WATER SAFETY PLAN
For
RAROTONGA

This document was prepared by ……..

This document was prepared on ……..

This document is due for revision ……..

This document was approved by Water Supply Owner……..

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WSP Introduction

This Water Safety Plan has been developed by the Department of Water Works (MoW), and includes input from NES, MoH, MMR, MoA.

The WSP aims to identify all the risks associated with the current water supply in Rarotonga and where possible offers solutions to eliminate or reduce the risk.

A WSP is a systematic assessment of every aspect of providing safe drinking-water, which will identify the events that could cause water to become unsafe to drink or affect the water supply system, and develop plans to manage these.

The WSP covers three aspects of the supply:

- Source and Catchment;
- Treatment, storage and distribution.
- Other components, such as staff and laboratory

The WSP helps identify whether any of the following four barriers to contamination are missing:

- Preventing contaminants entering the source water;
- Removing particles from the water (where many of the germs hide);
- Killing germs; and
- Preventing recontamination after treatment.

The WSP will be reviewed yearly in consultation with WSP Committee It will also be reviewed and updated when there is a system change or when activities in the Improvement Schedule have been completed and require updating to ensure the plan is the most current.

This WSP links into other water related projects including the WDM, WQM, and IWRM & HYCOS.

Organization details

1. **Community Name:**

2. **Supply Owner/Organization Name:** ……..

Contact Person: ……..

Postal Address: ……..

Contact: phone number: ……..

Contact fax number: ……

Contact email address: ……

3. Operator(s):

Contact Person: ……

Postal Address: ……

Contact: phone number: ……..

Contact fax number: ……

Contact email address: ……

4. Other Organization Information:

The Island of Rarotonga

Rarotonga is a volcanic island that stands 14750 feet (4500 meters) above the ocean floor. The island is 20 miles (32 km) in circumference and has an area of 26 square miles (67 km²). At a depth of 13000 feet (4000 meters), the volcano is nearly 31 miles (50 km) in diameter. The highest peak on the island above sea level is 2140 feet (658 meters).

The island is surrounded by a lagoon, which extends several hundred yards (meters) to the reef, which then slopes steeply to deep water. The reef fronts the shore to the north of the island, making the lagoon there unsuitable for swimming and water sports, but to the south east, particularly around Muri, the lagoon is at its widest and deepest. This part of the island is the most popular with tourists because of the suitability of the lagoon for swimming, snorkeling and boating. Agricultural terraces, flats, and swamps surround the central mountain area.

The chief town, Avarua, on the north coast, is also the capital of the Cook Islands. It retains the air of a 19th century South Seas trading post. Avarua is the economic and political hub of the Cook Islands with major commercial and government agencies located in or around Avarua.

Rarotonga is divided into 12 districts, the first six of which constitute the capital, Avarua:

1. Pue - Matavera
2. Tupapa - Maraerenga
3. Takuvaine - Parekura
4. Tutakimoa - Teotue
5. Avatiu - Ruatonga
6. Nikao - Panama
7. Ruaau - Arorangi
8. Akaoa - Arorangi
9. Murienua - Arorangi
10. Titikaveka
11. Ngatangiia - Muri
12. Matavera

Rarotonga Water Supply - Overview

Source

The Rarotonga water supply consists of 12 intakes, located in 12 catchments distributed around the island. These intakes capture water from 12 freshwater streams that are gravity fed either into storage tanks or straight into the distribution system.

These intakes are situated considerable distances inland, well away from residential, commercial or industrial activities. However, most of these catchments are a tourist attraction offering cross-island trekking, with most of the treks passing through or very close to the intake areas.

In addition, farming is quite common in most catchment areas, with some farms diverting water from the stream for irrigation purposes. The irrigation drains reunite with the streams eventually (in some cases, upstream to the intake).

Wild animals such as cows, goats, pigs etc are scattered throughout the catchment areas, and have easy access to the intake areas and contamination from faecal wastes is a strong possibility.

