FINAL EVALUATION

OPERATIONAL PROGRAM GRANT USAID 879-0251-G-SS-1005-00

Project 879-0251

HA'APAI WATER SUPPLY PROJECT

KINGDOM OF TONGA

JUNE 30, 1981 - MAY 31, 1985

BY

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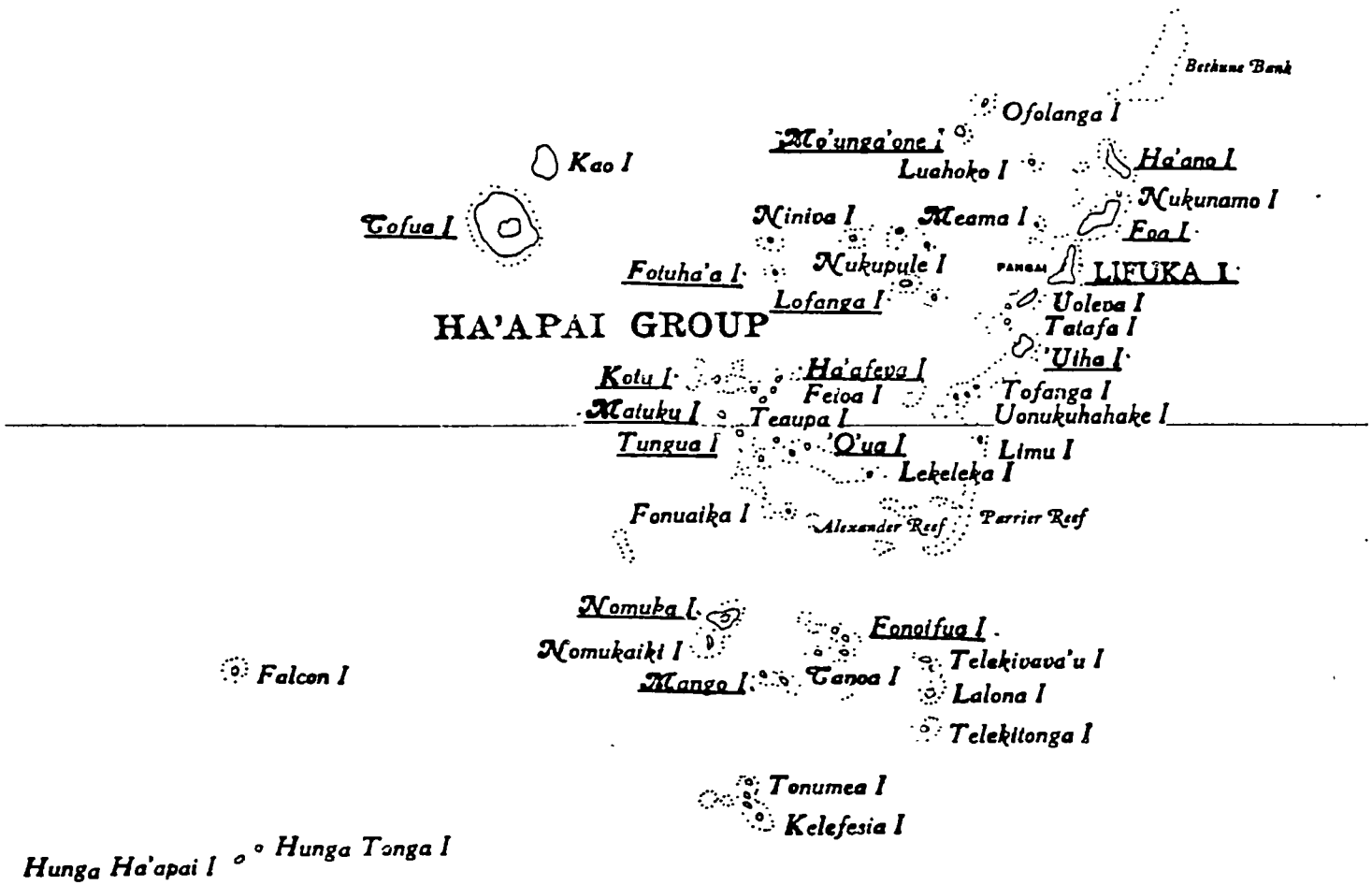
THE HA'APAI ISLANDS



NOTE:- The islands underlined (e.g. Tofua I) denote the inhabited islands of Ha'apai.

I. Introduction

On June 30, 1981, the United States Agency for International Development (USAID) signed a grant for the Foundation for the Peoples of the South Pacific (FSP) to provide partial support for a one year rural water supply development project in Tonga to improve the general well being of the Ha'apai people through the provision of safe and adequate water supply. The original aims of this project were:

a. To develop rural water supply schemes by building rain water catchments and well pumping schemes;

b. To improve existing water supply facilities where needed so as to supplement the new water supply schemes, and

c. To improve the health and sanitation of the Ha'apai people by providing a. and b..

The initial grant period was June 30, 1981 through December 31, 1982. This was amended on December 15, 1982 so as to extend this project through February 28, 1983 with no additional funds.

On February 27, 1983, this project was extended for an additional two year period (March 1, 1983 through March 1, 1985) with a specific goal of providing 520 water tanks of 1,000 gallon capacity each for individual living homes in the Ha'apai Islands.

On January 30, 1985, a final grant modification extended the term of the grant to May 31, 1985 with no additional funds. The total amount of funding provided by USAID under this three year grant was US$317,724.00.

FSP has conducted annual evaluations of this program (September 1982 and January 1984). The present evaluation was carried out from April 16 - 24, 1985 by David C. Wyler, the FSP Tonga Country Director.

FSP invited the Tonga Government to participate in the evaluation and they nominated Ms. Rosemary Dillon, the Regional Development Advisor for the Central Planning Department (for Ha'apai, Vava'u and the Niuas), Mr. Maka Vaipuna, Building Maintenance Supervisor for the Ministry of Works, and Mr. Sateki Telefoni, Public Health Officer of the Ministry of Health. The FSP accountant/bookkeeper, Mr. Maunaloa Taufahema, also joined this 5-member evaluation team.

FSP wishes to express its gratitude to the various Government departments for their willingness to participate in this strenuous exercise. In an eight day period the evaluation team visited 21 villages on 15 islands. The Tonga Defense Services' patrol boat, 'Ngahau Siliva', was used to transport the evaluation team from Nuku'alofa to the Ha'apai Islands and return.

The insights of these experienced government officials were invaluable, their stamina was superb and the experience was a learning one for all of the participants. The evaluation was also an excellent opportunity to keep the government informed of the FSP program as well as the actual current living conditions of the many remote Ha'apai islands.

The evaluation reports of the three government officials are included in Appendices II, III and IV.

II. Administration

The FSP/USAID assisted Ha'apai Water Supply Project was administered by the FSP Tonga Field Office in Nuku'alofa. This office was formerly located in Room 218 of the Tungi Arcade, but since July 1984 this office has been moved to the top floor of the new Taumoepeau Building in central Nuku'alofa.

The FSP Country Director in Tonga, David Wyler, is an American who has lived in Tonga for nearly ten years - six of these has been with FSP. He had also lived previously for two years in Ha'apai. This gives him exceptional qualifications.

He is in turn assisted by an excellent local staff consisting of an Assistant Country Director, Seini Vakasiuola, an Accountant/Bookkeeper, Maunaloa Taufahema and a Clerk/Typist, Tukasi Pale.

The quantity and quality of work carried out by this staff are excellent. Narrative reports are well done and up to date. Project accounts are well kept. A complete record of all expenditures and remaining project funds is available at any time.

