

APPENDIX A

TERMS OF REFERENCE TONGA WATER SUPPLY MASTER PLAN STUDY

A.1. Background

The Australian Government has assisted with improving village water supplies in the Kingdom of Tonga since 1982. However both urban and village water supply systems remain in a less than satisfactory state and considerable additional assistance is needed. The following key issues and constraints have been identified by the Government of Tonga for specific attention during the Fifth Five Year Development Plan, 1986-1990:

- * the lack of adequate legislation to regulate the development and exploitation of water resources at the national level;
- * the lack of any body responsible at the national level for policy and planning in the area of water resources;
- * the lack of clear lines of responsibility amongst the various ministries and agencies involved in the present system;
- * poor management at the village level of the village water schemes;
- * the lack of definitive data on the extent and sustainable yield of the exploitable water resources at the national level;
- * the need for clear policy guidelines and planning in relation to:
 - new wells and extraction rates
 - agricultural water supply systems
 - management of village water schemes
 - household water tank programs
 - upgrading of the urban reticulation systems
 - co-ordination of aid agencies and NGO's involved in rural water supplies.
- * the need for Tonga Water Board to be better capitalised to enable it to fully meet its obligations to the urban populations which it serves and to provide for future developments;
- * the increasing volumes and types of both human and industrial waste being generated by the growing population density of Nuku'alofa and the spread and expansion of industrial and commercial enterprises;
- * the establishment of new settlements in low lying areas where the water table is very close to the surface;
- * the lack of adequate legislation regarding sanitation and water disposal facilities at public and commercial premises.

A.2. Objectives

In general terms the objectives of the project will be to assist with the management and development of the Kingdom's water resources and in particular to prepare a Master Plan for:

- * the provision of safe and reliable water supply to the rural and urban populations of the Kingdom through a program of improvements, upgrading and extension of existing services;
- * The development of an efficient and effective institutional structure with appropriate management policies and programs for the planning, implementation, operation, maintenance and management of water supply and for the equitable and efficient utilisation and protection of water resources;

A.3. Study Tasks

A.3.1 Analyse and review the current status of water supply development plans and programs in Tonga including:

- * targets, objectives and rate of progress;
- * current sources of funds;
- * determination of priorities and needs;
- * institutional and legal framework.
- * interaction with other projects;

A.3.2 Inspect and analyse the existing water supply systems including:

- * urban supplies managed by the Tonga Water Board in Nuku'alofa, Neiafu, Pangai-Hihifo and 'Eua;
- * selected representative village supplies operated by village Water Committees under the overall responsibility of the Ministry of Health;

This task would include:

- * recording all existing facilities including their capacity and condition;
- * assessment of water abstraction, water usage and leakage;
- * collection of water quality data;
- * collection of data on current operation costs and water charges;
- * assessment of current operation and maintenance procedures;
- * assessment of current sanitation and waste disposal practices.

A.3.3 Review previous studies of the water resources of Tonga (17 have been carried out between 1971 and 1987) and estimate the current rates of abstraction of groundwater for all purposes including agriculture.

A.3.4 Consult with the Central Planning Department and other relevant departments to obtain data on future development plans for urban housing, industry and tourism. Using this data and available demographic data, in particular the 1986 population census, prepare demographic and development projections for each urban centre and selected villages.