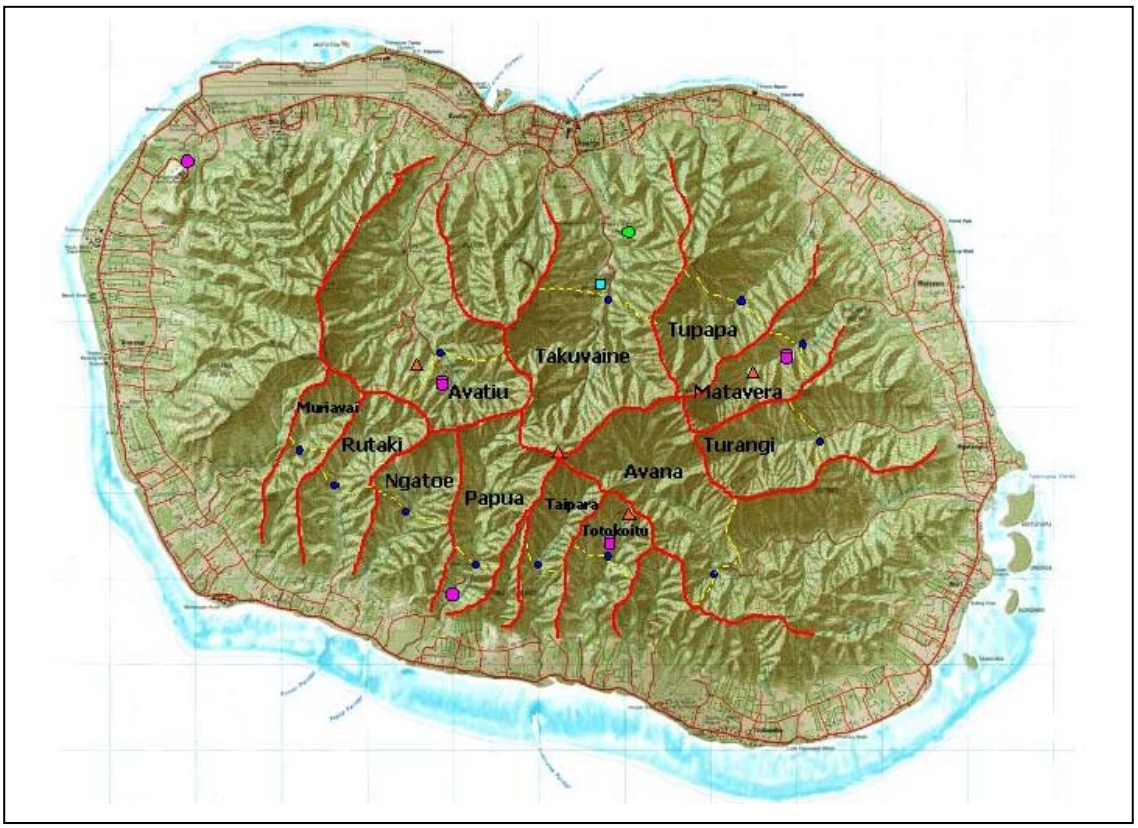


Figure 1: Map of Rarotonga showing the 12 Intakes and respective Catchment areas

Intakes

There are 12 intakes around Rarotonga:

1. Avatiu
2. Takuvaine
3. Tupapa
4. Matavera
5. Turangi
6. Avana
7. Totokoitu
8. Taipara
9. Papua
10. Ngatoe
11. Rutaki
12. Muriavai

Three of the intakes utilize off-stream rapid filtration system; five have in-stream rapid filtration while four have open intakes.

Plate 1: Open Intake
Plate 2: Off-stream rapid filtration
Plate 3: In-stream rapid filtration

Treatment

Currently, like in most Pacific island countries, Rarotonga has no chemical water treatment. Coarse gravel filters remove most solids and organic matter such as soil, leaves etc from the water but does not have the capacity to filter out bacteria.

The Rarotongan water supply comes from 12 stream water intakes, 8 of which have coarse gravel filters. The gravel filters can remove sticks, leaves and large objects from the water but will not filter out bacteria.

To prevent faecal and total coliform entering the water an industrial 5 micron filter is required. There are plans to install these filters in all stream intakes across Rarotonga. Ministry of Works staff advised there are no requirements for further stream intakes to be constructed, and that water supply can be ensured through improved management and storage.

Holding tanks are required to remove fine sediment from the water at each of the intakes. There are few such tanks in Rarotonga with the main one in the Takuvaine region. There are plans to install these tanks in all water intakes to remove sediments from soil erosion. A major cause of soil erosion is urban, industrial and agricultural development within the higher parts of the watershed.