III. Project Background

In 1979, the Peace Corps and the Government of Tonga, with support from USAID's Accelerated Impact Program (AIP), began a program to improve water supplies in the Ha'apai Island group of Tonga. The program met serious administrative difficulties and FSP, at the request of the Tonga Government and USAID, agreed to take it over. On June 30, 1981, FSP negotiated a one year Operational Program Grant (OPG) from USAID for the project with the approval of the Tonga Government.

From the beginning this program has been a collaborative effort between the Tonga Government (Ministries of Health and Works), the Peace Corps and FSP. A Peace Corps Volunteer was recruited and placed in Pangai, Ha'apai, under the Ministry of Works to manage the project. He hired a crew of 4 MOW daily laborers to implement the project.

Because the Ha'apai Islands are very small and have very limited fresh ground water supplies, they must rely almost entirely on rain water for their supply of freshwater. The initial goals of this project were to construct one well-water pumping system in the village of Fangale'ounga (Foa Island), and for the remaining villages 5,000 gallon capacity ferro-cement water tanks were to be constructed as well as adjacent roof catchment areas in order to fill them.

This plan, however, was totally revised in 1982 when Cyclone Isaac devastated Tonga, and particularly the Ha'apai Islands where nearly 90% of the buildings were damaged or totally destroyed. Up until this time, only the pumping system in Fangale'ounga had been started to be implemented.

As a direct result of this cyclone, FSP and the Tonga Government proposed a two-year extension of this grant in March 1983 which called for the construction of 520 1,000 gallon capacity water tanks which would be placed on private individual living houses. This project would coincide with the Tonga Government's hurricane housing reconstruction program which would construct approximately 700 new living houses in the Ha'apai Islands.

Because a serious drought immediately followed the cyclone for approximately 8 - 9 months, it was decided to construct metal tanks (Lysaught's zincalume type) because they could be built much quicker than the traditional ferro-cement tanks.

When FSP and the Tonga Government (Central Planning Department) conducted an annual evaluation in January 1, 1984, they found an unusually large number of these metal tanks leaking and that there was little community participation in the implementation of this project. As a result, they recommended that ferro-cement water tanks be built and that the villagers should become actively involved in this activity. In April 1984, the Niuola Women in Development Association of Fua'amotu Village (Tongatapu), a non-government women's development organization, began training Ha'apai villagers in the construction of 2,250 gallon capacity ferro-cement water tanks as the major element of this project.

In 1983 and 1984, the Peace Corps Manager and his M.O.W. crew tried out the construction of WHO designed 1,000 gallon capacity modular (square) ferro-cement tanks, but these proved to be too expensive and inappropriate for use in the Ha'apai Islands and so this activity was terminated immediately.

IV. Goals

The specific goal of this project is to increase the fresh water tank storage capacity in the Ha'apai Islands by 520,000 gallons by constructing 520 water tanks of 1,000 gallon capacity each.

In actual fact, 786 water tanks have been constructed with a total water holding capacity of 1, 421, 250 gallons by this project. The evaluation team surveyed 776 of these tanks. It is obvious that this project has overwhelmingly exceeded these goals.

The location of these tanks can be found in Appendix I.

V. Baseline Data

The following data summarize what has been accomplished to date by this project (1981-1985):

- Number of Villages Assisted 22
- Estimated Population Served' 5,600
- Number of Roof Catchment Areas Constructed 10(585m²)

- Number of Zincalume Tanks Constructed	297
- Number of Niuola Ferro-Cement Tanks Constructed	473
- Number of W.H.O. Ferro-Cement Tanks Constructed	5
- Number of 5,000 Gallon Ferro-Cement Tanks Constructed	11
- Number of Village Well-Pumping Systems Constructed	1
- Total Capacity of Tanks Constructed	1,421,250
- Additional Water Storage Capacity Rehabilitated[2]	462,000 gallons
- Additional Roof Catchment Structures Rehabilitated[2]	21 (420m²)

1. Based on the Tonga Government's 1984 Mini-Census of population

2. Denotes repair work completed to structures which were damaged by Cyclone Isaac in March 1982. All other statistics are not related to cyclone rehabilitation work, but to the project itself.

V. Evaluation

The 5-member survey (evaluation) team visited the Ha'apai Islands during the time period April 16 - 24, 1985 (see Appendix V). The town officers of each village / island met and greatly assisted the survey team in its effort by taking us to each tank on each of their respective villages. This was arranged previously by the MOH with messages announced over the local radio station. It should also be noted that sufficient rain had been received by all of the islands visited in February, March and April so that if the tanks had had no leaks, they most likely would have been found full or close to full. 776 of the total 786 tanks constructed by this project were visited. Hence, this was a very thorough survey of the work completed by this project. The findings of this survey can be found in Appendix I, and will be the basis of the following discussions. In almost every case, the tank owners were consulted by the survey team on the performance and condition of their tanks and guttering which proved very beneficial to the team.

It should also be noted here that a sixth person joined the survey for two days. Mr. Lloyd Belz, a W.H.O. Sanitary Engineer, joined the team on April 20th and 21st specifically to look at the Niuola ferro-cement tanks as well as the zincalume tanks from an engineering point of view. He inspected about 120 of the Niuola tanks in 'Uiha and Felemea villages and a few zincalume tanks in Pangai. His report and recommendations can be found in Appendix VI. His contribution to the survey was believed, by all of the survey team members, to be very helpful and most appreciated.

Zincalume Tanks - Of the 297 zincalume tanks constructed, 289 were surveyed. Only 8 tanks on the very remote island of Tofua were not seen. This was due primarily to the lack of time available with the patrol boat used for the survey and its concurrent excessive cost that would have been incurred.

These tanks were constructed by a 5-man M.O.W. work crew under the supervision of two Peace Corps Volunteers and one British VSO volunteer during the time period June 1983 through February 1985. 237, or 80%, of these tanks were found to be leaking. The majority of these leaks could be termed minor and were found in the middle and bottom seams. 103 tanks, or 26%, were ½ full or more, 186 tanks, or 74%, were less than ½ full of water. 22 tanks, or 9%, were completely empty. With 266 tanks, or 90%, completely guttered, it must be assumed that the workmanship was substandard.

Some factors most likely contri i
workmanship were 1) improper training of the M.O.W. work crew by the zincalume tank suppliers, Lysaught's of Nausori, Fiji, and 2) poor supervision of the M.O.W. work crew by the volunteer project managers. In June 1983, a plumber from Lysaught's Fiji came to Ha'apai to train the M.O.W. work crew. They were instructed to use 3 tubes of mastic sealant on each tank with one of these on the outside seams. The crew eventually increased the amount of sealant to 5 tubes for each tank with one of these on the inside seams. This proved to cut down tremendously on the bad leaking found in the January 1984 evaluation. The second PCV Project Manager (September 1983 - February 1984) rarely accompanied his work crew to supervise the on-site construction of these tanks and so it is assumed that less care and attention was given to the tanks constructed during this time period. Hence, the present leaks could be due to improper riveting, insufficient sealant applied during construction, or a combination of the two.

It seemed that the full tanks showed more leaks than the tanks that were less than ½ full. Most of the tank owners confirmed this by stating that when the tanks reached the ½ full mark, the leaks pretty much subsided and the water level held steady.

The approximate average cost to construct one zincalume tank was T$290.00. This includes materials, labor and freight, and does not include the local villagers' contributions nor guttering.

