TA No. 1775-MAR: Majuro Water Supply

Report of the Water Supply Engineer

Scott & Furphy Pty Ltd

February 1993

SCOTT & FURPHY PTY LTD
ENGINEERS AND PLANNERS
A.C.N. 004 938 087

MELBOURNE OFFICE
390 St. Kilda Road
Melbourne Victoria 3004
Australia
Telephone (03) 272 6666
Facsimile (03) 272 6611
Telex BRIXA AA32907
DX30575 South Melbourne

16. February 1993

Mr. Javier M. Gomez
Manager
Water Supply & Urban Development Division (East)
Infrastructure Department
Asian Development Bank
Manila, Philippines

Dear Sir,

Re: MARSHALL Islands: Proposed Majuro Water Supply Project
TA No. 1775-MAR: Report of the Water Supply Engineer

In accordance with my TOR, I am pleased to submit my report following the field trip to the Marshall Islands with the Mission and the subsequent period in the ADB Headquarters in Manila.

I have formally reported in regard to my TOR but I also offer some comments on the provision of additional water from a range of sources of supply. This is technically outside my brief and on which, I was advised by the Mission Leader was outside the scope of the Mission and warranted a Feasibility Study.

Yours sincerely,

GEOFFREY G. HENKEL
Water Supply Engineer
CMPS&F

Encl.: a/s

MARSHALL ISLANDS

PROPOSED MAJURO WATER SUPPLY PROJECT

TA NO. 1775-MAR:

REPORT OF THE WATER SUPPLY ENGINEER

Geoffrey Henkel
CMPS & F
74 Emu Bank
Belconnen 2617
Australia

16 February 1993

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MARSHALL ISLANDS: PROPOSED MAJURO WATER SUPPLY PROJECT (TA NO: 1775-MAR)

Report of the Water Supply Engineer

A. Introduction

1. The Government of the Marshall Islands has requested the Asian Development Bank (the Bank) for a loan to finance the further development of water supply facilities in Majuro.

2. As a consequence, a small-scale PPTA for Majuro Water Supply Project Fact-Finding Mission, TA No. 1775-MAR: Majuro Water Supply Project (the Project) was arranged for January/February 1993. The PPTA Mission consisted of Mr. Goh Gin Han (Team Leader), Mr. Geoffrey Henkel, Water Supply Engineer, Ms. Christine Dendy and Mr. Michael Powell, Financial Analysts.

3. In accordance with the Water Supply Engineer's Terms of Reference (TOR) the Water Supply Engineer (the Consultant) is required to submit a report to the Manager of the Bank's Water Supply and Development Division (EAST), Infrastructure Department.

4. The Consultant arrived in Majuro on 6 January 1993, departed for Manila on 2 February 1993 and will complete the first stage of the assignment (6 weeks) on 15 February 1993.

5. The proposed Project's objectives are:

(i) to provide a means of controlling the distribution of freshwater during the critical periods;

(ii) to safeguard, maximize and optimize the freshwater supply from the existing sources;

(iii) to conserve some more of the freshwater presently used for flushing toilets;

(iv) to establish a set of operating rules; and

(v) to promote greater cost recovery and water conservation efforts.

6. The major components of the Project were listed in the TOR as:

(i) rehabilitation works;
(ii) raising the storage at the airport;
(iii) installation of a second transmission main and distribution pipelines;
(iv) installation of a filter at Laura;
(v) demolition works;
(vi) extension of the seawater supply from the DUD area to the airport; and
(vii) consultant services for site investigations, engineering design, procurement, contract administration and construction supervision.

7. The Consultants' TOR are:

(i) review and where necessary, revise the Project design, scope, cost estimates and implementation arrangements;
(ii) prepare the general layout showing the major Project facilities;
(iii) prepare implementation schedule and project disbursement schedule for the Project;
(iv) finalize the terms of reference (TOR) and the cost estimates for the consultant services for detailed engineering design and construction supervision for the Project;
(v) finalize the water demand projections in detail suitable for the financial and tariff analyses;
(vi) determine the operating costs and depreciation charges for the financial and tariff analyses;
(vii) review the organizational setup, staffing and training needs for the Majuro Water and Sewer Company (MWSC) in cooperation with the consultant for financial, tariff and management aspects;
(viii) review the operation and maintenance (O&M) practices and determine O&M advisory services needed;
(ix) prepare or finalize the proposed TOR and cost estimates for the organizational and O&M advisory services for the purpose of preparing a request for ADTA;

(x) discuss the findings and recommendations with the Government and the Bank's Fact-Finding Mission;

(xi) provide assistance to the Fact-Finding Mission and if warranted, to the appraisal mission at a later stage; and

(xii) prepare comprehensive reports suitable for later incorporation in the project brief and appraisal report of the Bank.

8. The Consultant had been involved in Water Sector work in Majuro and was able to quickly come to terms with the Majuro Water Supply Project and in accordance with the Memorandum of Understanding (MOU) as a result of the Bank's July/August 1992 Reconnaissance Mission.

9. Some key issues which are yet to be resolved are commented upon. These cover:

(i) expansion of water supply sources; and

(ii) staffing level of Majuro Water and Sewer Company.

10. As a framework of reference, the Consultant prepared a Position Paper (Appendix 1) which addressed, population projects, water demand, system capability, potential sources of supply and indicative development strategy and the design basis for the transmission line into DUD.

11. This Report specifically addresses the TOR and has full regard to the Project as generally modified during the Fact-Finding Mission of January/February 1993 and the resultant MOU. The Report provides background to the MOU in regard to the defined Project as per Annex 2 of the MOU (see Appendix 2).

12. Otherwise, there were indepth discussions with the Manager of the MWSC and other key Government officials, technical data gathering and cost data extraction, refinement of the project and its components and development of cost estimates.

13. The TOR is now addressed after a brief statement on the status of the system.

B. Status of the System

14. The Majuro water supply seawater and freshwater systems have been reasonable well engineered systems in regard to the transmission and distribution design although there are problems. The systems are owned by the Government and leased to MWSC; MWSC has responsibility for the management, operations and maintenance.

15. There is general lack of funds available to MWSC; revenue is insufficient to meet full O&M costs and the Government subsidy has been insufficient. Spare parts are currently rundown and a competent technically trained organization is lacking.

16. Up to recent times, the MWSC was managed and operated by consultant. Managers, it now comes under the Ministry of Public Works. There are two key members of staff which are maintaining the technical side of MWSC together.

(i) Freshwater System

17. The freshwater system was installed predominantly in the early 1970's centered on the airport rainwater catchment. Earlier wells at Delap and some public roof catchments are directed into the system but now contribute little to the supply. Local well and public school roof sources of supply at Rita have been either discontinued or are in disrepair.

18. JICA undertook a major upgrading and augmentation of the freshwater system in 1985-88.

19. A full service metering program is now nearing completion.

20. The system consists of a number of pumping plants and simple treatment facilities, some storage and a long length of transmission/distribution main into town.

21. The system requires a fair degree of mechanical/electrical maintenance and this has suffered as a result of a lack of funds available to MWSC. The extensive pipe system is in good condition.

22. Majuro has a variable but high rainfall pattern with distinct wet and dry seasons and of recent times has experienced some very dry years. The freshwater system has insufficient inbuilt storage and consequently there are much less available supplies in the dry season and more so in the dry years.

23. MWSC operations consist of supplying the available water for variable periods of time and frequently with a very poor supply situation at the end of the line in Rita. Householders at the Rita end have had to resort increasingly on rainwater tanks and there is illegal direct pumping out of the mains. Some contamination of the freshwater system is recorded from time to time; probably caused by infiltration and/or cross connections.

24. The system is in need of rehabilitation, a means to better distribute water, and an expansion of sources of supply.

25. There is a need to provide for full cost recovery including a depreciation provision for future replacement of the large complement of fixed assets.

26. The organization of MWSC is in need of strengthening in terms of management, staffing and training and funding.

(ii) Seawater System

27. The seawater system was installed in the mid-1980's as a means to conserve potable water; it serves the main area of DUD.

28. The system consists of one pump station and a distribution system.

29. The system is relatively easy to maintain except for specific problems such as corroding valves. Pipelines are in good condition but pumping capacity is inadequate and consumers waste water through poorly maintained services.

30. The Project includes provision for a seawater expansion to Long Island which will not add greatly to system management.

(iii) Sewerage System

31. The sewerage system was also installed in the mid-1980's at the same time as seawater system; it also serves the main area of DUD.

32. The system consists of collection sewers, 7 lift pump stations, force mains, and chlorination plant and an ocean outfall.

33. The system is difficult to operate because of the extent of pumping and some poor selection of pump materials leading to corrosion and pump breakdown. Some pumps are currently being replaced. Sewers are in good condition.

34. Some pumping stations are in need of major rehabilitation because of corrosion.

35. There is also a need to make depreciation provision for replacement of a large complement of fixed assets as for the freshwater system.

C. Terms of Reference A(1) (Project Design, Scope Costs & Implementation)

Review and where necessary revise the Project design, scope, cost estimates and implementation arrangements.

C.1 Background

36. The Marshall Islands Government's request was for:

- a range of rehabilitation works for the water, seawater and sewerage systems;
- augmentation of the transmission main into DUD to effect more equitable/sectorized water distribution;
- raising of the Airport Reservoirs;
- a filter at Laura;
- an extension of the seawater system from DUD to Laura;
- demolition of elevated water tanks; and
- resource management studies.

37. The Reconnaissance Mission of July/August 1992 established the ADB project components as follows:

	$m
Rehabilitation Works	1.19
Transmission Main into DUD and Distribution Pipelines	2.50
Raising of the Airport Reservoirs	0.30
Filtration Plant at Laura	0.065
Long Island Seawater Extension	1.50
Demolition of Elevated Tanks	0.03
	5.585
Contingencies @ 25 per cent	1.40
	6.985
Engineering and Administrative Costs @ 15 per cent	1.045
	$ 8.03 m

38. The Reconnaissance Mission considered a number of alternative freshwater supply schemes and concluded that improvement/carryover storage was likely to be more cost attractive than either Airport catchment expansion or a MED desalination plant that was still being considered by the Government as an additional source of supply. The general conclusion was that the development of additional source(s) of supply should be the subject of a feasibility study and to date this has not been included in the Project.

C.2 Action Undertaken During the Mission

39. In accordance with the TOR, discussions were held with the Manager of Majuro Water and Sewerage Company (MWSC) about the requirements for the three systems in terms of rehabilitation, organizational needs and staffing, spare parts requirements, vehicle and equipment needs and general problems with the system.

40. Enquiries and file searches were made at the Capital Improvement Project (CIP) office on past and proposed capital works, reports and costs relevant to the project. However, actual backup cost estimates to the items listed in the Government's original request to the Bank for funding were not available.

41. The Secretary for Public Works briefed the Mission on the project including advice on other related projects.

42. Water quality data of the potable water supplied, both at source and within the piped system, was obtained from the EPA.

43. Electricity costs, an organizational chart and staffing of the electricity authority (Marshalls Electricity Corporation - MEC) was obtained from MEC and the feasibility of the operation of a MED desalination plant using waste heat from the power was discussed with MEC's General Manager.

44. Information was obtained from other Government Departments relating to possible industrial and commercial developments in Majuro as well as the legal situation with water sources, particularly Laura. (The Marshall Islands Government has not enacted a Water Act and ownership of underground water would seem to be in traditional ownership.)

45. A working group of MWSC and CIP personnel was setup to establish the extent and value of fixed assets and specifically to establish the historical and present day replacement costs of the existing systems.

46. Inspections were undertaken of the Water Supply and other systems under the control of MWSC.

47. A Position Paper was prepared by the Water Supply Consultant to establish a framework for assessing the Project. It covers:

- Population projections
- Freshwater demands based on unit demand projections
- The capability of the existing sources of supply in a Normal Year and in a 1 in 10-year Design Dry Year
- Potential sources of supply and their order of cost
- An indicative water resource development strategy
- Options for the new Transmission Main into DUD

This Position Paper is included as Appendix 1 of this report.

48. Cost estimates were prepared for the Project.

C.3 Operating Status and Rehabilitation Requirements for the Potable Water Supply System

49. MWSC advised of the operating status of plant equipment, storages and the pipe system in terms of life and rehabilitation needs. The system needs were covered

comprehensively from sources of supply to meter. MWSC reported that the system was 95 per cent metered and that full metering would be achieved early in the year.

50. Laura

a. A newly installed lens source of supply and transmission line with some problems at the wellfield caused by pump breakdown and the non-installation of lens monitoring equipment. Difficulties with obtaining a lease is preventing one wellfield pump from operating.

b. The wellfield was designed to produce 400,000 gallons/day with 24 hour pump operation of pumps. However, with only 4-6 pumps out of 7 effectively operating, actual production is averaging only about 300,000 gallons/day.

c. There is a case for standby wells as the pumps are designed for 24 hour operation which is clearly not achievable.

d. Water quality monitoring equipment had not been installed because of the lack of parts for the equipment to drive in well points.

e. The Project provides only for minor rehabilitation funds, although the Water Supply consultant has identified wellfield augmentation as a priority consideration.

51. Airport Catchment System

a. Damage to the collection system by Cyclone Axel is now virtually repaired.

b. Collection system has been cleared out and damaged pipe replaced.

c. Revetment/seawall on the Ocean side is now repaired.

d. During high tide and windy conditions seawater can splash over the seawalls into the airport runway rainwater catchment from both the ocean and lagoon sides and this can result in seawater pollution of the potable water collection system if rainwater capture is also occurring. This was reported as occurring on about 10-15 days per year. Such water needs to be dumped.

e. The intention is to construct concrete retaining walls along each side of the runway to protect the rainwater catchment. This work is under design in the CIP office and it is intended to fund the project using some $800,000 of US Department of Interior Funds. An additional 6m (20 feet) width of catchment will be added along the ocean side (over 81,000 ft runway length) providing nearly 4 acres of additional catchment. If funds permit, additional rainwater catchment at the end of runway on the reservoir side will be developed.

f. No specific rehabilitation requirements as the repair program is adequate.

52. Airport Catchment Pump Station No. 4
(Pumps water from a collection sump to the Airport storages)

a. Pump station pumps have been rehabilitated (JICA project)
b. Pump controls require replacement
c. A Total Dissolved Solids (TDS) meter is required to establish when there is seawater pollution
d. Minor building repairs required.
e. All rehabilitation requirements have been included in the Project.

53. Airport Storages
(5 raw water lined storages, 1 covered and lined treated water storage)

a. Two storages are new and a third one has been raised in level (JICA project).
b. The hyperlon lining on three of the raw water storages and the cover of the treated water storage are showing signs of deterioration. Some lining relates to the original 1972 storage development, other lining is more recent.
c. The lining on all the storages was inspected and evidence of reinforcement failure and color deterioration was noted. Early replacement within 5 years will be required.
d. The project has only included the recovering of the treated water storage although the relining of all the older storage lining will be necessary.

54. Treatment Plant C at the Airport Reservoir
(Filters, chlorinator, transfer pumps and pumps for DUD supply)

a. Some pump augmentation was undertaken by JICA in 1988.
b. The older pumps and filters are now requiring replacement.
c. Pump and Treatment Plant capacity should be upgraded at the same time as rehabilitation is undertaken to comply with future demand projections.
d. A deficiency is that the filter pump rising main doubles as a treated water outlet/suction main for the main transmission pumps into DUD.
e. There is a need for a proper materials storage building, as plastic pipes are stored out in the open.
f. There is a requirement for a staff amenities building.
g. A 40 ft x 24 ft building is required.
h. The project has included pump and filter rehabilitation and upgrading, a new filter rising main and a new materials storage and amenities building as well as spare parts requirements.

55. Water Treatment Plant B at Uliga

- This treatment plant is no longer required for supplying local lens water into the system.
- The facility has been converted into a booster pump station for Rita; inflow into the 500,000 gallon storage is via a pressure sustaining valve (70 ft residual head). Pump supply uses pressure controls for pump operation; a lower head than that otherwise necessary with the existing elevated tanks has been adopted. Elevated tank is not used.
- No further rehabilitation requirements for Treatment Plant B.

56. Water Treatment Plant A at Delap

- This treatment plant utilizes the Delap lens, hospital roof catchment and shortly the Capital Building and Nitijela Building roof catchments.

- The facility consists of a 500,000 gallon storage, filter pumps and filter units, pumps into the distribution system and a standby generator.
- Rehabilitation requirements are:
  - Building repairs
  - New filter unit
  - Replacement of electric controls
  - Replacement of the pump and chlorination equipment
  - Installation of metering
  - Hyperlon lining of the storage
- All these rehabilitation requirements have been included in the Project.

57. Distribution Mains

- Some 10,000 ft of 4" dia distribution mains is needed for replacement of old smaller dia mains which have reached the end of their useful life.
- This has been included in the Project.

58. In summary, rehabilitation requirements were identified and in general were included in the Project as defined by the MOU. Relining of the Airport Reservoirs was excluded from the project on the basis that the lining could have sufficient life left to be replaced using cash generated from revenue.

C.4 Rehabilitation of the Seawater System

59. The main concern with this recently installed system were isolating valves in Phase 2 of the system. The installed valves are only suitable for freshwater use and with seawater use there has been extensive corrosion leading to valve malfunction.

60. MWSC had considered replacement of some 100 valves but this would cost some $0.5m and clearly is not an acceptable cost.

61. After due discussion, a more economical approach was identified which would involve the use of pressure tapping equipment rather than the current practice of mains shutdown. This would permit a conventional isolating valve design layout with far fewer valves (20 no.)

62. This approach of providing some 20 isolating valves and pressure tapping equipment has been incorporated into the Project.

C.5 Rehabilitation of the Sewerage System

63. The sewerage system was down at the time of the Mission because of the failure of several pumps due to corrosion in Phase 2 of the System. Phase 1 pumps are not causing any problems because materials were better selected.

64. The Government has provided emergency funding for the replacement of three pumps and six other pumps remain with a very short life, possibly until 1994.

65. The problem originates from inappropriate selection of materials with corrosion of pump flanges and sewage spraying into motors.

66. MWSC is approaching the problem by replacement of the pumps and motors with similar units but with appropriate use of stainless steel which should provide a normal unit life of 10-15 years.

67. A similar problem has arisen with comminutors used to mash sewage prior to smaller sized pumps. The solution is to replace the comminutors with stainless steel materials.

68. Some sewerage system manholes have been damaged by construction activities of others.

69. These rehabilitation requirements have been included in the Project. However, it should be noted that pump unit failure is probably imminent and it may be necessary for the Government to initially meet the replacement cost with the Project retroactively funding.

C.6 Freshwater System Improvements

70. The TOR identified the following freshwater system improvements.

- o Raising of the storages at the Airport.
- o A new transmission line into DUD to effect better distribution.
- o Filtration Plant at Laura.

Improvements to the freshwater sources of supply as yet has not been included in the project.

C.7 Increased Water Storage at the Airport

71. It is proposed to increase the water storage at the airport reservoir both to increase carryover capacity and to provide storage for additional airport catchment currently under design.

72. JICA increased some storage capacity in 1988 by the provision of RC walls around 3 storage permitting raised TWL. As part of the Project, it is proposed to raise the TWL with walls around the remaining 2 raw water storages as well as the treated water storage. This will involve construction of RC walls as well as extension of the hyperlon lining. This is a relatively inexpensive storage expansion.

73. The raising of the walls by 1.2 mm as per JICA would provide for an additional raw water capacity of 15 ml (4 mg) taking the local raw water storage capacity to 98 ml (26 mg). Dry period supply capacity is increased by about 4 per cent. The JICA design is conservative and in detailed design it may be possible to achieve greater augmentation by a higher raising of TWL, particularly as up to twice the present storage volume would be usable carryover storage. The treated water storage capacity will be increased from 7.5 ml (2 mg) to 13.5 ml (3.5 mg).

C.8 Installation of Second Transmission Main

74. The presently limited available water cannot be equitably distributed as the linear configuration of the system results in consumers at the upstream end taking most of the water while the Rita consumers at the downstream end get little water. Excessive use obviously occurs with the better supplied consumers.

75. In the future, it would be desirable to be able to supply at the Peak Hourly Demand rate from the Airport Reservoir distributing either or both Airport catchment water and Laura water, particularly during the wet season when there is more adequate supply of water.

