

Solid Waste Management Challenges in Pacific Island Countries

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EXECUTIVE SUMMARY

Many Pacific island nations have emerging economies and are consuming a growing amount of consumer and disposable goods. These goods often result in the generation of significant inorganic solid waste streams such as car bodies, plastic bags and packaging. Traditionally, these waste streams were not generated or were small in volume and so easier to manage.

The authors have been working on these issues on a number of Pacific islands for some time and more recently have been working with the Government of Tonga to improve waste management on the main island of Tongatapu.

Tonga is one country, which in conjunction with AusAid, is taking a forward thinking approach to the growing problem of waste management. Nuku'alofa, the capital on the main island of Tongatapu, is a focal point of this growing problem. It has a population of 30,000, a steadily growing per capita income and is located on a coral island.

This work in Tonga, formed part of an AusAid institutional strengthening project. The authors believe that the lessons learnt in helping the Government of Tonga can be translated to other similar islands in Tonga and elsewhere in the Pacific.

Considering the poor state of waste management and the lack of any comprehensive plan on how to overcome the problems within Tonga, there was an urgent need to revisit solid waste management on the main island of Tongatapu. The authors were initially engaged to prepare and implement an effective Solid Waste Management Plan (SWMP) for Tongatapu.

It was recommended in the SWMP that the Tapuhia Quarry site be developed as a modern waste management facility. It was proposed that the site incorporate recycling facilities, an engineered sanitary landfilling operation and other site facilities to service the waste management needs of Nuku'alofa and the other villages on Tongatapu.

The authors and their Government of Tonga counterparts gained a great deal of experience, which can be applied elsewhere, by working through challenges such as:

- Limited suitably skilled staff are available to dedicate to the project;
- On island resources are limited and generally requires importing materials;
- Locating and designing a new landfill when town water is supplied from a scarce and diminishing groundwater resource;
- Obtaining landfill cover material on a coral atoll.

Landfilling is currently used as a means of swamp reclamation for valuable residential land;

Traditional land ownership by Nobles who are very reluctant to sell or lease land for waste management facilities;
Recycling in locations which are very remote from reprocessing facilities;
Widespread dumping and littering due to the lack and cost of services;
Traditional cultural waste disposal methods, in an era in which modern consumables can not be fed to domestic animals and should not be burnt.

These issues are not unique to the Pacific island countries. However, in these small coral islands the lack of resources, infrastructure and skills make the challenges even greater. The solutions to these challenges are rarely simple and must always be:
economically sustainable
socially and politically acceptable, and
environmentally responsible.

This project is successfully addressing a range of waste management challenges, which face many small, remote, coral island countries with emerging economies. The project provides an example of how countries that are similar to Tonga can work, through the local challenges, towards sustainable development.

KEY WORDS

Waste, Pacific, Tonga

INTRODUCTION

The Authors have been working for AusAid to assist the various government departments of Tonga to establish a socially and environmentally responsible waste management facility that includes a new landfill.

The project has highlighted to the authors the political, economic, social and environmental peculiarities of Tonga which make the establishment and operation of what is a fairly conventional integrated waste management facility, far more difficult than in Australia.

The lessons learnt by the authors are likely to be valuable in the establishment of similar waste management facilities on other Pacific Islands.

This paper provides an introduction into waste management in Tonga, outlines the new waste management facility and provides some details of the challenges and solutions identified by the authors

Background

Spread across the South Pacific Ocean, the Kingdom of Tonga consists of 171 islands of which less than 40 are inhabited.

Tongatapu is the main island of Tonga, with a land area of 260 sq km Tongatapu constitutes one third of the country's territory. The population of Tongatapu is approaching 70,000, approximately 70% of the nation's population. The majority of the island's population lives in the capital Nuku'alofa and its adjoining villages. The island is a pancake flat coral atoll, tilting slightly toward the north. Cliffs on the southern shore rise to 30m while the northern coast is submerging, evidenced by the maze of inlets, and mangrove-choked lagoons.

