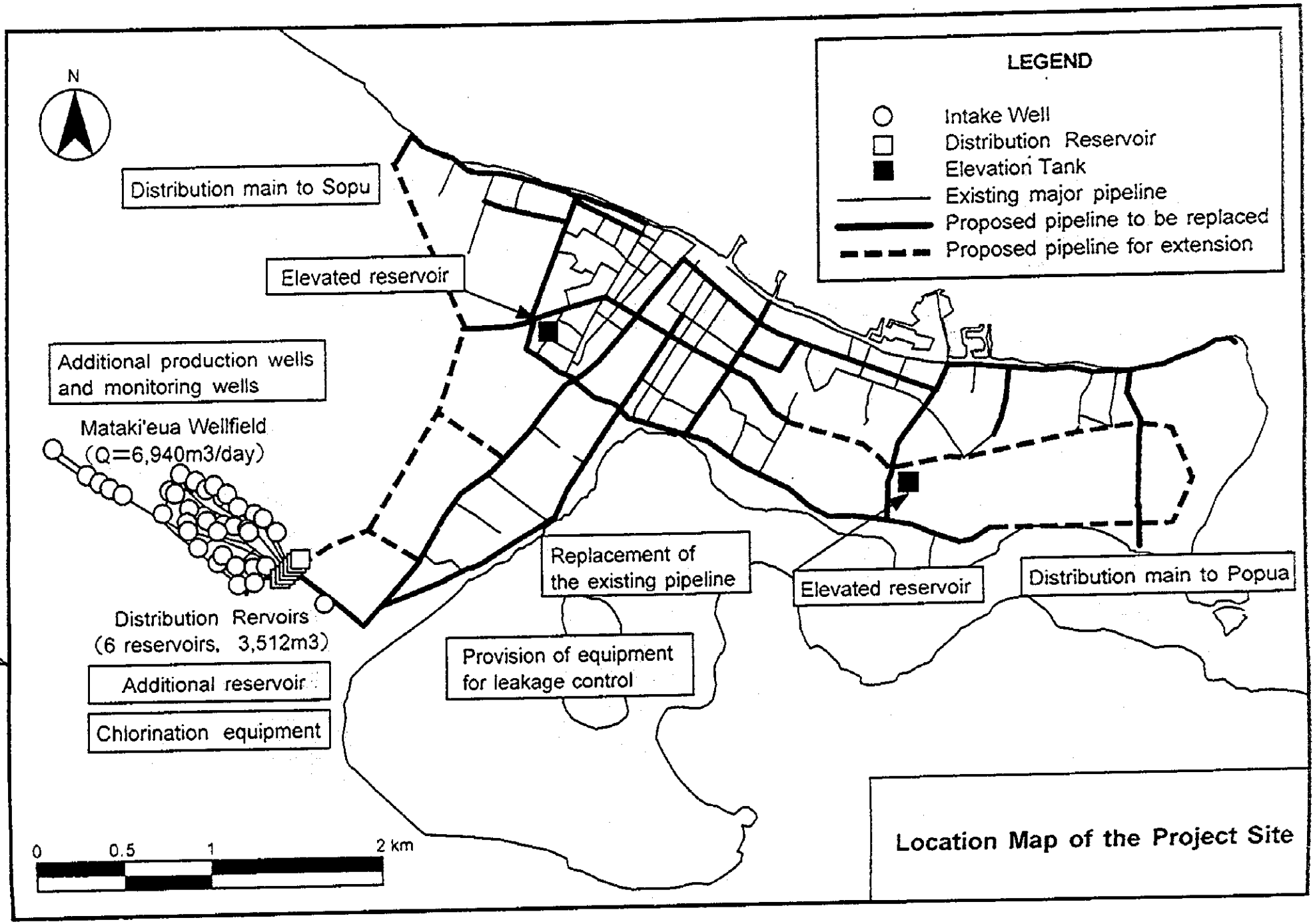
5) The need of an additional reservoir shall be assessed in reference to the production capacity and service level.

6) The construction of monitoring wells shall be subject to the hydrogeological study.

7) Provision of equipment will be determined subject to TWB's operation and maintenance program and storage plan, which shall be evaluated by the study team.

8) Continuous vigorous leakage control work of TWB is crucial for achieving the Project objective.

9) To consider installation of chlorination equipment, alternatives shall be studied on such parameters as safety, economy and handling easiness.


N
LEGEND
Intake Well
Distribution Reservoir
Elevation Tank
Existing major pipeline
Proposed pipeline to be replaced
Proposed pipeline for extension
Distribution main to Sopu
Elevated reservoir
Additional production wells and monitoring wells
Mataki'eua Wellfield
(Q=6,940m3/day)
Distribution Rervoirs
(6 reservoirs, 3,512m3)
Additional reservoir
Chlorination equipment
Replacement of the existing pipeline
Provision of equipment for leakage control
Elevated reservoir
Distribution main to Popua
0
0.5
1
2 km
Location Map of the Project Site

A4(1) - 4

ANNEX 1

ANNEX II

Items Requested by the Government of the Kingdom of Tonga

1. Facilities

(1) Construction of additional fifteen production wells and three monitoring wells and associated pipe work
(2) Construction of additional reservoir at Mataki'eua (main reservoir area)
(3) Installation of chlorination equipment at Mataki'eua
(4) Construction of two new elevated reservoirs and delivery mains at Houmakelikao and Longolongo
(5) Construction of new transmission mains to new elevated reservoirs
(6) Construction of new distribution mains to Popua and Sopu area
(7) Replacement and upgrading of existing asbestos cement mains

2. Equipment supply

(1) Leakage detection equipment and valves
(2) Back hoe x 1
(3) Trench digger x 1
(4) Vehicle, 8 ton truck x 1
(5) Vehicle, Van x 1
(6) Vehicle, 4WD Dual cab x 3
(7) Pipe cutting equipment x 2
(8) Concrete diamond saw x 2
(9) Trench compaction equipment x 1
(10) Spare parts for No. (1) to (9)

ANNEX III

JAPAN'S GRANT AID PROGRAM

(1) Grant Aid Procedures

1) Japan's Grant Aid Program is executed by the following procedures:

• Application	(Request made by a recipient county)
• Study	(Preparatory Study / Basic Design Study conducted by JICA)
• Appraisal & Approval	(Appraisal by the Government of Japan and Approval by the Cabinet of Japan)
• Determination of Implementation	(The Exchange of Notes between both Governments)
• Implementation	(Implementation of the Project)

2) Firstly, an application or a request for a project made by the recipient country is examined by the Government of Japan (the Ministry of Foreign Affairs) to see whether or not it suitable for Japan's Grand Aid. If the request is deemed suitable, the Government of Japan entrusts a study on the request to JICA (Japan International Cooperation Agency).

Secondly, JICA conducts the Study (Basic Design Study), using a Japanese consulting firm. If the background and objective of the requested project are not clear, a Preparatory Study is conducted prior to a Basic Design Study.

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

Fourthly, the Project approved by the Cabinet becomes official when pledged by the Exchange of Notes signed by both Governments.

Finally, for the implementation of the project, JICA assists the recipient country in preparing contracts and so on.

(2) Contents of the Study

1) Contents of the Study

The purpose of the Study (Preparatory Study / Basic Design Study), conducted on a project requested by JICA is to provide a basic document necessary for appraisal of the project by the Japanese Government. The contents of the Study are as follows:

(a) To confirm background, objectives, benefits of the project and also institutional capacity of agencies concerned of the recipient country necessary for project's implementation
(b) To evaluate appropriateness of the Project for the Grant Aid Scheme from a technical, social and economical point of view
(c) To confirm items agreed on by both parties concerning a basic concept of the Project
(d) To prepare a basic design of the Project
(e) To estimate costs involved in the Project

Final project components are subject to approval by the Government of Japan and therefore may differ from an original request.

Implementing the project, the Government of Japan requests the recipient country to take necessary measures involved which are itemized on Exchange of Notes.

2) Selecting (a) Consulting Firm(s)

For smooth implementation of the study, JICA uses (a) consulting firm(s) registered. JICA selects (a) firm(s) through proposals submitted by firms, which are interested. The firm(s) selected carry(ies) out a Basic Design Study and write(s) a report, based upon terms of reference made by JICA.

The consulting firm(s) used for the study is(are) recommended by JICA to a recipient country after the Exchange of Notes, in order to maintain technical consistency.

3) Status of a Preparatory Study in the Grant Aid Program

A Preparatory Study is conducted during the second step of a project formulation & preparation as mentioned above.

A result of the study will be utilized in Japan to decide if the Project is to be suitable for a Basic Design Study.

Based on the result of the Basic Design Study, the Government would proceed to the stage of decision making process (appraisal and approval).

It is important to notice that at the stage of Preparatory Study, no commitment is made by the Japanese side concerning the realization of the Project in the scheme of Grant Aid Program.

(3) Japan's Grant Aid Scheme

1) What is Grant Aid?

The Grant Aid Program provides a recipient country with non-reimbursable funds needed to procure facilities, equipment and services for economic and social development of the country under the following principles in accordance with the relevant laws and regulations of Japan. The Grant Aid is not in a form of donation or such.

2) Exchange of Notes (E/N)

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

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

4) Under the Grant Aid, in principle, products and services of origins of Japan or 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 origin.

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

5) Necessity of the "Verification"

The Government of the recipient country or its designated authority will conclude into contracts 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

In the implementation of the Grant Aid, the recipient country is required to undertake necessary measures such as the followings:

(a) To secure land necessary for the sites of the project and to clear and level the land prior to commencement of the construction work
(b) To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities in and around the sites
(c) To secure buildings prior to the installation work in case the Project is providing equipment
(d) To ensure all the expenses and prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid
(e) To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which will be imposed in the recipient country with respect to the supply of the products and services under the Verified Contracts

(f) To accord Japanese nationals whose services may be required in connection with the supply of the products and services under the Verified Contracts, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work

7) Proper Use

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

8) Re-export

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

9) Banking Arrangement (B/A)

(a) The Government of the recipient country or its designated authority shall 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 Government of the recipient country or its designated authority under the contracts verified.

(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 IV

Necessary measures to be taken by the Government of the Kingdom of Tonga

Following necessary measures should be taken by the Government of the Kingdom of Tonga on condition that the Government of Japan be extended to the Project.

1. To bear commissions to the Japanese foreign exchange bank for its banking services based upon the Banking Arrangement;

2. To ensure prompt unloading, tax exemption, customs clearance at the port of disembarkation in Tonga;

3. 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 Tonga and stay therein for the performance of their work;

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

5. To assign appropriate budget and administrative staff members for proper and effective operation and maintenance of equipment and instruments provided under the Grant Aid;

6. To use and maintain properly and effectively all the facilities constructed and equipment provided under the Grant;

7. To provide facilities for distribution of electricity, water supply and other incidental facilities in and around the sites; and

8. To bear all the expenses, other than those to be borne by the Japan's Grant Aid, which are necessary for construction of the facilities as well as transportation and installation of the equipment.

9. To secure land

10. To clear, level and reclaim the Site

TECHNICAL NOTES
ON THE BASIC DESIGN STUDY ON THE PROJECT FOR NUKU'ALOFA WATER SUPPLY IN THE KINGDOM OF TONGA

Based on the Minutes of Discussions signed on 14th June 1999 between the Basic Design Study Team (hereinafter referred to as "the Team") of Japan International Cooperation Agency (JICA) and Tonga Water Board in the Kingdom of Tonga, the consultant members of the Team had a series of discussions and conducted field surveys from 6th June to 20th July 1999.

As a result of the discussions and the surveys, both sides confirmed the technical conditions described as per attached ANNEX 1 and ANNEX 2.

Nuku'alofa, 20th July 1999

Mr. Okaga Toshifumi
JICA Basic Design Study Team

Mr. Saimone P Helu
Manager
Tonga Water Board

PROGRESS MEETING (No.1)

The meeting held on 28th June, 1st July and 6th July 1999 at TWB's head office.
Present: Managing Director and C/P member
JICA study team

Subject

I Concept of the project

The water supply system of the project will aim maximum use of the existing water source with 31 intake-wells in order to conserve groundwater from environmental aspect, and will supply sufficient water to consumers. The plan with target year of 2003 to achieve the above shall consider the water balance between water demand and existing maximum intake capacity.