76. The Position Paper (see Appendix 1) addressed the options which varied from the provision of a new tapping main to a new transmission main to meet future requirements.

77. Although there are some techniques to regulate demand through service restrictions to avoid a new line it is considered that the only feasible approach is to have a new line that can effect selective distribution.

78. It is therefore proposed to install a dedicated new transmission main with controlled cross-connections to the existing transmission main. The existing transmission main effectively becomes a distribution main during the time of a rationed supply.

79. The transmission lines need to meet future system demands based on the present high population projections of 6.3 per cent per annum. Year 2003 demand for DUD will have an estimated Peak Daily Demand of 8.5 mld and an estimated Peak Hourly Demand of 21 mld.

80. The new transmission line alone should be able to effect the supply of the year 2003 Peak Daily Demand of 8.5 mld to ensure equitable distribution. The existing and new transmission lines together should be able to meet the year 2003 Peak Hourly Demand of 21 mld. The relevant requirement is to provide for a new 350/250/200 diameter transmission compared to the existing 300/250/200 diameter transmission line.

81. The existing pumping station at the Airport Reservoir will be rehabilitated and upgraded to provide 50 per cent more capacity or say 9.8 mld capacity. This is sufficient to meet current peak daily demands and also up to year 2003. In the future, a new pump station will be required to provide for the extra requirement of 11.2 mld for meeting the year 2003 Peak Hourly Demand but this can be deferred from the present project and have regard to the method of system supply augmentation, yet to be determined.

82. The new transmission main must also have selected cross connections between the new and the existing transmission mains to provide operational flexibility and for equitable distribution. The cross connections will be fitted with manually controlled isolating/regulating valves as well as bulk meters to assist in leakage control.

C.9 Installation of Filter Plant at Laura

83. The newly completed lens supply at Laura is to be chlorinated but the operating experience to date with algae growth and silica requires the installation of a filter plant. It is therefore proposed as part of the Project to provide for filters and filter pumps as well as filter pump housing.

84. The wellfield may be expanded in the future and the new facilities should be provided with that in mind.

C.10 Extension of the Seawater Supply System

85. The Project will extend the seawater system coverage to include Long Island, that portion of Majuro between the bridge and the airport. This is a rapidly growing residential area currently with some 300 houses. A design has been prepared for such a seawater system service. This system extension will involve the installation of 2 shallow wells with submersible pumps. The system will have normal supply pump provision (2 pumps each of 0.16 mld capacity) as well as provision for a fire supply (0.32 mld capacity). The distribution system will consist of 7 km of 150 dia line and 8.4 km of 50 dia lines. Most of the pipes are in stock. (The PVC pipes have been in open storage for 8 months and requires protection.) Goetechnical advice will be required for the siting of the 2 wells.

86. This seawater supply system extension will save some 12 mg (45 ml) of potable water. Increased revenue can cover costs.

C.11 Demolition of Elevated Tanks

87. This was considered as inappropriate for loan funds as it is possible for MWSC to undertake the work by either contract, with a materials recovery offset, or in stages if cash is available from a revenue surplus.

C.12 New Seawater Pump Station at Rita

88. There is only a single pump facility supplying the whole seawater system. It has a rated capacity of 0.7 mgd (2.6 mld) whereas the present maximum daily demand if taken as 20 gpcd for 20,000 persons served would be 0.4 mgd (1.5 mld) and the Peak Hourly Demand can be taken as 0.8 mgd (3 mld).

89. MWSC report that there is a lot of wastage on the seawater system and it is proposed that there should be regular surveys of household services to ensure that there is an appropriate level of maintenance. So actual system usage could be much higher than 0.4 mgd but should be constrained to 20 gpcd (76 lpcpd) maximum daily usage.

90. MWSC has requested that there be a standby pump provision and augmentation and that the facility be provided at Rita to better balance pumping operations.

91. Apparently, CIP did attempt to provide a new well facility but it was not able to obtain sufficient seawater inflow. Pumping equipment is not now available. So some care is required for siting, using geotechnical advice.

92. It is proposed that a new seawater pump station be provided at Rita on the basis of a shallow well and submersible pump.

C.13 Spare Part Requirements

93. Spare parts continues to be a problem in the maintenance of the system, particularly on the mechanical/electrical side. In better times, key spare parts, particularly electrical controls and pump units, have been kept in stock and it has been possible to keep the system in reasonable operating shape. Under cash flow problems there has been a rundown in spare parts and when required these have had to be air flown in at significant cost.

94. The requirements for spare parts is about $150,000 and it seems appropriate to order these with the new pumps and equipment. Consequently no separately identified project item has been allowed for but rather the cost of pump sets etc. has been increased to cover appropriate spare parts.

C.14 Vehicle Requirements

95. MWSC has had a serious problem in maintaining a vehicle fleet due to, old vehicles, accelerated depreciation due to corrosion, cash flow constraints limiting replacements and a spate of accidents. MWSC was down to 3 vehicles during the period of the Mission and this is clearly an unbearable position as the desired fleet is of the order of 8 vehicles with the new organization of 52 staff and workers.

96. Rather than include a vehicle supply item in the Project is seemed best to include an appropriate vehicle item of $100,000 in the operating budget to cover vehicle replacement and maintenance, somewhat above the present provision of $50,000 per annum.

C.15 Equipment Requirements

97. MWSC requires 3 items of excavating equipment to maintain its operations in providing services and replacement of distribution mains. Two of these items are light backhoe/loader units while one is a heavier tractor type excavator. These items of

equipment are now 7-9 years of age and will need replacement in the near future. The replacement cost would be about $100,000.

98. Workshop equipment requires replacement if MWSC is to continue to undertake its own maintenance in-house. This would comprise an air compressor, welding equipment and hand tools at an estimated cost of $50,000.

99. Safety equipment is currently not yet provided for field workers in some dangerous situations. There is a need for breathing apparatus, protective gear and blower equipment. Estimated cost is $10,000.

100. It is intended that the MWSC will adopt strict cost accounting procedure and it may well contract out work. It seems appropriate to cover these above requirements through the MWSC operating budget either as a capital item provision or as operating cost rather than in the Bank Project.

C.16 Cost Estimates for the Project

101. Cost estimates were prepared utilizing available data in the Marshall Islands.

102. MWSC had obtained costs of most of the rehabilitation works and this data was utilized to develop component costs for the Project. Costs of plant and equipment was increased to include shipping costs, generally allowed at 15 per cent. These estimates are considered reliable.

103. The cost estimates for the transmission line was determined using pipe material and installation costs held by CIP office for the 300 dia Laura Transmission Main installed some 3 years ago. Supply costs have been obtained for 350/375 dia PVC pipe to establish the adopted estimate of $35/foot for the new transmission main.

104. Cost data were available for filter plant from MWSC and this was used for both Laura and Treatment Plant C estimated costs.

105. A seawater extension design for Long Island was available in the CIP office as well as the cost of pipe materials purchased for the project. This project requirement was measured and estimates prepared accordingly.

106. Cost estimates were prepared in accordance with the Bank's format of Civil Works and Plant, Equipment and Materials headings. The cost estimates were summarized in Annex 3 of the MOU (see Appendix 2). The detailed makeup/backup of Annex 3 costs is provided in Table 1.

TABLE 1

DETAILED COST ESTIMATES

		Total
Civil Works		
1.	Rehabilitation	
	Treatment Plant A - Installation	13,000
	Hyperlon Lining 0.5 mg - Installation	4,000
	Treatment Plant C - Installation	52,000
	Pump Station at Airport - Installation	10,000
	Feeder Main Pipe Laying	50,000
	Hyperlon Cover of Treated Water Reservoir at Airport Reservoir	50,000
	Laura Wells	10,000
		189,000
2.	Airport Reservoirs	
	Raising of Reservoirs	300,000
3.	Transmission Main Pipe Laying	800,000
4.	Filters at Airport	25,000
5.	Filter Plant at Laura - Installation	75,000
		1,389,000
Civil Works - Seawater		
1.	Long Island	
	Pipelaying	265,000
	Pump Station Installation	25,000
2.	Rehabilitation	
	Valves and Tapping Equipment	25,000
3.	New Pump Station at Rita	30,000
		345,000
Civil Works - Sewerage		
1.	Pumpset Installation	20,000
2.	Manhole Repairs	10,000
3.	Comminutors Installation	20,000
		50,000
Total Cost of Civil Works		**1,784,000**

		Total
Plant, Equipment and Materials - Freshwater		
1.	Rehabilitation	
	Treatment Plant A - Pumpsets	30,000
	Treatment Plant C - Pumpsets	228,000
	Pumps Station at Airport - Pumpsets	15,000
	Distribution Main Pipes	50,000
		323,000
2.	Transmission at Main Pipes	800,000
3.	New Filter at Airport Reservoirs	150,000
4.	Filter Plant for Laura	145,000
		1,418,000
Plant, Equipment and Materials - Seawater		
1.	Long Island	
	Pipes	35,000
	Pumpsets	80,000
2.	Rehabilitation	
	Valves	10,000
3.	New Pump Station at Rita	
	Pumpsets	80,000
		205,000
Plant, Equipment and Materials - Sewerage		
1.	Pumpsets	130,000
2.	Manhole Repairs	-
3.	Comminutors	100,000
		230,000
Total Cost of Plant, Equipment and Materials		1,853,000
Total Cost of Civil Works		1,784,000
Total Construction Cost of Project		**3,637,000**

107. The break-up between foreign and local costs were adopted in the MOU as follows:

Civil Works	10 per cent - 90 per cent
Plant Equipment and Materials	95 per cent - 5 per cent

The Civil Works break-up is based on the predominant use of local plant and labor whereas if an overseas company won the contract and used imported construction plant, the ratio could be 50-50.

C.17 Project Implementation Arrangements

108. The MOU has established that the Executing Agency for the Project will be the Ministry of Public Works (MPW) and the Project Implementation will be entrusted to a Project Management Office (PMO). The PMO will be headed by a full-time Project Manager and assisted by technical and administrative staff. Two individual consultants will be engaged under the loan to provide the necessary assistance to the PMO and MPW. One consultant will be experienced in planning, feasibility studies, engineering design and procurement while the other will be experienced in contract administration and training of technical personnel for O&M. These consultant will be working on an as-needed basis and it is possible that one consultant with the required breadth of experience could be utilized.

109. This is a sound approach and permits the Project to proceed on a stand alone basis.

110. At present MPW has no engineering staff or skilled management staff. It is intended to remedy this through an OMIP Grant recently obtained from the US Department of Interior. This may provide a suitable Government inhouse mechanism.

111. The MOU in Annex 6 (see Appendix 2) assumes that there will be several procurement contract packages and one main civil works contract apart from some minor Force account works by MWSC.

112. This is considered an appropriate approach but in view of the relatively small detailed design period there may be little time advantage in separate procurement of plant equipment and materials.

113. The more important question to address is the use of a single main contract.

114. There are a number of construction firms in Majuro which have undertaken this sized work. There is also the possibility of attracting an international contractor by upsizing the contract.

115. Clearly, there is no obvious answer. Locally based contractors in Majuro could better handle smaller packages but are capable of handling a larger package either individually or by joint venture. On the other hand, a single contract would provide construction flexibility and be easier to administer. In view of the need to minimize foreign outlays, the Government may favor smaller contract packages but the preference from a project management point of view is a single civil works contract.

116. All in all it would seem preferable to adopt a single large civil works contract.

117. The CIP Office is the only other potential constructing authority. It has handled large projects such as the Capital Building ($9 m) but only with the assistance of an Engineering Management firm. The CIP Office is currently "rudder less" and has no capability to assume any Project responsibility such as that required for the ADB Project. The proposal in the MOU is clearly preferred.

118. The MOU has provided a tentative implementation schedule in Annex 5 (see Appendix 2). The proposal to complete the project in 3 years assumes:

Loan Approval	:	September 1993
Recruitment of Consultant	:	6 months
Detailed Engineering Design	:	7 months
Bidding and Contract Awards	:	6 months
Supply of PEM & Construction of Civil Works	:	18 months

119. This time is considered adequate and it may be possible to trim time in Recruitment of Consultants and in Bidding and Contract Award. The time for Detailed Design and the supply and construction phase is considered appropriate

C.18 Possible Improvements to the Sources of Supply

120. The TOR requires the consultant to review and where necessary revise the scope of work. The following comments are made in that regard, although the Mission Leader stated that this was outside the requirements of the Mission and warranted a Feasibility Study.

121. In the course of the Mission, the consultant considered what might be appropriate to effect improvement to the sources of supply (see Position Paper - Appendix 1). In general, this issue is clouded with the Government again considering desalination and requesting the Mission to include Airport Catchment expansion in the Project. On the other hand, the Reconnaissance Mission had identified the need for water source development studies and favored the development of carryover storage to meet dry year requirements. While the consultant agrees with the Reconnaissance Mission sentiments, nevertheless the outstanding issue for the Marshallese Government is the supply of more freshwater to meet existing and growing demands. Technically, the issue is outside the consultant's TOR but the issue is likely to jeopardize the Project.

122. The Airport catchment expansion, beyond that under current design in the CIP office, would involve developing the area between the existing runway and the Airport storages as follows:

- Infill of low level land below high tide;
- A seawall protection on the ocean side;
- Regrading the catchment area and compacting the ground compatible with a future runway extension and sealing it with bitumen;
- A pump station and rising main; and
- Fencing along the road.

123. A rough/order of capital cost assessment has been undertaken in the Position Paper. It would cost of the order of $1.2 million for the development of about 10 acres of catchment. However, the yield would be marginal and dry period (normal year) and dry year performance would be significantly less. In a normal year, the estimated yield for the dry and wet periods respectively would increase from an existing 0.58/0.8 mgd to 0.66/0.88 mgd. A 1 in 10 year dry year output would be about 60 per cent of the Normal Year Output.

124. Thus, the extra output would be only of the order of 0.08 mgd for a capital expenditure of the order of $1.2 m. A significant amount of the paving and thus possibly half of the capital cost would be aborted expenditure should the airport be expanded as the runaway pavement would be developed on top of some of the paved catchment. Construction and consolidation requirements for a future runway would also add to the cost of the initial paving of the catchment.

125. The assessed cost of additional water is about $5 per thousand gallons and this could be distributed at little extra cost. Additional revenue on the basis of average tariff may be able to cover the costs.

126. The Laura lens would seem a much better proposition; it could be further developed for very little capital cost and has potential to supply significantly more water in normal years and probably with no drop off in dry years and even higher conjunctive use in dry periods to offset deficiencies with rainwater catchment supplies. The Laura lens was developed about 2 years ago and its development was based on a US Geological Survey investigation which proposed as a "rule of thumb" that the lens be exploited to 20 per of its long term recharge rate of 1.8 mgd i.e. to 0.4 mgd (1.5 mld). So far the lens has only been exploited to about 0.3 mgd as its 7 pumps of about 60,000 gallons/day need to be operated for 24 hours/day to achieve 0.4 mgd. One pump is not operated because the associated lease has not been finalized and there have been breakdowns with other pumps. It is thought that probably on average only 0.3 mgd has been pumped.

127. The wellfield could be easily expanded by 3 wellfield pumps to increase potential yield to say 90 per cent of 0.6 mgd or 0.54 mgd. The collector pipe, central storage, the main pump station and the transmission main from Laura to the Airport Reservoirs has capacity up to possibly 0.8 mgd. Local Laura demand would be about 0.2 mgd. Any wellfield expansion and operation would need to be closely monitored to avoid seawater intrusion. The provision of 3 additional wellfield pumps would yield an extra 0.16 mgd for a capital cost of about $100,000. There is a case to consider even greater expansion with careful operation and monitoring. The cost per thousand gallons is very low but there is risk that the wellfield will have limited capacity.

128. An alternative to increasing the Airport rainwater catchment would be the provision of additional storage on the land at the Airport. It is considered that a lined storage of possibly 20 mg would probably cost less than a pure rainwater catchment development and provide some carryover storage equivalent to about double the output of a pure rainwater catchment.

129. In summary, if the Government insists on additional catchment development at the airport, there is a strong case to try and develop it in the form of storage rather than as rainwater catchment. Irrespective of any development at the Airport there is a strong case to provide for some Laura wellfield expansion initially from 7 to 10 wells at a cost of only $100,000. There is a case for an even larger wellfield expansion for conjunctive use with careful operation and monitoring. (Note: The question of incorporating the airport catchment into the Project was discussed in Manila following the field Mission and it was agreed that the Bank would be prepared to incorporate a water catchment extension into the Project on the basis that the Airport, runway component was developed/funded by others.)

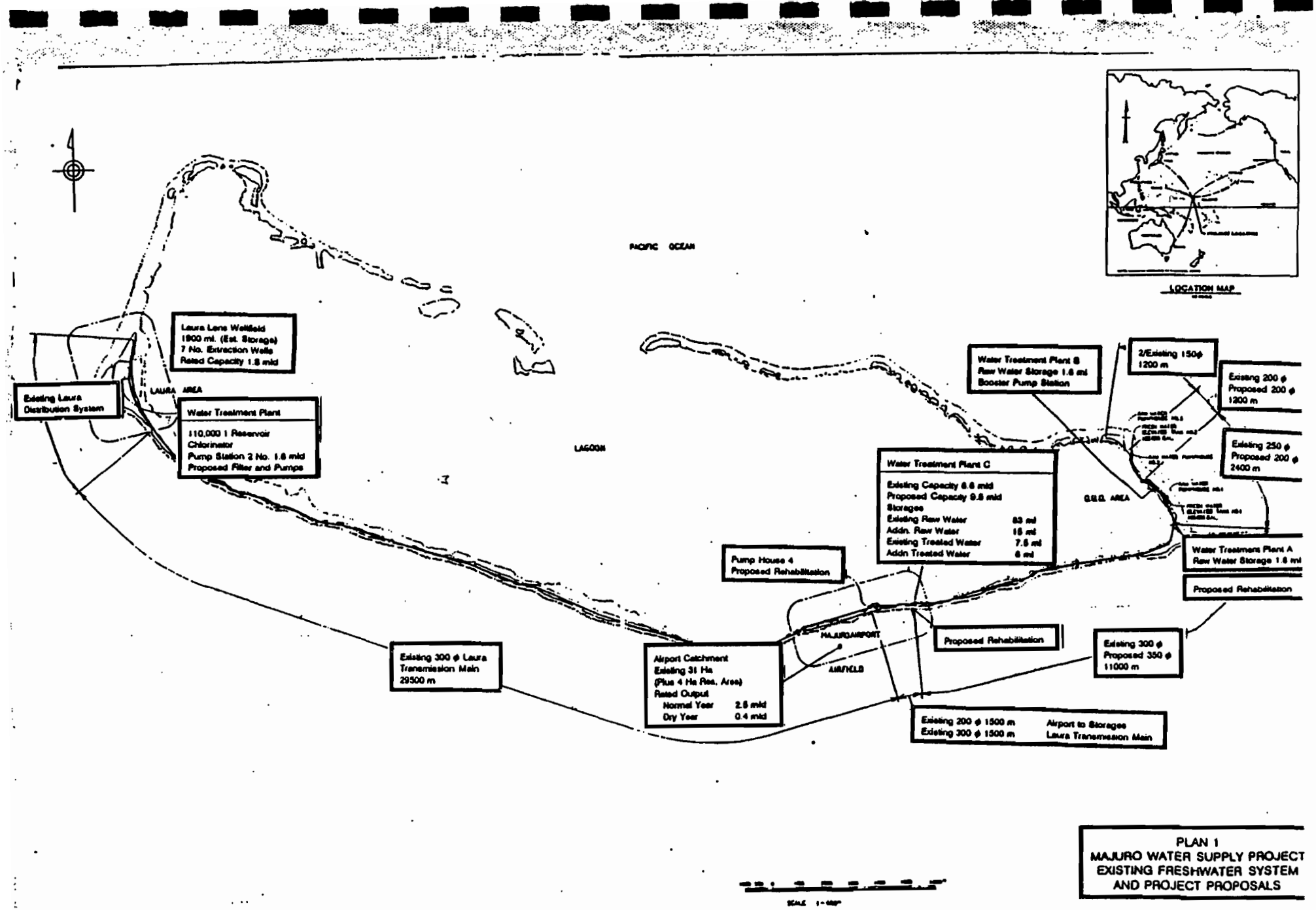
130. If there is this expansion of the sources of supply, involving a 10 acre expansion of the airport catchment and more particularly additional use of the Laura lens, then it is assessed that the supply then available could meet a normal year demand of 1.3 mgd (5 mld) and be able to supply 32 gpcd (120 lpcd). However, with a 1 in 10 year design dry year the supply would be reduced to about 25 gpcd (95 lpcd). This would significantly enhance the freshwater supply to Majuro and would provide a more balanced approach and specifically address the critical issue of water shortage.