Tonga is a constitutional monarchy based on the British parliamentary system. The current King is one of the world's most powerful reigning monarchs, he is the head of both the nation and its government. The legislature is composed of the speaker, the cabinet, appointed by the monarch, nine nobles selected by Tonga's 33 hereditary nobles and nine representatives elected by literate taxpayers over 21. Elections are held every three years.

The management of solid waste (garbage or rubbish) on Tongatapu is poor and is having a detrimental impact on the health of the community and the environment. Poor solid waste management practices occur not only in Nuku'alofa but in many villages across the island of Tongatapu, including many villages around the Fanga'uta and Fanga Kakau lagoon. The results of the poor solid waste management practices include:

Unsightly littering and indiscriminate dumping of solid waste in drains, waterways, on public and unoccupied private land;

The attraction and proliferation of insects, vermin and pests;

The creation of unsanitary (unhealthy) conditions and consequent risks to the health of the community; and

The pollution and degradation of local drains and waterways eg. lakes, mangroves, and wetlands, which is having a detrimental impact on local flora, fauna and the livelihood of the local community.

AusAid

AusAid, the Australian Agency for International Development, is responsible for the management of the official Australian Government overseas aid program. Australia's long-term objective in providing aid to Pacific island countries is to help them to achieve the maximum possible degree of self-reliance. Australia's assistance is concentrated in areas considered to have the greatest impact on development - economic reform and governance, education and training, health, environment and natural resources, and private sector development.

This project, the Tongan Environmental Planning & Management Strengthening Project aims to improve environmental planning and management, and to achieve a more certain investment environment as a result of establishing clear and consistent environmental regulations. As part of the project, Australia has provided a team of specialists to study the impact of increasing urbanisation on the fragile Fang'uta-Fangakakau lagoon system in the centre of the main island. The Tongan Government will use the study as a model when it tackles crucial environmental issues such as urban development, waste disposal, drainage of lagoons, mangrove clearance and the protection of aquatic resources.

TONGAN ENVIRONMENTAL PLANNING & MANAGEMENT STRENGTHENING PROJECT (TEMPP)

Waste Disposal

There have been several attempts to improve the management of solid waste on Tongatapu. However, few of the programs, activities or recommendations contained in the resulting documents have been successfully implemented. The upgrading of the existing waste disposal site at Tukutonga was partially successful but once the funding from the World Health Organisation ceased in late 1997 the landfilling operation reverted to its previous poor and unsanitary condition.

Considering the poor state of waste management and the lack of any comprehensive plan on how to overcome the problems, there was an urgent need to revisit solid waste

management on Tongatapu. An effective Solid Waste Management Plan (SWMP) that was sustainable (economically and environmentally) and acceptable to all stakeholders needed to be prepared and importantly implemented.

To successfully achieve such required the co-operation, participation and support of the Government of Tonga, all relevant Government agencies, the local community, as well as commerce and industry. The development and implementation of the SWMP needed to be a multi-Ministry exercise, with input also from the community, commerce and industry.

Solid Waste Management

There was an urgent need to prepare and implement an effective Solid Waste Management Plan (SWMP) for Tongatapu for the following reasons:

The existing waste disposal site at Tukutonga has reached capacity;

The importation of materials and products is ever increasing, leading to increased quantities of waste to be managed / disposed of;

Land available for waste disposal on Tongatapu is limited. The King owns the land, the nobles manage the land on behalf of the King, distributing parcels to the villagers. Land is not bought and sold;

Only limited waste minimisation and recycling is currently occurring, leading to increased quantities of waste requiring landfill disposal;

Many existing waste management activities are having a detrimental impact upon the health of the community as well polluting the environment;

Littering and indiscriminate dumping of waste is prevalent on publicly owned and unoccupied land throughout Tongatapu, including tourist sites such as parks, beaches, lakes, mangroves etc;

There are few legislative and regulatory controls for the management of solid waste, and ineffective enforcement of those that do exist;

There is a low level of community awareness of the problems created by improper waste disposal;

The existing waste collection service is inefficient and waste collection services are limited to approximately 20% of households and some institutional, commercial and industrial premises in Nuku'alofa; and

There are insufficient funds, resources and equipment allocated to provide an effective and sustainable waste management system.