There are two main types of defensive expenditures related to Rarotonga's public stream water filtering, partly the result of poor watershed conditions. These are:

1. The construction and installation of fine (5-micron) industrial water filters for all stream water intakes.

2. Capital and operating costs of water tanks to remove sediment at all stream water intakes.

Distribution

Rarotonga's water distribution system supplies water from 12 intakes located high up in the interior of the island to a population of just over 10,000 spread out mainly around the coast. The distribution system is entirely gravity fed and operates generally at high pressures.

The current water supply system is under stress, presumably from excessive and often irresponsible use by the population, and from leakage problems throughout the distribution network. Estimates of leakage range from 30-50% of the water drawn from the intakes.

Water Demand

Water is provided free to users in Rarotonga. Many studies have identified the excessive demand through real consumption and water losses as the major problem of Rarotonga's water supply system. None of the suggested improvements such as water pricing as a demand regulating measure have yet been implemented.

Table 1: Average Daily User Demands for Rarotonga (SOPAC, 2000)

User Type	Water Demand
Domestic, L/d per person	300
Commercial, L/d per establishment	3,835
Hotel, L/d per hotel	13,858
Industrial, L/d per establishment	10,384
Institutional, L/d per establishment	15,792
Agricultural, L/d per plot	3,400

These estimates are based on metered water use of specific buildings, and typical demand values.

Rarotonga Water Supply - Major issues and concerns

Flooding

1. Sediment deposits at intake

Rarotonga is prone to flooding during periods of heavy rainfall. The already shallow streams are severely affected by sediment, rock and debris deposits following the flooding event. DWW have had to engage in clearing up the sediment and rock deposits in order to make the intake operational again.

Plate 4: Heavy machinery used to clear 'choked up' intake after flooding
Plate 5: Muddy water at the intake after flooding

2. Damage to Infrastructure

Flood waters often cause major damage to the infrastructure, including the intakes, filters, pipeline networks etc. A considerable amount of the Department's operating budget is used on repairs and maintenance following flooding events.

3. High Turbidity

In addition, flooding usually causes another major problem: high turbidity. The basic gravel filters and the relatively short time at the storage tanks fail to remove the excessive sediment. Consumers have often complained of receiving 'chocolate brown' water after periods of heavy rainfall.

Drought

Most of the streams are fed through springs and are known to dry up during periods of severe drought. The current storage is not sufficient to store water over long periods of time.

Plate 6: Dry Stream bed during 1998 drought

Catchment Issues

The catchment related problems on Rarotonga that could affect drinking water quality were identified in a review of priority environmental concerns (Island Friends, 2004) and scoping study for the scoping document (Okotai, 2005) for an Economic Valuation of Watershed Pollution in Rarotonga. Summarizing these reports, it is possible to identify several major watershed problems on Rarotonga:

1. *Soil erosion and stream sedimentation*

Soil erosion can lead to stream sedimentation causing nutrient and sediment run-off into the ocean. Sometimes water coming from the tap can contain sediment if it has not passed through a settling tank or filter. Soil erosion is mainly caused by urban and industrial construction sites, vegetation clearance and soil tillage on cropland.

2. Herbicide and pesticide run-off

These products are used on cropland and in private gardens. They can potentially enter watercourses, remain in soil-water or enter the lagoon.

3. Fertilizer run-off

Crop and fruit growers on Rarotonga use considerable amounts of fertilizer to boost yields. Much of the fertilizers applied in farms are thought to be entering the streams and waterways, although no tests have been done to confirm this.

4. Livestock and animal waste

The presence of animals in the watershed can lead to faecal bacteria entering streams, the water supply and the lagoon. This often results from livestock being permitted into riparian areas or sensitive water catchment sites due to a lack of fencing.

5. Septic tank leakage and sewage

Most houses and businesses on Rarotonga have some type of septic tank. Depending on the type of septic tank used, this can lead to leakage of waste into the waterways, contributing to total and faecal coliform, and general water pollution.

6. Mosquito outbreaks from stream blockage and ponding

The dumping of waste in streams or blockage by other means can create ponding of water and lead to mosquito breeding. Often mosquito breeding sites are created by inappropriate solid waste disposal practices. The existence of mosquitoes is linked to dengue fever outbreaks.