- A.3.5 Using data obtained on current water usage and in consultation with the relevant authorities, establish design unit water requirements for urban and village consumers. These should cover a range from minimum essential requirements to desirable levels of supply reflecting variations in available water resources in different areas within the Kingdom. Water demand projections for each urban area and village would be developed for a 20 year design period.
- A.3.6 Formulate alternative programs for the improvement and development of each water supply system. Prepare preliminary engineering designs and order of cost estimates and using economic analysis rank alternatives in order of least cost. Evaluate the most highly ranked schemes in terms of social, health and environmental costs and benefits and select a preferred scheme.
- A.3.7 Develop conceptual engineering designs with sizes, capacities, levels, materials, control functions etc. for wells, pumps, pipelines, storage reservoirs etc. and prepare budget cost estimates of capital and recurrent expenditure (local and foreign).
- A.3.8 Prepare programs for phased implementation including programs for immediate improvements and a first stage development. Prepare corresponding capital expenditure schedules.
- A.3.9 Carry out financial analysis on a range of funding options and assess the water charges required with each.
- A.3.10 Assess the environmental, social and economic impact of the proposed water supply improvement program.
- A.3.11 Identify and make recommendations for further work required to overcome any problems of sanitation and wastewater disposal created through improved water supply.
- A.3.12 Establish standard design guidelines for use in the future planning and design of both urban and village water supplies.
- A.3.13 Formulate improvements to operation and maintenance procedures. Particular emphasis will be given to village level operation and maintenance, supply of spares and training.
- A.3.14 Plan a program of water supply leakage detection and control and demand management and determine the resources required to implement.
- A.3.15 Plan a system for keeping as built records of water supply facilities with emphasis on water pipelines.
- A.3.16 Plan a national control and monitoring system to determine and maintain a safe sustainable yield of good quality groundwater. Determine the resources required to implement the system.
- A.3.17 Review the current institutional arrangements and policy framework with a view to restructuring to provide for:
- * a national control and monitoring system to ensure a safe sustainable yield of good quality groundwater; and
 - * the possibility of gradual transfer to management of village water supplies to the Tonga Water Board.
- A.3.18 Formulate changes required to strengthen institutional capacity, overcome current deficiencies and anomalies and establish clear lines of responsibility and communication. Specific areas requiring definition would include:

- * management objectives
- * performance criteria
- * management information systems
- * financial management requirements
- * personnel management and staff development requirements
- * work programming arrangements.

A.3.19 Review the proposed National Water Resources Legislation (G.K. Wilkinson 1985) and recommend modification in line with any institutional restructuring recommended in 3.17 and 3.18.

A.3.20 Determine the organisation, management and administrative requirements of the Tonga Water Board and other institutions affected by proposed institutional restructuring and improvement to water supply systems.

A.3.21 Determine the requirements for staff training, equipment and facilities for the proposed institutional strengthening and long term improvements to water supplies.

A.3.22 Justify the study recommendations in terms of economic, financial, institutional, environmental and social impact.

A.3.23 Assess the viability and sustainability of the study recommendations identifying:

- * critical assumptions and sensitivity to risk;
- * availability of recurrent funding and the ability and willingness of consumers to pay for water;
- * availability of local staffing;
- * local construction capability;
- * operation and maintenance capability.

Note: Study Tasks A.3.3 and A.3.16 will be carried out jointly with the Hydrogeological staff in the Ministry of Lands, Survey and Natural Resources.

APPENDIX B

BIBLIOGRAPHY AND REFERENCE SOURCES

Australian International Development Assistance Bureau 1990; Terms of Reference, Management Plans for the Fanga'uta Lagoon System and for the Kingdom of Tonga.

Bureau of Statistics, Government of Tonga, Census of Population and Housing, Vol 1, 1976.

Bureau of Statistics, Government of Tonga, Census of Population and Housing, selected tables, 1986 .

Central Planning Department, 1987; Fifth Five Year Development Plan 1986-1990, Nuku'alofa.

Central Planning Department, Mid Term Review, Fourth Development Plan 1980-1985, Nuku'alofa.

Central Planning Department, 1988; Ha'apai 1988/95 Regional Plan, Nuku'alofa.

Crane, E.A., 1979; The Geography of Tonga, Wendy Crane Publisher.

Dale, W.R, 1988; Training Needs of Water Supply and Sanitation Organisations in Eight South Pacific Countries, Institute of Natural Resources, University of the South Pacific, 194pp.

Engineering and Water Supply Dept., South Australia Rainwater Tanks for Households Without A Mains Water Supply, June 1986.