The Solid Waste Management Plan, finalised in March 2000, formed the basis for the development of the Tapuhia Waste Management Facility.

Due to the very poor condition of the existing dump site and the fact that there is essentially no space left to fill, there is a very urgent need to establish a new landfill site. Further, it will take some time (years) for waste minimisation programs to become fully effective and there will always be residual mixed solid waste that cannot be disposed of other than by landfill.

It was therefore recommended in the Solid Waste Management Plan (SWMP) for Tongatapu that the Tapuhia Quarry site be developed as a modern waste management facility. It was proposed that the site incorporate recycling facilities, an engineered sanitary landfilling operation and other site facilities to service the waste management needs of Nuku'alofa and the other villages on Tongatapu.

Also, waste minimisation was identified in the waste management plan for Tongatapu as a major issue and a number of actions to minimise waste were proposed. This included

establishing a composting operation at the waste management centre to treat organic waste which comprises 40-50% of the waste going to landfill.

TAPUHIA WASTE MANAGEMENT FACILITY

Background

The proposed Tapuhia waste management facility is not conventional for Tonga or the Pacific. The Tongans will be stepping up from an open dump on swampy ground to a modern waste management facility that incorporates an engineered landfill as well as recycling and composting facilities. This presents some significant challenges in terms of funding, design, construction, management and operation.

Suitable land for waste disposal is scarce, therefore the exhausted quarry at Tapuhia that is currently redundant in its current form was recommended by the Authors and supported by the government as an appropriate landfill site. This is a very appropriate use for the quarry as it will allow it to be rehabilitated and available for future beneficial uses such as animal grazing, which is undertaken on adjoining rural properties.

A Waste Facility Design Adviser - Engineering (WFDA-E) was engaged to facilitate the engineering design of the facility with the Engineering Department of the Ministry of Works (MoW), providing technical advice and assistance. Similarly a Waste Facility Design Adviser - Operations (WFDA-O) was engaged to facilitate the development of an Management & Operations Plan (MOP) in conjunction with the Ministry of Works, Ministry of Health (MoH), and Department of Environment (DoE) officers.

Design Concept

The Tapuhia Waste Management Facility will be a modern waste management facility encompassing a gatehouse / vehicle reception facility, staff amenities, small vehicle waste disposal facility, recycling centre, a garden and wood waste processing facility, an engineered sanitary landfilling operation, and a storage shed / workshop for the landfilling plant and equipment.

An on site, split level small vehicle waste disposal facility (transfer station) will be centrally located within the site entrance area. Large trucks including the Government of Tonga garbage compaction truck(s) will be directed to the landfill operating face. All other vehicles shall deposit their waste at the small vehicle waste disposal facility or appropriate recycle area. No unauthorised person should be permitted to the landfill cell.

The small vehicle waste disposal facility has been orientated to minimise conflict between operation plant and the public and designed so that it could be extended to include another two bin bays if required.

The recycling centre will be located adjacent to the site entrance and comprise separate gravel hardstand parking area and fenced yard with storage shed for separated waste materials for re-use and recycling. A bunded area has been provided with the shed for the future collection of domestic waste oils and batteries (if recycled).

The garden and wood waste processing facility will be located beyond the recycle centre and comprise a gravel hardstand area on a compacted clay liner. It is proposed to provide a shredder for wood waste, and potentially tyre shredding, within the garden and wood waste processing facility. A roofed structure will be provided for this equipment, an attached shed

will be provided for the bulk storage of waste oils (and batteries). The garden and wood waste processing facility will have its own storage pond for runoff. This runoff may be re-used in the composting process or disposed of in a similar fashion as to that of the landfill leachate.

Two separated septage drying bed systems shall be constructed, each with a roof structure with opal translucent roof panels. The roofs will prevent rain from falling directly onto the drying areas, the translucent panels to maximise evaporation. It is proposed that the larger drying bed shall be for residential septic waste. When processed the product should be suitable for re-use in the compost process (if initiated) or taken off site for direct use on agricultural land. The smaller of the systems is proposed for industrial and commercial septage, and for overflow from the residential area should the need arise. It is likely that this septage will be contaminated and if so the waste will be landfilled. A simple drainage trench has been incorporated into the design to enable liquid to be collected and disposed of into the leachate treatment pond.