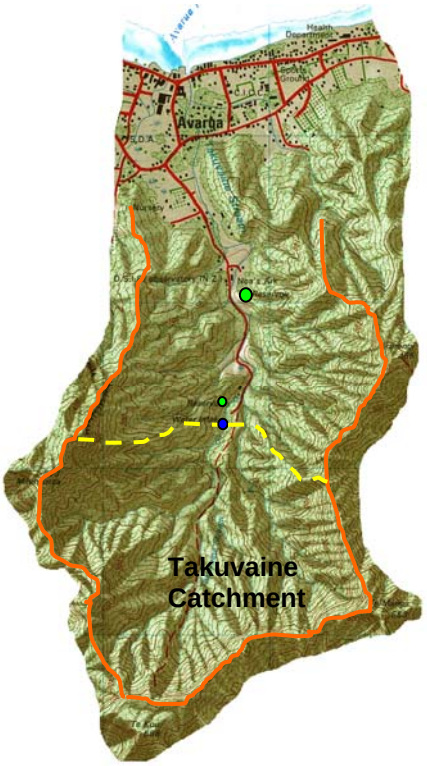
7. Liquid and solid waste disposal

One of the most significant environmental problems facing small island nations in the Pacific region is the disposal of solid and liquid waste. This is mainly due to the limited space available for waste disposal. A landfill site can generate a significant volume of liquid waste which, if not managed, can enter streams and waterways.

Takuvaine Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	61m above sea-level
Production:	1,933 m^3/day	**Date of Commission:**	1990

Catchment & Intake Description



- Located on the Eastern part of Rarotonga, the catchment covers approximately 161 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Takuvaine catchment is an active trekking area, with several tourists and locals passing through the catchment and intake areas on a daily basis;
- There are no residential, commercial or industrial establishments upstream to the intake;
- There is extensive cultivation of taro (water is irrigated directly from the stream and flows through the terraced taro fields before rejoining the stream, all of this upstream to the intake);
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;
- Kids have historically used this small dam as a swimming hole, but this has been actively discouraged through community policing and warning signage.

National Environment Service (IWP Project)

Takuvaine catchment is the pilot for the International Waters Programme (IWP) project's integrated catchment management plan, which identifies potential problems within the catchment and tries to manage them. One such example is tramping within the catchment, which was identified as a high risk, particularly from human waste (suspected defecation by tourists and/or locals).

As a result a toilet has been put in to reduce the risk of direct contamination of the water from trampers.