II Water Supply Plan

1. Existing intake capacity

① Ave. pumping rate of a well: 2.9 l/sec (=250.6 m^3/d)

② Number of existing wells : 31

③ Max. intake capacity : 7,767 m^3/day (=250.6 m^3/d x 31 wells)

④ Operation rate of intake pump

Pump operation rate	100%	95%	90%	85%	80%
No. of pump operation	31	30	28	27	25
Intake capacity (m^3/day)	7,767	7,378	6,990	6,601	6,213

2. Water demand

Water demand in 2003

Population (person)	Population served (95%)	Domestic (155 l/c/d)	Other category	Total water demand
31,738	30,151	4,673 m^3/d	875 m^3/d	5,549 m^3/d

III Design Conditions

1. Design capacity

Category	Water demand	Leakage (*1)	Daily Ave.	Daily Max. (*2)
Domestic (m^3/d)	4,673	825	5,498	6,873
l/c/d	155	27	182	228 (*3)
Others (m^3/d)	875	155	1030	1,287
Total (m^3/d)	5,549	980	6,528	8,160

Note: (*1) : Rate of leakage : 15% (*2) : Peak factor: 1.25

(*3) :193 l/c/d, in case excluding leakage water

2. Balance between design capacity and intake capacity

① Daily Ave. water : Satisfactory with 85% pump operation

② Daily Max. water : Shortage of 5% water demand under full operation

Maximum intake capacity (7,767 m^3/d) – Daily Max. demand (8,160 m^3/d)

= - 393 m^3/d (5 % shortage)

Max. intake capacity of 7,767 m^3/d corresponds to 217 l/c/d (183 l/c/d in case excluding leakage) ····· Considered to be acceptable.

3. Design condition

	Intake facility	Reservoir	Distribution	Chlorination and flow meter
(1) Design capacity				
① Exist. Daily Max.	7,767 m^3/d			
② Daily Max.		8,160 m^3/d		
③ Hourly Max.			12,407m^3/d	12,407m^3/d
(2) Operation	To use existing 31 wells	To use existing 6 tanks	Replacement and upgrading Continuos supply during 24 hours Min. Pressure at pipe end: Min. press.: 5m – 10 m	Start and stop: Automatic inter-locked system between flow meter and chlorinator Regulation of dosing rate: by manual

4. Distribution pipe

① Pipeline

Flow: Q=8,160 m^3/d for whole Nuku'alofa will be distributed to the East Zone by 3,180 m^3/d(40%) and to the West by 4,980 m^3/d (60%).

Construction of any branch pipelines shall not be allowed on the East Trunk Main, as well as house connections. After construction of the East Trunk Main, the existing booster pumps shall not be in use anymore.

② Pipe materials proposed

Ductile cast iron (DI) pipes with cement mortar lining:

for diameters of 250 mm and larger (250/ 300/ 350/ 400/ 450/ 500 mm)

PVC pipes:

for diameters of 200 mm and smaller (200/ 150/ 100/ 75/ 50 mm)

③ Basic criteria for house-connection branch

Branches for house connections will be made only from distribution pipes. It means that house-connection branch work will not be allowed from DI pipes (250-500 mm). Hence, for the purpose of the house connection branch work, DI pipelines (250-400 mm) will be attached with **side-distribution-pipelines of 50** mm PVC which will be additionally installed in parallel with the DI pipelines (250-400 mm) at the same time of the DI pipes construction. House connections shall be branched from the side-distribution-pipelines.

④ Fire hydrants and fire fighting work

The project will cover 1) Re-connection to the existing hydrants, and 2) Installation of T-branch (75 mm) pipes for proposed new hydrants.

⑤ Reservoir

The study result shows that the existing volume of the reservoirs is enough for the year 2003, even considering storage for fire fighting work.

Refer to attached appendix 3

IV Evaluation of the project

Comparison between present conditions and the project (Target year in 2003)

	(1) Present conditions 1999	(2) The project Target year in 2003	Improvement (2) – (1)
Rate of population served	95 %	95 %	0
Population served	29,170 persons	30,151 persons	981 persons
Water demand	3,379 m^3/d (consumption)	5,549 m^3/d	2,170 m^3/d
Unit water demand of domestic water	87 l/c/d (consumption)	155 l/c/d	68 l/c/d
UFW	53 %	15% + α	-(38- α)
DailyAve.	6,990 m^3/d	6,528 m^3/d	-462 m^3/d
Daily Max.	7,767 m^3/d	7,767 m^3/d	0
Unit water demand in Daily Max.	125 l/c/d	183 l/c/d	58 l/c/d
Ave. intake capacity	6,990 m^3/d	6,528 m^3/d	-462 m^3/d
Rate of Ave. pump operation /sets	90 % / 28 sets	84 % / 26 sets	-6% / -2sets
Max. Intake capacity	7,767 m^3/d	7,767 m^3/d	0
Rate of Max. pump operation / sets	100 % / 31 sets	100 % / 31 sets	0

The Pumping Rate from the Production Wells in Mataki'eua

	Well	Pumping Rate (liters/ec)						Pump Type
	No.	Jan-99	Feb-99	Mar-99	Apr-99	15-21/Jun/99*	Average	Turb/C-fugal
1	101	3.89	5.29	3.96	3.85	under repair	4.25	Mono 720
2	102	3.89	4.02	4.24	3.87	0.00	3.20	Mono 620
3	103	2.59	2.84	2.62	2.82	0.00	2.17	Mono 620
4	104	waiting for a pump installation						
5	105	2.76	2.62	2.68	2.61	0.00	2.13	Mono 620
6	106	2.86	2.53	2.65	2.66	2.89	2.72	S/Cross PDG
7	107	2.94	2.75	2.98	3.42	0.00	2.42	Mono 620
8	108	2.26	2.1	2.29	2.3	0.00	1.79	Mono 620
9	109	3.48	3.58	3.45	3.12	0.00	2.73	Mono 620
10	110	2.52	0.2	3.27	3.04	2.89	2.38	Mono 620
11	111	2.45	2.41	2.46	2.37	0.00	1.94	Mono 720
	111E	no data				═══	2.89	Elec. Centrif.
12	112	2.92	2.77	2.82	2.93	0.00	2.29	S/Cross PDG
13	113	4.68	4.46	4.65	4.60	0.00	3.68	Mono 720
14	114	1.99	1.43	1.42	2.26	0.00	1.42	S/Cross PDG
15	115	2.74	2.77	2.95	2.90	0.00	2.27	Mono 720
	115E	3.48	3.44	3.31	1.38	3.74	3.07	Elec. Centrif.
16	116	2.79	2.79	2.93	3.05	0.00	2.31	S/Cross PDG
17	117	3.18	2.90	3.01	1.42	under repair	2.63	Mono 720
	117E	2.88	3.16	3.05	3.10	═══	3.05	Elec. Centrif.
18	118	2.81	2.77	2.85	2.73	0.00	2.23	Mono 620
19	119	2.98	2.66	2.15	3.00	0.00	2.16	Mono 720
20	120	2.67	2.56	1.09	1.22	0.00	1.51	Mono 620
21	121	3.16	3.16	3.13	3.43	0.00	2.58	Mono 620
22	122	2.76	3.08	2.94	3.35	0.00	2.43	Mono 620
23	123	3.06	3.59	3.71	4.00	0.00	2.87	Mono 620
24	124	2.44	2.25	2.28	2.26	0.00	1.85	Elec. Mono 640
25	125	3.29	3.67	3.61	1.67	0.00	2.45	Mono 620
26	127	2.96	3.21	3.09	2.81	0.00	2.41	Mono 620
27	129	2.83	3.05	2.91	no data	2.89	2.92	Mono 620
28	211	2.46	2.24	2.39	2.29	0.00	1.88	Mono 620
29	212	2.77	2.76	1.82	no data	0.00	1.84	Mono 620
30	213	═══	═══	no data		2.89	2.89	Elec. Mono 620
31	214	═══	═══	3.04	2.68	0.00	1.91	Mono 620
	Total	88.49	87.06	89.75	81.14	15.30	72.35	
	Mean	2.95	2.90	2.90	2.80	2.55	2.82	
	(m3/day)	7646	7522	7754	7010	1322	6251	

e : JICA preparatory report

POPULATION

Appendix 2 - (1)

(1) Population of the service area in 1986 and 1996

District	Village	1996	1,986	Growth rate
Kolofo'ou	Kolofo'ou	9,220	10,044	-8.2%
	Maufanga	6,083	4,924	23.5%
	Popua	1,206	617	95.5%
	Tukutonga	341	220	55.0%
Kolomotu'a	Kolomotu'a	7,097	6,415	10.6%
	Haveluloto	3,305	3,070	7.7%
	Tofoakoloua	2,702	2,298	17.6%
Total		29,954	27,588	Ave. 8.6%
Annual Growth rate		$(29,954/27,588)^{1/10} - 1$		0.83%

Source: Department of Statistics, June 1999

(2) Population forecast of Nuku'alofa

Year		2,011		2003		1999		1996
District	Village	Pop.	Annual Growth Rate (%)	Pop.	Annual Growth Rate (%)	Pop.	Annual Growth Rate (%)	Pop.
Kolofo'ou	Kolofo'ou	10,437	0.83	9,769	0.83	9,451	0.83	9,220
	Maufanga	6,886	0.83	6,445	0.83	6,236	0.83	6,083
	Nukunukumot	26	0.5	25	0.50	24	0.50	24
	Oneata	3	0.5	3	0.50	3	0.50	3
	Popua	1,365	0.83	1,278	0.83	1,236	0.83	1,206
	Tukutonga	386	0.83	361	0.83	350	0.83	341
	Pangaimotu Is.	31	0.50	30	0.50	29	0.50	29
	Fafaa Is.	11	0.50	10	0.50	10	0.50	10
	Oneva Is.	9	0.50	8	0.50	8	0.50	8
	Ataa Is.	2	0.50	2	0.50	2	0.50	2
	Velitoa Hahak	11	0.50	10	0.50	10	0.50	10
	Velitoa Hihifo	18	0.50	18	0.50	17	0.50	17
Kolomotu'a	Kolomotu'a	8,034	0.83	7,520	0.83	7,275	0.83	7,097
	Haveluloto	3,741	0.83	3,502	0.83	3,388	0.83	3,305
	Tofoakoloua	3,059	0.83	2,863	0.83	2,770	0.83	2,702
	Hofoa	639	0.50	614	0.50	602	0.50	593
	Puke	476	0.50	458	0.50	449	0.50	442
	Sia'atoutai	336	0.50	323	0.50	317	0.50	312
Total	Nuku'alofa	35,471		33,240		32,178		31,404
Total	Service Area	33,908		31,738		30,706		29,954

Source: Annual Growth rate of rural area : Central Planning Department, June 1999
Population in 1996 : Tonga Population Census in 1996

PRESENT WATER CONSUMPTION

(1) Usage as from 20/05/98 to 20/06/99

	Yearly consumption		Monthly consumption		Category
Domestic	880,416	m^3/year	73,368	m^3/month	
Public	117,264	m^3/year	9,772	m^3/month	Including hospital, school and police station
Commercial	175,476	m^3/year	14,623	m^3/month	Including hotel, industry and restaurant
Total	1,173,156	m^3/year	97,763	m^3/month	

Source : TWB's Accountant Department

(2) Present Water Consumption in 1998

Category	Piped Water						Rain Water		Total Consumption	
	(1) No. of Connection	(2) *1 Population served	(3) Consumption (m3/month)	(4) Consumption (m3/d)	(5) Rate of Consumption (%)	(6) Unit consumption	(7) *4 Unit consumption	(8) Consumption (m3/d)	(9) Consumption (m3/d)	(10) Unit consumption
Domestic	5,307	29,170	73,368	**2,446**	**75%**	**84** l/cap/d	**3 l/cap/d**	**88**	**2,533**	**87 l/cap./d**
Public	131		9,772	**326**	**10%**	**2,487** l/connc./d	**99**	**13**	**339**	**2,586 l/connc./d**
Commercial	541		14,623	**487**	**15%**	**901** l/connec./d	**36**	**19**	**507**	**937 l/connec./d**
Total	5,979	29,170	97,763	**3,259**	**100%**	**112** l/cap/d *3		**120**	**3,379**	**115 l/cap./d *2**

Source: Central Planning Department and TWB's Accounting Department

Note *1: 1 Rate of population served : 95%, total population in 1999 : 30,706

*2: Per capita consumption including all category

*3: Rainwater for public and commercial was estimated to be 4% based on domestic water condition.

WATER DEMAND FORECAST (TARGET YEAR : 2003)

(1) Domestic water

Population (person)	31,738
Rate of Population Served	95%
Population Served (person)	**30,151**
Unit Demand (l/c/d)	**155**
Water Demand (m^3/d)	**4,673**

(2) Other category water

Unit in m^3/d

Category	Water demand 1999	Water demand 2003 (*1)	Note
Public	326	327	Increased rate: 0.83%/annu.
Commercial	487	548	Increased rate: 3%/annu. (investment + water increase)
Total	813	**875**	

Note (*1) : Calculation method of public water demand: $326 \times (1+0.0083)^4$

Calculation method of commercial water demand: $487 \times (1+0.03)^4$

(3) Rate of demand by each category

Unit in m^3/d

Domestic	Public	Commercial	Total
4,673	**327**	**548**	**5,549**
84%	6%	10%	100%

(4) Design capacity

Unit in m^3/d

Water demand	**5,549**		184 l/c/d (*3)	155 l/c/d (*4)
Daily Ave. capacity	**6,528**	5,549m^3/d / (1-0.15) (*1)	216 l/c/d (*3)	182 l/c/d (*4)
Daily Max.. capacity	**8,160**	6,528m^3/d x 1.25 (*2)	270 l/c/d (*3)	228 l/c/d (*4)

Note : (*1) : Rate of leakage water : 25% (*2): Peak factor : 1.25

(*3) : Total category / population servec (*4) : In case domestic water

Distribution Pipelines 6 July 1999

1. **Pipelines proposed for the year 2003** (See the map attached.)