Niuola Ferro-Cement Tanks - Of the 473 Niuola Ferro-Cement tanks constructed, 471 were surveyed. Only 2 tanks on the island of 'Uiha were unable to be seen due to the lack of time available on the day 'Uiha and Felemea villages were surveyed. These two tanks were also located far away from these two villages.

These tanks were constructed by the tank (home) owners, or villagers, themselves under the supervision of a work crew from the Niuola Women in Development Association during the time period April 1984 through March 1985. This was an impressive accomplishment in itself in that 473 tanks of 2,250 gallon capacity were constructed in less than 11 months.

Basically, Niuola (its supervisory crews varied in number from 8 to 14) would organize a village and conduct an initial training program where one or two tanks would be constructed

by the villagers. Then each home would be given the necessary materials (ie, cement, wire, forms, etc.) to construct their own tanks. The Niuola supervisory crews were actually Ha'apai people trained by Niuola staff from Tongatapu. They would then be present in each village to supervise the construction of the tanks.

382 tanks, or 81%, were found to be leaking. Again, the majority of these leaks could be termed minor and were found as vertical cracks on the lower half of the tanks and bottom leaks. The tanks that leaked badly leaked on the bottom. Many of the side leaks were found to have sealed themselves as these tanks are designed to do. 164 tanks, or 35%, were ½ full or more, 308 tanks, or 65%, were less than ½ full of water. 35 tanks, or 7%, were completely empty.

It is believed by the Evaluator that the workmanship was generally quite good in the construction of these tanks, but that the leaks are caused by a combination of lack of sufficient building materials and poor construction design. Each tank was built with 7 bags of cement with the walls constructed first, the floor next and the top, or cover, built last. One tank floor closely inspected by the W.H.O. engineer was found to be less than ½ inch in thickness and with no plastic (polythene) moisture barrier placed under it. This is believed to be the major problem with these tanks. A plastic moisture barrier must be placed under every tank to prevent the loss of moisture from the cement floor. Almost every tank is built on a sandy soil base which intensifies the loss of moisture from the cement. Also, it is believed that approximately 10 to 11 bags of cement should have been used to thicken the floors and walls and hence reduce the leaking. Two tanks were surveyed, one in Pukotala and one in Ha'ano, where 11 bags of cement were used in the construction of this tank type, and these tanks were found to be full of water to the top and with no leaks, which, the Evaluator believes, proves this point.

It was also observed that many of these tanks did not have proper covers, or lids, on them and many did not have water taps. This creates the situation where water must be dipped out from the top opening and allows for the probable and eventual contamination of the water inside. These tanks should be completely closed off so that foreign debris cannot enter as well as mosquitoes, and taps be utilized for the drawing of water. Much of this problem was found on tanks which were built next to houses with very low roofs which necessitated the construction of the tanks underground.

One final factor that did contribute to the leaking problem was that many of the tanks were built during a water (rain) shortage in Ha'apai, and, hence, the tanks did not cure properly. This caused the cement to crack and when rain eventually collected in these tanks, it leaked out immediately

The approximate average cost to construct one Niuola ferro-cement was T$160.00 which included materials, labor and freight, and does not include a substantial local village contribution nor the guttering.

W.H.O. Ferro-Cement Tanks - Only 5 tanks of this type were constructed in this project, and all of these were surveyed.

The W.H.O. designed modular (square) ferro-cement tank is a 1,000 gallon capacity tank that was constructed as an experiment by this project. Basically, these tanks are constructed by prefabricating one inch thick ferro-cement slabs that are approximately five feet long and five feet wide. These are prepared at a central site and then shipped to the tank locations and then joined together (ie, six slabs are joined to make one tank). The slabs are made on forms that have hundreds of criss-crossing high tensile steel wires attached to the forms, then the cement is poured over the steel, steel fibre is then sprinkled all over the slab, and then this mixture is vibrated (electrically) until a compact cement slab is formed. These slabs are then let to cure for about 2 weeks before being transported to the tank sites for construction. Each slab weighs approximately 80 - 100 pounds, and are very awkward to handle because of their size, weight and the hundreds of ends of the high tensile steel sticking out about 4 inches on all four sides.

This type of tank is very inappropriate for use (ie, for constructing) in Ha'apai. First, it needs sophisticated equipment - a vibrating table, imported high tensile steel and steel fibre, and specially made slab forms that can hold the high tensile steel. Second, making the slabs in Pangai was no problem but transporting these heavy awkward items to the outer islands was and remains so. Third, more than one supervisor is needed to effectively construct these tanks - one for the slab production and at least one on site to put the slabs together. Also, a minimum of two 4-man crews are needed to run both operations simultaneously. The result is a very high overhead. It is estimated that the total cost to produce one of these tanks

is in excess of T$300.00. Plus, there is little to no participation by the recipients, or tank owners, in their construction. Because of these factors, the construction of this tank type was terminated almost as fast as it began. They were built by the MOW work crew in 1983 and 1984.

All five tanks surveyed leaked on the bottom joints and a few on the sides. One tank was full and four were less than ¼ full of water. 2 were completely empty. The latter two were empty because of high use - they serve approximately 20 households in an area of Pangai that has no running water or wells.

5,000 Gallon Ferro-Cement Tanks - Only eleven tanks of this type were constructed, and these were all surveyed. This tank was the original tank type that was going to be constructed in every island / village under the original program proposal. These tanks were constructed by the MOW work crew during the time period October 1981 through May 1983, prior to the construction of the zincalume tanks. Along with these tanks were built ten (10) roof catchment areas which are used to catch rain to fill the tanks. These were also surveyed by the team and were found to be in excellent condition and fully guttered.

Five of the eleven tanks had no leaks, or 45%, while the remaining six, or 55%, were found leaking. These leaks were mostly from side cracks and one tap. Nine tanks, or 82%, were completely full, one was ½ full and one less than ¼ full. These tanks are located in villages that received either zincalume or Niuola ferro-cement tanks, and hence, was the reason for the nine full tanks. The people are using their own home tanks and not the larger community tanks. In fact, this is the situation the survey team found in every village visited - while people used their own individual home tanks, the community tanks were able to collect rain and remain full. Every village visited had at least one government community tank of at least 10,000 gallon capacity. This situation will prove extremely beneficial during drought situations which are often experienced in Ha'apai for periods of up to 5 or 6 months at times. The villages now have a reserve water supply from what used to be their primary fresh water source.

Guttering - Guttering was provided for every tank constructed in this project. The guttering was provided for by UNICEF and consisted primarily of 2 gutters, 1 downpipe, 1 rainhead gutter, 2 stopends, 1 joint, 5 brackets and 2 bends. Some houses (tanks) had a little more, and some less.

Overall, the survey team found 620 tanks, or 79%, completely guttered, 156 tanks with incomplete guttering, or 20%, and 10 tanks, or 1%, not sure. The majority of the incomplete gutterings found a shortage of either stopends, brackets, joints or bends, or a combination of these.

Another observation was that in many cases the houses did not have a sufficient surface (facia board) to hang the guttering from and so the guttering was either improperly hung or was hanging very precariously from the edge of the roof. Also, in most cases there was a shortage of brackets which connect the gutters to the houses. There is a great need to improve the existing guttering by training the tank owners in hanging the guttering properly.

Another observation made by the survey team was that most tanks were improperly covered. Many tanks had no lids at all over their small openings (usually 18" x 18") from which water is dipped from, or they had scrap pieces of iron or wood placed over them. In addition, many tanks had no protective sieve between the downpipe and tank to screen out foreign debris washed into the tank from the gutters during rainy periods. This is another area that needs to be dealt with to improve the overall quality of the water tanks in Ha'apai.