A simple gatehouse shall be constructed immediately inside the site entrance for use during operation of the facility as gatehouse and after hours as the caretaker's room. A new staff office/amenity building, complete with lunchroom, toilet and shower facilities, and all other necessary services will be constructed adjacent to the gatehouse.

The complex will also include a shed for storing and maintaining the landfilling plant and other equipment.

The quarry hole has been divided into four areas for staged development. The first landfill waste disposal cell to be developed will be in the southwest corner of the quarry. The cell shall be lined with a 500mm layer of low permeability compacted clay. A geosynthetic clay liner (GCL), Bentofix X1000 will be placed on top of the clay to form a composite liner system.

One leachate sump / extraction system, constructed during the initial works, will be provided for the entire quarry. The leachate sump will be provided with a further element to the liner system, that being 0.5mm Gundseal product. It in itself is a composite liner of bentonite clay attached to a HDPE flexible membrane. The leachate drainage system placed directly above the liner system will incorporate a network of pipes placed in a radial fashion centred about the sump. A 300mm layer of drainage aggregate will be placed over the entire floor of the cell to complement the pipe network. The drainage layer also provides a protective blanket for the liner system. Collected leachate from the landfilled waste shall be pumped to a leachate storage pond located outside the quarry void for treatment and disposal. Effluent from the leachate treatment plant will be disposed of via spray irrigation.

The side liner will be Bentofix X2000, with geofabrics on either side of the liner to provide protection from both the quarry face and initially UV radiation and then waste as it is placed against it.

Two leachate ponds will be provided, a treatment pond and an effluent storage pond. Leachate will be pumped from the landfill sump to the treatment pond. A further pump will recirculate and aerate the leachate. Following a suitable treatment and settling period the treated effluent passes to the storage pond for systematic spray irrigation over pasture.

Other associated works are proposed to enable the facility to operate in a safe, efficient and effective way.

Management and Operation Plan

The Management and Operation Plan was identified in the SWMP as an essential part of the establishment of the Tapuhia Waste Management Facility.

The Management & Operation Plan included:

Details of the existing site including location, land-use, ownership, site geology and hydrology, existing surface and groundwater quality, site soil characteristics;

The sources and characteristics (quantity and types) of waste to be managed at the WMF;

A general description of the proposed WMF including the layout of the facility;

Approval Process

The Management and operation framework for the WMF including the roles and responsibilities of the various GoT authorities;

Details of the proposed landfilling operation including:

The final landform;

Staging of the landfilling operation;

Waste disposal cell establishment including details of the leachate containment and management system;

Deposition and covering of landfilled waste;

Details of landfilling equipment;

Details of other proposed site activities including the re-use and recycling centre and the mulching / composting operation;

Management of stormwater at the site;

Site supervision and staffing;

Hours of operation;

Environmental management measures;

Environmental monitoring;

Health and safety management;

Fire controls;

Operation and maintenance of equipment;

Daily, monthly, quarterly and yearly checklists;

Record keeping and reporting;

Site rehabilitation and post closure management.

Contingency Plans

Funding

Estimates for capital and operating costs

A sub committee was formed of the MoW, MoH & EPACS personnel. This group was used to brainstorm and review alternative operational techniques for inclusion in the Management and Operations Plan. Also the sub committee was used to network with the various stakeholders to maximise ownership and input to the project.

The WFDA-O drafted up a Management & Operation Plan based upon outcomes from the sub committee, the directions provided in the Waste Management Plan and in puts from each of the relevant organisations.

Design and Construction Challenges

For a project of this nature to succeed in the long term the facility and associated functions needs to be sustainable. AusAid, as sponsor, required the Government of Tonga to formally acknowledge the project as a priority for the country and commit sufficient resources to fulfil their obligations. In developing the terms of reference for the project AusAid also stipulated

that the appropriate ministerial departments undertake the work, with assistance, to foster the concept of ownership of the project.