The hydraulic analysis of the distribution pipelines is still under study. The map shows the diameters ~~(tentatively proposed as of 6 July)~~ of major pipelines which are to be replaced/upgraded or newly added.

Flow: **Q= 8,160 m3/day** for whole Nuku'alofa (Daily Maximum capacity for year: 2003) will be distributed to the **East** Zone by **3,180 m3/day** (40%) and to the **West** by **4,980 m3/day**.(60%).

The diameter of the principal trunk main delivered from the Mataki'eua Reservoirs will be 500 mm (Distance: L = 1,365 m from the Reservoir to Node J-206, the southern-cross of Taufa'ahau Road and Vaha'akolo Road).

For the East Zne, a particular trunk main (**East Trunk Main**) with 350 mm diameter will be constructed, which is to be branched from the 500 mm principal main at the above J-206 and proceed to the entrance of the East Zone, Node J-38, the place of the existing booster pumping station. Its distance will be L= 3,608 m.

(Note 1): Construction of any branch pipelines shall not be allowed on the East Trunk Main, as well as house connections.
(Note 2): After construction of the East Trunk Main, the existing booster pumps shall not be in use anymore.

The **West Trunk Main** branched from the 500 mm principal trunk main will have 400 mm of diameter with L= 1,588 m, and continue to 350 mm with L= 1,157 m, towards north.

2. **Pipe materials proposed**

- **Ductile cast iron (DI)** pipes with cement mortar lining:
  for diameters of 250 mm and larger **(250/ 300/ 350/ 400/ 450/ 500 mm)**
- **PVC** pipes:
  for diameters of 200 mm and smaller **(200/ 150/ 100/ 75/ 50 mm)**

3. Basic criteria for house-connection branch

Branches for house connections will be made only from distribution pipes of 200/150/100/75/50 mm PVC pipes. It means that house-connection branch work will not be allowed from DI pipes (250-500 mm). Hence, for the purpose of the house connection branch work, DI pipelines (250-400 mm) will be attached with **side-distribution-pipelines of 50 mm PVC 50** which will be additionally installed in parallel with the DI pipelines (250-400 mm) at the same time of the DI pipes construction. House connections shall be branched from the side-distribution-pipelines.

4. House connections to be re-connected by the project

Technical details on the existing house connections are important and necessary in order to estimate construction cost and to plan time schedule of construction work.

The following data are required:
(1) **Standard drawings** of the existing house connections (service pipes) showing pipe materials/ diameters/ sizes/ distances/ tapping bands/ water meters/ stop cocks/ water taps/ etc. by each size and category (domestic/commercial/public).
(2) **List** of number (quantity) of the exiting connections to be re-connected on the pipelines to be replaced/upgraded, by each pipeline section, showing pipeline No. (Node to Node) and number (quantity) of connections by each size and so on.

5. Fire hydrants and fire fighting work

- Location of fire hydrants proposed = At important and strategic places
- Fire hydrants will be placed on large pipelines of at least 150 mm diameter or larger pipes.
- Fire fighting flow is to be considered in hydraulic calculation of distribution pipelines study. The flow for fire-fighting work is supposed to be 1.00 m3/min = 16.67 l/sec.

< Scope or demarcation of the Japanese-side responsibility >

It is considered that the project fund be spent or concentrated on the proper water supply purpose, such as pipes/ valves and equipment. As for fire hydrants, therefore, the following is proposed:

The project will cover 1) Re-connection to the existing hydrants, and 2) Installation of T-branch (75 mm) pipes for proposed new hydrants.

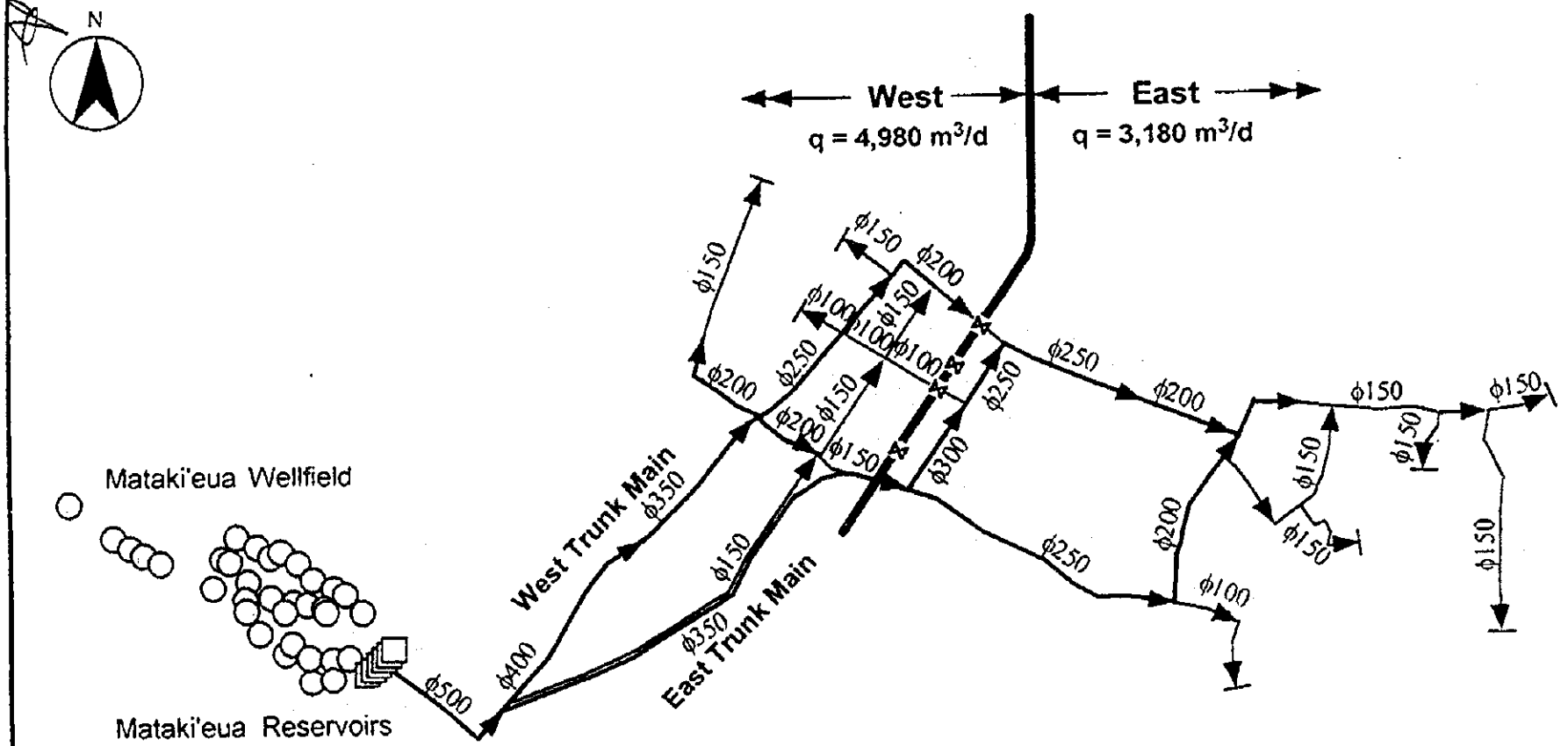
(Note) A list of the existing fire hydrants is required.

6. Reservoir

Volume of reservoirs in Mataki'eua is under study. The tentative study result shows that the existing volume of the reservoirs is enough for the year 2003, even considering storage for fire fighting work.

- The existing volume = 3,515 m3 (Total of 6 reservoirs in Mataki'eua)
- The daily maximum capacity in 2003 = 8,160 m3/day
- Storage = 10.3 hours capacity for 8,160 m3/day,
  or 9.8 hours capacity plus fire fighting reserve of some 200 m3
- Theoretical volume required in the adjusted demand pattern for Nuku'alofa
  = 5.4 hours capacity plus reserve for fire fighting work
  = 1,823 m3 + 200 m3 = 2,023 m3 (< existing 3,515 m3) → O.K.

For more detailed analysis, a record of water level variation of the existing reservoirs on a certain day (24 hours' continuous record of water levels by one hour step) is required.



Daily Maximum Q = 8,160 m³/day

Service Area and Distribution for the Year 2003

Progress Meeting (No.2)

The meeting held on 13th and 16th July, 1999 at TWB's head office.

Present : Managing Director and C/P member
JICA study team

Subject

1. Elevated tanks

Considering advantages/disadvantages of several factors and construction costs, the construction of direct distribution main, (without an elevated tank) is recommended in this project.

Refer to attached Appendix 1.

2. Chlorination

(1) Determination of the system

From viewpoint of safe handling and easy maintenance, the hypochlorite dosing system is recommendable. Although cost for hypochlorite would be more expensive than liquid chlorine, the cost among the total expense would be still little due to small dosing capacity.

Refer to attached Appendix 2.

3. Deign rate of leakage water

After the project, the leakage could be conclusively said as follows:

Present ACP area : 5%–10% (by replacement with new pipes)

Present PVC area : 20% (by TWB's effort)

Total : 11%-14%, say 15%

In conclusion, percentage of leakage will be planned to be 15 % in the whole service area, after the project completion.

4. Provision of equipment

The equipment to be provided by the Project will be used leakage control and maintenance for intake pumps.

As for vehicle, TWB shall prepare budget (approx. T$10,000) for garage construction.

TWB estimates total cost for the maintenance at T$19,000/year.

The equipment to be provided is shown in Appendix 4.

16 July 1999

Elevated Tank System

Regarding the distribution system, two alternatives have been studied. They are:
Case 1 : Construction of an elevated tank and construction of a transmission pipeline
Case 2 : Construction of a direct distribution main pipeline

Considering advantages/disadvantages of several factors shown in the following comparison table and construction costs of the both alternatives, the **Case 2 (construction of a direct distribution main, without an elevated tank)** which would have more advantages is **recommended** in this project.

Comparison Table

Items	Case 1 (Elevated Tank)	Case 2 (Without Tank)
(1) Reliability of water supply	Reliable	Reliable
(2) Against disasters	Care of both cyclone and earthquake	Care of earthquake
(3) Maintenance work for tank	Water level control and tank cleaning	Not required
(4) Maintenance cost for pipes	Less expensive	More expensive
(5) Flexibility of extension work	Rather difficult	Flexible
(6) Main pipe capacity	Q=Daily maximum flow	Q x 180% (Peak hour flow)
(7) Land use	Tank occupies some land area	Land not required
(8) Construction cost (Tentative cost)	More expensive (T$ 4,381,700-)	Less expensive (T$ 3,245,200-)

13 July 1999

Cost Estimate of the Elevated Tank System

Regarding the distribution system, two alternatives have been studied with construction cost comparison. They are :

Case 1 : Construction of an elevated tank and construction of a transmission pipeline

Case 2 : Construction of a distribution main pipeline

< Study Conditions >

- Supply capacity = Daily maximum demand for the year 2003 = 8,160 m3/d
  (East Zone: 3,180 m3/d + West Zone: 4,980 m3/d)
- Volume of the elevated tank = (10 hours volume) + (Storage for fire fighting work)
- Flow of the transmission pipeline = Same as the daily maximum demand (Constant flow)
- Flow of the distribution main pipeline = (Daily maximum demand) x 180% (Peak hourly flow)

The following shows the size of facilities for the **East Zone** system and its cost comparison..