D. Terms of Reference A(ii) (General Layout of Project Facilities)

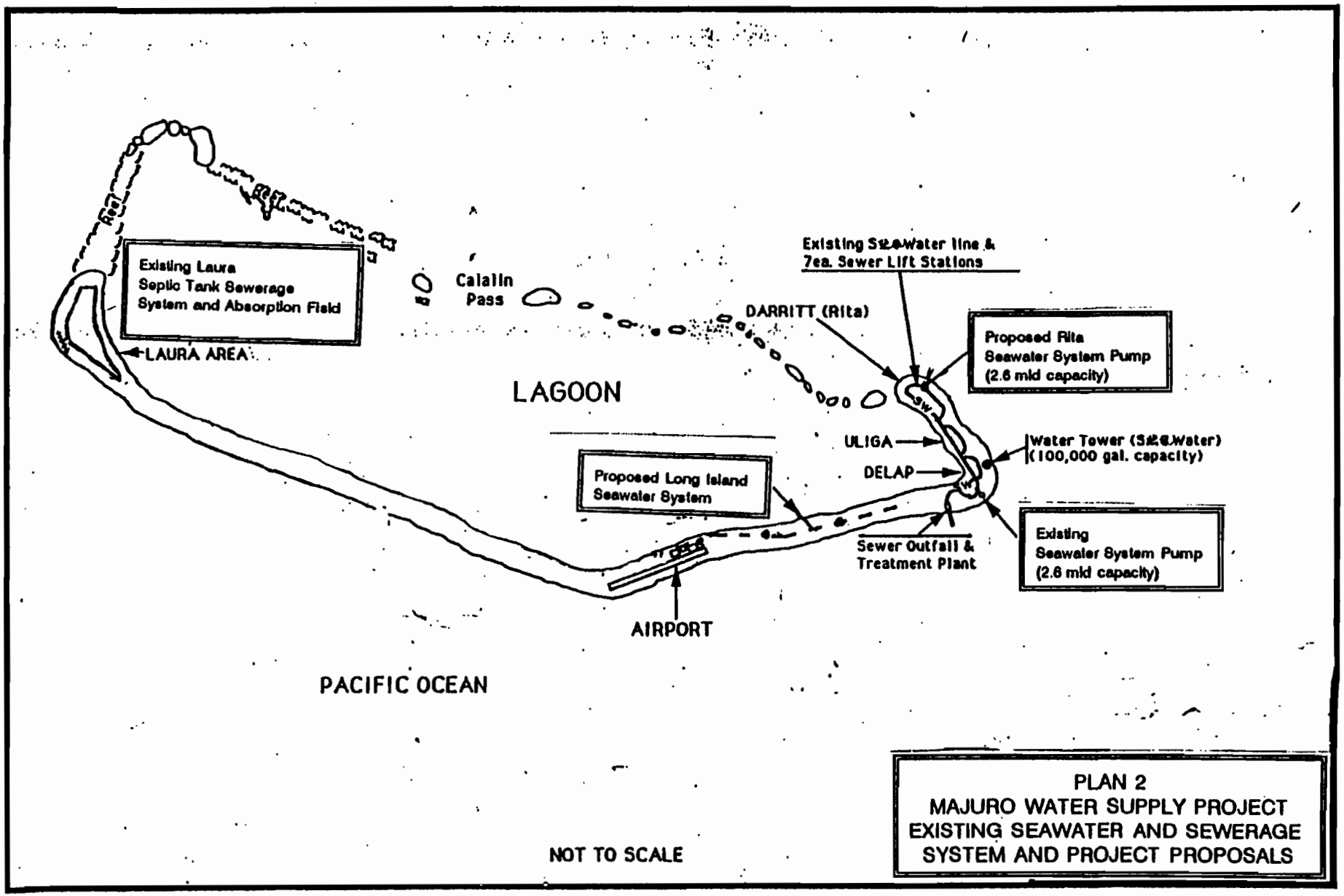
Prepare the general layout showing the major Project facilities.

131. A general a layout plan showing the existing freshwater system and project proposals has been prepared (see Plan 1).

132. A layout plan showing the seawater and sewerage system proposals is shown in Plan 2.



PLAN 1
MAJURO WATER SUPPLY PROJECT
EXISTING FRESHWATER SYSTEM
AND PROJECT PROPOSALS


Existing Laura
Septic Tank Sewerage
System and Absorption Field
LAURA AREA
Calalin
Pass
LAGOON
Existing Seawater line &
7ea. Sewer Lift Stations
DARRITT (Rita)
Proposed Rita
Seawater System Pump
(2.6 mld capacity)
ULIGA
DELAP
Water Tower (Seawater)
(100,000 gal. capacity)
Proposed Long Island
Seawater System
Sewer Outfall &
Treatment Plant
Existing
Seawater System Pump
(2.6 mld capacity)
AIRPORT
PACIFIC OCEAN
NOT TO SCALE
PLAN 2
MAJURO WATER SUPPLY PROJECT
EXISTING SEAWATER AND SEWERAGE
SYSTEM AND PROJECT PROPOSALS

E. Terms of Reference A(iii) (Implementation and Disbursement Schedules)

Prepare implementation schedule and project disbursement schedule for the Project.

133. A tentative implementation schedule is provided and was incorporated in the MOU as Annex 5 (see Appendix 2).

134. A disbursement schedule showing the Project cost by the capital works component over the project implementation period 1996-1997 is shown on the attachment, prepared by the Financial Analysts.

MAJURO WATER & SEWERAGE PROJECT

SCHEDULE OF PROJECT CAPITAL COSTS AND INCREMENTAL WATER AVAILABLE

PROJECT:	Expected Life (Years)	Capital Cost ($'000 US$)	Physical Contng. (%)	Engineer & Design (%)	Contng Other: (%)	Foreign Comp. (%)	Local Comp (%)
Estimated Inflation: Foreign % / Local %							
Presumed Bank re Rehabilitation % of Completion							
CAPITAL WORKS							
Pumps, Filters & Equipment	15	500	10%	10%	10%	60%	30%
Buildings	30	50	10%	10%	10%	60%	30%
Hypochlorination	20	0.30	10%	10%	10%	60%	30%
Reticulation & Piping	40	100	10%	10%	10%	60%	40%
TOTAL Base		1,200					
WATER PRODUCED (M m³/y)	-						
WATER CONSERVED (M m³/y)	-						
Increased Airport Reservoir Storage % of Completion							
CAPITAL WORKS							
Additional Storage	40	300	10%	10%	10%	60%	70%
TOTAL Base		600					
WATER PRODUCED (M m³/y)	60						
WATER CONSERVED (M m³/y)	-						
Transmission Main % of Completion							
CAPITAL WORKS							
Transmission main	40	1500	10%	10%	10%	60%	40%
Pumping Station - Civil	20	50	10%	10%	10%	60%	30%
Pumpsets and equipment	15	150	10%	10%	10%	60%	30%
Piping	40	25	10%	10%	10%	60%	40%
TOTAL Base		1725					
WATER PRODUCED (M m³/y)	-						
WATER CONSERVED (M m³/y)	-						
Lauca Filtration Plant % of Completion							
CAPITAL WORKS							
Pumpsets / Filters	15	150	10%	10%	10%	60%	30%
Pumping Station - Civil	20	20	10%	10%	10%	60%	30%
Piping	40	10	10%	10%	10%	60%	40%
TOTAL Base		230					
WATER PRODUCED (M m³/y)	-						
WATER CONSERVED (M m³/y)	-						
Lauca Washbasin Extension % of Completion							
CAPITAL WORKS							
Pumps and Piping	15	100	10%	10%	10%	60%	30%
TOTAL Base		100					
WATER PRODUCED (M m³/y)	-						
WATER CONSERVED (M m³/y)	-						

TOTAL PROJECT COST							
1993	1994	1995	1996	1997	1998	1999	Tot.
5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	
5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
-	10%	60%	20%	10%	-	-	0%
-	75	450	150	75	-	-	750
-	5	25	10	10	-	-	50
-	80	225	300	150	-	-	755
-	15	90	30	17	-	-	150
-	-	-	-	-	-	-	-
-	185	1,200	490	245	-	-	2,120
-	138.8	771.8	257.3	139.8	-	-	
TOTAL							
-	10%	60%	20%	10%	-	-	0%
1993	1994	1995	1996	1997	1998	1999	Tot.
-	42	200	62	46	-	-	446
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	42	200	62	46	-	-	446
-	30	150	60	30	-	-	330
Project Costs: TOTAL							
-	10%	50%	20%	10%	-	-	0%
1993	1994	1995	1996	1997	1998	1999	Tot.
-	225	600	1,120	354	-	-	2,210
-	7	22	56	9	-	-	74
-	21	64	111	35	-	-	210
-	5	11	10	4	-	-	37
-	-	-	-	-	-	-	-
-	285	745	1,304	399	-	-	2,840
-	172.5	517.5	862.5	172.5	-	-	
Project Costs: TOTAL							
-	10%	60%	20%	10%	-	-	0%
1993	1994	1995	1996	1997	1998	1999	Tot.
-	35	154	56	20	-	-	300
-	4	20	8	8	-	-	44
-	1	8	8	2	-	-	15
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	80	180	80	84	-	-	510
-	22	132	44	22	-	-	320
Project Costs: TOTAL							
-	-	60%	30%	10%	-	-	0%
1993	1994	1995	1996	1997	1998	1999	Tot.
-	-	14	110	15	-	-	140
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	14	110	15	-	-	140
-	-	10	66	10	-	-	86

FOREIGN COMPONENT							
1993	1994	1995	1996	1997	1998	1999	Tot.
5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	
-	10.0%	60.0%	20.0%	10.0%	-	-	
-	68	340	127	68	-	-	622
-	4	27	9	5	-	-	45
-	75	454	180	90	-	-	781
-	8	54	18	10	-	-	90
-	-	-	-	-	-	-	-
-	147	918	518	188	-	-	1,841
FOREIGN							
-	10.0%	60.0%	20.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	12	77	26	14	-	-	129
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	12	77	26	14	-	-	129
FOREIGN							
-	10.0%	60.0%	20.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	133	660	220	100	-	-	1,201
-	6	11	16	4	-	-	36
-	16	61	20	10	-	-	174
-	2	6	11	2	-	-	22
-	-	-	-	-	-	-	-
-	145	461	776	181	-	-	1,533
FOREIGN							
-	10.0%	60.0%	20.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	35	132	42	22	-	-	206
-	2	15	4	2	-	-	31
-	1	5	2	1	-	-	9
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	38	140	48	25	-	-	246
FOREIGN							
-	-	10.0%	60.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	-	11	84	12	-	-	117
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	11	84	12	-	-	117

LOCAL COMPONENT							
1993	1994	1995	1996	1997	1998	1999	Tot.
5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
-	10.0%	60.0%	20.0%	10.0%	-	-	
-	10	57	24	10	-	-	104
-	4	23	10	5	-	-	47
-	10	121	42	22	-	-	205
-	6	36	14	7	-	-	66
-	-	-	-	-	-	-	-
-	46	286	100	52	-	-	483
LOCAL							
-	10.0%	60.0%	20.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	30	157	65	34	-	-	316
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	30	157	65	34	-	-	316
LOCAL							
-	10.0%	60.0%	20.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	65	327	147	80	-	-	617
-	4	11	10	4	-	-	36
-	4	20	23	8	-	-	44
-	1	4	6	2	-	-	15
-	-	-	-	-	-	-	-
-	84	266	210	100	-	-	1,010
LOCAL							
-	10.0%	60.0%	20.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	5	32	11	5	-	-	54
-	2	10	5	2	-	-	33
-	1	4	1	1	-	-	6
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	8	46	17	9	-	-	80
LOCAL							
-	-	10.0%	60.0%	10.0%	-	-	
1993	1994	1995	1996	1997	1998	1999	Tot.
-	-	3	26	3	-	-	31
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	3	26	3	-	-	31

SCHEDULE OF PROJECT CAPITAL COSTS AND INCREMENTAL WATER AVAILABLE

PROJECT:	Expected Life (Years)	Capital Cost @ 2] (1000 US$)	Physical Contng & Design (%)	Engineer Design (%)	Contng Other (%)	Foreign Comp. (%)	Local Comp. (%)	TOTAL PROJECT COST								FOREIGN COMPONENT								LOCAL COMPONENT							
															Tot								Tot								Tot
Estimated Inflation: Foreign %								3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%		3.4%	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%									
Local %								5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%										5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
Sewerage System -- Long Island		0						Project Costs:			TOTAL								FOREIGN								LOCAL			
% of Completion								-	10%	60%	30%	10%	-	-	0%	-	10.0%	60.0%	30.0%	10.0%	-	-		-	10.0%	60.0%	30.0%	10.0%	-	-	
CAPITAL WORKS															Tot								Tot								Tot
Pumpsets & Equipment	15	100	10%	10%	10%	60%	30%	-	14	86	86	16	-	-	146	-	11	69	26	11	-	-	116	-	3	16	6	3	-	-	30
Pumping Station -- Civil	30	8	10%	10%	10%	60%	60%	-	1	4	2	1	-	-	7	-	0	2	1	0	-	-	4	-	0	2	1	0	-	-	4
Piping	40	300	10%	10%	10%	60%	40%	-	42	200	86	47	-	-	436	-	25	120	56	27	-	-	260	-	17	107	27	20	-	-	101
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		408						-	56	300	121	63	-	-	599	-	36	220	77	40	-	-	379	-	20	127	44	23	-	-	215
Share								-	40.0	24.3	61	40.0	-	-																	
WATER PRODUCED (M m³/y)	-																														
WATER CONSERVED (M m³/y)	13																														
Sewerage System Rehabilitation								Project Costs:			TOTAL								FOREIGN								LOCAL			
% of Completion								-	-	10.0%	90%	-	-	-	0%	-	-	10%	90%	-	-	-		-	-	10%	90%	-	-	-	
CAPITAL WORKS															Tot								Tot								Tot
Valves	15	50	10%	10%	10%	60%	40%	-	-	5	47	-	-	-	53	-	-	5	26	-	-	-	31	-	-	2	20	-	-	-	22
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		50						-	-	5	47	-	-	-	53	-	-	5	26	-	-	-	31	-	-	2	20	-	-	-	22
Share								-	-	5.0	51.0	-	-	-																	
WATER PRODUCED (M m³/y)	-																														
WATER CONSERVED (M m³/y)	-																														
New Rifle Pumpstation		0						Project Costs:			TOTAL								FOREIGN								LOCAL			
% of Completion								-	-	10%	90%	-	-	-	0%	-	-	10%	90%	-	-	-		-	-	10%	90%	-	-	-	
CAPITAL WORKS															Tot								Tot								Tot
Pumpsets & Equipment	40	110	10%	10%	10%	60%	30%	-	-	10	147	-	-	-	165	-	-	12	116	-	-	-	128	-	-	5	31	-	-	-	94
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		110						-	-	10	147	-	-	-	165	-	-	12	116	-	-	-	128	-	-	5	31	-	-	-	94
Share								-	-	11	80	-	-	-																	
WATER PRODUCED (M m³/y)	-																														
WATER CONSERVED (M m³/y)	-																														
Sewerage System Rehabilitation		0									TOTAL								FOREIGN								LOCAL			
% of Completion								-	10%	40%	40%	10%	-	-	0%	-	10%	40%	40%	10%	-	-		-	10%	40%	40%	10%	-	-	
CAPITAL WORKS															Tot								Tot								Tot
Pumping Equipment	15	150	10%	10%	10%	60%	30%	-	21	90	90	30	-	-	210	-	10	50	70	10	-	-	170	-	4	10	10	5	-	-	40
Manholes	40	10	10%	10%	10%	60%	40%	-	1	6	6	2	-	-	15	-	1	5	4	1	-	-	9	-	1	2	2	1	-	-	6
Connections	15	120	10%	10%	10%	60%	30%	-	17	66	71	16	-	-	170	-	10	54	56	15	-	-	135	-	6	14	15	4	-	-	57
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		280						-	56	160	169	63	-	-	406	-	80	130	130	84	-	-	324	-	0	84	86	0	-	-	82
Share								-	20	112	112	20	-	-																	
Technical Assistance								Project Costs:			TOTAL								FOREIGN								LOCAL			
% of Completion								-	10.0%	80.0%	20.0%	-	-	-		-	10.0%	80.0%	10.0%	-	-	-		-	10.0%	80.0%	10.0%	-	-	-	
															Tot								Tot								Tot
Technical assistance	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

MAJURO WATER & SEWERAGE PROJECT

Annex
Page

SCHEDULE OF PROJECT CAPITAL COSTS AND INCREMENTAL WATER AVAILABLE

PROJECT:	Expected Life (Years)	Capital Cost ($'000 US$)	Physical Contng (%)	Engineer & Design (%)	Contng Other (%)	Foreign Comp. (%)	Local Comp (%)	TOTAL PROJECT COST 1999	2004	2005	2006	2007	2008	2009	Tot.	FOREIGN COMPONENT 1999	2004	2005	2006	2007	2008	2009	Tot.	LOCAL COMPONENT 1999	2004	2005	2006	2007	2008	2009	Tot.
Subsequent Inflation	Foreign %							5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%		5.4%	5.4%	5.4%	5.4%	5.4%	5.4%	5.4%								
	Local %							5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%										5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	
TOTAL ALL PROJECTS:	CAPITAL EXPENDITURE BY PROJECT																													
	Freshwater System Rehabilitation							–	100	1200	415	215	–	–	2030	–	147	615	615	100	–	–	1641	–	40	285	100	51	–	–	489
	Increased Airport Reservoir Storage							–	42	285	83	40	–	–	446	–	12	77	20	14	–	–	139	–	30	107	60	24	–	–	245
	Transmission Main							–	200	740	1284	200	–	–	2540	–	146	461	776	161	–	–	1536	–	54	280	515	100	–	–	1004
	Laura Filtration Plant							–	50	100	60	24	–	–	215	–	20	140	40	25	–	–	226	–	6	40	17	6	–	–	65
	Laura Wellfield Extension							–	–	14	110	10	–	–	140	–	–	11	94	12	–	–	117	–	–	3	16	5	–	–	24
	Seawater System – Long Island							–	20	600	121	60	–	–	800	–	60	223	77	40	–	–	570	–	20	127	44	20	–	–	230
	Seawater System Rehabilitation							–	–	6	47	–	–	–	52	–	–	5	28	–	–	–	61	–	–	2	20	–	–	–	22
	New Rita Pumpstation							–	–	10	147	–	–	–	160	–	–	12	116	–	–	–	128	–	–	6	31	–	–	–	34
	Sewerage System Rehabilitation							–	20	100	100	40	–	–	400	–	20	120	120	24	–	–	320	–	6	24	24	8	–	–	80
	Technical Assistance							–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	TOTAL							–	500	3044	3407	600	–	–	6600	–	504	1900	1811	440	–	–	4411	–	250	900	896	240	–	–	2200

SUMMARY	CAPITAL EXPENDITURE BY PROJECT (US $'000)	1999	2004	2005	2006	2007	2008	2009	Tot.
	Freshwater System Rehabilitation	–	139	773	357	139	–	–	1,388
	Increased Airport Reservoir Storage	–	30	190	66	30	–	–	300
	Transmission Main	–	575	815	803	175	–	–	1,735
	Laura Filtration Plant	–	33	153	44	22	–	–	220
	Laura Wellfield Extension	–	–	10	66	10	–	–	106
	Seawater System – Long Island	–	41	340	81	41	–	–	405
	Seawater System Rehabilitation	–	–	4	32	–	–	–	36
	New Rita Pumpstation	–	–	11	80	–	–	–	101
	Sewerage System Rehabilitation	–	20	112	112	20	–	–	264
	Technical Assistance	–	–	–	–	–	–	–	–
	TOTAL ALL PROJECTS Constant prices (1999)	–	422	1,801	1,837	433	–	–	4,461
	Physical contingencies 10.00%	–	42	179	183	43	–	–	446
		–	464	2,179	1,799	476	–	–	4,907
	Engineering 10.00%	–	77	300	306	73	–	–	810
		–	540	2,500	2,006	550	–	–	5,717
	Price contingencies	–	60	400	802	106	–	–	992
	TOTAL ALL PROJECTS Current Prices	–	600	2,911	2,407	656	–	–	6,600

F. Terms of Reference A(iv) (TOR and Cost Estimates for Consultant Services for Design and Construction Supervision)

Finalize the terms of reference (TOR) and the cost estimates for the consultant services for detailed engineering design and construction supervision for the Project.