AusAid's commitment to the Government of Tonga to sponsor the design, construction and operation of the waste management facility was limited. The landfill design, whilst taking into consideration future stages, provided details and documentation for the first cell only. The commitment by AusAid to the facility's construction and operation is also finite. The Tongan government will have to assume, at some point in time, full responsibility for the ongoing concerns at the facility.

Project officers were based within the ministerial offices, supervising counter-part officers. The WFDA-E was based in the Ministry of Works (MoW), engaged to facilitate the engineering design and drafting work to a level of detail as required for construction of the waste management facility at Tapuhia.

Logistically it was difficult for the ministries to allocate appropriately skilled staff and resources to enable them to dedicate any significant time to the project to fulfil their obligations. With limited technically skilled staff available significant demands are made on their time to resource the various on going projects for the entire country.

Hydrology. There is no surface fresh water supply on Tongatapu, in fact use of domestic fresh water tanks have only just become common practice. The population is almost totally reliant on a sub-surface lens of fresh water below the island. Consequently, and not surprisingly, the Tongan people are fearful about contamination of their water supply. This is evident in the location of previous dumps on coastal fringes, these waste disposal practices are contributing to a significant and wide spread environmental degradation. An assessment of the ground water in the vicinity of the adopted site indicated that the ground water flowed toward a village, and their ground water bore. Management of the ground water issues was of paramount importance in the development of the facility.

Geology. Tongatapu is a coral atoll. There is limited clay on the island for construction of traditional low permeability compacted clay liners. An amount of clay exists at the site adopted. The clay, overburden from the previous activities, has been stockpiled. The nature of the clay is dubious, the testing undertaken was inconclusive. Poor quality control of the testing procedures was suspected. Given that clay is not used for construction activity in Tonga the geotechnical laboratory available was not set up for such, nor were the technicians familiar with the material. Consequently the clay was to be used as a preliminary base liner, providing only limited low permeability capabilities and forming a suitable foundation for a geosynthetic liner. Use of synthetic liners in Tonga raises some fairly unique issues. It's a long way from a supplier, all materials need to be shipped into the country from either Australia or New Zealand. No local designer or contractors have had any experience with synthetic liners, let alone in a sanitary landfill operation. It was considered important that the liner adopted was simple to install, not requiring special equipment or knowledge, and could be a little forgiving. Welded liners were regard as too complicated to consider so it was determined to use overlapped geocomposite liners as the primary defence in the multi-liner system. It was considered that this liner system could be successfully installed by the local labourers, under the guidance of Ministry of Works personnel following a suitable on the job training period.

Leachate. The integrity of leachate collection, treatment and disposal is dependent on the ability of the MoW, as operators of the facility, to maintain operations. Rigorous attention to the ongoing management and monitoring of the facility is the greatest challenge to the

success of the project. The collection of the leachate within the landfill follows fairly standard practice, gravitational flow to the landfill sump. However the treatment and disposal of the leachate requires constant mechanical and human participation. A sump pump directs the flows to the leachate pump, a further pump aerates and circulates the leachate in a treatment process. A third pump enables the treated leachate to be irrigated. The system as developed requires continuous intervention to ensure the leachate is disposed of at a suitable rate. Whilst the design accommodates a significant factor of safety there are dynamics in the Tongan culture that have to be considered. Tonga has a significant rainfall during the wet season and leachate storage is limited. Power outages are common and can last for days, and equipment tends to deteriorate quickly in the severe atmospheric conditions requiring rigorous servicing. To offset these circumstances additional capacity was incorporated into the system and backup diesel pumps recommended.

Management and Operation Challenges

A principal priority of the Management and Operation Plan (MOP) was the establishment of separate implementation and regulation agencies and an inter-agency working group. Specifically MoW has construction equipment and expertise, MoH has expertise in inspection, disease control and amenity issues and the DoE has expertise in environmental monitoring. The working group provides a forum for regular communications between the implementation and regulatory agencies.