< Facilities > (East Zone)

Case 1 : (Elevated tank) + (Transmission main)

- Volume of the elevated tank = (3,100 x 10/24) + 100 m3 = 1,425 m3
- Distance of the transmission main (From Mataki'eua to the East Zone) = 6,100 m
- Flow of the main = 3,180 m3/d = 36.81 l/sec (24 hours' constant flow)
- Diameter of the main = 350 mm for 3,000 m and 300 mm for 3,100 m
- Headloss in the main = (0.55 x 1/1,000 x 3,000) + (1.18 x 1/1,000 x 3,100) = 5.31 m

Case 2 : (Distribution main pipeline)

- Distance of the main = 6,100 m
- Flow of the main = 3,180 m3/d x 180% = 66.25 l/sec (Peak hourly flow at 07:00 a.m.)
- Diameter of the main = 400 mm throughout
- Headloss in the main = 0.87 x 1/1,000 x 6,100 m = 5.31 m

< Cost Comparison > (East Zone)

Case 1

- Elevated tank (V=1,425 m3) construction cost = T$ 1,737,800-
- Transmission pipeline construction cost

  350 mm : 3,000 m x 462 T$/m = T$ 1,386,000-

  300 mm : 3,100 m x 409 T$/m = T$ 1,267,900-

Total cost (Case 1) = 1,737,800 + 1,386,000 + 1,267,900 = **T$ 4,391,700-**

Case 2

- Distribution main pipeline construction cost = 6,100 m x 532 T$/m = T$ 3,245,200-

Total cost (Case 2) = T$ 3,245,200-

(Note): The above costs are tentatively estimated.

< Conclusion >

Case 2 is more economical than Case 1.

(Note 1)

The above study is for the East Zone. As for the West Zone, Case 2 will have much more economical advantage, because the volume of the elevated tank will be bigger and the distance of the pipeline shorter; accordingly the cost difference between Cases 1 and 2 would be larger.

(Note 2)

An advantageous cost factor of the Case 2 is in that the Case 2 does not require construction of a new tank; but effectively use the existing Mataki'eua reservoirs which have sufficient capacity.

Comparison on Chlorination Materials

Liquid chlorine [Cl_2] and Calcium hypochlorite [$Ca(OCl)_2$] are compared so as to design the chlorination equipment for the Nuku'alofa Water Supply System As a result, comparing the risk of liquid chlorine accident and the expensiveness of calcium hypochlorite, calcium hypochlorite is recommendable on account of its lower risk of accident and small amount of dosage which costs more expensive but still affordable enough for TWB.

1. Water Quality / Chlorine Dosage

Chlorine dosing test for raw water (Mataki'eua Water Reservoir No.6 inlet water) shows that chlorine dosage of about 0.7 mg/L can satisfy the suitable residual chlorine for distribution. This is mainly due to good water quality of the raw water, such as its low ammonia contents that may largely affects chlorine consumption. Refer to the attached "Chlorine Dosing Test Result".

2. Comparison Table

	Liquid Chlorine	Calcium Hypochlorite
Properties	Confined in a container as liquid and gas. If unconfined, it rapidly vaporizes to gas that reacts with most elements and causes respiratory irritation.	Granular powder Absorbent Readily soluble in water
Handling	Transportation shall be performed by the authorized personnel equipped with gas mask	Easy to handle by anyone with short instruction
Access Road	Rough access road to and around the facility shall be improved for transportation	Current road is possible to use
Additional facility	Neutralizing equipment Thermostatic apparatus Personnel protective equipment (gas masks, emergency showers, etc.)	Any special apparatus is not required.
Structure	Seismic design shall be considered Fire resistant building	Normal building structure
Special Care in Operation and Maintenance	To store away from other materials and facilities To perform daily test for leaks of containers, piping and equipment To prevent moisture which will cause serious corrosion problems in pipes and equipment To prepare spare parts for lead gasket, injector, etc.	To store in dry room (cooler) To store separate from other chemicals To use clean dry implements to prevent reactions with organic materials such as oils, grease, etc.
Personnel	Special trained staff who are fully familiar with all of the hazards and the safeguards necessary for the safe performance of the work.	Today's staff can manage
Availability	Possible	Currently in use
Laws and Regulation	Strictly regulated (Hi-pressure Gas Regulation, Hi-pressure vessel regulation, Japan)	Not regulated (in Japan)
Capital Cost	T$45,000 (TWB report)	T$45,000 (TWB report)
Chemical Cost	T$7,723 per annum (4.63T$/kg)	T$12,085 per annum (4.71T$/kg)

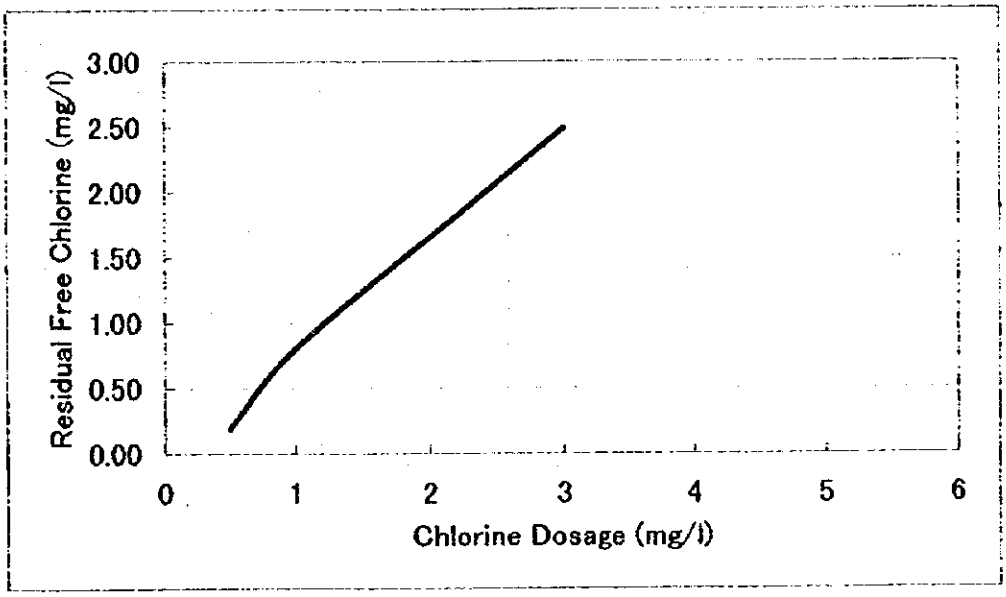
3. Design Conditions

Water Flow Capacity	Daily Average : 6,528 m^3/day Daily Maximum : 8,160 m^3/day Hourly Peak Flow : 8.61 m^3/min (12,407m^3/day)
Dosing Rate	Maximum : 1.5 mg/L Average : 0.7 mg/L
Dissolving Tank Capacity	175 liters (Two days capacity of daily max distribution)
Dosing Equipment	Metering type chemical pump
Store Capacity for Chemical	More than one month

Chlorine Dosing Test Result

Sample Water:	Mataki'eua No.6 Reservoir (inlet water)
Date:	24-Jun-99
Time:	14:30 pm
Weather:	Clear
Temperature:	NA
Water Temperature:	NA
pH:	NA

Dosage	Contact Period (min)	Residual Chlorine (mg/l)
0.5mg/l	40min	0.19
1mg/l	40min	0.80
2mg/l	30min	1.65
3mg/l	30min	2.49
4mg/l	30min	>2.50
5mg/l	30min	>2.50
6mg/l	30min	>2.50

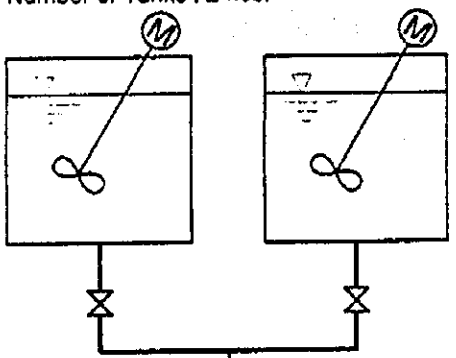


Reference:
Ammonia Contents of Mataki'eua Raw Water
Minimum: 0.004 mg/L
Maximum: 0.013 mg/L
Average: 0.006 mg/L
(Source: "Surveillance of Groundwater Quality in Tonga", WHO, 1996)

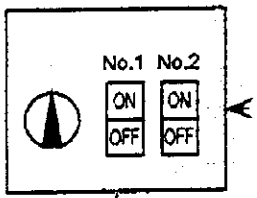
CHLORINE DOSING SYSTEM

DISSOLVING TANK

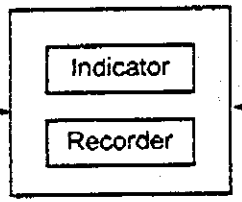
Tank Capacity : 175 Liters/tank
(2 days capacity of Max. day production)
Number of Tanks : 2 nos.

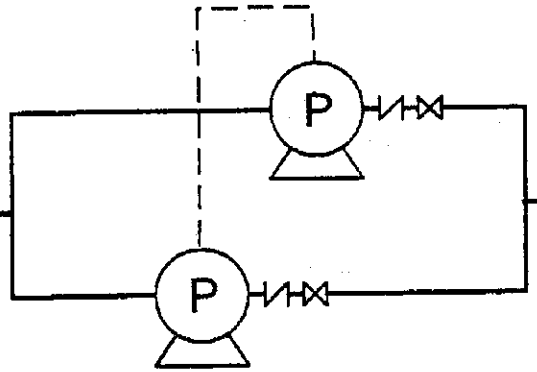


PUMP CONTROL PANEL



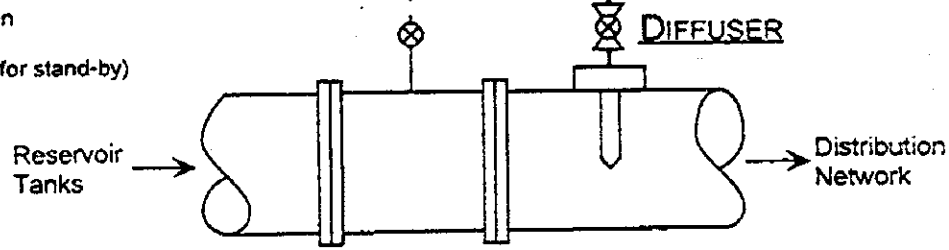
INSTRUMENT PANEL





METERING PUMP

Pump Capacity : 0.20 m3/min
Average Pump Discharge : 0.05 m3/min
Number of Pumps : 2 sets
(one for duty, one for stand-by)



FLOW METER

Chemical to be used : Calcium Hypochlorite (Powder, 65%)
Average Dosage : 0.7 mg/L- Chlorine
Maximum Dosage : 1.5 mg/L-Chlorine

APPENDIX 3

Leakage of PVC Service Areas

The Team conducted leakage survey on 4 sites of the existing PVC service area. Among them, a representative site No.4 (50 mm PVC) showed the 7-10%, say 10% of leakage. This is under the condition of 50 mm PVC area with supply pressure of 5.6 m.

Leakage of other areas of 75 PVC with representative pressure of 8.4 m and 100 mm PVC of 8.9 m pressure was theoretically estimated by calculation. The results are 17.0 % for 100 mm PVC area, 15.9 % for 75 mm and 10.0% for 50 mm, making about 15% on average.

PVC Area	Present		After Project	
	Leakage	Pressure	Leakage	Pressure
50 mm PVC	10.0%	5.6 m	26.3%	13.0 m
75 mm PVC	15.9%	8.2 m	26.3%	13.0 m
100 mm PVC	17.0%	8.9 m	26.3%	13.0 m

After the project completion, water pressure will be raised to 12-14% in average. In that case, the leakage is predicted to be 24.0% - 28.6%.; 26.3% in average. It is expected that the leakage be reduced to 20% by the effort of TWB, after the project completion.

PROVISION OF EQUIPMENT

No.	Request from TWB		Proposed by the Team	
	Equipment	Q'ty	Equipment	Q'ty
1	Leak detection equipment and valves	1 set	Ultra-sonic flow meter Correlation type leak detector Box locator	2 sets 1 set 1 set
2	Back hoe	1 set	Back hoe 0.2m³	1 set
3	Trench digger	1 set	Trench digger	1 set
4	Vehicle, 8 ton truck	1 set	exclude	
5	Vehicle, van	1 set	exclude	
6	Vehicle, 4 WD Dual cab	3 sets	Vehicle, 4 WD Dual cab .	1 set
7	Pipe cutting equipment	2 sets	Pipe cutting equipment	2 sets
8	Concrete diamond saw	2 sets	Concrete diamond saw	2 sets
9	Trench compaction equipment	1 set	Trench compaction equipment	1 set
10	Intake pump with engine	3 sets	Intake pump with engine	3 sets
11	Truck with crane, 4 ton	1 set	Truck with crane	1 set
12	Spare parts (item 2 to 11)	l.s.	Spare parts (item 2,3and 6 to 11)	l.s.

MINUTES OF DISCUSSIONS
ON THE BASIC DESIGN STUDY ON THE PROJECT
FOR NUKU'ALOFA WATER SUPPLY
IN THE KINGDOM OF TONGA
(EXPLANATION ON DRAFT REPORT)

In June 1999, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Basic Design Study Team on the Project for Nuku'alofa Water Supply in the Kingdom of Tonga (hereinafter referred to as "the Project") to the Kingdom of Tonga (hereinafter referred to as "Tonga"), 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 Tonga on the components of the draft report, JICA sent to Tonga the Draft Report Explanation Team (hereinafter referred to as "the Team"), which is headed by Mr. Noriaki Niwa, Deputy Rsdident Representative, Australia Office, JICA, from October 26 to November 2, 1999.