Finkel and Finkel, Ltd., 1986; Proposal for the Preparation of a Master Plan for the Development of the Water Resources and Irrigated Agriculture of Tongatapu, January.

Forbes, R.H., 1977; First Report on Geoelectric Survey of Tongatapu Island, Kingdom of Tonga, Tonga Water Board, 25pp.

Forbes 1978; Geoelectric Soundings, January 1978 Continuation of the Geoelectric on Tongatapu Island.

Fuavao, V.A. and S. Tiueti, 1988; Water Quality Studies on Some Drinking Water Supplies in the Kingdom of Tonga, Environmental Stud. Rep. 39, University of South Pacific, 17pp.

Gibbs, H.S., 1976; Soils of Tongatapu, Tonga, New Zealand Soil Survey Report 35, Wellington.

Hadwen, P., 1988; Orientation Report - Tonga, Internal report TON/1, Water Resources Assessment and Planning in the Pacific islands, RAS/87/009, United Nations, Suva, Fiji.

Hunt, B., 1979; An Analysis for the Groundwater Resources of Tongatapu Island, Kingdom of Tonga, Journal of Hydrology, 40, pp185-196.

P.N. Jayaprakash 1987, Planning and Management of Village Water Supply Schemes in the Kingdom of Tonga.

Kafri, u., 1989; Assessment of Groundwater Potential in the island of Tongatapu, Kingdom of Tonga, Geological Survey of Israel, Ministry of Energy and Infrastructure, January.

Laurie, Montgomerie and Pettit Pty Ltd, 1984, Suva Water Supply Master Plan Study.

Lao, C., 1978; Field Visit Report (16 April to 4 May 1978), Groundwater resources study of Tongatapu, World Health Organisation, Regional Office for the Western Pacific.

Lao, C., 1979; Assignment Report (25 October to 5 December 1978), Groundwater Resources Study of Tongatapu, World Health Organisation, Regional office for the Western Pacific, 59pp.

Lataimaumi, F.H., P. Speijer and P.Tupou, 1988; Meteorological Data at the Experimental Farm in Vaini, 1988, Ministry of Agriculture, Fisheries and Forestry (also reports for previous years.)

Longworth and Mackenzie. 1989; Village Water Supply Project, Kingdom of Tonga, Review Report, May, prepared for the Australian International Development Assistance Bureau

Magno, T.B.,m 1982; A Design Analysis of Rainwater Catchment Area and Storage Requirement in Ha'apai Island Group, Tonga, World Health Organisation, unpublished report.

Ministry of Health, Government of Tonga, Reports for the years of 1984,85,86,87,88,89

Mosley, B., 1989; Follow-up Mission - Tonga, 16-18 January 1989, Internal report TON/2, Water Resources Assessment and Planning in the Pacific Islands, RAS/87/009, United Nations, Suva, Fiji, February.

Mosley, B., 1989; Follow-up Mission - Tonga, 20-26 may 1989, Internal report TON/3, Water Resources Assessment and Planning in the Pacific Islands, RAS/87/009, United Nations, Suva, Fiji.

Muller, A.G., 1978; Report, Inspection of Water Supply Problems, Islands of Tongatapu and 'Eua, Kingdom of Tonga, sponsored by Rotary International, May.

Newton Consultants (N.Z.) Ltd, 1989, Report on findings in regard to the Tonga Water Boards Nuku'alofa Water Supply System.

Pak-Poy & Kneebone P/L. 1989; Village Water Supply Project, Kingdom of Tonga, Planning Report prepared for the Australian International Development Assistance Bureau

Pfeiffer, D.I., 1971; Outline of Hydrogeology of the Island of Tongatapu (Kingdom of Tonga, South Pacific), United Nations Economic Commission for Asia and the far East, October, unpublished report, 15pp.