Pumping System - One pumping system was constructed by this project in the village of Fangale'ounga (Foa Island). It was built by the MOW work crew during the time period December 1981 through September 1982. A 15 foot deep well was dug by hand by villagers about ½ mile from the village. A 3½ h.p. diesel motor and pump was installed at the well site which pumps ground water to a 3,000 gallon metal tank (also provided by UNICEF) standing on a 22' concrete tank stand in the village. 10 taps were provided throughout the village with one additional tap having been put in since its original construction.

An eleven member village water committee has been established to administer and operate this system. Each family pays T$1.00 per month for use of this system (ie, its operation and maintenance). Some families are very poor and have

been delinquent with their payments, and so the village has run fund-raising events (eg, kava clubs, dances, etc.) to raise funds to assist these needy ones. There has been no mechanical problems to date with the pump or diesel motor. One 44 gallon drum of diesel fuel lasts approximately 5 to 6 months and so is very efficient. One villager is in charge of the motor and pump, and one other is in charge of collecting the monthly payments. There is an excess of T$120.00 in the committee's bank book at present! The system is working very well in this small village.

However, one minor problem that has developed since its construction is that the well is now producing water that is slightly brackish. The evaluation team was unable to establish whether the well is being overpumped or that the entire water lens under Foa Island is being depleted (2 other villages have pumping systems on Foa as well). Approximately 2,000 gallons of water is pumped (ie, used) daily by the village of 218 people with much of this being used for agricultural purposes.

VII. Summary and Recommendations

Summary - 786 water tanks and one pumping system were constructed by this project over a 3½ year time period. Approximately 5,600 people in 22 villages on 16 islands have benefitted directly from this project. Hence, the cost-benefit ratio for this project was US$56.74 per beneficiary. Even though 80% of the total tanks constructed are leaking and 20% of the guttering is incomplete, it was quite evident to the Evaluator and the survey team that the fresh water supply in the Ha'apai Island group has been tremendously improved and, as a result, the health and sanitation of the Ha'apai people has been improved as well. The villages and people in general were much more tidy and clean in 1985 than they were in 1981. This can be attributed, I believe, directly to two factors - 1) the new living houses built under the Hurricane Housing Program, and 2) the increase in availability of fresh water supplies provided by the FSP Ha'apai Water Supply Project.

Also, what started out as a basic construction project ended up as a very real village-oriented development project. In the last year of the project 473 ferro-cement water tanks were constructed by 473 families, or by the villagers themselves.

This project, however, is only one step in assisting the Ha'apai islanders in becoming more self-sufficient in the supply of fresh water as well as improving their health and sanitation. More can and needs to be done, and the following recommendations provide an avenue for the further improvement of the existing fresh water supply in Ha'apai.

Recommendations - The Evaluator, after consultations with the CPD, MOW, MOH, and the WHO engineer, would make the following recommendations:

1. That this project be extended for a minimum period of one year so as to repair the leaking zincalume and Niuola ferro-cement tanks so that they would be as near 100% water tight as possible.

2. In the process of repairing these tanks, the villagers, or tank owners, be trained in the repair of these tanks.

3. Coinciding with the repair of the tanks, an effort should be made to upgrade the current condition of the guttering connected to these tanks. This effort would, obviously, include the training of the villagers, or tank owners, in the proper methods of installing the guttering on their homes.

4. That all of the water tanks be provided with water taps and be made mosquito / foreign debris proof. Again, training the tank owners in this activity would be an integral part of this effort.

5. That the Ministry of Health make more of an effort, possibly through the use of the radio, in providing information to the owners of water tanks in the proper maintenance and use of water tanks.

Findings of the Ha'apai Water Supply Project Survey:

1. Tanks Built (Total) - 786 (TOTAL CAPACITY - 1,421,250 GALLONS)

2. Tanks Surveyed (Total) - 776 (TOTAL CAPACITY - 1,408,750 GALLONS)

   - 8 zincalume tanks on Tofua Island not seen
   - 1 Niuola tank on Tatafa island not seen ('Uiha)
   - 1 Niuola tank on 'Uiha Gov't. Primary School not seen (Felemea)

3. Date of Survey - April 16 - 24, 1985

4. Total Zincalume Tanks Surveyed - 289 (289,000 Gallons Capacity)

Mango	-	61	Matuku	-	21
Fonoifua	-	20	Fotuha'a	-	20
Nomuka	-	100	Lofanga	-	50
'O'ua	-	24	Pangai	-	4
Kotu	-	34			

5. Total Niuola Ferro-Cement Tanks Surveyed - 471 (1,059,750 GALLONS CAPACITY)

Ha'afeva	-	61	Pukotala	-	20
Tungua	-	58	Ha'ano	-	41
'Uiha	-	82	Muitoa	-	18
Mo'unga'one	-	33	Koulo	-	36
Felemea	-	61	Holopeka	-	28
Fakakakai	-	34			

6. Total W.H.O. Ferro-Cement Tanks Surveyed - 5 (5,000 Gallons Capacity)

Holopeka	-	1
Pangai	-	4

7. Total 5,000 Gallon Ferro-Cement Tanks surveyed - 11 (55,000 Gallons Capacity)

Fotuha'a	-	1	Ha'ano	-	2
Mo'unga'one	-	1	Muitoa	-	2
Fakakakai	-	2	Pangai	-	1
Pukotala	-	2			

8. Guttering -

	Complete (%)	Incomplete (%)	Not Sure (%)	Total (100%)
Zincalume	266 (90%)	23 (8%)	8 (2%)	297
Niuola	338 (72%)	133 (28%)	2 (-)	473
W.H.O.	5 (100%)	0	0	5
5,000 F.C.	11 (100%)	0	0	11
TOTALS	620 (79%)	156 (20%)	10 (1%)	786 (100%)

9. Leaking -	No (%)	Yes (%)	Not Sure (%)	Total (100%)
Zincalume	44 (15%)	237 (80%)	16 (5%)	297
Niuola	51 (11%)	382 (81%)	40 (8%)	473
W.H.O.	0	5 (100%)	0	5
5,000 F.C.	5 (45%)	6 (55%)	0	11
TOTALS	100 (13%)	630 (80%)	56 (7%)	786 (100%)

10. Water Levels -	Full-3/4(%)	3/4-½(%)	½-¼(%)	¼-Empty(%)	Completely Empty	Not Sure
Zincalume	42 (14%)	61 (12%)	86(29%)	100 (34%)	22 (9%)	8(3%)
Niuola	76 (16%)	88 (19%)	101(21%)	207 (44%)	35 (7%)	2(-)
W.H.O.	1 (20%)	0	0	4 (80%)	2 (40%)	0
5,000 F.C.	9 (82%)	0	1(9%)	1 (9%)	0	0
TOTALS	128 (16%)	149 (19%)	188(24%)	311 (40%)	59 (8%)	10(1%)

NOTES ON SURVEY FINDINGS:

1. These statistics were collected and compiled by the 5 member survey team.

2. The information provided for in items 4 through 7 gives the names of the villages and the total number of tanks built in these villages by this project.

3. Item 8 - Guttering: Complete means that each of these tanks (hence, houses) have at least 2 gutters, 1 downpipe, 1 rainhead gutter, 2 joints, 5 brackets and 2 stop ends connected to them. Incomplete means that either one or more of these items were missing or that they were not yet connected. Not sure are the 10 tanks not seen by the survey team.