135. An Outline Terms of Reference for the Project Consultant for Detailed Engineering Design and Construction Supervision is provided and was incorporated in the MOU as Annex 9 (see Appendix 2).

136. Cost estimates for the consultant services are provided (see Table 2) and in summary for was incorporated in the MOU as Annex 10 (see Appendix 2).

TABLE 2
ESTIMATED COST OF CONSULTANT SERVICES
($'000)

	Foreign Cost	Local Cost	Total
A. Financed by the Bank			
1. Remuneration and per diem*	440	180	620
2. International Travel*	65	-	65
3. Communications and Reports	30	-	30
4. Equipment and Misc. supplies	20	-	20
Subtotal A	*555*	*180*	*735*
B. Financed by the Government (Majuro office cost)			
1. Remuneration and per diem	-	75	75
2. Office Accommodation	-	30	30
3. Communications and Reports	-	10	10
4. Office Supplies and Utilities	-	15	15
5. Local Transport	-	20	20
Subtotal B	-	*150*	*150*
Total (A + B)	***555***	***330***	***885***

* It is estimated that for design and supervision, there will be:

70 weeks of Engineer's time
100 weeks of Technical Assistant and Drafting time
14 weeks of per diem
13 no international travel trips

G. Terms of Reference A(V) (Water Demand Projections)

Finalize the Water Demand Projections as may be needed for the Financial and Tariff Analysis.

137. Freshwater demands have been established in the Position Paper (Appendix 1) for water supply design purposes. They include a liberal allowance of 20 per cent for non-domestic use which is not appropriate in determining assured revenue and probably should not be included in the Financial Analysis.

138. Potable water sources and production are assessed as follows:

	Daily Production (mgd)	Annual Production (mga)	(mla)
Existing Situation			
DUD Wells	0.05	18	68
Airport Catchment	0.69 (av)	252	953
Laura Wells			
6 wells @60,000 gpd @ 90%	0.32	118	446
Subtotal for MWSC	1.06	388	1467
Private Roof Catchment			
1000 houses @45,000 gp annum	0.12	45	170
Total for all existing sources	1.18	433	1637
Proposed Additional Sources			
Laura last well (1994)	0.05	20	75
Airport Reservoir Expansion (1997)	0.01	5.5	21
	0.06	25.5	96
Total for all sources	1.24	458.5	1733

139. Of the above sources there would be an expected growth of 6.3 per cent per annum in private roof catchment.

140. If Laura Wellfied is expanded from 7 wells to 10 wells then the total daily production would average 0.54 mgd (2 mld) and the annual production would be 197 mga (745 mla) compared to an estimated 138 mga (54 mla) with 7 wells.

141. If an additional 10 acres of airport rainwater catchment is developed then the additional daily production would average 0.08 mgd or 30 mga (113 mla).

142. The water demand for the Financial and Tariff Analysis can be adopted as follows:

1993

Potable water usage	40 gpcpd
Toilet usage if from freshwater system	12.5 gpcpd
	52.5 gpcpd or 198.5 lpcpd

1993 Demand including toilets

52.5 x 25880 x 365 = 496 mga or 1875 mla

143. In 1993 this demand could be met as follows:

	mga	mla
MWSC Freshwater (0.75* x 388 mga)	291.0	1100
MWSC Seawater (12.5 x 20,000 x 365)	91	344
Roof catchments	45	170
Bottled water purchases	0.5	2
Total Available	427.5	1616
Deficiency in Supply	68.5	259
Total Demand	496	1875

* 25 per cent allowance for losses and unaccounted for water.

144. Long Island seawater extension will produce a saving of 12 mga (45 mla) of potable water and this would apply after 1997.

145. In regard to leakage it could be expected that with a full service metering program and the installation of bulk meters associated with distribution from the new transmission line that MWSC would reduce leakage from its system. The leakage loss adopted in 1994 of 20 per cent of supplies could be reduced progressively to 15 per cent in 1997. The long term aim should be 10 per cent.

H. Terms of Reference A(vi) (Operating Costs and Depreciation Charges)

Determine the operating costs and depreciation charges for the financial and tariff analysis.

146. These have been determined in close consultation with the Financial Analyst.

147. O&M costs have been determined on the following basis:

- The existing 1993 O&M budget has been used as a basis with adjustments to comply with projected changes.
- Labor costs have been increased to reflect the change in the size of the organization.
- Chemical costs have been increased only for inflation as the 1993 budget figure is appropriate.
- Power costs have been determined from MEC records as up to 1993 the Government directly met power costs. The 1990/91 period is a more appropriate normal supply period than 1991/92. Allowance has been made for the subsequent commissioning of the Laura wellfield. Tariff increases have been factored in.
- Maintenance and supplies have been increased only for inflation as the 1993 budget figure is considered appropriate. $17,000 additional has been allowed for in 1997 as a result of the Project.
- Provision for the higher vehicle and equipment requirements has been provided as a capital works purchase item of $30,000 per annum.

148. The method of determining the current value of all the existing MWSC assets is setout in the Financial Analyst's Report.

149. The water supply consultant together with the Manager of MWSC and the head of CIP undertook a review of all available cost data and together determine current asset value of all fixed assets.

I. Terms of Reference A(vii) (Organization, Staffing and Training)

Review the organizational setup, staffing and training needs for the Majuro Water and Sewer Company (MWSC) in cooperation with the consultants for financial tariff and management aspects.

I.1 General

150. The review in this report concentrates on technical aspects of the MWSC organization and has been prepared as complementary to that prepared by the Financial Analyst.

151. MWSC has been operating under very constrained conditions brought about by its low cash flows and limited perspective of its Board.

152. The Board of MWSC needs to be strengthened and broadened so that it has a more business and consumer service perspective. Its present composition of Ministerial and public service appointments is too narrow for the proper functioning of the Board charged with the management and operation of one of major utilities on Majuro.

153. The MWSC has been operationally managed up to recent times by an American management firm but this has been discontinued and it is now directly under the Ministry of Public Works and is staffed under the Public Service Commission regulations.

154. The General Manager is a key member of staff apart from his management function. He is American and utilizes his waterworks experience to the full in the technical and operational areas.

155. The head of the Operations Department is a Marshallese who is very experienced in the Majuro Waterworks systems and is competently able to manage day to day operations on a need to fix and how to fix basis.

156. Other technical staff are not so well educated and specifically lack technical education; they have essentially learned on the job and have limited capability.

I.2 Present Organization

157. An organization chart for the present Majuro Water and Sewerage Company (MWSC) staffing is shown in the attachment, Organization Chart - 1992.

158. At present, there are 34 employees under a General Manager, The organization is divided between an Operations Department and an Administration and Accounting Department.

159. The following points can be made:

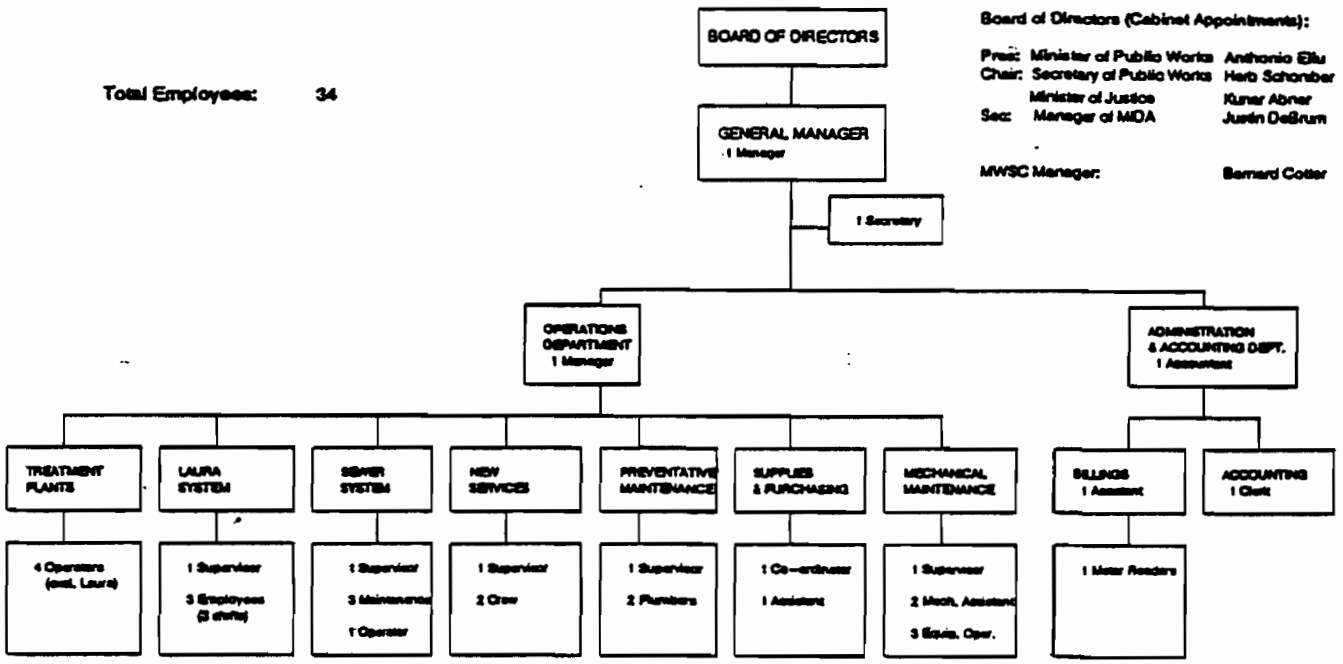
- The Operations Department is further divided into seven functional groups.
- The General Manager and the Accountant are expatriate staff, the remainder are Marshallese.
- There are no formal training programs although it is stated that on the job training is occurring.
- The present staffing is limited by available funding. All staff are employed under Public Service Commission (PSC) regulations.
- There is a general lack of technical staff to undertake O&M competently. On the other hand, contracting out O&M work has not been feasible because of the lack of funds.

160. In the recent Operations and Maintenance Improvement Program (OMIP), Third Year Review, October 1992, it was stated that PSC was not in a position to effectively contribute towards the improvement of the Ministry of Public Works involved in O&M activities. Consequently, there was a recommendation for OMIP funds to be made available to improve the structure, laws, policies, training activities and staffing of the PSC. This may result in the employment of a consultant to implement a modern governmental human resource development program.

MAJURO WATER & SEWERAGE COMPANY

ORGANIZATIONAL CHART 1992

Total Employees: 34



Board of Directors (Cabinet Appointments):

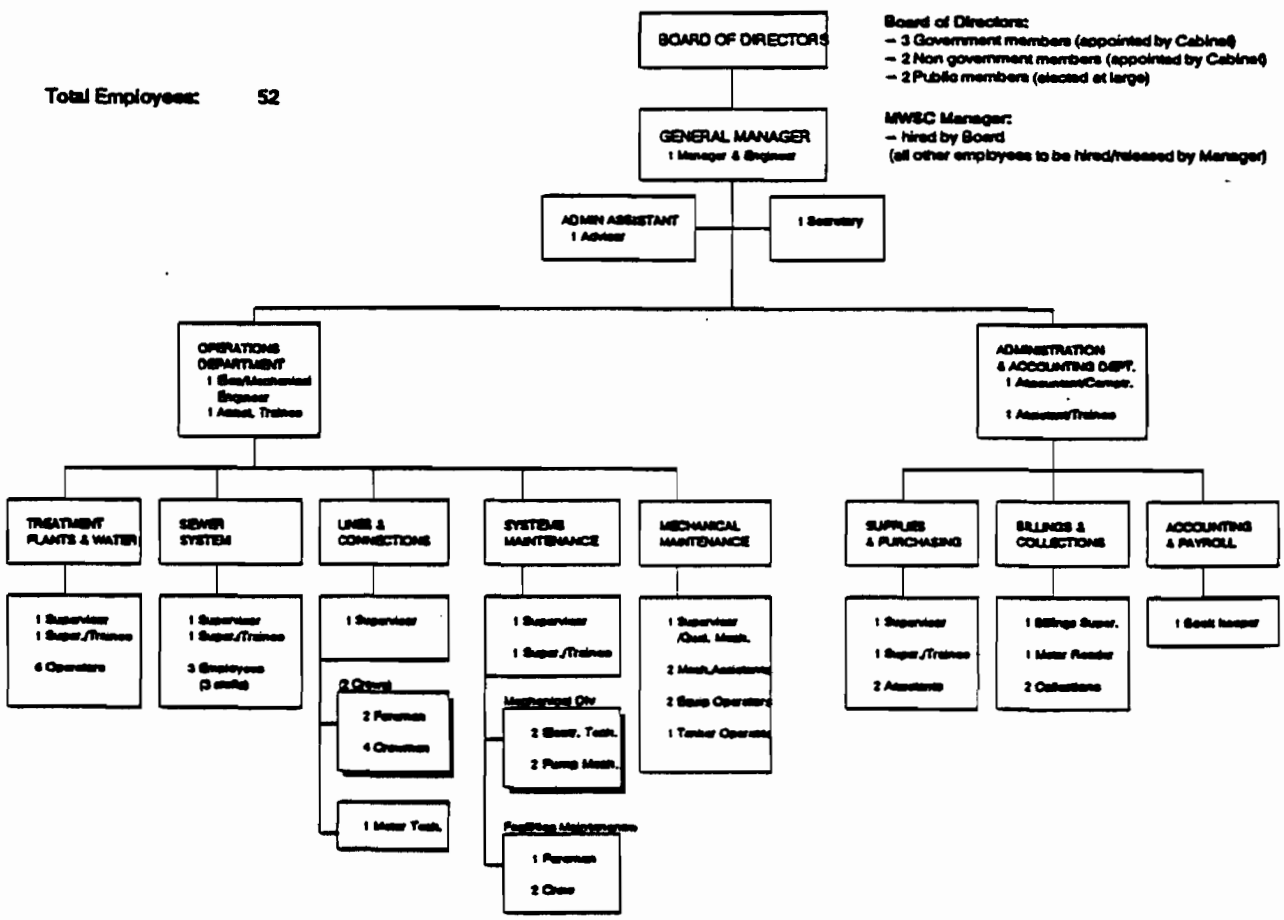
Pres:	Minister of Public Works	Anthonio Eliu
Chair:	Secretary of Public Works	Herb Schonber
	Minister of Justice	Kunar Abner
Sec:	Manager of MDA	Justin DeBrum

MWSC Manager: Bernard Cotter

MAJURO WATER & SEWERAGE COMPANY

ORGANIZATIONAL CHART – PROPOSED

Total Employees: 52



Board of Directors:
- 3 Government members (appointed by Cabinet)
- 2 Non government members (appointed by Cabinet)
- 2 Public members (elected at large)

MWSC Manager:
- hired by Board

(all other employees to be hired/released by Manager)

161. For the purpose of making recommendations on staffing and training, it will be presumed that MWSC training will need to occur within the organization. If PSC is revitalized then there could be some consideration of integrating staff development with appropriate PSC programs.

162. The intention also is that there is to be an Advisory Technical Assistance for Project Implementation that will address a Review of MWSC's organization and staffing plan and recommend modifications needed over the next 5 years. It seems appropriate in this report to confine reporting to that necessary for achieving an MOU and associated project costs.

I.3 Reorganization of the MWSC

163. The MWSC has been an O&M organization since its inception and its future role will be the same.

164. The General Manager of the MWSC was consulted on his perspective of a better organization. He considers this could be undertaken through minor reorganization; some staff strengthening through expatriates and staff training of Marshallese on the job.

165. The Marshall Electricity Corporation (MEC) has provided a model in terms of the use of expatriate personnel to train Marshallese. The situation with MEC is that the General Manager is an expatriate but functional management under him has been transferred to Marshallese personnel by utilizing expatriate personnel to train staff over several years. MEC has retained a core of expert O&M expatriate personnel in on-line maintenance work but not in management.

166. As a result of the MWSC General Manager's perspective and MEC's experience an organization chart can be developed along the lines of the attachment, see Organization Chart -Proposed.

167. Basically, it is proposed that there should be some 7 key expatriate personnel each with an Assistant/ Trainee. The intention would be that the expatriate staff would be on a 2-year/extendable to 4 or 5 years contract and in that time they would train their replacements.

168. The Operations Department would be reorganized into 5 groups compared to the present 7 groups, although an existing group, Supplies and Purchasing, would be transferred to the Administration and Accounts Departments. The proposed total staff of the Operations Department is 38.

169. The ongoing requirement is for the management of a reasonable large sized Engineering organization delivering public utility services to about 2000-3000 consumers. The system is experiencing growth in the number of services but essentially this requires only the provision of new services. Construction of new facilities is likely to be done by others such as the ADB project.

170. The systems under the control of MWSC consist of 3 large pipe systems together with a number of pump and treatment facilities the latter requiring expertise in the O&M of Mechanical and Electrical plant and equipment.

171. The future requirements, once rehabilitation is undertaken, will be preventative maintenance. Consequently, there needs to be emphasis on planned maintenance rather than breakdown maintenance as in the past.

172. Therefore, it is proposed that there should be a General Manager who is an Engineer with appropriate management capability. The Operations Department should be headed by an Electrical/Mechanical Engineer.

173. It is considered that 3 or 4 of the Operations Department Groups should initially be headed by expatriate staff each with an assistant supervisor/trainee.

174. MWSC has been operating on a minimum of staff necessitated by staff constraints and based on an American Waterworks philosophy of an effective staff with the use of labor saving mechanical equipment. It can be described as a lean and hungry organization. As such it can be made effective provided that there is appropriate staff/worker selection and they are given proper training.

175. MWSC seems to be operating satisfactorily in the civil engineering area but not in the electrical and mechanical areas. MWSC has a large electrical component in its O&M responsibilities. It has no electrically trained expatriate or Marshallese staff and calls upon MEC for assistance. This need must be specifically addressed in the reorganization. There is also a general deficiency of technical staff in MWSC stated to be because such staff cannot be afforded. This should be overcome in the reorganization and with better funding.

176. There are deficiencies in the keeping of Engineering records; supervisors provide sketches of connections but there is not a proper and easily referable system of record keeping. This warrants the development of large scale plans showing the location of the public systems and service connections as far as the meters. The problem could be addressed either as a special project or by the employment of a staff draftsmen and surveyor. However, MEC has reached a stage where an Automated Mapping/Facility Management (AM/FM) system would be invaluable, NTA has initiated the digitising of aerial photos for a base map, while the OMIP report has recommended that there be funding for the development of a public utility distribution system overlay as part of an AM/FM system for Majuro. It is considered that MWSC should await this development and not yet put on drafting and survey staff but select and train staff to utilize the AM/FM system. If this does not eventuate then it should develop its own records and mapping system for the distribution systems and services.

177. Staff salary cost is a major consideration in the size of the organization. The Mission MOU considered a larger organization of 84 staff based on general waterworks experience. This would include about 60 in the Operations Department of which about 30 would be unskilled workers. The present requirements for workers should be based on the continued use of labor saving mechanical equipment and the specialized need for

mechanics and electricians for plant O&M. As such there is no case for a large pool of unskilled workers. They would also not seem affordable.

178. Staff salaries are in some degree of flux with the statutory minimum wage being $2/hour and likely to be increased to $2.25/hour. Consequently, salary plus statutory and housing benefits and overtime is likely to result in a minimum wage of $5000-$6000 for unskilled workers. The Government is considering some salary flattening within the Public Service to reduce the salary charge on the Budget particularly as there is unemployment and private wage rates are lower. Salaries of expatriate staff in the Operations Department would vary from $20,000 - $40,000, but in terms of costs with the addition of benefits and allowances, the total cost could be as much as $23,000 - $54,000.