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

Nuku'alofa, November 1, 1999

Mr. Noriaki Niwa
Leader
Draft Report Explanation Team
Japan International Cooperation Agency
Japan

Mr. Saimone P Helu
General Manager
Tonga Water Board
The Kingdom of Tonga

ATTACHMENT

1. Components of Draft Report

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

2. Japan's Grant Aid Scheme

Tongan side understands the Japan's Grant Aid Scheme and the necessary measures to be taken by the Government of Tonga as explained by the Team and described in Annex II and Annex III of the Minutes of Discussions signed by both parties on June 14, 1999.

3. Schedule of the Study

JICA will complete the final report in accordance with the confirmed items and send it to the Government of Tonga by the end of December, 1999.

4. Other Relevant Issues

4-1 The Team explained JICA training program of waterworks engineering to be held in June, 2000. For the sake of the technology transfer on sustainable operation and maintenance, Tongan side pointed out the need for technical training of counterpart TWB personnel in Japan.

4-2 The Team underlined the importance on proper operation and maintenance of the facilities and equipment by Tongan side, which might be constructed and provided under Japan's Grant Aid scheme, especially on sufficient budget allocation for maintenance.

4-3 Both sides confirmed the followings on condition that the Japan's Grant Aid is to be extended to the Project:

(1) (a) Any pipelines cut in the construction work will be restored by the Japanese Contractor under the Project.

(b) Pavement excavated by the pipeline constructions will be repaired by the Japanese Contractor under the Project.

NN.

(c) Instructions for operation of leakage control equipment will be conducted by the manufacture's/supplier's supervisor before handing over to TWB.

(d) "Warning tape" will be installed approx. 30cm above the top of the pipes to be constructed under the Project.

(2) (a) TWB will take necessary measures to obtain permission of road reserve during construction period of the Project.

(b) Leakage control program by TWB will be carried out in order to reduce PVC leakage to 20 %, the target of the Project, by year 2003 by using leakage control equipment to be provided by the Project. Schedule of the leakage control is shown as ANNEX I.

(c) PVC pipelines and a garage to be constructed by TWB will be completed in accordance with the Project schedule. Budget allocation and personnel for these construction works will be provided by TWB. The construction schedule is shown as ANNEX II.

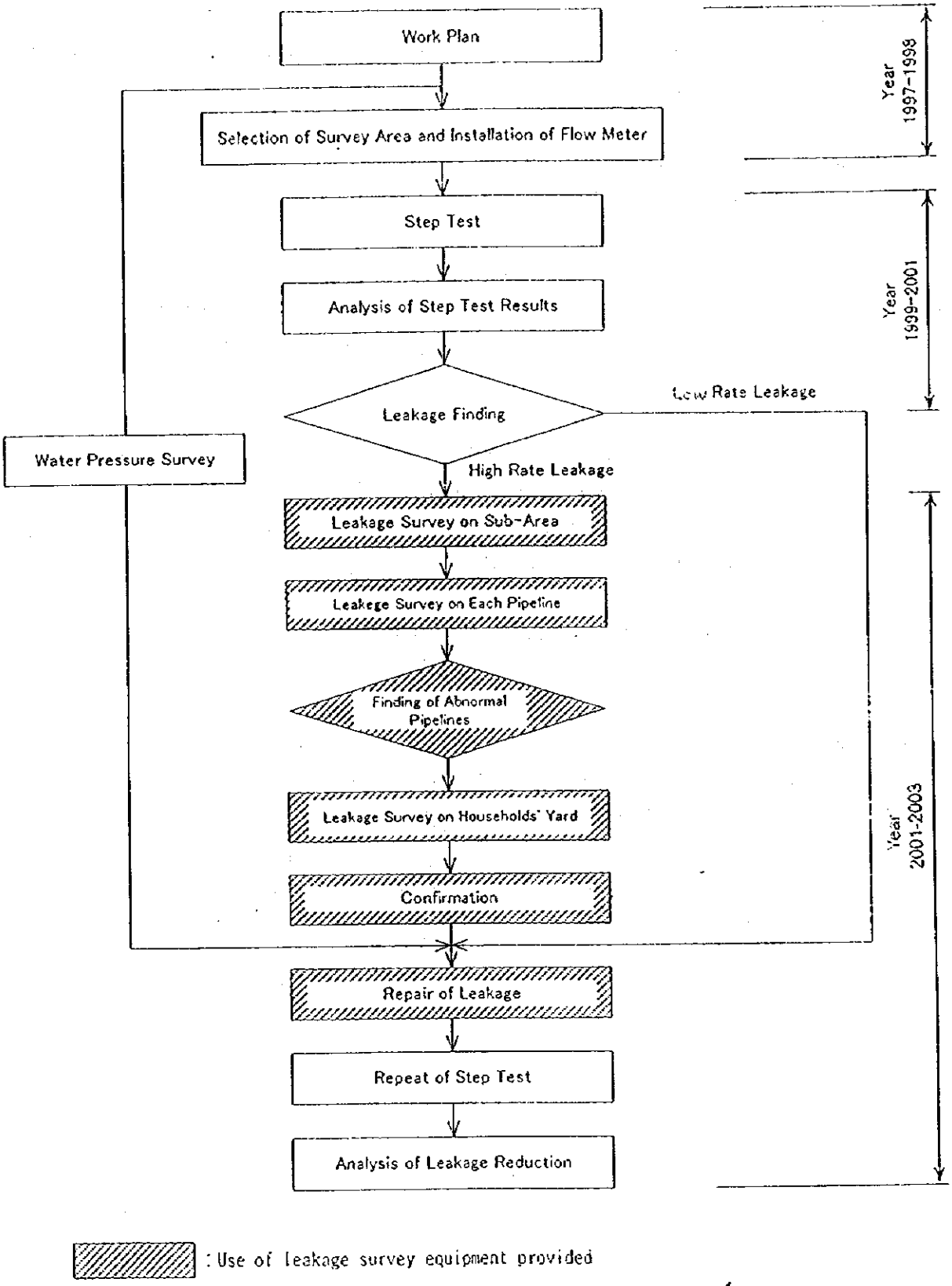
(d) The pick-up truck to be used for leakage control works will be operated by the work schedule as per ANNEX III.

(3) (a) Engineer(s) appointed by TWB shall be involved in construction supervision. Transfer of knowledge on construction management would be done through on-the-job training (OJT) during the construction period.

(b) The existing pipes will be abandoned at the existing position after construction of new pipes.

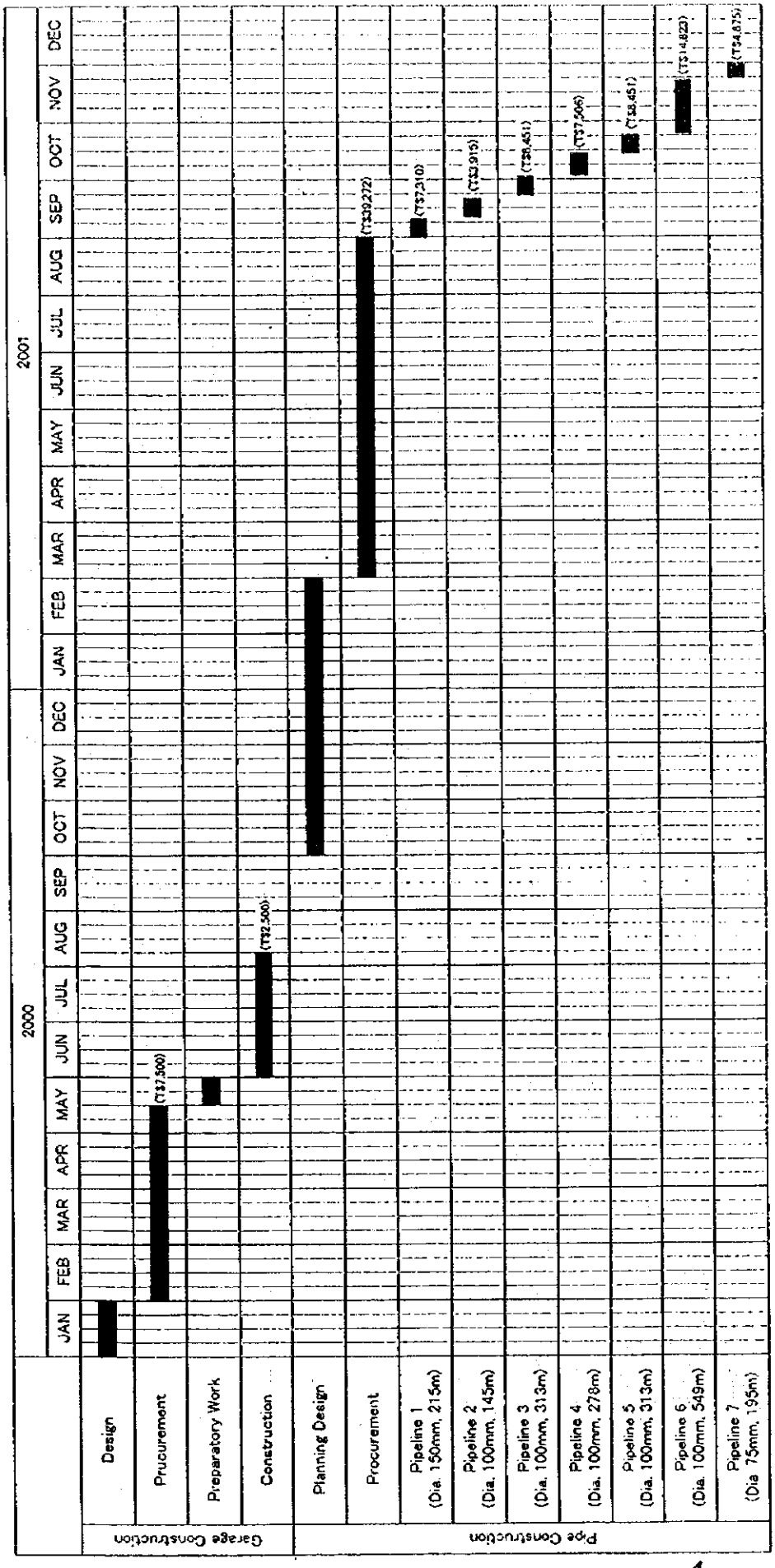
NN

LEAKAGE CONTROL SCHEDULE



ANNEX H

IMPLEMENTATION SCHEDULE OF THE GARAGE AND DISTRIBUTION PIPELINE TO BE FUNDED AND CONSTRUCTED BY TWB – 2001



Weekly Schedule for the Pick-up Truck to be Provided by the Project for TWB Leakage Control

Work Item	DAY 1 (Monday)	DAY 2 (Tuesday)	DAY 3 (Wednesday)	DAY 4 (Thursday)	DAY 5 (Friday)
Site surveying of the area to be tested					
Identify the pipeline of a particular section					
Locate the existing pipes					
Repair/ replace the leaked pipes					

APPENDIX 5 POPULATION SERVED AND WATER DEMAND

(1) Population Growth Rate (Year 1986 to 1996)

District	Village	Year 1996	Year 1986	Growth rate
Kolofo'ou	Kolofo'ou	9,220	10,044	-8.2%
	Maufanga	6,083	4,924	23.5%
	Popua	1,206	617	95.5%
	Tukutonga	341	220	55.0%
Kolomotu'a	Kolomotu'a	7,097	6,415	10.6%
	Haveluloto	3,305	3,070	7.7%
	Tofoakoloua	2,702	2,298	17.6%
Total		29,954	27,588	Ave. 8.6%
Annual growth rate		$(29,954/27,588)^{1/10} - 1$		0.83%

Source: Department of Statistics, June 1999

(2) Population Forecast of Nuku'alofa

		Year 2011		Year 2003		Year 1999		Year 1996
District	Village	Population	Annual growth rate (%)	Population	Annual growth rate (%)	Population	Annual growth rate (%)	Population
Kolofo'ou	Kolofo'ou	10,437	0.83	9,769	0.83	9,451	0.83	9,220
	Maufanga	6,886	0.83	6,445	0.83	6,236	0.83	6,083
	Nukunukumoto	26	0.5	25	0.50	24	0.50	24
	Oneata	3	0.5	3	0.50	3	0.50	3
	Popua	1,366	0.83	1,278	0.83	1,236	0.83	1,206
	Tukutonga	386	0.83	361	0.83	350	0.83	341
	Pangaimotu Is.	31	0.50	30	0.50	29	0.50	29
	Fafaa Is.	11	0.50	10	0.50	10	0.50	10
	Oneva Is.	9	0.50	8	0.50	8	0.50	8
	Ataa Is.	2	0.50	2	0.50	2	0.50	2
	Velitoa Hahake	11	0.50	10	0.50	10	0.50	10
	Velitoa Hihifo	18	0.50	18	0.50	17	0.50	17
Kolomotu'a	Kolomotu'a	8,034	0.83	7,520	0.83	7,276	0.83	7,097
	Haveluloto	3,741	0.83	3,502	0.83	3,388	0.83	3,305
	Tofoakoloua	3,059	0.83	2,863	0.83	2,770	0.83	2,702
	Hofoa	639	0.50	614	0.50	602	0.50	593
	Puke	476	0.50	458	0.50	449	0.50	442
	Sia'atoutai	336	0.50	323	0.50	317	0.50	312
Total Nuku'alofa		35,471		**33,240**		32,178		31,404
Total Service Area		33,908		**31,738**		30,706		29,954