4. Item 9 - Leaking: No means that these tanks had no leaks when surveyed by the 5-member team. They may or may not have been patched, however, by the tank owners. Yes means that either the tanks were seen leaking by the survey team or that the tanks were near empty after heavy rains indicating bad leakage. Not sure includes the 10 tanks not surveyed, tanks with no guttering connected to them yet, and tanks that had insufficient roof catchment areas, some water and no visible leaks.

5. Item 10 - Water Levels: The completely Empty figures are also included as part of the ¼-Empty figures. Not sure are the 10 tanks not surveyed.

APPENDIX 11

CENTRAL PLANNING DEPARTMENT

Cable: "CEPLAN" Phone: 21-366

P.O. Box 827 *Nuku'alofa* *Tonga*

Our Ref: 39/4/1 -L-385

15 May 1985

Mr D Wyler
Country Director
F. S. P.

Dear David

Please find attached a copy of my report on the review of the Ha'apai Water Supply project conducted from the 16-24 April 1985. Apologies for the delay in submission.

Yours sincerely

CENTRAL PLANNING DEPARTMENT TONGA GOVERNMENT

MPaletau

for Rosemary Dillon
for DIRECTOR OF PLANNING
RD/sl

APPENDIX II

EVALUATION R PORT: HA'APAI WATER SUPPLY PROJECT (US AID).

1 INTRODUCTION

A field survey and evaluation of the Ha'apai Water tank construction project was conducted from the 16-24 of April, 1985. This project was funded through a US AID Grant administered by the F.S.P. The specific goal of the project was to increase the fresh water tank storage capacity in the Ha'apai islands by 520,000 gallons. This was to be achieved through the construction of at least 520 water tanks of 1,000 gallon capacity by March 1, 1985. Representatives from the F.S.P., the Ministry of Health, the Ministry of Works and Central Planning Department participated in the field evaluation.

A total of 777 tanks were surveyed. This included 289 1,000 gallon zincalume tanks, 472 2,250 gallon Niuola Ferro-cement tanks, 5 W.H.O. modular ferro-cement tanks and 11 5,000 gallon ferro-cement community tanks.

The aim of the survey was to assess the effectiveness and success of the project in meeting it's goals.

All the inhabited islands of the Ha'apai group were visited in the course of the evaluation, with the exception of Tofua. Good use was made of the Tongan Defense Services vessel - the 'Silver Arrow'. By using this vessel it was possible for the evaluation team to move relatively quickly from island to island. Appendix 1 outlines the schedule followed in terms of islands visited and number/type of tanks surveyed.

2 BACKGROUND

The Ha'apai region consists of 55 widely dispersed islands, 16 of which are inhabited. The inhabited islands range in size from 0.33 km^2 to 55.63 km^2. In 1976 approximate 12% of the Kingdoms population was residing in Ha'apai.

The Ha'apai people are largely dependent upon rain water and hand dug wells for their fresh water supplies. Rainwater catchments and tanks however, have not been adequately developed to meet the water requirements of the people. Tonga is also prone to droughts. In addition some of the islands in the group are completely dependent on rain water, with their ground water being either brackish or inaccessible.

The Ha'apai water supply project was developed to meet the urgent needs of the Ha'apai people for improved water supply. Initial emphasis of the project was on the construction of 5,000 gallon ferro-cement community water tanks and catchment structures.

This was subsequently changed to the construction of tanks on private dwellings following the impact of Hurricane Isaac which devastated Ha'apai in March 1982 and a prolonged drought which followdd Isaac

It was felt that construction of smaller tanks on private households would more effectively meet the needs of the Ha'apai people and increase water storage capacity. Larger "community" tanks/catchments were felt to be more prone to lack of maintenance and cyclone damage. Construction of tanks on private households was able to make use of newly constructed hurricane house roofs not damaged by Isaac. Funds that would have been used to construct community catchment structures were able to be used to build additional tanks.

Intially zincalume crated metal tanks were constructed on private dwellings under the project. These tanks with a capacity of 1,000 gallons consist of curved segments of zincalume crated corrugated sheet metal which are rivetted to other, with a mastic seal applied in between the rivetted reams to prevent water leaking. The company manufacturing these tanks (Lysanghts), sent over a trainer to demonstrate how the tanks should be constructed. An M.O.W. work crew, working under the supervision of a Peace Corps Supervisor subsequently commenced construction of these tanks in Ha'apai. The tanks were found to leak. An inspection of the leaking tanks was made by a representative from Lysaughts and it was felt that the tanks were leaking due to insufficient mastic having been applied to the reams. Initially the M.O.W. work crew had been advised to use 3 tubes of mastic per tank. It was felt that this should be increased to five. Two hundred and twenty additional tubes of mastic seal were provided by Lysaughts and used to repair tanks in January 1984 (results of this survey appeared to indicate that the application of additional mastic still did not solve the leakage problem). It was decided to cease construction of further zincalume tanks and to use instead the W.H.O. designed square ferro-cement slab tanks.

The W.H.O. tank with a capacity of 1,000 gallons consists of number of square ferro-cement slabs/panels which are constructed and then later assemble together. Problems were also encountered with this tanks type. Due to logistical and technical reasons it was decided after the construction of three of these tanks in Ha'apai that this tank type was not appropriate. As well as construction of the W.H.O. tank being lengthy and technical, difficulties were encountered in transporting the heavy panels to outer islands for assembling.

The F.S.P. then negotiated with the Niuola Women in Developmemt Association to construct a round ferro-cement tanks with a capacity of 2,250 gallons in the remaining areas covered by the project. A major difference associated with this tank type was that construction of the tanks was undertaken by the village households themselves, with the Niuola Association providing necessary training through constructing "demonstration" tanks.

3 SURVEY RESULTS

Overall it is felt that the Ha'apai water tank contruction project has substantially improved the rain water supply storage capacity, in the Ha'apai Group.

A total of 786 tanks of varying capacities and types have been constructed (776 of which were actually inspected). The goal of constructing at least 520 tanks of 1,000 gallon capacity has therefore been well surpassed.

The major problem however, is the fact the majority of the tanks built leak or are not completely water tight. The severity of leaks was found to vary from extremely minor to serious.

TABLE 1: SURVEY RESULTS

	Niuola F.C. (2,250 gallons)	Zincalume (1,000 gallons)	W.H.O. (1,000 gallons)
No. of Tanks Surveyed	472	289	5
Tanks Leaking %	81	80	100
Guttering Complete %	72	90	100
No. of Consumers	2,668	1,741	?
Water Levels Observed * in Tanks %			
Full - ¾	16	15	20 (1 tank)
¾ - ½	19	21	0
½ - ¼	21	29	0
¼ - 0	44	35	80 (4 tanks)
	100%	100%	100%

* Last heavy rain was in April 1985 for all island except Mango and Fonoifua where it was in March 1985.

Table 1 provides comparative data obtained during the survey on the Niuola, Zincalume and W.H.O. tanks. In particular information in provided on the percentage of tanks found to be leaking, how full the tanks were at the time of the survey, and the percentage of tanks for which guttering was complete (that is functioning properly and with sufficient materials). It should be noted that if there were any visible water leaks on a tank, whether minor or major, the tank was classified

In addition, while the level of water in each tank at the time of the survey was recorded, it was recognized that the amount of water in any tank was a function of many factors including amount of rain received, size of catchment, adequacy of guttering etc. Quite a few tanks were found to lack adequate guttering and/or sufficient roof catchment to enable rain water to be effectively captured and chanelled into the tanks.