179. The MOU requires that the Government advise on the appropriate recurring costs for wages and housing allowances and consider the appropriate staffing level. Financial projections in the MOU were based on 52 staff but with significantly higher salary and allowance levels than that advised to the Mission by the PSC.

180. The conclusion based on the need to operate and maintain a reasonably stable and rehabilitated system and the likely cost of staff and workers is that the minimum requirement for the MWSC is for a staff of 52. Some 7 expatriate staff initially employed would be replaced by Marshallese over 2-5 years but system expansion and work activities would probably result in some offsets on the addition of some skilled staff when expatriates left. The proposed expansion of staff with the Operations Department from 26 existing to 38 will enable MWSC to select suitable staff to be trained to meet future needs.

I.4 Training Needs of the MWSC

181. The experience in the Marshall Islands is that off shore training generally results in the loss of Marshallese personnel to foreign countries where pay is better.

182. Consequently, the more favored approach is on-the-job training in the Marshall Islands using expert expatriate personnel. In the light of MEC experience, this approach would be satisfactory for the training of sub-professional and skilled staff.

183. The staffing of the 2 key Engineering positions, General Manager/Engineer and Electrical/Mechanical Engineer in charge of the Operations Department, will be more difficult. It would seem that suitably qualified overseas trained Marshallese Engineers will need to be attracted by expatriate level salaries.

184. Training requirements for sub-professional and skilled staff should follow a conventional apprenticeship program. This would require the Ministry of Education to establish a technical education program for apprentices to serve the various Government authorities; MWSC, MEC, NTA and private employers.

185. In the interim, personnel training would be undertaken by the expatriate technician personnel after selection of suitable high school or vocational school graduates skilled in Mathematics and English and after an appropriate work experience trial. The expatriate technicians would be responsible for imparting craft skills to their assistants/trainees under the general management of the Electrical/Mechanical Engineer in charge of the Department. As necessary formal training programs and sessions should be introduced within the MWSC but largely it would utilize a master craftsman-apprentice on the job process of development.

186. The most promising trained craftsmen could be considered for overseas vocational training in say an appropriate developing country.

187. Otherwise, there is a need for some English and Mathematics training of skilled workers to improve their job performance. This should be sponsored and paid for by the Government Scholarship Board using Marshall Islands College courses.

J. Terms of Reference (viii) (O&M Practices and Advisory Services)

Review the operation and maintenance (O&M) practices and determine O&M advisory services needed:

J.1 Freshwater System Operation

188. The following approach is proposed:

- operational practices of the MWSC have been based on a responsive approach to the situation rather than a planned operational approach;
- there is a need to plan operations to ensure that there is an optimized capture of all available water;
- a standard recording and reporting system should be adopted with formal monthly reports;
- a metering assessment of water capture at the Airport is required and this should be related to rainfall and the efficiency of capture on an event or monthly basis of record. Reasons for water losses should be recorded and estimates made of such losses. As necessary steps should be taken to remedy situations resulting in losses of water;
- as part of the Laura Lens operation, each wellfield pump should be recorded (as at present) but summed on a monthly, seasonal and annual basis. Reasons for operational malfunction should be recorded and estimates made of efficiency; and
- operating rules should be established for the use of the different sources of supply with the following aims:
  - using available Airport water with Laura water as a supplement
  - a reasonable shandy mix to effect suitable supply water quality
  - filling airport storages by December 1 each year
  - planning and controlling system demands to available supplies
  - treatment plant meters should be summed up on a monthly basis
  - once the new transmission line is in with bulk metered cross connections for distribution, attempts should be made to establish the extent of system losses on a sectional basis

- a service meter rotation and calibration program should be introduced
- MWSC should institute a program to control system losses and plan to progressively reduce losses to 10 per cent

J.2 Seawater System Operation

189. The following approach is proposed:

- o this is an unmetered supply and it will be necessary to routinely inspect all premises on a 1 or 2 year frequency to identify the need for service toilet unit maintenance;
- o pumped seawater flow should be estimated by either meter or pump operation; and
- o attempts should be made to keep unit demands reasonable and losses managed and controlled.

J.3 Sewerage System Operation

190. The following approach is proposed:

- o pumped flows should be assessed and related to the number of consumers services; and
- o any high infiltration should be identified and as appropriate steps taken to control it.

J.4 Maintenance Practices

191. The following approach is proposed:

- o maintenance practices for MWSC have been based on a breakdown maintenance approach. With the new organization, it is intended to proceed to planned or preventive maintenance;
- o in adopting a preventive maintenance program, the following approach is proposed:

- the Preventive Maintenance Program would be computerized
- each facility would be given an identifying number and each maintenance unit would be licensed (e.g., Pump 1, Motor 1, pipe and valves, Filter 1, etc.)
- the data on each maintenance unit would be standardized with a computerized equipment listing card providing all key data
- there would be reference to key O&M Manuals and Drawings which would be filed under the same reference system
- routine frequent maintenance would be listed out and provided as an Operational Instruction
- periodical maintenance would be listed and the system would throw up maintenance requirements on, say, a 3 monthly cycle for the use of maintenance staff
- job cards would be used to record maintenance in the field and then be used as an input to the computerized equipment listing card
- the maintenance group head in consultation with the Electrical/Mechanical Engineer would prepare the periodical maintenance schedule and review activities and maintenance frequencies in the light of experience
- specialized training needs would be identified and action taken to implement on-island or off-island training
- as appropriate, there would be contact with and advice sought from equipment suppliers

J.5 O&M Advisory Services

192. In regard to O&M advisory services:

- use should be made of any specialized expertise in the other public utilities
- a specialized O&M consultant could be engaged, charged with making specified visits to discuss O&M needs and otherwise be an advisor and a link with mainland suppliers

K. Terms of Reference (ix) (TOR and Cost Estimates for O&M - ADTA)

Prepare or finalize the proposed TOR and cost estimates for the organizational and O&M advisory services for the purpose of preparing a request for ADTA:

193. In this regard:

- an ADTA TOR has been provided in the MOU in Annex 14 (see Appendix 2). Cost estimates were provided as Annex 15 of the MOU (see Appendix 2);
- it is possible to get a much better basis on the capability of potential sources of supply provided that an effort is made to record and collect data on the existing catchment sources;
- for the airport source, efforts could be made to summarize Airport Pump No. 4 operations and relate these to rainfall events and daily rainfall readings. This would provide facts on the current status of the system now that repairs following Cyclone Axel have been effected. From this information, an effort could be made to determine initial loss and continuing loss rainfall/runoff factors as well as other system losses and water dumping so leading to a more reliable assessment of run-off and water capture, the installation of a meter(s) should be high priority;
- for the Laura Less supply, it will not be possible to make any better assessments until:
  - the lens behavior with exploitation is characterized
  - monitoring of salinity is undertaken as proposed in the US Geological Survey Report
  - wellfield capacity should be expanded as a means to determine the lens characteristics
  - the government's water rights should be protected by a water law that specifies that all subsurface water be state water

194. The following revised TOR to that provided in Annex 14 of the MOU is proposed for Component D Operation and Maintenance for the Project as currently defined.

Specific Objective for O&M

(i) Establish the operating rules for all the freshwater pumping and availability of supply particularly during the critical periods.

(ii) Ensure that there is adequate metering within the system in order to determine the efficiency of water harvesting and the measurement of bulk demands to minimize losses. In this regard, a bulk metering strategy and costing is to be determined and this will be incorporated into the Project.

(iii) Study the excessive pumping operations of the seawater operation, determine the causes of wastage and recommend remedial measures. Ensure that there is sufficient bulk metering such as at the pump stations and identify the need for other bulk meters to enable system analysis to be undertaken.

Considerations for O&M - Freshwater System

195. The MWSC needs to change from a responsive organizational approach to a planned operational approach.

196. There is a need to plan operations to ensure that there is optimized capture of all available surface water and conjunctive use of Laura water.

197. A standard recording and reporting system should be adopted with formal monthly reports. The performance of the Airport rainwater catchment needs to be determined with bulk metering with the intention that the various water losses (runoff, leakage and dumping) can be identified by study in the future.

198. The performance of the Laura Lens operation need to be recorded (as at present) but summed up on a monthly, seasonal and annual basis. This will need to be related to water quality monitoring in order for the lens to be characterized.

199. Operating rules and requirements should be established for.

- o the different sources of supply to cover any preferred water use (possibly use the Laura source as a supplementary supply):
- o a reasonable shandy mix of the two sources to effect a suitable water quality for consumers (e.g. hardness)
- o the filling of the Airport storages at the start of the dry season
- o the planning and control of system demands to available supplies during critical periods
- o leakage survey requirements
- o a service meter rotation and calibration program
- o instituting a program to control system losses progressively and to set a final target (e.g. 10 per cent).

Consideration for O&M - Seawater System

200. The MWSC needs to better manage losses of the seawater system. In the absence of consumer metering there is a need to consider some form of bulk metering together with a routine inspection of all premises.

Estimate of Cost of Undertaking Component D

201. An expatriate consultant would be used. It is assessed that it could involve about 2 man months of input involving say 7 weeks study and 2 weeks writeup, all in the field but possibly including some time Manila.

202. The cost estimates would be:

			$
A.	**Financed by the Bank**		
	1.	Remuneration and per diem	
		9 man weeks @ $3850	34,650
		Per diem 9 weeks @ $1000	9,000
	2.	International travel - 1 trip @$5000	5,000
	3.	Communications and Report	1,000
	4.	Contingency	5,000
		Subtotal (A)	54,650
B.	**Financed by the Government**		
	1.	Local Transportation - 7 weeks @$200	1,400
	2.	Office Accommodation	1,000
	3.	Communications and Report	450
	4.	Contingencies	500
		Subtotal (B)	3,350
		Total (A) + (B)	$58,000

L. Concluding Remarks

203. The project has been developed as a result of 2 field Missions in response to the Government's stated needs, although the question of adequacy of water sources remains an issue.

204. As such, the project has been designed to rehabilitate the 3 systems (freshwater, seawater and sewerage) to full working order, to provide for better and equitable water distribution, to extend the seawater supply to conserve potable water and to construct other limited new works. The project also provides for some stringent strengthening of the MWSC in terms of management, staffing, revenue, demand management (with higher tariffs) and depreciation provision.

205. However, the Project does not address the central issue of the water shortage in that there is no proposal to expand sources of supply. This is to be the subject of a future assessment. It warrants a small scale PPTA of 3-6 man months.

206. The Consultant has responded to this TOR in reviewing the project design and providing cost estimates. The report sets out the basis for the project as defined in the Mission and incorporated into the Mission MOU.

207. Water demand projections have been undertaken on the basis of a high growth rate of 6.3 per cent per annum and in the absence of reliable local data, will an adopted unit demand for potable water of 40 gpcpd (151 lpcpd) and toilet needs if required from the freshwater system of 12.5 gpcpd (47 lpcpd).

208. The capacity of the existing water sources has been assessed using best estimates as the adequacy of the water sources vary with the season and the annual rainfall. Supplies are limited in the dry season and throughout the whole year in a dry year.

209. The existing sources of supply have proved limited even in a normal year and this is confirmed by the use of adopted unit demand figures. The system has now been fully metered (early 1993) and tariffs have been increased (January 1993) which is expected to

suppress demand. This may limit demand to the available supply but the scenario could well be that after an initial check, demand will grow and exceed supply. It will be exceedingly important to check consumer's response to higher tariffs and then to develop an appropriate demand design basis.

210. The TOR did not require the Consultant to address sources of supply except in terms of reviewing the scope of the Project. The Mission Leader also advised that the sources of supply question was outside TOR and the Mission and warranted a Feasibility Study. In fact, to gain some appreciation of the options and costs and a general framework of reference, a broad general assessment was made of the capacity and costs of the various possible sources to provide additional potable water supplies.

211. The Government has now requested the Bank to include an extension to the Airport Catchment in the project. This is relatively costly in capital terms and also in the cost of water per thousand gallons. Other sources of supply (e.g. Laura Lens and a water storage scheme) would seem to be lower in cost and offer wider benefits in terms of dry period supplies. An extension to the Airport Catchment with a production cost of about $5/1000 gallons may be met by expected increased sales at the expected average tariff value.

212. Discussions in Manila after the Mission, favor the development of the Airport catchment as part of the Project only in the event that the Airport and runway extension is undertaken and funded by others.

APPENDIX 1

THE PROPOSED MAJURO WATER SUPPLY PROJECT

POSITION PAPER

THE PROPOSED MAJURO WATER SUPPLY PROJECT

Position Paper

1. Introduction

The Majuro Atoll has experienced a series of droughts in recent years with the rainfall in 1992 being 86 inches compared with the long term average of 130 inches. An assessment of 37 years of rainfall records indicate that the 10 year frequency dry year would have a rainfall of about 100 inches.

Majuro is the capital and it has been growing at an inter-censal rate of 6.3%, about 2% above the national average due to in-migration from the outer islands. The estimated population for September 1993 to be serviced by the water supply system is 26,000 persons.

The water supply system has an inadequate capacity. The normal year catchment capacity is about 1.15 mgd (4.3 Mld) while the total demand is assessed as 1.5 mgd (5.7 Mld). The water systems consist of a potable water supply system, a seawater system for toilets and firefighting and a sewerage system; the latter 2 systems service only part of the town. They are operated by Majuro Water and Sewerage Company (MWSC) which is a wholly owned government enterprise under the Public Works Department.

The Republic of Marshall Islands Government (RMI) has requested the Asian Development Bank (ADB) for a loan. As a result of a Loan Reconnaissance Mission of July/August 1992, a project identification was made (see Appendix 1) which indicated a need for an $8m project, as well as the need for advisory technical assistance (ADTA) to strengthen the MWSC's financial planning and management and improve its O&M practices.

The follow-up Fact Finding Mission of the ADB of January/February 1993 is the subject of further Engineering and Financial Assessments of the project.

This paper sets out the water supply and seawater systems needs in the context of the overall situation and available water resources. The Majuro Atoll is shown on Plan 1.

2. Population Projection

The population of Majuro Atoll in the 1988 census was 19,143 and the 1980-88 growth was at the rate of 6.3% p.a. for the 8.16 year inter-censal period. National growth was 4.2% p.a. for the same period and this indicates an outer island drift to Majuro of about 2% p.a.

National population growth is at a very high level by world standards. The age distribution shows that about 50% of the population is under 15 and this is a high fertility rate unless it is suppressed by Family Planning. The number of births in Majuro Hospital for 1992 was down compared to previous years and this would support some maintenance of the status quo and reflects some success of family planning policies.

Projections have been made of population trends. The National Population Policy July 1990 document indicates that with a 4.3% p.a. growth rate, a constant projection, there would be about a 50% increase in national population over 10 years while with a low projection of about 3.4% p.a., about a 40% increase in national population would occur. If the Majuro population growth continues with the same rate of outer island in-migration,i.e. at 6.3% p.a., the Majuro population could increase by about 85% over 10 years and 150% over 15 years.

It is considered that there is likely to be a continued significant outer-island in-migration to Majuro over the period of water supply projections of 10-15 years and that the high fertility status of the population even with family planning policies will be factors resulting in high population growth.

It is therefore proposed to adopt a most likely Majuro growth rate of 6.3% p.a. for water supply planning.

3. Water Supply Demand

The potable water supply system supplies DUD, Ajeltake-Arrak and Laura constituting about 97.5% of the total Atoll population.

There is some significant growth in population on Long Island and Ajeltake-Arrak and this may warrant some bias in the distribution of population growth but for the purpose of the exercise we have held a constant growth for the different urban components of Majuro.

The 1988 Census and previous CIP 1992 projects are shown on Plan 2.

The population and household break-up for 1988 and 1993 (@ 6.3% growth rate) is shown in Table 1.

At present the water supply system has about 1,650 services as many services service multiple/extended households. In the future, it can be taken that the number of services could increase from the equivalent of 59% of households to 80% of households with multiple households services decreasing in number.

The population and household projection for the potable water services population with a 6.3% p.a. growth rate and a constant household size is assessed as follows:

	Population	Households	No. of Services
1993	26,000	2,950	1,730
2003	48,900	5,435	4,350
2008	65,000	7,375	5,900

Table 1: Population and Household Data

Urban Population Serviced	1988 Census	30 Sept '93 Estimate	1988 Census	30 Sept '93 Estimate
Laura	1,575	2,138	188	255
Ajeltake-Arrak	898	1,219	110	150
(Laura to airport)		3,357		405
Majuro Urban - (DUD plus Long Island)	16,670	22,624	1,876	2,546
Total Serviced	19,143	25,981	2,174	2,951

Note: The average household size is 8.8 persons.

The 1993 population serviced by the saltwater system is assessed as 20,000 persons excluding Long Island (i.e. 77% of the population serviced with potable water). In the future, as part of the project, the salt water system will include Long Island, a total area with a 1993 population of 22,600 persons (i.e 91% of the population serviced with potable water).

The population projection serviced by the saltwater system will probably include Laura within 10 years. Thus only Ajeltake-Arrak with a 1993 population of 1,219 persons may not be supplied (i.e. 95% of the population serviced with potable water).

The potable water demand for the existing population and for the expected population in years 2003 and 2008 has been estimated in Table 2.

The peak daily demand can be supplied over 24 hours with float operated valves or be rationed and supplied over say 16 hours with 4 or 5 areas supplied for a period of 3-4 hours/day.

The peak hourly demand can be taken as 1 gpm/service and is assessed as follows:

	No. of Services	Peak Hourly Demand (mgd)
1993	1,730	2.5
2003	4,350	6.3
2008	5,900	8.5

Table 2

	1993	2003	2008
1. Domestic Demand			
Population	26,000	48,000	50,000
Unit Demand (gpcpd)	40.00	40.00	45.00
Subtotal (mgd)	1.04	1.92	2.93
2. Toilet demand not supplied by salt water (mgd) (12.5 gpcpd)	0.07	0.05	0.06
3. Total domestic demand (mgd)	1.11	1.97	2.97
4. Non-domestic demand (20%) (mgd)	0.22	0.39	0.60
5. Total metered demand (mgd)	1.33	2.36	3.57
6. Reticulation losses (mgd)	0.27(20%)	0.24 (10%)	0.36 (10%)
7. Total demand on supply sources (mgd)	1.60	2.60	3.93

3.2 Seawater Demand

This can be taken as a nominal requirement of 20 gpcpd as peak daily demand. The present maximum daily demand can be taken as 0.4 mgd for the 20,000 persons supplied. The peak hourly demand can be taken as 0.8 mgd for 770 services or the equivalent of 0.7 gpm/service.

The actual pumping requirement will reflect losses in the reticulation system as well as wastage in the toilets. The saltwater system pump rate capacity is 0.7 mgd and this would seem barely adequate. It is proposed that additional pump capacity be provided at Rita.

4. Capacity of Potable Water Supply Sources

4.1 General

There are 4 existing sources of supply as follows:

Airport runway
Laura lens
Roof catchments
Delap lens

There are potential sources of supply as follows:

Airport expansion
Laura lens expansion
Roof catchments expansion
Desalination
Lagoon storage

4.2 Rainfall

Rainfall records are now available for 37 years and these have been assessed.

Rainfall is heaviest in the wet period from June to November and the dry period is usually December to May.

The long term average rainfall for Majuro is 130 inches and is similar over the length of the island. Although the wet and dry periods vary in length and rainfall quantity, it can be taken that normal rainfall in the wet period is 55-65% of the total and 35-45% in the dry period. For the purpose of this report a 66.7-33.3 split would seem appropriate.

The lowest rainfall recorded is about 80 inches and this occurred in 1982/83. In 1992 the rainfall was 86 inches.

It is considered that an appropriate design event is a 1 in 10 year dry year. This is assessed as a 100 inch rainfall event; 75% of normal. The split between wet and dry can be taken as 88-22,as a worst case. In effect this constitutes a near normal annual rainfall for the wet period. The dry period is the more critical and requires carryover storage.