Source: Annual growth rate of rural area: 0.5%, June 1999 Central Planning Department

Population in 1996: Tonga Population Census in 1996

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	Oneata	3	0.5	3	0.50	3	0.50	3
	Popua	1,365	0.83	1,278	0.83	1,236	0.83	1,206
	Tukutonga	386	0.83	361	0.83	350	0.83	341
	Pangaimotu Is.	31	0.50	30	0.50	29	0.50	29
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Total Nuku'alofa		35,471		33,240		32,178		31,404
Total Service Area		33,908		31,738		30,706		29,954

Source: Annual growth rate of rural area: 0.5%, June 1999 Central Planning Department

Population in 1996: Tonga Population Census in 1996

(3) Household

District	Village	Year 2003	Year 1999	Annual Growth rate(%)	Increment (1986-1996)	Year 1996	Year 1986
Kolofo'ou	Kolofo'ou	1689	1,579	1.6	7	1,501	1,494
	Maufanga	1033	966	1.6	219	918	699
	Nukunukumoto	2	2	1.6		4	
	Oneata	2	2	1.6		1	
	Popua	203	189	1.6	87	180	93
	Tukutonga	62	58	1.6	17	55	38
	Pangaimotu Is	2	2	1.6		5	
	Fafaa Is	2	2	1.6		2	
	Oneva Is	2	2	1.6		1	
	Ataa Is	2	2	1.6		1	
	Velitoa Hahake	2	2	1.6		2	
	Velitoa Hihifo	2	2	1.6		3	
Kolomotu'a	Kolomotu'a	1402	1,311	1.6	206	1,246	1,040
	Havelulotu	572	534	1.6	39	508	469
	Tofoakolotua	469	439	1.6	128	417	289
	Hofoa	2	2	1.6		96	
	Puke	2	2	1.6		71	
	Sia'atoutai	2	2	1.6		50	
Total households of Nuku'alof		5,449	5,094		703	5,061	4,122
Total households in service ar		**5,429**	**5,075**		703	4,825	4,122
Growth rate(%) 1989-1996			(4825 - 4122) / 4122			17.1%	
Annual growth rate (%)			$(4825/4122)^{1/10} - 1$			**1.6%**	

Source: TWB data and Tonga population census in 1996

(3) Household

District	Village	Year 2003	Year 1999	Annual Growth rate(%)	Increment (1986-1996)	Year 1996	Year 1986
Kolofo'ou	Kolofo'ou	1689	1,579	1.6	7	1,501	1,494
	Maufanga	1033	966	1.6	219	918	699
	Nukunukumoto	2	2	1.6		4	
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	Tukutonga	62	58	1.6	17	55	38
	Pangaimotu Is	2	2	1.6		5	
	Fafaa Is	2	2	1.6		2	
	Oneva Is	2	2	1.6		1	
	Ataa Is	2	2	1.6		1	
	Velitoa Hahake	2	2	1.6		2	
	Velitoa Hihifo	2	2	1.6		3	
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Total households of Nuku'alof		5,449	5,094		703	5,061	4,122
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Growth rate(%) 1989-1996			(4825 - 4122) / 4122			17.1%	
Annual growth rate (%)			$(4825/4122)^{1/10} - 1$			1.6%	

Source: TWB data and Tonga population census in 1996

(4) Prensent Water Consumption

Water consumption by category of water usage

Category	Annual consumption	Monthly consumption	Remarks
Domestic	880,416 m^3/annum	73,368 m^3/month	
Public	117,264 m^3/annum	9,772 m^3/month	Offices, hospitals, schools and police station
Commercial	175,476 m^3/annum	14,623 m^3/month	Hotel, industry and restaurant
Total	1,173,156 m^3/annum	97,763 m^3/month	

Data: Water consumption data from 20 May to 20 June 1999 (TWB Accountant Department)

Present Water Consumption

Category	Piped Water						Rain Water		Piped and rain water	
	(1) No. of connection	(2) (*1) Population served	(3) Monthly consumption (m^3/month)	(4) Daily average consumption (m^3/day)	(5) Ratio among categories (%)	(6) Unit consumption	(7) (*3) Unit consumption	(8) (*4) Total rain water consumption (m^3/day)	(9) Total consumption (m^3/day)	(10) Unit consumption
Domestic	5,307	29,170	73,368	2,446	75%	84 l/cap/day	3 l/cap/day	53	2,498	87 l/cap/day
Public	131		9,772	326	10%	2,487 l/connect/day	124 m3/day	8	334	2,611 l/connect/day
Commercial	541		14,623	487	15%	901 l/connect/day	46 m3/day	12	499	947 l/connect/day
Total	5,979	29,170	97,763	3,259	100%	112 l/cap/day (*2)		73	3,331	115 l/cap/day (*2)

Source: Central Planning Department and TWB's Accounting Department

Note: (*1) Total population of the service area in 1999 is 30,706. Rate of population served is 95%

(*2) Per capita consumption including all categories

(*3) Rain water consumption of public and commercial users is assumed to be 5% of the domestic users that is same ratio of the piped water consumption

(*4) Rate of rain water users is assumed to be 60%.

(5) Trend of Unaccounted-for Water (m^3/month)

Month	Year 1995			Year 1996			Year 1997			Year 1998		
	Production	Metered w.	UFW	Production	Metered w.	UFW	Production	Metered w.	UFW	Production	Metered w.	UFW
Jan		146,007		180,500	138,724	23%	192,300	128861	33%	211,300	116,000	45%
Feb		132,086		167,500	97,510	42%	167,700	83,399	50%	195,400	86,680	56%
Mar		104,908		182,100	98,264	46%	186,200	91,993	51%	204,800	97,600	52%
Apr	192,000	113,162	41%	175,200	102,110	42%	166,100	83,794	50%	198,800	88,200	56%
May	189,000	86,000	54%	179,400	80,213	55%	165,000	99,789	40%	208,600	101,000	52%
Jun	165,000	91,292	45%	167,700	96,696	42%	167,000	90,330	46%	205,100	97,600	52%
Jul	175,000	92,600	47%	175,500	99,616	43%	169,700	76,168	55%	213,200	92,200	57%
Aug	179,000	84,516	53%	174,900	102,020	42%	182,200	92,900	49%	212,000	93,400	56%
Sep	179,000	104,287	42%	168,500	90,400	46%	176,600	88,343	50%	210,231	94,700	55%
Oct	181,000	98,755	45%	174,300	93,200	47%	177,900	90,800	49%	215,600	104,900	51%
Nov	169,300	100,914	40%	178,300	103,200	42%	176,800	99,900	43%			
Dec	179,200	81,168	55%	183,900	84,340	54%	199600	86900	56%			
Total	1,608,500	1,235,695	23%	2,107,800	1,186,293	44%	2,127,100	1,113,177	48%	2,075,031	972,280	53%
Monthly Average	**176,722**	**102,975**	**42%**	**175,650**	**98,858**	**44%**	**177,258**	**92,765**	**48%**	**207,503**	**97,228**	**53%**
Daily Average (m3/day)	5,957	3,432		5,855	3,295		5,909	3,092		6,917	3,241	

(5) Trend of Unaccounted-for Water (m^3/month)

Month	Year 1995			Year 1996			Year 1997			Year 1998		
	Production	Metered w.	UFW	Production	Metered w.	UFW	Production	Metered w.	UFW	Production	Metered w.	UFW
Jan		146,007		180,500	138,724	23%	192,300	128861	33%	211,300	116,000	45%
Feb		132,086		167,500	97,510	42%	167,700	83,399	50%	195,400	86,680	56%
Mar		104,908		182,100	98,264	46%	186,200	91,993	51%	204,800	97,600	52%
Apr	192,000	113,162	41%	175,200	102,110	42%	166,100	83,794	50%	198,800	88,200	56%
May	189,000	86,000	54%	179,400	80,213	55%	165,000	99,789	40%	208,600	101,000	52%
Jun	165,000	91,292	45%	167,700	96,696	42%	167,000	90,330	46%	205,100	97,600	52%
Jul	175,000	92,600	47%	175,500	99,616	43%	169,700	76,168	55%	213,200	92,200	57%
Aug	179,000	84,516	53%	174,900	102,020	42%	182,200	92,900	49%	212,000	93,400	56%
Sep	179,000	104,287	42%	168,500	90,400	46%	176,600	88,343	50%	210,231	94,700	55%
Oct	181,000	98,755	45%	174,300	93,200	47%	177,900	90,800	49%	215,600	104,900	51%
Nov	169,300	100,914	40%	178,300	103,200	42%	176,800	99,900	43%			
Dec	179,200	81,168	55%	183,900	84,340	54%	199600	86900	56%			
Total	1,608,500	1,235,695	23%	2,107,800	1,186,293	44%	2,127,100	1,113,177	48%	2,075,031	972,280	53%
Monthly Average	**178,722**	**102,975**	**42%**	**175,650**	**98,858**	**44%**	**177,258**	**92,765**	**48%**	**207,503**	**97,228**	**53%**
Daily Average (m3/day)	5,957	3,432		5,855	3,295		5,909	3,092		6,917	3,241	

(6) Water Demand Forecast

A. Forecast on domestic water

[A1] Population	31,738 persons	[A1]:(2) pouplation forecast
[A2] Rate of population served	95 %	
[A3] Population served	30,151 persons	[A3]=[A1]×[A2]
[A4] Unit demand	155 L/cap/day	
[A5] Water demand	4,673 m^3/day	[A5]=[A3]×[A4]

B. Forecast on other categories

Category	Water demand		Calculation	Remarks
	year 1999	year 2003		
[B1] Public	326	337	[B1-2000]=[B1-1999]×$(1+0.0083)^4$	Increase rate : 0.83%/annum
[B2] Commercial	487	539	[B2-2000]=[B2-1999]×$(1+0.0025)^4$	Increase rate : 2.5 %/annum
[B3] Total	813	876		

C. Design capacity

	Design capacity	Calculation	Water volume per capita
[C1] Water demand	5,549 m^3/day	[C1]=[A5]+[B3-2000]	184 l/c/d
[C2] Daily average production	6,529 m^3/day	[C2]=[C1]/(1-0.15[Leakage:15%])	217 l/c/d
[C3] Daily maximum productio	8,161 m^3/day	[C3]=[C2]×1.25[Daily max. factor:1.2	271 l/c/d