Despite the fact that approximately 80% of both the Niuola and the Zincalume tanks were found to be leaking, the Majority of both these tank types were observed to be holding between a quarter to a completely full tank of water (see Table 1) In the case of the Niuola tanks this was 56% of all tanks and 65% in the case of the Zincalume tanks. 44% (207) of the Niuola tanks were less than a quarter full and in the case of the zincalume tanks 34% (99) were less than a quarter full. The larger tank capacity of the Niuola tanks (2,250 gallons) should be noted in the context of the above.

With regard to the W.H.O. designed tanks, four of the five surveyed were found to be less than a quarter full with all of these tanks leaking mainly on their bottom joint seams.

Attempts by households to patch leaking tanks, both Niuola and zincalume, were observed. In general attempt at patching the Niuola ferro-cement tanks appeared much more successful than did attempts to patch the zincalume tanks.

In the case of the zincalume tanks the majority of leaks were on the side seams where mastic had been applied and around the bottom edge of the tanks. The mastic seal obviously is not fulfilling its' function. Some households had attempted to patch these leaks unseccessfully with cement and other objects (material, paper, rubber), all of which could not adhere properly to the tank metal.

In the case of the Niuola tanks most of the visible leaks were on the lower sides of the tank with tension cracks showing at the bottom of many. According to the W.H.O. adviser this indicates insufficient tension steel. In addition according to the W.H.O. adviser the majority of serious leaks in these tanks are probably the result of poor workmenship on the constructionof the tank bottom. It was felt that many of the badly leaking Niuola tanks probably had cradks on the bottom of the tank (there were not visible however). In many cases however, successful patching of Niuola leaking tanks with cement was observed. In addition some leaks were observed to have healed themselves.

The Niuola tanks were constructed with only 7 bags of cement each. It is felt and recommended that at least two to three bags of cement be used with any future tanks of this type.

A major concern relative to both the Niuola and Zincalume tanks was the lack of adequate screening/straining of incoming water on many tanks. In addition many of the Niuola tanks lacked taps. Water was withdrawn from a hole in the top of these tanks. This is considered less hygienic than the use of taps. Many tanks from which water was withdrawn by container, also lacked lids to seal the hole at the top when not being used. Lids are needed to seal the tank water from animals, insects, light etc.

Another problem relating to both types of tanks was the lack of adequate/proper guttering and down pipe connections on some tanks. In some cases this was a result of a lack of know how relative to the placing and connection of the ~~gutt~~ guttering. Many tanks could have held more water if greater attention had been given to guttering and providing a good water catchment area.

5,000 Gallon Community Ferro-Cement Tanks

Eleven of these tanks built in the early stage of the project were surveyed. The majority were 'three quarters to full' of water, with six out of the eleven leaking, but none badly. Guttering was complete on all of them. These tanks appear to be providing a good back up water supply to the villages in which they are located.

4 CONCLUSION AND RECOMMENDATIONS

It is felt that the Ha'apai Water tank project has made a substantial contribution towards improving water supply in Ha'apai. While problems have been encountered with the various tank types used, much has been learnt and those involved with the project attempted to respond to problems as they emerged. Unfortunately no time was available to ~~ad~~ adquately test the effectiveness of the various tank types prior to implementation, due to the severity of water problems experienced in Ha'apai. The majority of tanks appear to be able to hold at least a quarter or more of a tank full of water. There is a real need to follow up on the repair of tanks constructed if possible.

The Ha'apai water tank project should not be viewed as a discrete activity which is now complete. There is a need to follow through the project - to ensure tanks are repaired if possible and properly/hygienically maintained. Regular visits by a technical person capable of advising households on the maintencence of their tanks are needed (possibly on a yearly basis).

The education and training of local village people in Ha'apai in the construction, maintenance and repair of water tanks is built to be a crucial compenent relative to improving Ha'apai's Water supply situation.

RECOMMENDATIONS

1 That further investigation be carried out to determine the best means of repairing leaking tanks (zincalume, Hiuola and W.H.O.).

2 That such repairs be carried out if possible and/or appropriate advice be given to local people to enable them to complete repairs themselves.

3 That emphasis be given to the education and training of local village people in such areas constructing, maintaining and repairing water tanks and conserving water use.

4 That this project continues to be maintained and the possibility of a technician capable of visiting Ha'apai on a yearly basis to provide technical guidance to local people on their water tanks, be considered.

5 That long term research be carried out possibly through much institution as the USP Appropriate Technology Section to be further investigate the most appropriate types of water tanks for Tonga.

APPENDIX II

APPENDIX 1: ISLANDS VISITED AND TANKS SURVEYED

16 APRIL 1985

- Mango Island (16 zincalume Tanks)
- Fonoifua Island (20 Zincalume Tanks)
- Nomuka Island (30 Zincalume Tanks)

17 APRIL

- Nomuka Island (70 Zincalume Tanks)
- 'O'ua Island (24 Zincalume Tanks)
- Ha'afeva Island (25 Niuola Ferro-Cement Tanks)

18 APRIL

Ha'afeva Island (18 Niuola Ferro-Cement Tanks)
- Tungua Island (38 Niuola Ferro-Cement Tanks)
- Kotu Island (34 Zincalume Tanks)
- Matuku Island (21 Zincalume Tanks)

19 APRIL

- Fotuha'a Island (20 Zincalume Tanks)
- Lofanga Island (50 Zincalume Tanks)
- 'Ofu'anga'one Island (33 Niuola Ferro-cement Tanks)

20 APRIL

- 'Uiha Village, 'Uiha Island (82 Niuola Ferro-Cement Tanks)
- Felemea Villiage, 'Uiha Island (61 Niuola Ferro-Cement Tanks)

22 APRIL

- Fakakakai Village, Ha'ano Island34Niuola Ferro-cement TAnks)
- Tukotala Village, Ha'ano Island (20 Niuola Ferro-cement Tank)
- Ha'ano Village, Ha'ano Island (41 Niuola Ferro-cement Tanks)
- Muitoa Village, Ha'ano Island(18 Niuola Ferro-cement Tanks)

23 APRIL

- Koulo Village, Lifuka Island (36 Niuola Ferro-cement Tanks)
- Holopeka Village, Lifuka Island(28 Niuola Ferro-cement Tanks)
- Pangai Village, Lifuka Island (5 W.H.O. Modular Tanks and

MINISTRY OF WORKS

Cable: MINWORKS
NUKU'ALOFA

P.O. Box 57
Nuku'alofa,
TONGA.

APPENDIX III

REF. SW/23/724/85.

9 May 1985

Director of F.S.P.
NUKU'ALOFA

Dear Sir

RE: FINAL EVALUATION OF HA'APAI WATER SUPPLY PROJECT :

Please find attached report on the assessment we made from 16th - 24th April 1985.

This is also copied to all participants of the trip and also Director of Works, Acting Assistant Secretary MOW, Lloyd Belz and Temaleti Vakasiuola.

Sorry for late submission.

Yours faithfully

N Vaipulia
for Director of Works

NV:LT

Attch.

cc: Director of Works
Acting Assistant Secretary MOW
Sitaleki Telefoni MOH
Maunaloa F.S.P.
Rosemary Dillon CPD
Lloyd Belz - WPRO
Temaleti Vakasiuola - NWDA

APPENDIX III

REPORT ON FINAL EVALUATION OF HA'APAI WATER SUPPLY PROJECT

(16th - 24th April 1985)

Introduction :

Water is no doubt one of the very important basic necessities of human beings and as a must for everyday use per every individual per home. Most of the times we are not aware how important water is, until it runs short and worst of all when there is no water.

I must thank F.S.P. not only their tremendous assistance to all the people of Ha'apai island group for providing water storage tanks but also making this survey trip around the islands possible so that all of us participating in the assessment survey realised the effectiveness and success of the project despite some technical faults of workmanship.