Pfeiffer, D. and L.W. Stach, 1972; Hydrogeology of the Island of Tongatapu, Kingdom of Tonga, South Pacific, Geologisches Jahrbuch, Reihe C, 4, Hannover, 13pp.

Robinson K., 1987; Report of the Tonga Village Improvement Water Supply and Sanitation Project, Australian Development Assistance Bureau.

Spennemann, D.H.R., L.H. Belz and G.Byrne, 1989; The Potential Impacts of Projected Climatic Change and Sea Level rise and Tongatapu, Kingdom of Tonga, Studies and Reviews of Greenhouse Related Climatic Change Impacts on the Pacific Islands, ed. Pernetta, J.C. and Hughes, P.J., pp 36-67.

Stach, L.W., 1974; Arrangements for Geoelectric Survey Project. Tongatapu Island, Advisory Services Report, United Nations Development Program TON/72/002, Bangkok.

South Pacific Commission, 1984; Pollution Sources Survey of the Kingdom of Tonga, November.

South Pacific Social Sciences Association; 1977, A Polynesian Village the process of change in the Village of Hoi, Tonga, Penisimani.

Statistics Department, Government of Tonga, Population Census 1986, Bulletin No. 1.

Tappin, D.R., 1983; Country Report for the Kingdom of Tonga, Workshop on Hydrogeological Mapping, Bandung, Malaysia, Ministry of Lands, Surveys and Natural Resources, Nuku'alofa, Tonga.

Taylor, R.C., 1973; An Atlas of Pacific islands Rainfall, Data Report No. 25, HIG 73-9, Hawaii Institute of Geophysics, University of Hawaii.

Thompson, C.S., 1986; The Climate and Weather of Tonga, New Zealand Meteorological Service, Misc. Publ. 188(5), Wellington. New Zealand.

United Nations, 1983; Tonga, Groundwater in the Pacific Region, Natural Resources/Water Series No. 12, Department of Technical Co-operation for Development.

van der Molen, W.H., 1979; An Analysis of the Groundwater Resources of Tongatapu Island, Kingdom of Tonga - Comments, Journal of Hydrology, 40, pp197-199.

van Putten, F., 1989; Follow-up Mission - Tonga, 20-22 and 25-26 May 1989, internal report TON/3, Water Resources Assessment and Planning in the Pacific Islands, RAS/87/009, United Nations, Suva, Fiji, June.

Waterhouse, B.C., 1974; Water Supply, Tongatapu Island, Tonga, Drilling Program, New Zealand Geological Survey, unpublished report, 8pp.

Waterhouse, B.C., 1974; Water Supply, Tongatapu Island, Tonga, New Zealand Geological Survey, September, unpublished report, 7pp.

Waterhouse, B.C., 1984; Water supply Review, Kingdom of Tonga, New Zealand Geological Survey, November, 56pp.

Wilkinson, G.K., 1985; Final Report and Proposal on National Water Resources Legislation for Tonga, Advisory Services and Fellowships in Agriculture, Fisheries, Livestock and forestry, RAS/79/123, Legal Office, Food and Agriculture Organisation of the United Nations, Rome.

Womens Development Section, 1989; Annual Report, Ministry of Agriculture, Forestry and Fisheries, Government of Tonga.

WRC Swindon, 1989, Summary of Modelling Work done on the Nuku'alofa Water Distribution System, December.

Yao, K.M., 1980; Assignment Report (13 to 29 October 1979), Drinking Water Quality Monitoring and Surveillance, World Health Organisation, Kuala Lumpur, Malaysia, 27pp.

APPENDIX C

NIUAFO'OU DESIGN CRITERIA

C.01 General

Design criteria and planning assumptions applied to the Tonga Water Supply Master Plan for rural centres are based on accepted engineering practices for public water supplies as applicable to local conditions.