The MoW are identified within the MOP as being responsible for the “planning, design, construction, operation and rehabilitation of the Tapuhia WMF”. The MoW need to be intimately involved with the construction process to both learn how, and understand why, the facility is developed. Consequently it was recommended that the MoW be awarded the contract as primary contractor. This may require additional labour to be hired as well as professional staff, but does not negate the use of sub-contractors on some construction elements. Further it was recommended that the MoW retain in-house elements of the construction that are peculiar, within Tonga, to this landfill development, such as clay compaction, liner placement. It is highly desirable for MoW to obtain and retain these skills for replication in future cell construction.

The construction and operation of this facility introduces many new techniques, products, equipment, responsibilities, and requirements foreign to most of the people likely to be involved with the project and requires a change to the approach previously adopted.

Based upon the experiences at the existing Tukumotu Dump training, detailed procedures, checklists and a periodic external advice program was needed. Staff within each of the departments had useful skills and experiences however it was apparent that these staff needed additional support and training. In particular the future site management, equipment operators and labourers would benefit from an on site training program.

It was therefore recommended that suitable and sufficient training and supervision be provided; during the construction phase, prior to operation, and during the initial implementation of operation. Training should be made available to the MoW staff at the site, and relevant off site personnel and other GoT agencies identified in the MOP.

For the facility to operate as planned new plant, machinery and equipment currently not available will be necessary and was recommended.

Although it is not exclusively the case, equipment maintenance is often undertaken on a breakdown basis rather than on a preventative basis. Therefore, equipment was selected to be dedicated to the Facility, low maintenance and the facility was provided with dedicated maintenance staff and budget.

As the familiar operation and regulation functions were only loosely established within the Government a problem detection, characterisation and resolution procedure was included in the MOP. For all of the likely and common problems, Contingency Plans were prepared as specialist advice is unlikely to be readily available in the future when incidents arise.

The MOP also provided estimates of operational costs and a funding mechanisms that would include transitional arrangements and would only rely upon Aid funding during the initial construction and operating phases. This aspect will be especially important when the construction of subsequent cells is required.

Future Opportunities

Future planned stages of the project are to continue with the implementation of the Waste Management Plan, including:

Construction and operation of the new landfill site and associated facilities;

The new site is not located within the populated area of Nuku'alofa, but central to the island. To make it easy for people to dispose of their waste in an environmentally sound manner when the new site is operational, it was recommended that a transfer station be provided in the Nuku'alofa area. This Transfer Station should be a prelude to a network of transfer stations across Tongatapu.

The current skeletal waste collection system, within Nuku'alofa be overhauled and expanded and an island wide, if not national, recycling strategy be devised and implemented.

Review of opportunities for privatisation;

Maximise existing viable recycling initiatives, eg organic waste, aluminium cans, semi-precious metals (copper, brass etc);

Scavenging rights for reusable waste deposited at the facility, eg timber, fire wood, and other goods;

Initiatives to enable other wastes to be recycled or reused, eg waste oil, car batteries, PET & HDPE plastic bottles; and

Initiatives to enable troublesome wastes to be recycled or reused, eg import levies.

CONCLUSION

The authors and their Government of Tonga counterparts gained a great deal of experience, which can be applied elsewhere, by working through challenges such as:

Limited suitably skilled staff are available to dedicate to the project;

On island resources are limited and generally requires importing materials;

Locating and designing a new landfill when town water is supplied from a scarce and diminishing groundwater resource;

Obtaining landfill cover material on a coral atoll.

Landfilling is currently used as a means of swamp reclamation for valuable residential land;

Traditional land ownership by Nobles who are very reluctant to sell or lease land for waste management facilities;

Recycling in locations which are very remote from reprocessing facilities;

Widespread dumping and littering due to the lack and cost of services;

Traditional cultural waste disposal methods, in an era in which modern consumables can not be fed to domestic animals and should not be burnt.

These issues are not unique to the Pacific island countries. However, in these small coral islands the lack of resources, infrastructure and skills make the challenges even greater. The solutions to these challenges are rarely simple and must always be:
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REFERENCES

TEMMP, (March 2000) Solid Waste Management Plan for Tongatapu.
TEMMP, (June 2001) Tapuhia Waste Management Facility Management and Operation Plan.
TEMMP, (June 2001) Development Works for the Tapuhia Waste Management Facility, Tongatapu, Kingdom of Tonga, Specification.

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