The characteristic rainfall and runoff for Majuro can thus be summarized as follows:

	Normal Year	Dry Year
		(1 in 10 years)
For the Year		
Rainfall (inches)	130	100
Rainfall volume in year		
Per sq. foot (gallons/annum)	84.5	65
Per acre (mga)	3.68	2.83
Per hectare (mla)	34.8	26.8

	Normal Year	Dry Year (1 in 10 years)
For the dry period		
Rainfall in period (inches)	43 33-1/3	22 (22%)
Rainwater volume in dry period		
Per sq. foot (gallons/annum)	28	14.3
Per acre (mga)	1.22	0.62
Per hectare (mla)	11.5	5.9

4.3 Airport Catchment

The existing airport catchment is 78.5 acres and the associated reservoir surface area is 9.6 acres. The current intention is to increase the catchment area by about 10 acres through some widening along the runway as well as some additional paved catchment at the eastern end or town side.

The situation of a normal rainfall of 130 inches and for a 1 in 10 year design dry year rainfall of 100 inches is set out in Table 3 on the basis of an 80% capture from the runway and taking account of the evapo-rainfall capture with the reservoir.

There may be pumping records available at the Airport Pumping station which could provide achieved capture. However, the airport catchment has been subject to cyclone damage, seawater intrusion on high tide rainy days and possibly intake and pipe system blockages. For this assessment, it is probably best to use a theoretical approach.

Normal rainfall of 130 inches results in an estimated runoff capture of 231 mg (80% of rainfall) from the existing runway. The reservoir has a direct rainfall capture of 35 mg but it has an annual evaporation loss of 60-75 inches, say 16 mg, i.e. net gain of 19 mg. The total annual capture is therefore 250 mg or 0.68 mgd average. The existing rainwater storage of 22 mg is insufficient as a carryover for a normal dry period and when the proposed 5 mg reservoir expansion is completed it will still be inadequate.

The proposal to expand the airport catchment by 10 acres will increase the capture by about 10%.

The assessment in Table 3 results in a Normal Year yield with the existing situation varying from 0.58 mgd in the dry period to 0.80 mgd in the wet period with the available storage of 22 mg.

The assessment for a 1 in 10 year Design Dry Year is a yield with the existing situation varying from 0.34 mgd in the dry period to 0.68 mgd in the wet period.

Table 3

	Area (Ac)	Normal Year (mga)	1 in 10 Year Design Dry Year (mga)
Existing Annual Performance			
Runoff from airport (80%)	78.5	231	178
Reservoir Capture	9.5	35	27
Reservoir Evaporation (65")	8.5	-16	-16
Total Capture		250	189
Daily Supply		0.68 mgd	0.52 mgd
Regd. Storage Depletion in Dry Period		42 mg (16.7%)	72 mg (38%)
Available Storage		22 mg	22 mg
Available Supply in Dry Period		105 mg (0.33x250+22)	63 mg (0.22x189+22)
Daily Supply in Dry Period		0.58 mgd	0.34 mgd
Available Supply in Wet Period		145 mga (0.67x250-22)	125 mga (0.78x189-22)
Daily Supply in Wet Period		0.80 mgd	0.68 mgd
Annual Performance after Expansion			
Runoff from airport (80%)	88.5	260	200
Reservoir Capture	9.5	35	27
Reservoir Evaporation (65")	8.5	-16	-16
Total Capture		279	211
Daily Supply		0.76 mgd	0.58 mgd
Regd. Storage Depletion in Dry Period		47 mg	80 mg
Available Storage		27 mg	27 mg
Available Supply in Dry Period		120 mg (0.33x279+27)	73 mg (0.22x211+27)
Daily Supply in Dry Period		0.66 mgd	0.4 mgd
Available Supply in Wet Period		160 mgd (0.67x279-27)	138 mg (0.78x211-27)
Daily Supply in Wet Period		0.88 mgd	0.76 mgd

After catchment and reservoir expansion the Normal Year yield would be 0.66 mgd in the dry period and 0.88 mgd in the wet period; while the 1 in 10 Year design dry year would be 0.4 mgd in the dry period to 0.76 mgd in the wet period. The only way to gain full capacity in the 1 in 10 year design dry year period would be to have additional carryover storage of up to 70 mg.

4.4 Laura Lens Supply

4.4.1 Available Supply

The Laura lens supply has been developed to a level of 0.4 mgd on the basis of a US Geological Survey investigation.

The wellfield consists of 7 wells of nominal 60,000 gallons per day capacity on the basis of 24 hours/day operation. At present only 6 of the wells are operating as one lease has not been signed. The wellfield has been in operation for about 2 years and the current maximum output is some 0.34 mgd. As yet monitoring bores are not operating as intended and recommended. Thus the behavior of the lens with the current level of exploitation is not known. The U.S. Geological Survey assessment was that about 50% of the rainfall would be lost by evapo-transpiration. Other more recent data indicates that with coconut tree cover, total transpiration could be 12"-30", i.e. less than 25%. The long term recharge rate for the 450 acre (180 ha) lens catchment was estimated to be 1.8 mgd but it may be higher if in fact there is less evapo-transpiration loss. The lens spills both to the ocean and to the lagoon. The "rule of thumb" recommendation adopted by the U.S.Geological Survey is to exploit the lens to 20% mgd, of long term recharge, i.e. as a sustainable yield, subject to careful monitoring. Other assessments suggest a sustainable yield of 6-12% of the annual rainfall i.e. 8-16 inches or 0.3 to 0.6 mgd. The lens nucleus or bubble has an assessed freshwater volume of about 500 mg; it fluctuates with the rainfall pattern. The subsurface conditions are porous coral. The assessment of lens volume has been made on the basis of test wells and electromagnetic modeling. The investigation also determined the behavior of the lens top surface or the water table following rainfall; it initially rises but then settles as water sinks and spills to the sea.

The capacity of the transmission line to the airport storages is 0.86 mgd and together with the needs of the local Laura supply system, about 1 mgd could be delivered if available from the wellfield. This is less than the dry year recharge value but well above that normally considered as sustainable. However the lens behavior in terms of storage and water quality is yet to be characterized.

Transmission capacity exists to use the Laura lens and it can be used for dry period make-up and even a greater continuous supply provided that monitoring supports greater exploitation. It is therefore essential that monitoring, which would measure the chloride level at different depths and thus establish the size of the nucleus or bubble of freshwater.

In view of the current critical shortage of available water sources it is proposed that:

1) monitoring be installed immediately and operated in accordance with in the U.S. Geological Program.

2) the outstanding lease be signed as a priority.

3) the wellfield be expanded progressively with the initial development be to 0.8 mgd to achieve a constant yield of 0.6 mgd and a conjunctive dry period use of 0.2 mgd to makeup for 1 in 10 dry year deficiencies.

4) the government's water right to Laura lens be protected by a water law that specified that all subsurface water be state water.

4.4.2 Water Quality of Laura Lens

The water quality of Laura lens is typical of lens water with significant contact with limestone.

The physical and chemical characteristics based on some 2 years of water quality of either well water or mixed water at the transmission reservoir can be summarized as follows:

	Range	Allowable US standards
Turbidity	0.17 - 0.58 NTU	1 NTU
PH	7.3	
TDS	238 - 349 mg/l	500 mg/l
Chloride	20-30 mg/l	500 mg/l
CaCO3 Hardness	188 - 342 mg/l	500 mg/l
Nitrate	3 - 8 mg/l	10 mg/l
Fluoride	0.19 mg/l	
Total Coliform	30 - 89+/100 ml	
Faecal Coliform	8 - 233/100 ml	0

The lens water was also subject to a comprehensive trace element and pesticide test in April 1991 and the water was below the detection limit.

A Langelier Index (LI) was determined on a water sample in June 1992. This showed a positive LI result of 0.36. The water was non-corrosive and the positive LI indicates that it was slightly oversaturated with CaCO3 and that there could be some scaling of pipes and equipment.

The water is generally of a high quality although it is relatively hard and soap lathering may be difficult and warrant the use of special soap. WHO standard is for a highest desirable limit of 100 mg/l with a maximum permissible limit of 500 mg/l.

The water is low in turbidity and can be safely chlorinated which would sterilize the water and eliminate the coliform count.

It is reported that the water does grow algae and this can occur at the well point. This is probably due to significant nitrate and phosphorus levels (the latter has not been measured). It is therefore proposed that filtering be undertaken. This could be by micro strainers at the wellpoint or by a sandfilter at the storage prior to transmission and chlorination.

The lens can be exploited so long as the TDS and chloride levels remain satisfactory. If the lens is over-pumped there will be saltwater intrusion and it is possible that the lens will take some time to return to normal. It will be important to monitor chloride levels to ensure the lens is not over-pumped.

4.5 Roof Catchment

Roof catchment offers a traditional method of water supply. It can be undertaken by householders as a supplementary supply. It can also be undertaken with public buildings that have large roof areas.

4.5.1 Domestic Roof Catchment

A number of householders in DUD and particularly in Rita are rising roof catchments.

The 1987 report "A Comprehensive Water Study of Majuro Atoll" by Pacific Management Corporation undertook a household survey of water catchments in 1986. It assessed that up to 40% have tanks with about 7% having oversized tanks (4,000-40,000 gallons). There is thus possibly 1,000 houses with roof catchments using, in general, 600 or 900 gallon tanks for storage.

The 1987 report assessed that the average roof area as 682 sq. ft. On such a roof 1 inch of rainfall would amount to 446 gallons.

The potential rainwater capture for this 682 sq. ft. average sized house is provided in Table 4.

The actual rainwater capture with a relatively small domestic tank may be significantly less than the potential rainwater capture. This will be dependent on rainfall distribution and may be about two-thirds of the wet period rainfall but probably most of the dry period rainfall. Thus the possible supply with full domestic rainwater capture is likely to be about 15%-50% of the maximum daily demand requirement of 40 gpcd a household.

Table 4

Volume Available	Unit House Gallons	1,000 Houses (mga)	All 3,000 Houses (mga)
Normal year rainfall (84.5 gall/sqft)	58,000 (18 gpcpd)	58	174 (0.48 mgd)
Dry Period Yield (33.3% x 90%)	17,000 (12 gpcpd)	17	51 (0.28 mgd)
Wet Period Yield (66.7% x 66.7%)	26,000	26	78 (0.43 mgd)
1 in 10 Year Dry Rainfall (65 gall/sqft)	44,000 (14 gpcpd)	44	132 (0.36 mgd)
Dry Period Yield (22% x 90%)	9,000 (6 gpcpd)	9	27 (0.15 mgd)
Wet Period Yield (78% x 66.7%)	23,000	23	69 (0.38 mgd)

4.5.2 Government Building and Commercial Building Roof Catchments

In the past government buildings, including Rita Elementary School, government warehouses and the high school were fitted with rainwater catchments and a pipe collection system took the water for treatment at Treatment Plant B. This system has fallen into disrepair and is not operating.

The only extensive roof catchment system operating is the hospital collection system. This is functioning well and is servicing the hospital throughout the current period.

The Capital Building and Nitijela Building have been fitted with a roof catchment collection, comprising in total about 58,000 sq. ft. of catchment.

Other commercial buildings and some hotels have been fitted with roof catchments.

The extent of Government and commercial roof catchment areas operating of the potential catchment is not known.

If there was a total of 0.5 m sq.ft. of roof catchment, the annual yield would be about 40 mga or about 0.1 mgd.

This would not seem to be a significant potential source of supply.

4.6 Delap Lens

Three shallow wells have been developed in the DUD area but two have been discontinued following pollution and/or seawater intrusion.

The Delap lens near the hospital is being used as a supply for the hospital. It is currently showing signs of higher salinity due to the 1992 low rainfall and the dry season. As a source of supply it can contribute about 0.05 mgd.

4.7 Desalination

Desalination for Majuro has been considered over the years. Tenders were actually called some years ago but no contract was awarded. More recently a Presidential Committee has again been considering desalination.

There is some local experience with a multi-effect distillation (MED) type of plant at Ebeye. The plant of 0.25 mgd capacity was installed in 1988 by the Government but is owned and operated by a Government company. It utilizes wasteheat from the power plant. Knowledge of its true operating cost is not known although the information would be obtainable but would need to be extracted by separating out power station and desalination costs. It is said that the desalination plant is directly wired in without separate metering and O&M staff are commonly employed on both the power plant and the desalination plant. A stated cost of $2.50/1000 gallons is not realistic and would represent some cross-subsidy. The true water cost, speculatively, could be $7.50/1000 gallons.

The options for Majuro are either an MED plant or a Reverse Osmosis (RO) plant. As with the Ebeye plant an MED plant would operate on wasteheat from the power station while an RO plant would be self-standing. An MED plant would probably be operated by the Marshalls Electricity Company (MED) while an RO plant would probably be operated by the MWSC.

Discussions with the General Manager of MEC indicates that there is sufficient power demand to provide the necessary wasteheat to permit an MED plant to operate over 24 hours. There would be some loss of power plant efficiently but not significantly so. There would be a reduced output over night when only 2 diesel generators operate.

An RO plant has reasonably known costs and there has been recent tenders and offers to supply desalinated water at Saipan. It is assessed that it would be more costly to operate then an MED plant.

It would appear from the recent Presidential committee enquiries and other available data that cots for desalination plant is coming down. Capital costs for both types of plant seem to be less and the RO plant is now available with an energy recovery unit.

Recent indications are that costs will be lower but are still much higher than conventional sources if available. This suggests its use as a complimentary source of supply but

there are high capital charges and there is a need to flush out the system during stoppages to avoid corrosion damage.

With the limited sources of supply available for Majuro and its likely continued high growth rate it seems inevitable that at some time in the future (10 years plus) desalination will be required. It would also provide a further diversification of supply offering water during the dry season and/or in dry years.

4.8 Lagoon Reef Storage

The need for carryover storage has been highlighted with the recent dry years.

The shortage of land suggests the possibility of a lagoon storage.

Two years ago the feasibility of a floating storage in the lagoon was investigated. It found that a large storage of 120 mg would cost $15-25m. It would need to develop a new and untried concept. Its security in a typhoon would be a concern.

There are sites on the lagoon reef between the airport and Laura. The porous nature of the coral would require the development of an impervious basin using concrete or a membrane. There is a possibility of coupling it with capture of the spill from the Laura lens but the latter could possibly be effected by an independent capture system.

The preferred site may be one closer to the airport to permit more economical transmission.

The following concept is in mind:

- a rockfill wall or embankment on the lagoon side above wave splash level utilizing coral rock preferably from the basin but possibly the harder ocean coral rock.
- a flexible membrane that could float with the tide; it would normally be weighed down with freshwater and if the freshwater level is above high tide level it would be flat onto its rock base
- alternatively an anchored concrete lining could be used; it would need to be structurally strong and anchored into the reef such that it could resist high tidal head
- the width of the storage is limited by the reef width so the embarkment would be relatively long to achieve the desired storage capacity
- the storage would have a rainwater capture capability but its yield would be reduced by evaporation; this suggests the use of a relatively deep storage component with the use of the excavated coral as rockfill. Additional rainwater capture could be obtained by pumping from an impervious catchment, much as it is undertaken at the airport.

- an inlet/outlet facility on-shore.

This carryover storage approach is foreseen as a possible conventional supply addition as well as a means to supplement other sources of supply in dry periods and dry years.

A relatively large storage of 100-150 mg would be desirable.

5. Cost of Developing Additional Water Resources

The cost of developing additional water resources can be determined and then comparatives drawn on the basis of total annual costs; capital charges at 10% interest rate and O&M costs.

5.1 Airport Expansion

An expansion of the airport catchment is currently underway utilizing some US Department of Interior funds of some $800,000.

It is not known how far this funding will go but an assessment has been made of the cost of providing a rainfall catchment on the eastern end of the airport if some 10 acres was developed as an extra catchment development.

The following is the estimate of cost:

Fill 5,000 cyd @$15	75,000
Regrading & bitumen sealing 436,000 sq.ft. @$2	872,000
Stormwater system	10,000
Pump station	50,000
Rising main	5,000
Fencing - 2,500 ft. @$17	43,000
Revetment seawall - 2,000 ft. @$75	150,000
Total Cost	1,205,000 say $1.2M

This will provide an additional 29 mga on the basis of 10 acres of catchment. There may be other catchment area of about 5 acres or so that could be developed at a comparable cost.

The life of the project can be taken as 40 years.

The cost assessment of this source is as follows:

	Total Cost ($)	Unit Cost per 1000 gal. ($)
Capital Cost	1,200,000	41.4
Annual Cost		
Capital charge ($1,200 @ 10.01%)	120,000	4.1
O & M cost (say 1%)	12,000	0.6
Pumping	5,000	
Total Annual Cost	137,000	4.7

5.2 Laura Lens Expansion

The Laura lens supply can be augmented by the addition of more wells in the wellfield at a small capital cost involving only the costs of the wells and some pipe connection costs. A header main exists and this can utilized.

The development of further wells to double the present output from 0.4 mgd to 0.8 mgd, an extra 146 mga is assessed as follows:

The unit cost is very low and even if production has to be doubled, the total annual cost will be very low. Additional capacity up to 1.1 mgd could be obtained for this order of cost.

	Total Cost	Unit Cost/ 1000 gal.
Capital Cost		
7 wells and piping	$140,000	
Sand filters	60,000	
Total	$200,000	1.37
Annual Cost		
Capital charges		
Wellfield (20 years)		
$140,000 @ 11.75%	16,500	0.11
Sand filters (10 years)		
$60,000 @ 16.28%	9,800	0.07
	26,300	0.18
O & M costs		
Labor (5% of $200,000)	10,000	0.07
Energy	14,600	0.01
Chemicals	2,900	0.02
Parts	1,500	0.01
	29,000	0.2
Total Annual Cost	55,300	0.38

5.3 Domestic Roof Catchment Expansion

It is assumed that the existing household catchments relate to 1,000 houses and that the roofs of a further 2,000 houses could be exploited.

The proposal would be to add guttering, downpiping and a 600-900 gallon tank. Tanks cost $600-800.

The cost of development should be of the order of $1,000/house. Production can be taken as about 80% of a normal year rainfall, i.e. 43,000 gallons/house or 86 mgd from 2,000 houses.

The cost assessment of this source for 2,000 houses is as follows:

	Total Costs ($)	Unit Costs/ 1000 gal.
Capital Cost	2,000,000	23.3
Annual Cost		
Capital charge ($2m@11.75%)	235,000	2.73
O&M cost, say $50pa/house	100,000	1.16
Total Annual Cost	335,000	3.89

5.4 Government Building and Commercial Building Roof Catchments

It is not possible to assess the cost of development of roof water catchments for large buildings. They will be dependent on roof area and whether it is decided to treat the water with a raw water pipe collection system.

It can be considered that costs/1000 gallons would be comparable to domestic roof catchment systems, although there would be lower capture costs but possibly the need for filtration.

5.5 Desalination

Desalination costs are set out in the 1987 Water Study and are available from recent proposals.

Based on the best available data, the following cost assessments are set out in Table 5.

Table 5: Comparative Costs of MED and RO Desalination Plants

		MED	RO
Capacity			
	Rated (mgd)	400,000	400,000
	Av. daily (mgd)	380,000	400,000
Output			
(95%)	mga	132	140
Energy consumption/1000 gal.		8.5	30
Turnkey price		$4.7m*	$2.5m
Feedwater & post treatment storage and pump station - Allow.		$0.25m	$0.25m
Annual Cost	say	$5 m	$2.75m
Capital Charge (15 yr) 13.15%		$0.62m	$0.33m
1. cost/1000 gallons		4.7	2.3
2. O&M cost/1000 gallons for plant			
	Chemicals	0.3	0.7
	Energy (@17/kwh)	1.3	5.1**
	Parts	0.3	0.8
	Labor	0.5	0.7
		2.4	7.3
3. Feedwater & post pumping & treatment costs - Allow.		0.5	0.5
4. Total cost (1+2+3)		7.6	10.1

* This includes a construction interest component.
** This cost can be reduced to $3.3 with energy recovery.

Currently MSWC is obtaining RO turnkey costs for the Presidential Committee. In July 1992, an MED offer from Ambient Technologies Incorporated (Israeli plant) was obtained.

A recent offer to the Commonwealth Utilities Corporation (CUC) in Saipan for an RO plant 1 mgd rated capacity indicates that RO would cost the order of $8/1,000 gallons with an energy recovery unit.

It would seem that the order of cost for a desalination plant including associated works would be $8-10/1,000 gallons.