The rural centres exclude Nuku'alofa, 'Eua, Neiafu and Pangai-Hihifo which are all operated by the Tonga Water Board. All rural reticulated supplies are managed by Village Water Committees

C.02 Basic Criteria

The system will be designed to provide a continuous and satisfactory water service to all consumers. Drinking water quality will meet the WHO International Guidelines for drinking water. All water quality shall, where possible, meet the WHO guidelines.

Lake water abstraction shall be managed and controlled such that the security and reliability of the water supply source is guaranteed.

Source development, treatment facilities and the transmission system will be designed to supply the maximum daily demand. Reticulation mains will be designed to supply peak flow by drawing from operational storage.

C.03 System Parameters

Minimum Desirable Distribution Pipe Size	:	50mm
Minimum Acceptable Pressure	:	10m
Maximum Desirable Pressure	:	50m

Isolated structures built on hill tops may require installation of private booster systems. These private systems would be provided and maintained by the consumer.

C.04 Pipe Roughness Values:

Colebrook White formula, roughness factor to be determined but generally $K = 0.15\text{mm}$ for new pipes.

C.05 Service Reservoir

12 hour average daily demand to provide both operational and emergency storage.

C.06 Fire Flow:

Fire hydrants shall be located at intervals not exceeding 90m in residential areas.

C.07

For Transfer Pumping Stations:

Standby capacity is provided by the existing rainwater supplies.

Power Supply:

Diesel driven motors will be used to drive pumps.

C.08

Water Requirements

Water demand criteria are discussed in Section 5

C.09

Peaking Factors

Maximum Daily Demand = 1.25 x (Average Annual Daily Demand)

Peak Diurnal Flow = 2.50 x (Average Annual Daily Demand)

Factors apply to both domestic and non-domestic demands. However, the peak diurnal flows for each occur at different times as described in Section 5.

C.10

Distribution Requirements

Isolation valves are required on branches and at intervals not exceeding 1000m along transmission mains. The distribution and reticulation system will be designed so that dead ends are minimised and wherever possible an alternative supply is available at any point in the system. The alternative supply refers to direction of flow ie. a ring main system is required in preference to dead end branches.

Supply under emergency conditions is discussed in detail in section 10.

Service reservoirs will be roofed and be provided with valved inlet, outlets and scours, and an overflow. By pass pipework shall be built at all reservoirs to enable regular reservoir maintenance without interruption to supply.

C.11

Structural Criteria

Seismic loading is to be used in the design of all structures. Hydraulic structures shall be designed to allow for the effective mass of their contents. For design purposes a seismic acceleration in accordance with New Zealand Zone A requirements will be adopted.

The design wind velocity shall be not less than 66m/s.

APPENDIX D

UNIT COST RATES.

All prices are in Tonga Pa'anga at early 1991 price levels.

D.1 Pipelines

D.1.1 Pipe Materials

NOMINAL DIAMETER (mm)	PIPES & FITTINGS (\$/m)
12	2.2
50	4.5
75	6.6
100	8.8

D.1.2 Pipeline Construction

NOMINAL DIAMETER (mm)	UNIT COST (1) (\$/m)	
	Urban (2)	Non urban (3)
12	(4)	(4)
50	42	30
75	58	42

- (1) Assumes excavation is in "other than rock" material
- (2) Construction in established urban area
- (3) Construction in non-urban area
- (4) Assumes consumer install pipework downstream of water meter and the total cost of \$150 per services includes cost of meter.

D.2 RESERVOIRS

VOLUME (kL)	ELEVATED OR GROUND LEVEL	COST (\$)
22.5	Ground level	9,000

Costs include siteworks, pipework, fittings, valves and flowmeters but exclude land costs.

D.3 TRANSFER PUMPING STATION

ITEM	UNIT	COST
Centrifugal pumps (Q = 2L/s, H = 170m) with 5.5kW diesel motor	item	12,000
Building	m ²	\$3,000
Fuel Storage tank, pipework and valves	item	\$10,000
Total		\$25,000

APPENDIX E

FINANCIAL ANALYSIS SPREADSHEETS