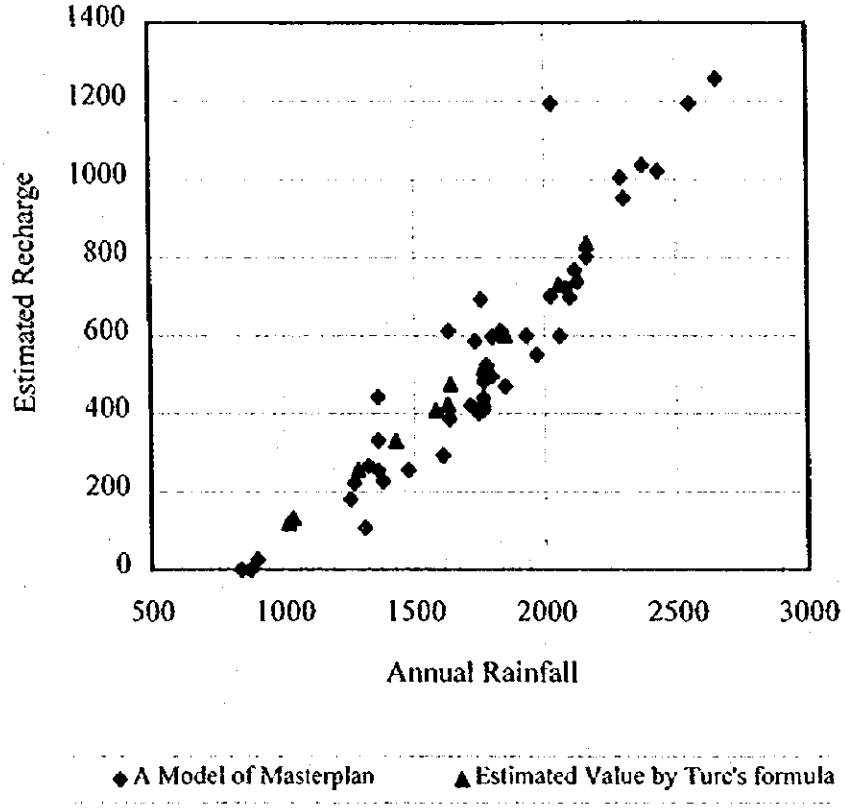
APPENDIX 6 WATER SOURCE

The Pumping Rate and Working Hours of the Production Wells Pumps in Mataki'eua

Well	Pumping Rate (liters/ec)						Pump Type	Working hours (h/month) : Operation ratio (%)									
No.	Jan-99	Feb-99	Mar-99	Apr-99	15-21/Jun/99*	Average	Turb/C-fugal	Jan-99		Feb-99		Mar-99		Apr-99		Mean	
101	3.69	5.29	3.96	3.85	under repair	4.25	Mono 720	714.37	96.0%	474.37	70.6%	704.21	94.7%	694.13	96.4%	646.77	89.4%
102	3.89	4.02	4.24	3.87	2.78	3.76	Mono 620	716.31	96.3%	575.39	85.6%	661.19	88.9%	699.26	97.1%	663.04	92.0%
103	2.59	2.84	2.62	2.82	3.11	2.80	Mono 620	712.46	95.8%	570.21	84.9%	704.33	94.7%	694.28	96.4%	670.32	92.9%
104	waiting for a pump installation																
105	2.76	2.62	2.68	2.61	2.31	2.60	Mono 620	715.51	96.2%	570.28	84.9%	694.10	93.3%	694.11	96.4%	668.50	92.7%
106	2.86	2.53	2.65	2.66	2.89	2.72	S/Cross PDG	709.18	95.3%	576.19	85.7%	661.25	88.9%	681.17	94.6%	656.95	91.1%
107	2.94	2.75	2.98	3.42	3.34	3.09	Mono 620	695.50	93.5%	644.14	95.9%	704.35	94.7%	670.14	93.1%	678.53	94.3%
108	2.26	2.1	2.29	2.3	2.27	2.24	Mono 620	594.19	79.9%	647.51	96.4%	637.51	85.7%	52.10	7.2%	482.83	67.3%
109	3.48	3.58	3.45	3.12	3.44	3.41	Mono 620	687.01	92.3%	645.09	96.0%	704.19	94.6%	670.26	93.1%	676.64	94.0%
110	2.52	0.2	3.27	3.04	2.89	2.38	Mono 620	720.17	96.8%	647.42	96.3%	259.09	34.8%	680.40	94.5%	576.77	80.6%
111	2.45	2.41	2.46	2.37	4.84	2.91	Mono 720	622.59	83.7%	622.47	92.6%	704.51	94.7%	670.39	93.1%	654.99	91.0%
111E	no data				*****	2.89	Elec. Centrif.	No data				595.42	80.0%	703.00	97.6%	649.21	88.8%
112	2.92	2.77	2.82	2.93	3.06	2.90	S/Cross PDG	724.48	97.4%	647.26	96.3%	714.52	96.0%	673.36	93.5%	689.91	95.8%
113	4.68	4.46	4.65	4.60	4.46	4.57	Mono 720	713.26	95.9%	648.44	96.5%	703.10	94.5%	672.38	93.4%	684.30	95.1%
114	1.99	1.43	1.42	2.26	2.60	1.94	S/Cross PDG	712.08	95.7%	641.35	95.4%	461.08	62.0%	677.57	94.1%	623.02	86.8%
115	2.74	2.77	2.95	2.90	2.48	2.77	Mono 720	671.12	90.2%	632.51	94.1%	657.09	88.3%	666.43	92.6%	656.79	91.3%
115E	3.48	3.44	3.31	1.38	3.74	3.07	Elec. Centrif.	701.53	94.3%	626.59	93.2%	703.22	94.5%	702.30	97.5%	683.41	94.9%
116	2.79	2.79	2.93	3.05	2.54	2.82	S/Cross PDG	728.24	97.9%	646.29	96.2%	704.22	94.7%	671.30	93.2%	687.51	95.5%
117	3.18	2.90	3.01	1.42	under repair	2.63	Mono 720	716.25	96.3%	594.47	88.5%	704.59	94.7%	133.38	18.5%	537.17	74.5%
117E	2.88	3.16	3.05	3.10	*****	3.05	Elec. Centrif.	691.47	92.9%	615.31	91.6%	654.00	87.9%	702.00	97.5%	665.70	92.5%
118	2.81	2.77	2.85	2.73	1.52	2.54	Mono 620	688.16	92.5%	640.27	95.3%	706.11	94.9%	668.19	92.8%	675.68	93.9%
119	2.98	2.66	2.15	3.00	3.09	2.78	Mono 720	710.16	95.5%	638.27	95.0%	632.34	85.0%	614.22	85.3%	648.75	90.2%
120	2.67	2.56	1.09	1.22	1.87	1.88	Mono 620	704.35	94.7%	643.40	95.7%	702.25	94.4%	665.59	92.4%	678.90	94.3%
121	3.16	3.16	3.13	3.43	3.34	3.24	Mono 620	729.15	98.0%	634.59	94.4%	658.43	88.5%	672.55	93.4%	673.68	93.6%
122	2.76	3.08	2.94	3.35	3.42	3.11	Mono 620	720.54	96.8%	572.23	85.2%	660.48	88.8%	676.27	93.9%	657.38	91.2%
123	3.06	3.59	3.71	4.00	3.02	3.48	Mono 620	681.48	91.6%	567.30	84.4%	658.33	88.5%	672.07	93.3%	644.80	89.5%
124	2.44	2.25	2.28	2.26	2.24	2.29	Elec. Mono 640	672.00	90.3%	648.00	96.4%	720.00	96.8%	720.00	100.0%	690.00	95.9%
125	3.29	3.67	3.61	1.67	2.79	3.01	Mono 620	709.37	95.3%	567.33	84.4%	657.46	88.4%	672.13	93.4%	651.57	90.4%
127	2.96	3.21	3.09	2.81	2.30	2.87	Mono 620	672.17	90.3%	568.13	84.5%	658.33	88.5%	644.42	89.5%	635.76	88.2%
129	2.83	3.05	2.91	no data	2.89	2.92	Mono 620	634.30	85.3%	568.18	84.6%	658.24	88.5%	532.21	73.9%	598.23	83.0%
211	2.46	2.24	2.39	2.29	2.39	2.35	Mono 620	672.00	90.3%	624.00	92.9%	720.00	96.8%	720.00	100.0%	684.00	95.0%
212	2.77	2.76	1.82	no data	2.35	2.43	Mono 620	651.14	87.5%	630.35	93.8%	690.59	92.8%	672.38	93.4%	661.12	91.9%
213	***	***	no data		2.89	2.89	Elec. Mono 620	*****	*****	*****	*****	359.15	48.3%	165.59	23.0%	262.37	35.6%
214	***	***	3.04	2.68	2.96	2.89	Mono 620	*****	*****	*****	*****	682.29	91.7%	698.24	97.0%	690.27	94.3%
Total	88.49	87.06	89.75	81.14	83.86	86.06		20790.54	93.1%	18327.34	90.9%	21495.97	87.6%	20601.82	86.7%	21104.84	89.6%
Mean	2.95	2.90	2.90	2.80	2.89	2.89		693.02		610.91		651.39		624.30		639.54	
(m3/day)	7,646	7,522	7,754	7,010	7,245	7,436											

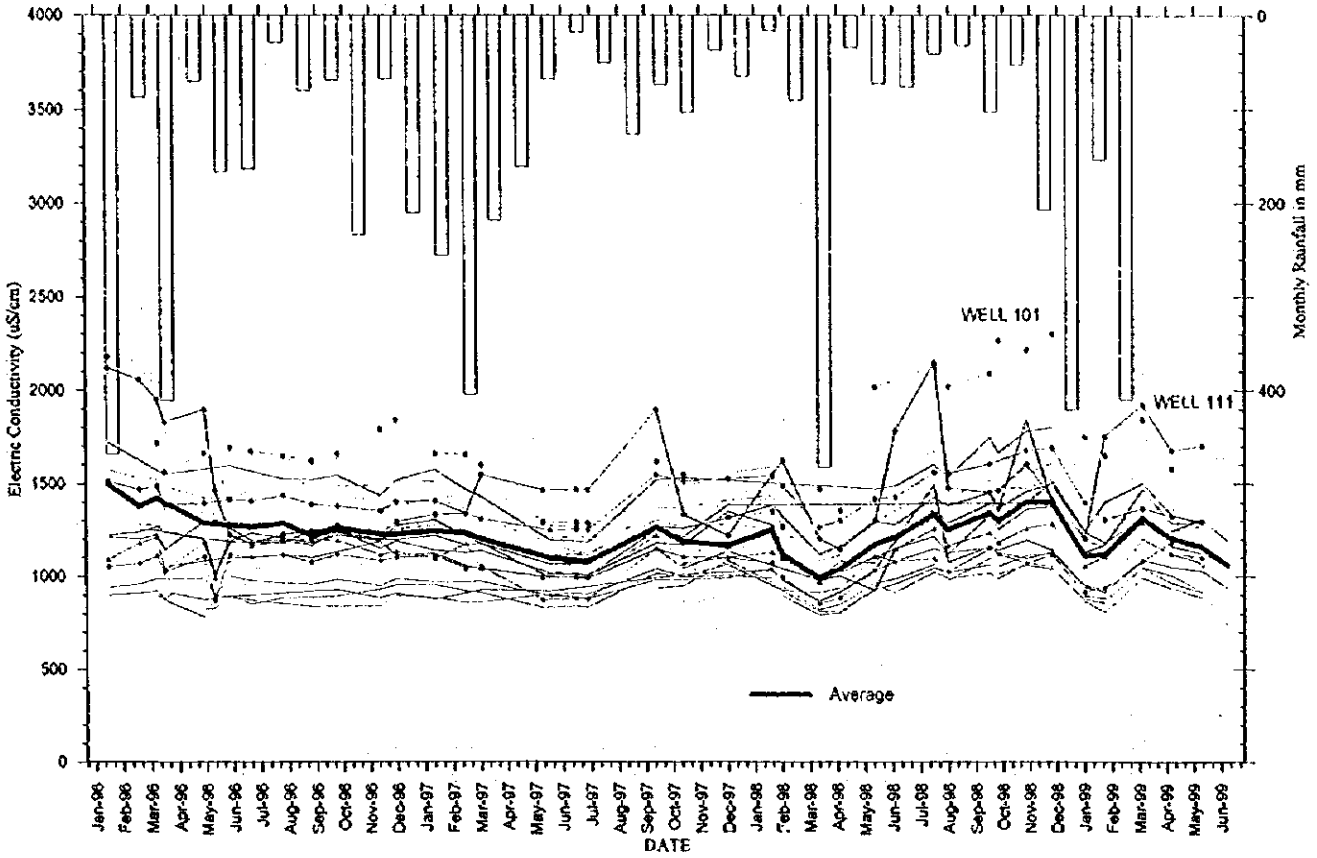
*:by JICA

Relation between Annual Rainfall and Estimated Recharge

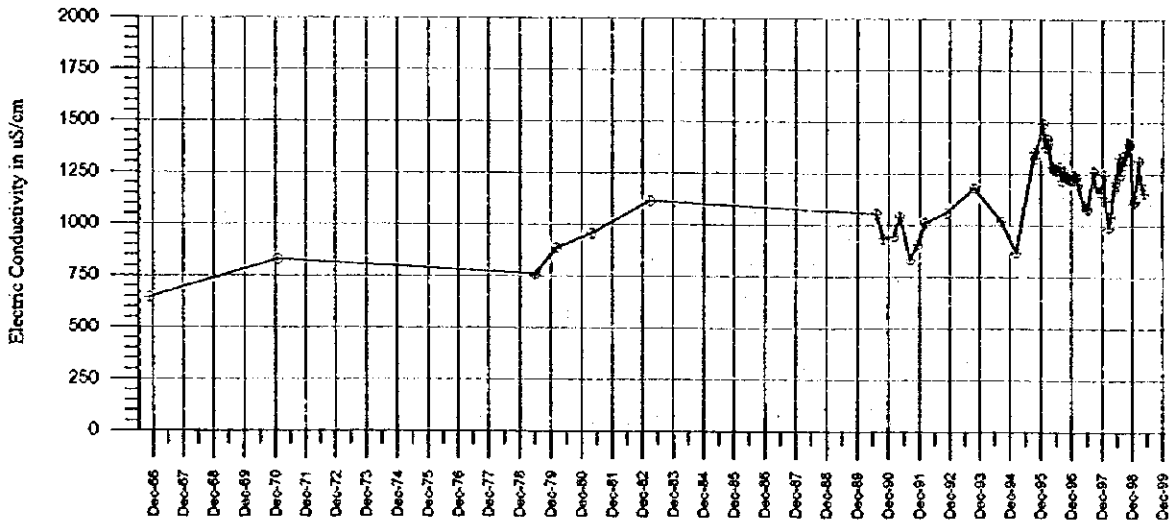


(Source)
Data for 1947-1990: A Model of Master Plan (TWB)
Data for 1988-1998: Estimated Value by Turc's Formula (JICA Basic Design Study Team)

Electric Conductivity in Mataki'eua from 1996 to 1999



Change of EC from 1966 to 1999
(Mean Value of Makaki'eua Wells)



Water Quality of Raw Water

Raw Water	Mataki'eua Wellfield
Sampling Point	Mataki'eua Reservoir No.6
Time / Date	14:30 / 24th June 1999
Weather	Previous day: Clear, Day of sampling: Clear

Item	Unit	Raw Water Quality	WHO Guideline for Drinking Water
Hardness	[mg/l]	205.2	–
Calcium	[mg/l]	55.8	–
Magnesium	[mg/l]	10.5	–
Bicarbonate	[mg/l]	53.9	–
Sulfate ion	[mg/l]	12.8	250
Chloride ion	[mg/l]	125.4	250
Total Dissolved Solids (TDS)	[mg/l]	605	1000
Aluminum	[mg/l]	<0.01	0.2
Iron	[mg/l]	<0.01	0.3
Manganese	[mg/l]	<0.005	0.1
Cadmium	[mg/l]	<0.001	0.003
Arsenic	[mg/l]	<0.001	0.01
Zinc	[mg/l]	0.03	3
Copper	[mg/l]	<0.01	2
pH		7.7	<8.0(preferable)
Specified organophosphorus	[mg/l]	<0.1	–

(Note)
The raw water, which was sampled in the field, was analyzed in Japan.