5.6 Lagoon Reef Storage

A quick assessment has been undertaken of a lagoon storage on the reef of 100 mg (378 ml) capacity with a surface area of about 28 acres (10 Ha).

It has been assumed that the width would be 600 ft. (180m) and that the storage length would be 2000 ft. (600m) with a depth of 12 ft. (3.6m). The catchment would be larger with an additional 3,000 ft (900m) length; total catchment would thus be 70 acres with a normal year yield of 258 mga; net available water 206 mga after evaporation losses, i.e. 0.56 mgd.

It is proposed that the rockfill embarkment be to E1 11 on the basis that high tide is E16. this is some 3 ft. above that adopted for the airport protective wall.

The estimated capital cost would be about $7m.

The annual cost is assessed as follows:

	Total Cost $	Unit Cost per 1000 gal. $
Capital Charge (25 years) $7m@ 0.11	770,000	3.74
O&M Cost		
Liner, pumping	30,000	0.15
	800,000	3.89

5.7 Comparative Cost of Water from Different Sources

The comparative cost of water from different sources can be summarized in Table 6 with capital provided at 10% or at (6%).

Table 6

Source	Extra Annual Production (mga)	Capital Cost ($m)	Total Annual Cost ($)	Annual Cost 1000 gal.
Airport Expansion *) (10 acres)	29	1.2	137,000	4.7 (3.3)
Laura Lens Expansion (0.4 mgd to 0.8 mgd)	146	0.2	55,000	0.38 (0.34)
Roof Catchment (extra 2000 houses)	86	2	335,000	3.89 (3.18)
Desalination				
MED	132	5	1,000,000	7.6 (6.6)
RO	140	2.75	1,400,000	10.1 (9.6)
Lagoon Reef Storage	206	7	800,000	3.89 (2.81)

5.8 Discussion on Cost and Source Options

Table 6 indicates the development that could possibly be followed for the Majuro Water Supply System.

The Laura lens is the least cost option due to the fact that the transmission line is in place with a capacity of 0.86 mgd. The concern is whether the lens can support higher exploitation without saltwater intrusion. Nevertheless, the cost of supply is so low and the capital expenditure so little that further wellfield development with monitoring should proceed as the highest priority. Even if the lens has limits on its sustainable yield below wellfield capacity, it would still be most useful as a conjunctive use source.

The airport expansion is a low cost development option but it has not got any carryover storage provision and it has a much lower yield in the dry period.

Roof catchments are expanding under the present dry conditions as a direct result of the MWSC having insufficient capacity. The cost of roof catchments would appear to be not unreasonable but they are inadequate for the total domestic requirements.

A lagoon reef storage is attractive in cost and would appear to have merit ahead of desalination. Its size or components could be selected such that it is developed in 2 stages to lessen the cost.

*) If the catchment area is extended to 15 acres and a reservoir of 15 mg is included the extra annual production is 69.5 mga with a capital cost of $1.99 million. The total annual cost

Desalination would appear to be the highest cost option and should be deferred until after conventional sources are exploited.

5.9 The peak daily total demand on the system as assessed in Table 2:

Year 1993	1.6 mgd
Year 2003	2.6 mgd
Year 2008	3.93 mgd

It is possible to adopt an indicative water resource development strategy as set out in Table 7.

Table 7

	Normal Year Capacity Dry/Wet Period (mgd)	1 in 10 Year Design Dry Year - Dry/ Wet Period (mgd)
Existing Sources		
Existing airport catchment	0.58/0.8	0.34/0.68
Laura lens	0.34	0.34
Existing Roof catchments	0.09/0.16	0.05/0.13
Total	1.01/1.28	0.73/1.15
Proposed Initial New Sources		
Additional Airport Catchment (DOT)	0.08/0.08	0.06/0.08
Laura lens	0.46/0.29	0.46/0.37
Total of Existing & Proposed Initial Sources	1.55/1.65	1.25/1.60
Proposed Further Sources		
Laura lens	0/0	0/0.09
Lagoon storage/roof catchments	1.05/0.95	1.35/0.91
Total of All Sources	2.6/2.6	2.6/2.6

The strategy would seem to be to develop:

Laura lens wellfield to 0.8 mgd on a conjuctive us basis
Additional airport catchment by 10% (already funded DOI project)
Lagoon storage and/or roof catchments of about 1 mgd;
roof catchments have a capability of only 0.15/0.43 mgd

This will provide sufficient sources of supply for up to Year 2003.

6. Water Transmission to DUD

The current situation is that peak hourly demand of DUD exceeds the capacity of the transmission main and with limited sources of supply the water is supplied on a rationed basis varying from twice/day to once in 3 days. Further as the system is of linear configuration with direct tappings on the distribution main, services nearer the airport gain a good supply while services at Rita are poorly served.

MWSC has proposed that a second transmission main be installed to permit fairer distribution on a rotation basis. This will also permit rationing when supplies are limited.

There are 3 broad options:

1) Utilize the present 12"/10"/8" line as a bulk distribution line for the supply of the daily requirement and install a tapping main for rotational distribution. This would mean that all consumers would need a carryover storage.

2) Install a new bulk distribution line that has capacity for peak hourly demand and utilizes the existing 12"/10"/8" line as a reticulation supply.

3) Install a second bulk distribution line that would be used for rotational distribution rationing; the existing and second line together would have sufficient capacity to meet the peak hourly demand.

These options have been assessed and costed on the basis that they would meet the requirements for the next 10 years.

The required design capacity for Year 2003 for the DUD area (87 per cent of total demand) is as follows:

Peak Daily Demand	2.26 mgd (8.5 mld)
Peak Hourly Demand	5.5 mgd (21 mld)

The existing distribution line consists of the following:

Airport - Delap	36,600 ft of 12" AC (11.0 km of 300 dia)
Delap - Uliga	7,600 ft of 10" AC (2.3 km of 250 dia)
Uliga - Rita elevated tank	4,000 ft of 8" AC (1.2 km of 200 dia)

The existing Treated Water Pump Station at the Airport Reservoir consist of 3 No. 600 gpm x 230 ft head pumps (3 No. 38 liters/sec x 70m head). Total design capacity with 2 duty pumps is 1200 gpm 1.73 mgd (6.6 mld) if 1 pump is set aside as a standby. The three pumps can deliver about 2.6 mgd if operating at rated capacity; just above DUD estimated peak daily demand for Year 2003 of 2.2 mld. MWSC in fact operates the 3 pumps when sufficient water is available. It would be desirable to upgrade the pump capacity by 50 per cent, the limit to upgrading the pump exchange.

This means that:

Option 1 Requires either 3 new higher duty pumps or a fourth pump to permit a standby to deliver 2.6 mgd. The 3 pump configuration is preferred so as not to require reconstruction of the pump station.

Option 2 & 3 Requires both an upgrading of the existing pump station as well as supplementary pumping capacity with 2 duty pumps operating on the new line.

The third option involves a 14" dia (350) and then a duplication of the existing distribution system while the second option requires a new 18" dia (450) 10"/8" 12" dia (300) bulk distribution.

There is a need for increased pumping provision at the Airport Reservoir Pumping Station/Treatment Plant C. The present distribution pump capacity is 3 No. 600 gpm x 230 ft., i.e. 2.6 mgd. This is sufficient to meet the Peak Daily Demand for Year 2003 (Option 1). However, there is a need to provide for a standby pump, i.e upgrade the 3 pumps by say 50% as well as to provide for greater filter capacity.

For options 2 and 3 the requirement is to achieve the Peak Hourly Demand for DUD of 5.5 mgd. This can be provided by:

a) a new pumping station of 2.9 mgd duty capacity plus

b) an upgraded existing pumping station with 2.6 mgd duty capacity.

The estimated capital cost of these options are:

Option 1, New Tapping Main		$
48,000 ft. of 6" dia @$13		624,000
Cross connections 10 No. @$5,000		50,000
Tappings 1,000 No. @$500		500,000
Upgrade Pumping Airport Reservoir Station and Filters		300,000
Total Cost	$1,	474,000

Option 2, New Feeder for Peak Hourly Demand	$
18,300 ft. of 18" dia @$45	824,000
18,300 ft. of 16" dia @$40	732,000
7,400 ft. of 12" dia @$30	222,000
4,000 ft. of 8" dia @$20	80,000
Cross connections 10 No.* @$7,500	75,000
Upgrade Airport Reservoir Station and Filters	300,000
New Airport Reservoir Pumping Station	200,000
Total Cost	2,433,000

Option 3, New Feeder with existing feeder for peak hourly demand	$
36,700 ft. of 14" dia @$35	1,285,000
7,400 ft. of 10" dia @$25	185,000
4,000 ft. of 8" dia @$20	80,000
Cross connections 10 No.* @$7,500	75,000
Upgrade Airport Reservoir Pumping Station and Filters	300,000
New Airport Reservoir Pumping Station	200,000
Total Cost	2,125,000

* The number of cross connections can probably be 5 no.

The new tapping main is the least cost option as expected. However, it provides no capacity for future Peak Hourly Demand; it will simply permit rotational distribution/rationing of available water. All consumers will need carryover storage.

The preferred solution is Option 3 which utilizes the existing feeder as well as a new feeder to supply Peak Hourly Demand. If necessary, the new feeder an be utilized as a bulk distribution main to permit rotational distribution/rationing if necessary. The extra cost of about $0.6 m over Option 1 is a worthwhile investment in future capacity.

So adopt Option 3 at a cost of about $2.1M.

APPENDIX 2

MEMORANDUM OF UNDERSTANDING (MOU)

SELECTED ANNEX

THE PROJECT

Background

1. The Majuro Atoll is the seat of the Government and capital of the Republic of the Marshall Islands (RMI). The atoll consists of 45 islands and has a lagoon about 38 km long from the east to the west and 11 km wide from the north to the south. At the eastern end of the lagoon is the Darrit-Uliga-Dalap (DUD) area which is made up of three former islands (Darrit, Uliga and Dalap) and the reclaimed area around them totalling about 365 acres. There is only limited fresh groundwater in this area. The DUD area is linked to a chain of islands by a single-lane bridge along the southern rim of the lagoon. These islands themselves are linked up by embankment causeways forming a long and narrow island some 40 km long. Laura with an area of about 450 acres is the western most island that was linked up by cause ways. A significant groundwater source is found in Laura. The international airport is constructed on one of these reclaimed lands near the middle of the long island some 17 km west of the DUD area. The reclaimed area at the airport is about 200 acres. The topography is flat and narrow in most places with a maximum elevation of about 3 m above the sea level. Saline water is found beneath the long island and in most part of the DUD area.

2. The Majuro Atoll is one of the two major urban centers of RMI. The other is the Ebeye island of the Kwajalein Atoll. The Majuro Atoll has a population of about 25,000 or about 49 percent of the country's population (51,000). Some 18,500 are living in the DUD area and 2,000 in Laura. Most of the remaining population live on the long island between the two population centers. The natural population growth of RMI is high at 4.2 per cent. The population growth rate in Majuro is even higher due to in-migration from the outer islands. Between 1980 and 1988 censal years, Majuro has experienced a growth rate of 6.49 per cent; most of the population growth occurred in the densely populated DUD area. it is believed that this high growth rate has continued to this day. In the DUD area are located the capitol complex, older government buildings, commercial and banking center, the college and the General Hospital. A new commercial center is being developed at the southern end of the DUD area. A new capitol building and a major hotel are being constructed in this new area. Newer governmental buildings, a coconut oil refinery, an inter-island shipping harbor and the electric generation plant are also located in the same vicinity. With the extension of public utility services along the long island, urbanization is fast extending towards the airport.

3. Majuro has two major sources of fresh water: one of them depends on collection of rainfall runoff from the runway and the adjacent paved area at the international airport, and the other is the groundwater in Laura. Many residents and commercial establishments augment their supplies obtained from the public freshwater supply system by collecting the rain water from their own roof catchments. They also install some storage facilities to maximize their private supplies from the roof catchments, but these private water storage facilities are often small and only sufficient for meeting one week's domestic water uses. There are two other minor freshwater supplies in the DUD area: one of them comprises

a system of rainwater catchment at the General Hospital, and the other consists of two small diameter shallow wells equipped with pumps in the heart of the DUD area. The airport supply has been roughly rated at about 2,500 cubic meter per day (cu m/d) based on the average annual rainfall received. Its development is intended to supply the DUD area only. During the dry season, this supply would drop considerably. The Bank's Reconnaissance Mission has previously assessed reliable supply at only about 400 cu m/d for the worst recorded drought.1/ This is because of the very limited water storage available on the island. A major storage scheme on land has never been seriously investigated because of the uncertainty of land acquisition or the high leasing cost it would entail. With the development of the fresh groundwater supply (1,500 cu m/d) in Laura in the last two years, the total freshwater supply in Majuro has reached 4,000 cu m/d on an average year, but this is still short of the present requirements estimated by the Mission at about 5,500 cu m/d. The last extension is intended to augment the airport supply to the DUD area, but it also benefitted for the first time residents in Laura and those living along the way to the airport. The extension of the service area also means that during critical periods less water would be available to the DUD area. This diminished supply is estimated at about 900 cu m/d only. During the dry season, severe water rationing still has to be imposed and most of the residents in the DUD area are getting their freshwater supply in two periods of about three hours each once in four days. This was the some unhappy situation in Majuro today.

4. Majuro is also served by a seawater supply system. This system has a supply capacity of about 3,800 cu m/d serving mainly the DUD area. This supply is used for flushing toilets and for fire fighting. A centralized sewerage system and an ocean outfall were also constructed to serve the same area supplied with sea water. This development is the first major freshwater conservation effort attempted in RMI. There is as yet a plan to extend the seawater supply to area outside the DUD area. Further saving of fresh water has been identified by Majuro Water and Sewer Company (MWSC) on the long island between the bridge and the airport. The potential saving is estimated by the Mission at about 120 cu m/d in this area. The possibility to extend the seawater supply service in Laura had been investigated in the past, but not recommended for implementation because of low population density and the risk of contaminating the groundwater below. The population density west of the airport is also too low at the present time for the introduction of a separate system there.

5. The last Bank Mission also examined six other potential freshwater supply schemes2/ and a roof catchment scheme in the field and considered that two or three of these schemes might warrant further study to a feasibility level

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1/ This drought has a critical period of six months and a recurrent interval of once in 35 years, which is closed to the design reliability required by most water supply authorities.

2/ An innovative solution was brought to the Mission's attention upon its return to the Bank's Headquarters; it involves the installation of a huge floating catchment-cum-storage reservoir in the lagoon.

for their development to meet the long-term freshwater supply requirements in Majuro. According to the Mission's assessment, a total supply of about 8,000 cu m/d or an increase of about 100 per cent over the present average supply would likely to be needed by the year 2002. A major water resource development study will be needed to identify the least-cost solutions, rank the potential solutions and formulate a bankable first-phase project for the long-term freshwater supply for Majuro. The timing and financing for the study in the form of project preparation technical assistance (PPTA) remain to be established by the country operational strategy study (COSS) to be undertaken by the Bank in 1993. A major freshwater supply scheme looked into by the Mission is a desalination scheme investigated by the Government since the mid-eighties: a low-temperature multi-effect distillation (LT-MED) seawater desalination plant using waste heat from a power generating plant1/ operated by the Marshall Energy Company (MEC). Tenders for the LT-MED desalination plant were received recently. An evaluation committee was formed by the Government to study the tender proposals. Evaluation of this plant has been discontinued and no recommendation has been made. The investigation of this scheme and the development of the groundwater in Laura had overshadowed the works that would be able to improve the availability and reliability of the existing freshwater supplies.

6. The Majuro's freshwater supply is delivered through two separate systems of transmission mains: one system runs from the Laura wellfield to the airport with a designed capacity of 1,000 cu m/d and another system from the airport to the DUD area with a maximum design capacity of 5,000 cu m/d to the center of the DUD area. The older transmission mains from the airport to the DUD area are used as distribution pipelines as well and in the absence of a duplicate mains, none of the service area can be isolated for the purpose of supplying freshwater to the various segments of the service area by following a rationing roster during critical periods. As a result, water rationing cannot be imposed in an optimal way. There is therefore an urgency to duplicate this mains to provide a means of controlling the distribution of freshwater, thus improving the availability and reliability of the freshwater supply in the DUD area. The new transmission mains from Laura is not used as a distribution pipeline for the most part of the route and the water demand en route is still low. There is therefore no urgency to improve the delivery system there as yet. The implementation of a scheme that would facilitate the control of the distribution of freshwater supply from the airport to the DUD area as well as other improvements have been, although mooted since 1986, overshadowed by the implementation of the Laura groundwater development and the investigation of the LT-MED desalination plant. The more urgent works are now being proposed by the Government for possible inclusion in the proposed Project. The proposals were first examined by the Bank's Reconnaissance Mission in August 1992 and various aspects of the Project are reviewed by the consultants under the PPTA (No. 1775-MAR) financed by the Bank. The Fact-Finding Mission for the proposed Project is also assisted by the same consultants.

1/ The power plant is located in the southern end of the DUD area.

Project Approach

7. Pending the completion of the water resource development study, the least-cost solution for the next major expansion of the freshwater supply for Majuro cannot be determined. To improve the current supply situation, it would be necessary to look into measures that would help to optimize freshwater supply from the existing sources, control the distribution of fresh water to all the residents during critical periods, keep the cost of water distribution down, conserve some more of the freshwater resources, promote greater cost recovery and water conservation, improve the reliability and availability of freshwater and seawater supplies through rehabilitation and establishment of a set of operating rules. The last will also ensure that the water quality of the Laura source is not jeopardized by overpumping, and the refilling of the reservoirs at the airport can be planned well in advance so that the reservoirs are full at the beginning of the critical periods. Through these efforts, the existing freshwater supply system would be able to supply an average of 150 liters per capita daily (lpcd) during an average year and 80 lpcd during the most severe drought.

Objectives and Scope

8. The Project's objectives are therefore: (i) to provide a means of controlling the distribution of fresh water during the critical periods; (ii) safeguard, maximize and optimize the freshwater supply from the existing sources; (iii) conserve some more of the fresh water presently used for flushing toilets; (iv) to establish a set of operating rules: and (v) to promote greater cost recovery and water conservation efforts. The Project is therefore formulated to meet a major part of the country's sector objectives, ensure a reliable freshwater supply of about 2,000 cu m/d for Majuro in time of most severe drought and a supply of 4,000 cu m/d on an average year, afford a positive control over the distribution of fresh water in the DUD area, make available an additional supply of 120 cu m/d of fresh water to the DUD area, and provide additional households with flushing water for their toilets in time of drought. The MWSC's financial position will also be considerably strengthened over the next few years.

Project Facilities

9. The Project will consist of the following major components:

A. Freshwater System

1. Rehabilitation Works

Treatment Plant C at Airport Reservoir

(i) Raw-water pumpsets for filters
600 gpm, 120 ft, 25 hp, 4 No.
38 l/sec, 36 m, 18 kw

(ii) Filtered water pumpsets to treated water storage
900 gpm, 25 ft., 10 hp, 2 No. (57 l/sec, 8 m, 8 kw)
(standby 500 gpm - existing)
32 l/sec

(iii) Treated-water pumpsets for DUD (Treatment Plant C)
900 gpm, 230 ft, 70 hp, 3 No.
(57 l/sec, 70 m, 53 kw, 3 No)

(iv) Filters
- 600 gpm, 3 No.
(38 l/sec)

(v) New store building 40 ft. x 24 ft.
(12 m x 7.2 m)

Treatment Plant A

(vi) Filter unit, pump controls, 1 pump, chlorinator and meter (~~60~~ 175 gpm capacity)
11 l/sec.

Pump Station 4 at Airport

(vii) Pump controls, TDS monitor and building repairs

Other Facilities

(viii) Distribution pipelines
Diameter (mm) 100 Length (m) 3,000

(ix) Recovering of airport treated water reservoirs comprising 5,000 sqm. as well as the (0.5 mg) 1.9 ML reservoir at Treatment Plant A (1,250 sqm) (Some 8,000 sqm of hyperlon is available in stock).

2. Raising of the Reservoir Storage

Construction of 1.2 m high water retaining walls (with extra hyperlon edging) around the following reservoirs at the airport:

(i) Raw-water reservoirs, extra (2 mg) 7.5 ml/res., 2 No. for a total of 26 mg 98 ML

(ii) Treated water reservoirs, extra (1.5 mg) 6 ml, 1 No. for a total of (3.5 mg) 13.5 ml

3. New Transmission Mains

Installation of 14.6 km of 350/250/200 mm diameter transmission mains from the airport to the DUD area.