Zincalume Corrugated Water Tanks :

Most of the zincalume water tanks were constructed in a hurry so that the consumers could store some water because during that period water was scarce. This project was under the direction of a Fijian personnel. He taught the MOW group of men how to construct the corrugated water tanks. These tanks were not made of water tight by way of soldering because solder won't adhere to zincalume. So they used flexible adhesive sealant applied to all joints except the top. From my observation they must have used 3 different sealants. None of these really stuck on the joints due to smooth condition of the tank. You could peel off residue on joints and it seemed that the bonding was not 100%.

Recommendation :

(a) All leaking joints should be dry and clean and a more suitable adhesive sealant should be used to patch up the joint.

(b) It seemed oily on some surfaces, care should be taken when making new tanks to make sure to remove oily film from edges to be joined.

(c) Any new adhesive should be experimented and approved before using.

.../2-

Ferrocrete Cement Water Tanks :

Most of these tanks are leaking, mainly at the bottom and bottom joint where it meets the cylindrical wall. The Niuola taught and demonstrated to the people of every island villages of Ha'apai Group of how to construct the tanks. From there onwards the people made the tanks under supervision of the Niuola.

The way I see it, they constructed the wall then the bottom and the top. It's OK but I guess care was not taken when treading on reinforced wire and also rendering the wall made the bottom wire dirty and moved. Also there was one evidence, the bottom has no damp proof membrane. This of course is very important especially at Ha'apai group where ground is sandy and porous which absorbs moisture and wet cement leaving sand only for the bottom while pouring mix to make bottom floor.

These tanks were made of 7 bags of cement. Now you can visualise what happened in the construction of each tank whatever cement left to do the bottom was so limited. It is a pity that the bottom should be stronger and water proofed to withstand the pressure which is exerted on it, but did not comply.

Recommendation :

(a) It is very expensive to correct the tanks but a cheaper way to tackle this is by patching up cracks on wall with ordinary mortar.

(b) The bottom floor should be dry and clean. An assortments of water proofing agents or products which applied to existing floor before a new mix can be poured,

(c) If the wall needs to be thickened, I suggest that the existing wall should be coated with water proofing chemical on inside wall before applying additional rendering.

(d) 4 strands of barbed wire should be added to within 400 mm off the bottom horizontally to withstand tension cracks caused by pressure when tank is full. This only applies to new tank construction.

D. WYLER F.S.P.

APPENDIX IV

HI L. Sateki Telefoni

Director of Health through SMO i/c (PH) & SHI

1 May 85

Re: Final Evaluation of Rain Water Schemes at Ha'apai Group build by F.S.P. under U.S. Programme

I would like to forward the report of the above evaluation which was carried out by the team consist of F.S.P staffs, representative from Central Planning, Ministry of Works and myself from the Ministry of Health, the purpose of this survey to aware of the present situation of this particular project, which has been done on 16th to 24th April 1985.

Method of Survey

The survey Form designed and agreed by the team member before they left for Ha'apai.

The informations and datas that related to this survey, were collected similarly by the team members from every single tank, householder's approached were very interested to the team to make good efforts on reporting.

Recommendations was approved by the team to individually process and submit to their own director for his approval and further consideration and take necessary action.

Sir, finally, details and recommendations of this evaluation attached.

Yours faithfully,

Latu S. Telefoni
Health Inspector.

LST/sa

My survey was based on these following categories.

1. Type of tank and its nature state
2. Water capacity during observation
3. Guttering materials
4. Leaking tank
5. Consumer's information

1. Type of Tank

a. Aluminium sheets were connected with patching chemical component, and when its full capacity (1000 gals) the water pressure become stronger and extend the tank's size and give rise to pop out with a small tiny holes on both wall and bottom of the tank.

b. Ferro-cement tank (2250 gals) made of sand mixed with 7 bags of cement for every single tank, and walled with wiremesh and the thickness of the tank was about 5/8 inch.

2. Water Capacity; Full capacity to half full capacity, I recommended this stage as a minor leaks and provide minor repair, and from half full capacity down to completely empty, I therefore recommended this stage as a major leaks and to provide major repairs.

3. Guttering Materials: I was divided into two items as (a) complete and (b) incomplete guttering.

a. Complete guttering: was defined equally for full supply of gutters' materials!

b. Incomplete guttering: was defined as a gutter with no down pipe, no stop ends, no brackets plus not enough supplies.

4. Leaking Tank: was divided into three categories

a) No leak: Tank with totally free of any leakage during this observation survey

b) Leaking: An evidence of leaks shown on a small tiny leaks on sides and bottom of the tank

c) Not sure: No evidence of leaks can be seen during the survey took place but householder's information stated that after a heavy rain, the water capacity drop down very fast, must be badly leak somewhere at the bottom of the tank.

Recommendations

a. To provide a draft estimate by P.O.W. for a extra expenses for repairing and to complete the guttering supply for every single tank which they were needed a minor and major repair, again to allocate a source of fund for the above repairing.

b. To provide a overflows system for every single Limeslume tank and use Aeration Basing and also obtaining of fitting tight lid and provide screening wire on both outlet and inlet pipe.

c. To encourage and educate the public on using wisely of rain water, particularly to the islands' people, to avoid of any water shortage.

d. I strongly belief that if those leaking tank and incomplete guttering will not repair, these can produce a public health problems in future.

APPENDIX IV

Name of village and Islands	WATER IN TANK					GUTTERING		TOTAL TANK		LEAKING TANK			
	Full-3/4	3/4-1/2	1/2-1/4	1/4-empty	Comp. empty	Complete	Incomplete	Zincalume	Ferro-cement	No	Yes	Not sure	No. of consumer
1. Nango	Nil	1	7	8	nil	14	2	16	-	4	11	1	117
2. Fonoifua	1	6	4	9	1	17	3	20	-	14	5	1	113
3. Nomuka	7	21	32	30	10	91	9	100	-	20	76	4	569
4. 'O'ua	9	5	6	2	2	21	3	24	-	15	8	1	165
5. Ha'afeva	16	11	19	12	3	46	15	-	61	8	50	3	428
6. Tungua	10	13	12	20	3	53	5	-	58	7	50	1	363
7. Kotu	4	4	11	11	4	31	3	34	-	1	33	-	128
8. Matuku	4	3	7	7	nil	21	nil	21	-	1	20	-	132
9. Fotuha'a	1	4	6	7	2	17	3	20	-	6	14	-	190
10. Lofanga	17	17	10	6	nil	49	1	50	-	2	48	-	355
11. Ho'unga'one	5	7	5	15	1	24	9	-	33	-	33	-	208
12. Uiha	8	11	18	25	10	53	29	-	82	9	62	11	459
13. Felemea	10	10	17	22	2	58	3	-	61	7	48	6	261
14. Pakaikai	4	7	4	14	5	17	17	-	34	4	29	1	139
15. Pukotala	7	3	3	4	3	6	144	-	20	3	13	4	124
16. Ha'ano	5	6	10	16	4	29	12	-	41	7	28	6	190
17. Nuitoa	4	4	3	5	2	10	8	-	18	-	16	2	102
18. Houlo	1	2	9	17	1	25	11	-	36	3	30	3	211
19. Holopeka	4	4	12	7	1	13	10	-	23	4	23	1	144
Total	117	145	195	247	54	600	157	185	472	115	597	45	4437

NOTE: Total Zincalume tank 279 which contain 189000 gallons in capacity.
Total Ferro-cement tank 472 which contain 1062000 gallons in capacity.