APPENDIX 7 FINANCIAL STATEMENTS OF TWB

TONGA WATER BOARD

BALANCE SHEET

	June 1998	*June 1997*	*June 1996*	*June 1995*	*June 1994*
CAPITAL & RESERVES					
Capital	2,065,040	752,521	752,521	752,521	752,521
Sinking Fund Reserve	433,719	352,452	217,239	0	0
Deferred Income Reserve	0	1,087,087	1,087,087	0	0
Asset Replacement Reserve	85,121	62,521	0	0	0
Retained Profits	652,933	406,954	392,443	393,082	218,898
Total Capital & Reserves	3,236,813	2,661,534	2,449,290	1,145,603	971,419
PRESENTED BY: CURRENT ASSETS					
Cash Float	50	70	50	50	50
Bank Account	422,675	359,780	290,459	172,479	60,650
Niuatoutapu Bank Account	0	0	29,981	59,600	0
Trade Debtors	218,348	120,728	104,870	175,557	268,932
Accrued Income	11,023	9,933	0	0	0
Sundry Debtors	857	2,632	2,771	3,433	3,543
Stock in Trade	117,501	114,037	141,659	103,664	84,598
Preparyment	303	6,569	7,888	6,255	8,644
Income Tax Benefit					23,321
Total Current Assets	770,758	613,749	577,678	521,038	449,738
LESS CURRENT LIABILITIES					
Sundry Creditors	15,152	15,488	24,503	48,579	68,304
Employee's Savings	268	29	794	1,294	1,294
Accrued Payables	10,027	2,525	10,931	10,022	52,251
Provision for Audit Fees	4,200	4,200	8,400	8,400	10,500
Provision for Income Tax	128,506	151,865	85,907	23,973	0
Provision for Bonus	15,000	20,000	15,000	0	0
Total Current Liabilities	173,153	194,107	145,535	92,268	132,349
WORKING CAPITAL	597,605	419,642	432,143	428,770	317,389
ADD INVESTMENTS					
Term-Deposits	722,622	410,000	300,000	100,000	0
Sinking Fund Saving Account	333,719	352,452	217,239	0	0
Asset Replacement Fund	12,500	62,521		0	0
ADD FIXED ASSETS	1,836,275	1,734,292	1,821,726	945,440	976,098
Total Investments and Fixed Assts	2,905,115	2,559,265	2,338,965	1,045,440	976,098
LESS LONG-TERM LIABILITIES					
Provision for Staff Pension	175,584	219,645	186,921	157,007	127,744
Loan-Govt of Tonga	90,323	97,728	104,916	112,000	118,245
Loan-Tonga Development Bank	0	0	0	0	76,079
Project Fund Hedl (NTT)	0	0	29,981	59,600	0
Total Long Term Liabilities	265,907	317,373	321,818	328,607	322,068
TOTAL NET ASSETS	3,236,813	2,661,534	2,449,290	1,145,603	971,419

TONGA WATER BOARD

INCOME STATEMENT

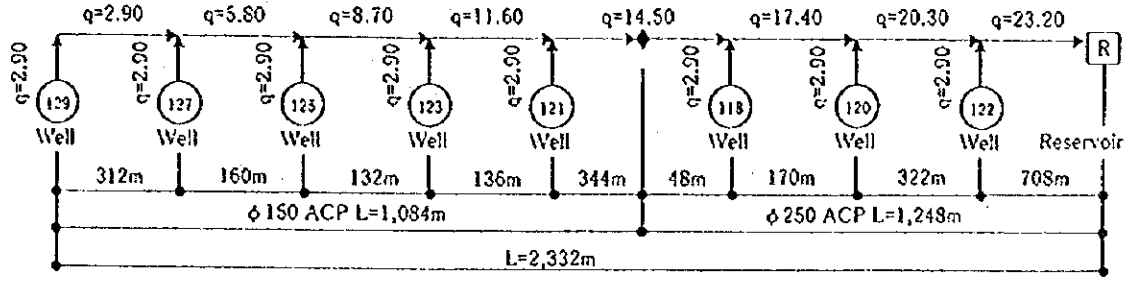
	1997/98	1996/97	1995/96	1994/95	1993/94
INCOME					
Gross Profit	11,386	7,421	7,099	7,018	7,466
House Rent	1,500	1,600	4,800	1,700	1,280
Water Sales	1,591,916	1,231,322	1,106,985	1,111,936	1,050,063
Services Fees	37,442	213,675	302,016	170,646	143,957
Installation	2,393	1,470	2,740	2,830	2,830
	28,592	25,430	—	—	—
	32,564	25,517	—	—	—
Interest	55,061	35,467	11,977	0	0
Bad Debt Recovered	4,223	1,603	5,774	1,103	258
Other Income	16,334	22,485	18,091	8,258	4,577
Australian Aid	5,290	0	0	7,289	41,995
MakaveProject	23,429	0	0	0	0
Proceed Sale of Fixed Asset	-2,600	2,000	0	0	0
Subsidy (among TWB)	2,000	11,500	17,000	19,500	26,500
Total Income	1,809,530	1,579,490	1,476,483	1,330,281	1,278,926
EXPENCSES					
Administration	403,339	447,573	394,269	292,132	617,445
Financial	175,338	178,440	184,032	231,131	
Engineering	53,449	30,551	31,878	27,171	
Production	388,705	392,506	375,695	375,373	390,641
Distribution	182,366	141,327	132,047	130,845	240,914
Stock & Credit Control	27,944	62,325	54,985	17,147	
Water Quality	12,733	5,885	4,313	0	
Special Expenses	15,291	10,592	10,819	785	
Subsidy (among TWB)	2,000	11,500	17,000	19,500	26,500
Total Expenses	1,261,166	1,280,699	1,205,038	1,094,084	1,275,500
Net Operating Income Before Tax	548,364	298,791	271,446	236,197	3,426
Less Provision for Bonus	15,000	20,000	15,000	0	0
Taxable Income	533,364	278,791	256,446	236,197	3,426
Less Provision for Tax	128,506	65,957	61,934	53,673	-4,745
Net Operating Income After Tax	404,858	212,834	194,512	182,524	8,171
Add Abnormal Income	0	0	1,087,087	0	0
Transfer Reserves	-103,866	0	0	0	0
Net Profit and Abnormal Income	300,992	212,834	1,281,599	182,524	8,171

APPENDIX 8 HYDRAULIC CALCULATION OF RAW WATER MAIN AND INTAKE PUMP

Hydraulic Calculation of Raw Water Main and Intake Pump

An existing representative raw water main, or rising main, in Mataki'eua Wellfield is given in the following chart.

Hydraulic Chart of a Raw Water Main



Hydraulic Calculation

Dia (mm)	150	150	150	150	150	250	250	250	250
q (l/sec)	2.90	5.80	8.70	11.60	14.50	14.50	17.40	20.30	23.20
v (m/sec)	0.16	0.33	0.49	0.66	0.82	0.30	0.35	0.41	0.47
I (‰)	0.27	0.98	2.08	3.54	5.35	0.44	0.62	0.83	1.06
L (m)	312	160	132	136	344	48	170	322	708
h (m)	0.08	0.16	0.27	0.48	1.84	0.02	0.11	0.27	0.75

Hydraulic formula : Hazen-Williams (C=130 for ACP)

Σh=3.98m

The existing main is composed of 150 mm ACP with 1,084 m distance and 250 mm ACP with 1,284 m, totaling 2,332 m of the distance. The main transmits raw water of groundwater taken from 8 production wells. Average pump flow is 2.90 l/sec (=174 l/min = 0.174 m^3/min) ; totaling 23.20 l/sec with the 8 wells. The existing raw water main will be able to transmit groundwater of full pumps' operation.

< Intake Pump Calculation >

- Operation water level of the production well = +0.50 m .....(A)
- Elevation of the reservoir = +27.00 m .....(B)
- Actual pumping head = (A) - (B) = 26.50 m .....(C)
- Loss of head in the pipeline = 3.98 m .....(D)
  (See the Hydraulic Calculation Table.)
- Loss of head around the pump = 2.50 m .....(E)
- Total pumping head = (C) + (D) + (E) = 32.98 m --> 33 m

Pump power :
R = 0.222 x 0.174 x 33 x (1/0.50) = 2.55 PS/each

Engine output :
P = R x (1+A)/ϕ (ϕ :0.85 for flat-belt)
= 2.55 x (1+0.25) x (1/0.85)
= 3.75 PS --> 4.0 - 4.5 PS/each

APPENDIX 9 STUDY ON THE ELEVATED TANK SYSTEM

Appendix – 9 Study on the Elevated Tank System

Regarding the distribution system, two alternatives have been studied. They are,

Case 1: Construction of an elevated tank and a transmission pipeline to the tank

Case 2: Construction of a direct distribution trunk main of a larger diameter, without elevated tank

Considering advantages/ disadvantages of several factors shown in the Table of the both alternatives, the Case 2 is recommended in this Project. Among the comparison factors, difference in construction cost is remarkable. Concerning maintenance cost, Case 2 become little more expensive for the larger diameter than the Case 1. As the transmission capacity in Case 1 is a constant for 24 hours, the diameter of the pipe is smaller so that the pipe cost would be smaller but pipe capacity be also smaller. In Case 2, the larger diameter is required to have a capacity of peak hour (180% of the daily average distribution). Therefore, the pipe cost of Case 2 become bigger but the pipe capacity can be bigger. As for future extension work, Case 2 is more advantageous, because the points of water inflow to the pipe network can be added with flexibility in Case 2, but the points would be limited to the elevated tank in Case 1 so that the extension work would be difficult.

Comparison Table

Item	Case 1	Case 2
(1) Reliability of supply	Reliable	Reliable
(2) Against disasters	Care of both cyclone and earthquake	Care of earthquake
(3) Maintenance work	Water level control and tank cleaning	Not required
(4) Maintenance cost for pipes	Less expensive (smaller diameter)	More expensive (larger diameter)
(5) Main pipe capacity	Q = Daily maximum flow (Reservoir to Elevated tank) As the transmission capacity is a constant, the diameter of the pipe is smaller so that the pipe cost would be smaller but pipe capacity be also smaller	Q x 180% flow (Reservoir to Service area) Little more expensive than the Case 1 due to the larger diameter so as to be capable of peak hour flow capacity
(6) Flexibility of extension work	Rather difficult Additional tank would be difficult to construct. The points to water inflow to the network is limited to the tanks so that the extension work would be difficult.	Flexible The points of water inflow to the network can be added with flexibility
(7) Land use	Tank occupies some land area	Land not required
(8) Construction cost (Tentative)	More expensive (T$ 4,381,700-)	Less expensive (T$ 3,245,200-)

(Note)
The construction cost for Case 1 is estimated on assumption that one elevated tank in the east zone and transmission pipeline from the Mataki'eua reservoir to the elevated tank is constructed.
The construction cost for Case 2 is estimated on assumption that a direct distribution trunk main is constructed from the Mataki'eua reservoir.