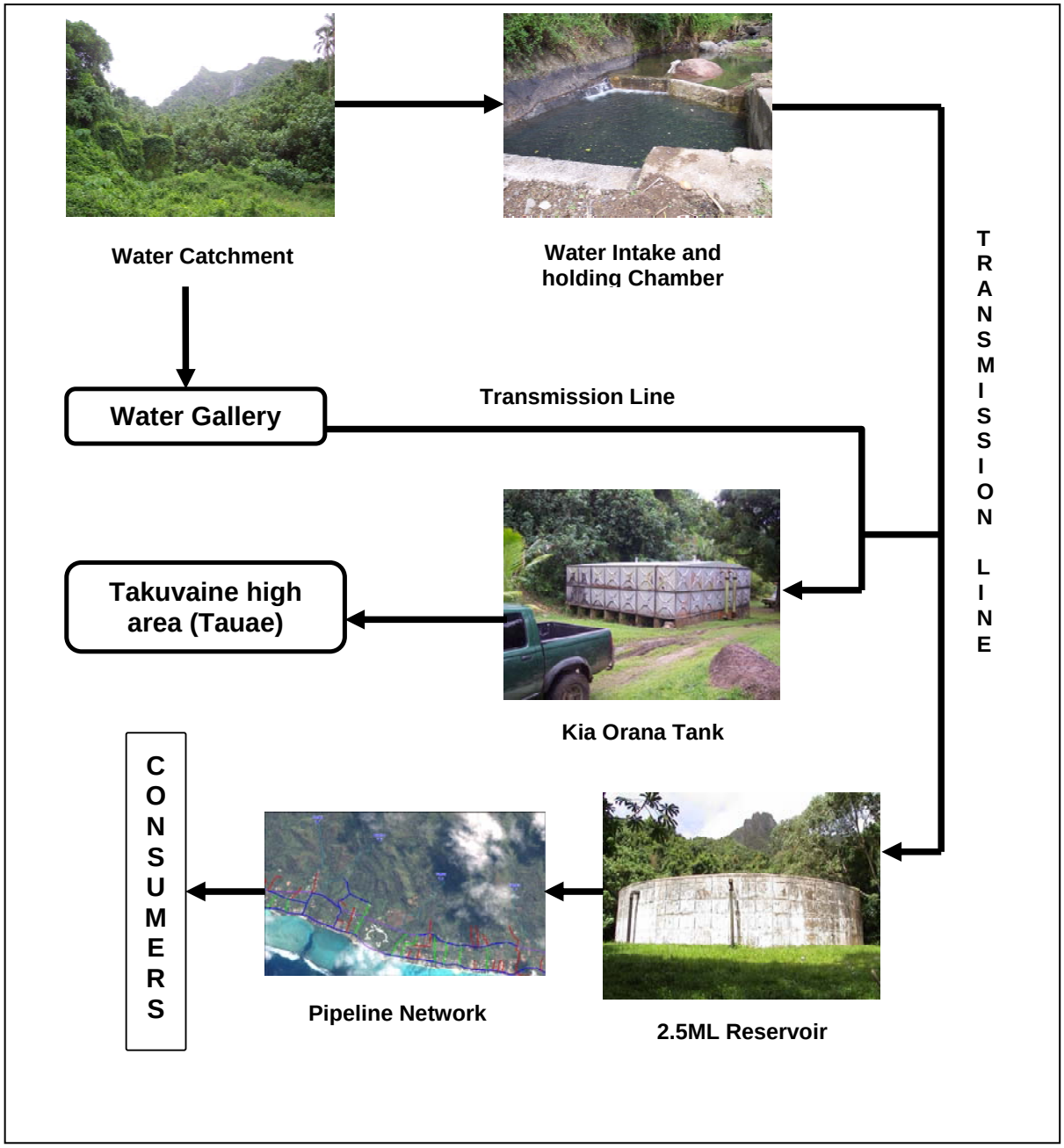


Figure 2: Schematic for Takuvaine Intake

Storage & Treatment

- Water from here flows under gravity into two storage tanks, one with a capacity of 45,000 L and the other with a capacity of 2.5 million Litres.
- The 45,000 L steel tank is filled by the gallery while the 2.5 million litres reservoir is filled from the water intake.
- Both these tanks have a float switch which shuts off the water when the tanks are full.
- The 45,000 litres (Kia Orana Tank) feeds the high area of Takuvaine (Tauae), while the 2.5ML tank feeds part of Tupapa, township of Avarua and part of Avatiu.
- The 2.5ML tank was built in 1974 and currently holds approximately 2 days storage for the township of Avarua. It is solidly constructed of concrete panels and the MoW has a regular inspection programme to ensure that there are no leakage or contamination problems. The inside of the tank is checked when it is cleaned.
- This storage tanks also acts as settling tanks.
- There is a 6 monthly cleaning programme for both tanks.
- There is no treatment.

Distribution

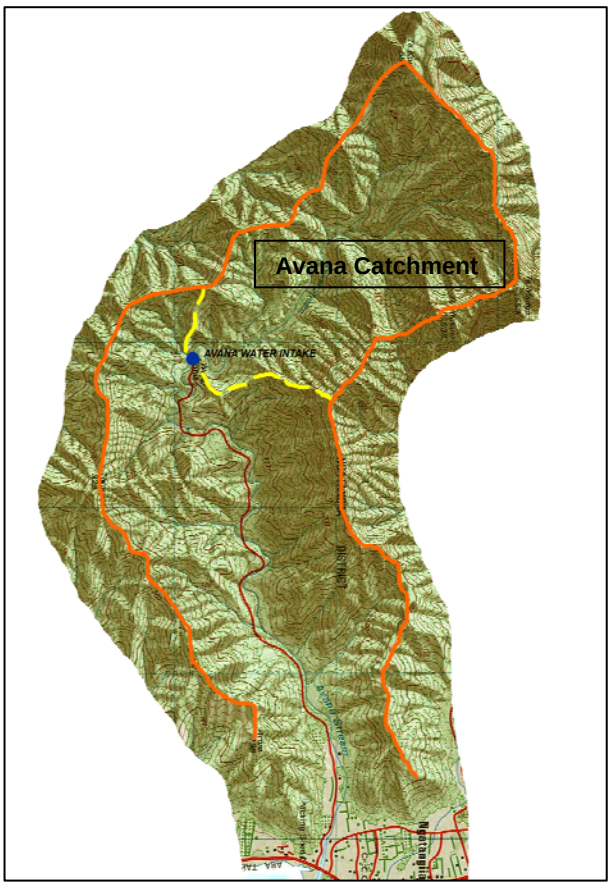
- Water is gravity fed into the distribution network
- The water from the Kia Orana tank gravity feeds to the high area of Takuvaine, (Tauae).
- The water from the 2.5ML tank gravity feeds to part of Tupapa, the whole of Avarua and part of Avatiu.
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