350 dia.	11.0 km.
250 dia.	2.4 km.
200 dia.	1.2 km.
up to 5 No. cross connections	

4. Filters at Laura

360 gpm, 2 No.
25 l/sec.

B. Seawater System

1. Rehabilitation Works

(i) Isolating Valves. Replace approx. 170 valves with 20 No. and provide pressure tapping equipment.

(ii) Provision of an additional and standby shallow well for the seawater system with 1 No. pump and pump house at Rita with capacity 500 gpm x 160 ft (30 hp).

2. Extension of the system from the bridge to the airport

(i) Installation of 2 shallow wells each with submersible pumps of 150 gpm x 150 ft. capacity (10 hp) and with 1 well fitted with a fire pump of 300 gpm x 150 ft. (20 hp), 2 pump houses, and 7 km of 150 mm diameter and 8.4 km of 50 mm distribution pipelines in the Long Island area between the airport and the bridge to supply seawater to the residents. Most of the pipes and fittings are in stock.1/

10 l/sec x 45m (6Kw)
20 l/sec x 45m (12Kw)

(ii) Installation of 330 seawater service connections and 6 fire hydrants for Long Island.

C. Sewerage System

1. Rehabilitation Works

(i) 6 No. replacement sewerage pumpsets in ss

(ii) 4 replacement comminutors in ss

(iii) manhole repairs

D. Consultant Services

Consultant services for site investigations, engineering design, procurement, contract administration and construction supervision.

1/ MWSC is to ascertain that the pipes, etc. are not damaged by sunlight.

COST ESTIMATES
(M$ million)

Item	Foreign Exchange	Local Currency	Total
A. Freshwater System			
Civil Works			
1. Rehabilitation Works	19,000	170,000	189,000
2. Pipelaying - transmission mains	78,000	722,000	800,000
3. Raising of reservoirs	75,000	225,000	300,000
4. Installation - filters	10,000	90,000	100,000
	182,000	1,207,000	1,389,000
Plant, Equipment and Materials			
1. Pipes, valves and fittings	807,500	42,500	850,000
2. Pumpsets	267,500	5,500	273,000
3. Filters	280,000	15,000	295,000
	2,107,000	63,000	1,418,000
B. Seawater System			
Civil Works			
1. Pipelaying at Long Island Ext.	26,000	239,000	265,000
2. Rehabilitation Works	3,000	22,000	25,000
3. Installation of new pump station at Rita	5,000	5,000	55,000
	34,000	311,000	345,000

Item	Foreign Exchange	Local Currency	Total
Plant, Equipment and Materials			
1. Pipes, valves	43,000	2,000	45,000
2. Pumpsets	152,000	8,000	160,000
	195,000	10,000	205,000
C. Sewerage System			
Civil Works			
1. Rehabilitation Works	5,000	45,000	50,000
Plant, Equipment and Materials			
1. Pumpsets	123,500	6,500	130,000
2. Comminutors	95,000	5,000	100,000
	218,500	11,500	230,000
Total Construction Cost	1,989,500	1,647,500	3,637,000
Consultant Services	555,000	330,000	885,000
Physical Contingencies	282,000	215,000	497,000
Price Contingencies	1,193,500	335,500	1,529,000
IDC	150,000		150,000
Total Project Cost	4,170,000	2,528,000	6,698,000

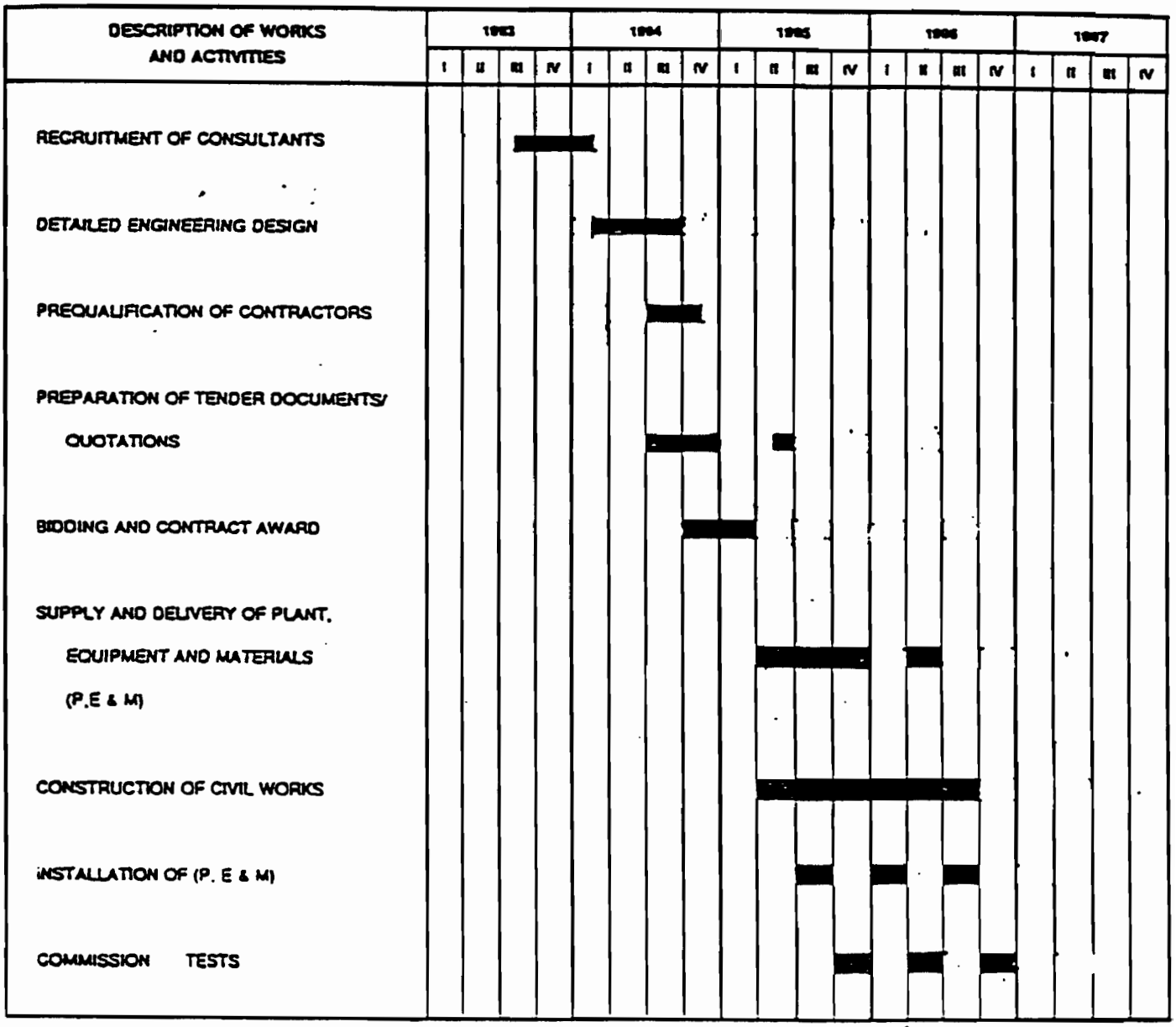
Annex 4

TENTATIVE FINANCING PLAN
($ million)

Contract	Cost Estimates FX	LC	Total	Bank FX	LC	Total	Government FX	LC	Total
Civil Works	0.37	1.98	2.35	0.37	0.97	1.34	-	1.01	1.01
Plant, Equipment and Materials	2.92	0.11	3.03	2.92	-	2.92	-	0.11	0.11
Consultant Services	0.73	0.44	1.17	0.73	0.22	0.95	-	0.22	0.22
IDC	0.15	-	0.15	0.15	-	0.15	-	-	-
	4.17	2.53	6.70	4.17	1.19	5.36	-	1.34	1.34

Annex 5

THE MAJURO WATER SUPPLY PROJECT
Tentative Implementation Schedule



Annex 6

LIST OF CONTRACT PACKAGES

Procurement of Plant, Equipment and Materials

1. Pump, motors and control packages

   For the freshwater system

   For the seawater system

   For the sewerage system

2. Filters

3. Comminutors

4. Civil Works and Installation

   Main contract inclusive of pipes, valves and fittings

   Force-account works by MWSC

OUTLINE TERMS OF REFERENCE FOR TWO INDIVIDUAL CONSULTANTS

I. Background

1. The Government of the Republic of Marshall Islands has obtained a loan from the Asian Development Bank to implement the Majuro Water Supply Project. The objectives and the scope of the Project are given in the attached sheet. The Ministry of Public Works (MPW) will be the Project Executing Agency and a Project Management Office (PMO) will be set up by MPW to carry out day-to-day Project management. The Project will be implemented with the assistance of a foreign consulting firm to be engaged in accordance with the Bank's Guidelines on the Use of Consultants. This Project Consultant will carry out detailed engineering design, provide procurement and contract administration assistance, and construction supervision, including reporting on the progress of the Project, cost monitoring, assistance in making withdrawal applications, and maintaining of the Project accounts. The Project is to be implemented over a three-year period. The two individual consultants will provide all assistance to MPW and PMO in supervising, reviewing and approval of the works carried out by the Project Consultant. One of the consultants will be engaged for the detailed engineering design and procurement stage and the other for the contract award and construction supervision stage. However, the same consultant be retained for both assignments if a suitably qualified and experienced consultant can be selected for both the assignments. The consultants will be working on an as-needed basis.

II. Terms of Reference

2. The consultants will carry out their respective assignments in line with the objectives, taking into account the MPW's and PMO's needs for external assistance and their responsibilities in Project implementation as specified in the Loan Agreement. The consultants will carry out but not limited to the following major tasks:

A. The Design Consultant

(i) review and comment on the detailed engineering design, scope, cost estimates, and implementation arrangements, including tender packaging;

(ii) review the draft pre-qualification and tender documents including the contract estimates, conditions of contract, technical specifications, bill of quantities and contract periods; and

(iii) review the evaluation report on pre-qualification of civil works contractors.

B. The Construction Supervision Consultant

(i) review the tender evaluation reports and report on post-qualifications of civil works contractors;

(ii) review the recommendations for contract award; and

(iii) determine the adequacy of the site supervision, reporting requirements, administration and management of progress payment, and recording; and advise on the quality of materials received and workmanship of construction carried out by the contractors.

Annex 8

INPUT OF TWO INDIVIDUAL CONSULTANTS
SCOPE OF WORK AND COST ESTIMATES

Preparation Phase

- Review of the Project planning and design, procurement, implementation arrangements and the format for progress reports
- One field trip of 2 weeks and 2 weeks home office

Design Phase

- Review of the prequalification and major bill of quantities, tender documents, cost revision and the updated implementation schedule
- Two field trips each of 1 week and 4 weeks home office

Tender Phase

- Review all the major tender evaluation reports and recommend major contract awards
- Two field trips of two weeks and 2 weeks home office

Construction Phase

- Review the adequacy of site staff, construction supervision, reporting and record keeping, and workmanship/quality control
- Three field trips of 1 week and 4 weeks home office

Cost Estimates

Consultant Services	-	22 manweeks @$3,850	$ 84,700
International Travel	-	8 trips @$5,000	40,000
Per diem	-	10 weeks @$1,000	10,000
			$134,700
			say $135,000

OUTLINE TERMS OF REFERENCE FOR THE PROJECT CONSULTANT FOR DETAILED ENGINEERING, DESIGN AND CONSTRUCTION SUPERVISION

I. Background

1. The Government of the Republic of Marshall Island (RMI) has obtained a loan from the Asian Development Bank for the Majuro Water Supply Project. The Project is to be implemented over a three-year period. The procurement will be carried out in accordance with the Bank's Guidelines for Procurement and the Loan Agreement entered into between the RMI and the Bank. The Project objectives, scope, cost estimates and the tentative implementation schedules are attached. The Project Executing Agency is the Ministry of Public Works (MPW). A Project Management Office (PMO) will be set up by MPW to manage the Project. Two individual consultants will be engaged by MPW to assist them in supervising the Project implementation and the works of the Project Consultant and to advise them in the engineering aspects, procurement and contract awards which need their approval or concurrence.

II. Scope of Work

2. The Project Consultant will carry out detailed engineering design, provide construction supervision services and procurement and contract administration assistance, including testing and commissioning, reporting on the progress of the Project, cost monitoring, assistance in making withdrawal applications and maintaining of the Project accounts and provision of as-built plans. The Consultant may undertake the design either in the field or in home office after making field visits to Majuro. The Consultant is to appoint a Resident Engineer/Construction Manager in Majuro for the duration of the construction, but he would have to be supported by the engineering specialists who will visit Majuro when their services are needed. The Project Director of the consultant team will also be required to make regular field visits.

III. Design Considerations

3. The Consultant is to review the Project requirements in the light of any changed circumstances but the Project as formulated should not normally be varied. The water demand projections should be reviewed and capacities refined as part of the detailed design procedures. There shall be close consultation with MWSC.

4. The Project facilities must be properly integrated with the existing facilities and the O&M practices. Rehabilitation works should be designed with careful selection of durable materials and for ease of operations and maintenance. Minimum disruption to normal operations should be observed during construction.

5. The design of the new freshwater transmission main and the cross connections to the old mains should ensure that a suitable route is selected on

the road reserve so as not to cause damage to other utilities and to the existing transmission mains (asbestos cement). Zone metering and manually operated control valves should be provided for the cross connections.

6. The design of the Laura filter shall be decided after an evaluation has been made of all the feasible alternatives, including conventional rapid sand and slow sand filters and microfilters.

IV. Terms of Reference

7. The Project Consultant will carry out but not limited to the following major tasks:

(i) Review and update the existing data base for the Project design.

(ii) Carry out field and site investigations and topographical survey as needed.

(iii) Determine the cost-effective solutions for the freshwater transmission systems and filteration plants.

(iv) Prepare detailed engineering designs, bill of quantities and tender documents.

(v) Review and update cost estimates on a contract-by-contract basis and the related financing arrangements.

(vi) Advise on contract packaging, tenders, the related invitation for tenders, and prequalification of civil works contractors.

(vii) Prepare a design report on the above.

(viii) Evaluate the tenders or quotations received, seek clarifications from tenderers, prepare the tender evaluation and prequalification reports, conduct post-qualifications as needed and recommend contract awards.

(ix) Review, monitor and update the implementation schedules.

(x) Prepare progress reports.

(xi) Advice MPW and PMO on contract awards, progress payments and variation orders.

(xii) Conduct any price and technical negotiations with the contractors as requested by MPW and PMO.

(xiii) Provide assistance to PMO and MPW in making loan withdrawal applications, liquidation of the imprest accounts and submission of various reports to the Bank.

(xiv) Supervise all the construction and installation works carried out by the contractors.

(xv) Administer the contracts and monitor the performance of the contractors.

(xvi) Approve the shop and construction drawings submitted by the contractors.

(xvii) Oversee the mobilization of the contractors and shipment of goods from overseas by the suppliers, and take delivery of plant, equipment and materials.

(xviii) Ensure compliance with the conditions of contract and technical specifications.

(xix) Verify the works completed and the goods delivered to the site, and inspect plant, equipment and materials delivered to the sites.

(xx) Resolve disputes between MPW/PMO/MWSC and the contractors or suppliers.

(xxi) Acceptance of all the completed works.

(xxii) Monitor the progress of construction, check monthly claims and works completed, and advice on progress payments.

(xxiii) Advise on the extension of time and changes proposed by the contractors.

(xxiv) Witness the commissioning and other tests.

(xxv) Prepare O&M manual in consultation with the suppliers.

(xxvi) Check on the final quantities.

(xxvii) Advise on release of retention moneys and the making of final payments.

(xxviii) Prepare as-built drawings other than those submitted by the suppliers.

(xxix) Assist in start-up and training of the plant operating staff.

(xxx) Prepare the Project Completion Report as requested by MPW and PMO.

(xxxi) Assist MPW and PMO during the visits of the Bank's Project Administration Missions and answer their queries.

Annex 10

ESTIMATED COST OF CONSULTANT SERVICES
($'000)

		Foreign Cost	Local Cost	Total
A.	Financed by the Bank			
1.	Remuneration and per diem	440	180	~~530~~ 620
2.	International travel	65	-	65
3.	Communications and reports	30	-	30
4.	Equipment and Misc. supplies	20	-	20
	Subtotal A	555	180	735
B.	Financed by the Government			
1.	Remuneration and per diem	-	75	75
2.	Office Accommodation	-	30	30
3.	Communications and reports	-	10	10
4.	Office supplies and utilities	-	15	15
5.	Local transport	-	20	20
	Subtotal A	-	150	150
	Total (A + B)	555	330	885

Annex 11

THE PROPOSED LIST OF PERSONNEL FOR MWSC

	Prof. Staff	Subprof. Staff	Skilled Workers	Unskilled Workers
A. Head Office				
PSC Salary Scale ($'000/year)	40-33	30-10	9-5	3
Chief Engr/Mgr.	1			
Waterworks Superintendent		1		
Sewerage Superintendent		1		
Admin. & Finance Mgr.	1			
Accountant		1		
Internal Auditor		1		
Tech. Assistant			1	
Surveyor			1	
Draughtsman			1	
Tracer				1
Clerk			1	1
Wage Clerk			1	
Audit Clerk			1	
Cost/Billing Clerk			1	
Stock Clerk				1
Pay Cashier		1		
Secretary			1	1
Telephone Operator/ Office boy				1
Survey labourer				2
Subtotal A	2	5	8	7
B. Other locations				
Laura		1	4	4
Airport catchment		1	6	12
Distribution				
- Freshwater		1	4	4
- Seawater		1	4	4
Sewer & P/S		1	4	2
Workshop/Store		2	2	2
Revenue Collection		1	2	~~28~~
Subtotal B	0	8	26	28
Total (A & B)	2	13	34	35
Op. Department		2	29	31

ADVISORY TECHNICAL ASSISTANCE FOR PROJECT IMPLEMENTATION

Outline Terms of Reference

I. Objective

1. The main objectives of the advisory technical assistance are: (i) to improve the MWSC's financial planning and management; (ii) to recommend a strategy for improving the cost recovery and improve MWSC's financial position; (iii) to improve the reliability and availability of freshwater supply in Majuro in time of drought; and (iv) to optimize the operations of the seawater supply system.

II. Scope

2. The individual consultants will reviews MWSC's operations and records covering both the freshwater, seawater and sewerage systems as well as technical, organizational, financial and commercial aspects of the operations to extent relevance for their studies.

III. Terms of Reference

3. Specifically, the consultants will be required to carry out the following:

A. Institutional and Legal Aspects

(i) Examine the adequacy of the existing legal and institutional frameworks relevant to MWSC's operations including (a) the establishment and incorporation of MWSC, (b) the aspects pertaining to the transfer of the existing operating assets to MWSC, and (c) those aspects that impinge upon the MWSC's operating efficiency;

(ii) Examine the need to introduce water and sewerage legislation to govern MWSC's operations; and

(iii) Review the records or minutes of the MWSC's Board of Directors and study its decision-making process, recommending the improvements needed in such areas as (a) the composition of the Board, (b) that for making tariff changes on a timely basis, (c) that for making major investment decision, and (d) that for scrutizining the operating efficiency and for controlling O&M costs.

B. Organization and Staffing

(i) Review MWSC's organization and staffing plan; and

(ii) Recommend modifications needed over the next five years.

C. Financial Planning and Management

(i) Revalue the operating assets of MWSC;

(ii) Carry out tariff studies and recommend a revised tariff structures, taking into account the practices of MEC and socio-economic aspects such as affordability;

(iii) Review and update the financial projections for the next five years;

(iv) Introduce a computer-based stock-keeping system and to provide training; and

(v) Study the adequacy of the existing accounting systems and recommend important changes for improving the systems and its use.

D. Operation and Maintenance

(i) Establish the operating rules for all the freshwater pumping and availability of supply particularly during the critical periods;

(ii) Study the excessive pumping operations of the seawater operation, determine the causes of wastage, and recommend remedial measures; and

(iii) Recommend the optimization of the operation of the seawater supply system, including major modifications of the system.