APPENDIX V

HA'APAI WATER PROJECT

FINAL EVALUATION ITINERARY

Tuesday, April 16th -	Depart Nuku'alofa, Complete Mango, Fonoifua and part of Nomuka Islands. Overnight Nomuka.
Wednesday, April 17th -	Complete Nomuka, 'O'ua and part of Ha'afeva Islands. Overnight Ha'afeva.
Thursday, April 18th -	Complete Ha'afeva, Tungua, Kotu and Matuku Islands. Overnight Ha'afeva.
Friday, April 19th -	Complete Fotuha'a, Lofanga and Mo'unga'one Islands. Overnight Pangai.
Saturday, April 20th -	Complete 'Uiha and Felemea Villages. Overnight Pangai.
Sunday, April 21st -	Free Day. Collate Statistics to Date.
Monday, April 22nd -	Complete Fakakakai, Pukotala, Ha'ano and Muitoa Villages. Overnight Pangai.
Tuesday, April 23rd -	Complete Fangale'ounga, Koulo, Holopeka and Pangai Villages. Finalize Collating of Statistics. Overnight Pangai.
Wednesday, April 24th -	Depart Pangai, Return to Nuku'alofa.

APPENDIX VI

WPRO - MEMORANDUM

From L. Selz | To Dr S. Foliaki | Date 26 April 1985

Our ref. LS/85/57 | Attention

Your ref.

Originator | Subject REVIEW OF NIUOLA WATER TANKS.

On 20 April I joined David Wyler F.S.P., Uaka Vaipuna C.O.W., Rosemary Dillon C.P.O., Sitaleki Telefoni H.O.H., and Manunaloa Taufahema F.S.P. in their inspection and review of the rain water storage tanks in 'Uiha and Felemea Ha'apai. The tanks were financed by Foundation for the People of the South Pacific and constructed under the direction of the Niuola Women in Development Association lead by Temaleti Vakasiuola. Approximately 120 tanks were inspected.

First I must personally congratulate Temaleti, her group and F.S.P. for the tremendous task they have accomplished. The construction of these tanks, in the islands of Ha'apai, rates in the same magnitude of accomplishment as the hurricane house project. The tanks aren't perfect, there are areas that need attention that I shall detail, (with the aid of the brilliant glow of hindsite), but none of these remarks should detract from my congratulations for getting the job done.

Discussion & Recommendations

The foremost problem is that approximately 30 to 70% of the tanks are not sufficiently water tight.

The cause of the majority of serious leaks in these tanks is because of poor workmanship in the tank bottom. Black plastic must be used under the mesh and the mesh must be positioned when pouring the bottom. The mortar must be well mixed in a mechanical mixer.

Tension cracks show at the bottom of a high percentage of the tanks. This indicates an insufficient amount of tension steel. Two No. 9 wires (3.5 mm dia.) should be added. The first 10 cm from the bottom and the second 20 cm from the bottom. These wires should be as hoops with an over lap of 70 cm.

The guttering and spouting installation needs professional guidance and the trainers need to be trained. Eave trough brackets are spaced too far apart and usually insufficiently anchored. The spouting from the trough to pipe adaptor is invariably installed with an improper bend, often end caps are omitted. In some areas it may be necessary to furnish a 1" x 6" board to serve as a mounting board for the trough. Because of the odd angle required from the trough head to the tank a double elbow should be used so it allows rotation in both direction.

sufficient money must be allocated to cover guttering, spouting and their support and one large part of the training must be on this component. After the tank is completed and repaired, maintenance of the guttering becomes the most important part of the project. It should be added here that vines should not be allowed on the catchment roofs or near the eave troughs because of the cover it offers to rats and the possible contamination from that sources.

There is no need to slope the rain pipe over the 5 degrees provided for in the plastic bend.

All materials must be screened before using - including cement if there are any sign of lumps. Cement lumps cannot be succesfully broken by mixing.

The setting of the tanks in holes should be discouraged. In this enlightened age of contamination sources the use of "throw in buckets" in rain water storage tanks should be heavily discouraged. The tanks should be built at or preferably above the ground on a stand at least 4 inches high. The tank should be sealed and screened from mosquitoes, bugs and light. (Light causes green algs to grow in the tank). Bucket holes are hazards for children and the probability of a drowning, while low, is distinctly possible.

The connection of the tap to the tank needs improvement. The use of a fitting at the wall, whether a floor flange, elbow or coupling along with a thickened concrete wall pad inside the tank.

In the rush and push to build the tanks the straining of the incoming water and blocking out of light and insects has been neglected. A strainer design should be worked out and used on each tank, the overflow screened or plugged (I personally see no need for the overflow) and all openings sealed.

The walls of the tank vary somewhat in thickness. They have been reduced as much as possible for reasons of economy. I feel more thickness would be better and recommend that a minimum thickness of 1" (25 mm) be used.

A high percentage of the cracks in the walls occoured on the sunny side of the tank. The fresh plaster should be protected from the sunlight. Futher the plaster should be recented, if it is to be, while last layer is as fresh as possible. The plaster should be kept continuously wet for at least a week.

For the first few years these tanks are used, starting a few months after the construction, a team should travel thru the Islands, at least once per year furnishing parts if necessary, to see that the tank owners have a proper gutter installation, that any leaks are patched, that the tank is properly screened and sealed. This team should be accompanied by someone with legal authority to enforce the proper use of the gift.

I would consider the construction of these tanks acceptable for the upcoming Norwegian aid project providing the following recommended items are included. The provision of a M.O.H. inspector for the construction say once per week may be advisable.

Recommended items for improving Niuola 10 m^3 tank.

1. Wall, floor and roof thickness - 75 mm minimum.

2. Install tap 25 to 75 mm from the bottom of the tank using a fitting or ring as a seepage stop.

3. Install the tank at or 3" above the ground level.

4. The entering water to be screened thru a screen of standard design.

5. Eave trough and fittings should be included in the project and special attention and training be given to its installation.

6. The freshly placed mortar must not be exposed to direct sunlight, must be kept constantly wet for one week and must recieve the next coat within 2 days.

7. Two number 9 (3.5 mm) tension hoop wires be added over the diamond mesh before plastering. The first 10 cm from the bottom the second 20 cm from the bottom.

8. The bottom coat on a plastic sheet and special care be taken with the reinforcing mesh placement.

cc: David Wyler, F.S.P.
Naka Vaipuna, M.O.W.
Sitaleki Telefoni, M.O.H.
Rosemary Dillon, C.P.D.
EHE, Manila via WRC, Suva.

Lloyd

APPENDIX VI

WPRO - MEMORANDUM

From L. Belz | To Dave Wyler, F.S.P. | Date 29 April 1985

Our ref. LB/85/60 | Attention

Your ref.

Originator | Subject ZINK GALLUM TANKS - HA'APAI.

Per our discussion in Ha'apai I went over and looked at Doug's steel tank.

The first thing that impressed me was the economy in riveting. Fine idea if the rivets are perfectly driven - an unlikely happening in Tonga. Riveting is a fine art and involves more than hitting the end of the rivet with a hammer - the edge should be peened around the edges with a round hammer for full tightening power.

My suggestion for the problem of leakage on these tanks, particularly in the walls is to have your supervisor (possibly your P.C. volunteer) study riveting theory for a couple hours then on a few tanks try adding a lot of pop rivets from the outside only.

If this loosens the existing rivets reset them with someone inside and out using proper techniques.

Since no caulking will be effective without tight rivets and even very thin caulking would be effective with tight rivets it would be a worthwhile experiment.