Feature	Details	Feature	Details
Catchment area - ha	161	*Trunkline*	
Intake Elevation – m	69	• Diameter (mm)	200
Instream Filteration bed area (m^2)		• Material	Steel
Concrete weir	Yes	*Kia Orana Tank*	
Flush out line		• Volume (m^3)	
• Diameter (mm)	200	• Material	
• Material	Mild steel	• *Shape*	*Square*
Intake pipes		*Takuvaine Reservoir*	
• Number	4	• Volume (m^3)	2,500.00
• Diameter (mm)	200	• Material	Concrete
• Material	uPVC	• Shape	Round
Holding Chamber			
• Volume (m^3)			
Infiltration Gallery	*Yes*		

Avana Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	81m above sea-level
Production:	3,396 m^3/day	**Date of Commission:**	Year 1964

Catchment & Intake



- Avana intake (from Avana Stream) is located approximately 4km inland from the main road on the Eastern side of the island in a valley surrounded by steep mountains and receives relatively high rainfall
- The access road is fairly rough with 19 stream crossings (intake is not easily accessible)
- The catchment area is approximately 240 hectares of fairly steep mountains that are mostly covered with forest, dense bush and tall grass
- There is no human activity other than adventurous tourists and locals.
- The intake is susceptible to flooding from heavy rain and can completely cover the supply pipeline and the access road. This can prevent access to the intake for up to 3 days.
- The Avana intake supplies water to about half the Rarotonga's population including areas with high tourism activity. The area covered by Avana extends from Avana Bridge along the main road towards the western side of the island and ends at the Sanatorium road. Totokoitu and Papua intake also links with Avana and jointly feeds the area covered by Avana.
- There are two systems in Avana. One system is an open intake which consists of a concrete weir bridging the river, a rock wall on the left bank which acts as a barrier to keep large debris from entering the holding chamber. The holding chamber is directly behind the rock wall and the holding chamber is constructed of, the side directly behind the rock wall is made up of concrete blocks and while the rest of the structure is of in-situ concrete. This system was constructed in 1962.
- The second system is an infiltration gallery system, which collects groundwater water from a freshwater lens located some 6m underground
- Both systems supply water to the pipeline network, however in times of high flow in the stream (high head) the groundwater system is automatically shut off by a non return valve.

Plate 7: (a) The Avana Stream; (b) Avana catchment area

Storage & Treatment

- There is some settling before water passes into the holding tank from the retained pool behind the concrete weir.
- As it moves through the wall structure of the holding tank, large suspended matter is removed
- As the water enters the distribution main, it passes through a coarse wire netting (mesh) which removes any remaining debris and large solids or suspended matter

Plate 8: (a) Holding chamber at Avana Intake; (b) Wall conditions of the Holding chamber at Avana Intake

Distribution

- The Avana water supply system consists of two collection systems, water intake which is sited in-stream and a water gallery which is located close to the water intake and spanning a distance of one hundred metres. A non return valve is installed on the outlet pipe of the gallery whereby when the flow in the intake is high the non-return valve on the gallery will isolate the gallery from the system. When the flow in the intake equates the flow in the gallery then the two systems will operate concurrently.
- From the infiltration galleries and intake, the water flows under gravity down an asbestos cement pipe where it joins the reticulation on the main road.

- There is no storage within this system.
- The pipe crosses the Avana Stream nineteen times and where it crosses these crossings, the pipe is constructed of a metal alloy. This is joined with a flexible coupling, which has the ability to "pop off "when extreme forces are acting upon it e.g. during a flood. This enables this piece to be reconnected within a short period of time. The bolts, which hold the metal pipe together, are covered with denso tape to prevent corrosion (the tape is replaced once every two years).

Plate 9: (a) Pipe transporting water from Avana Intake to the distribution main; (b) Stream crossing – gabion basket wall has been constructed to support concrete pillars from being washed away during floods.

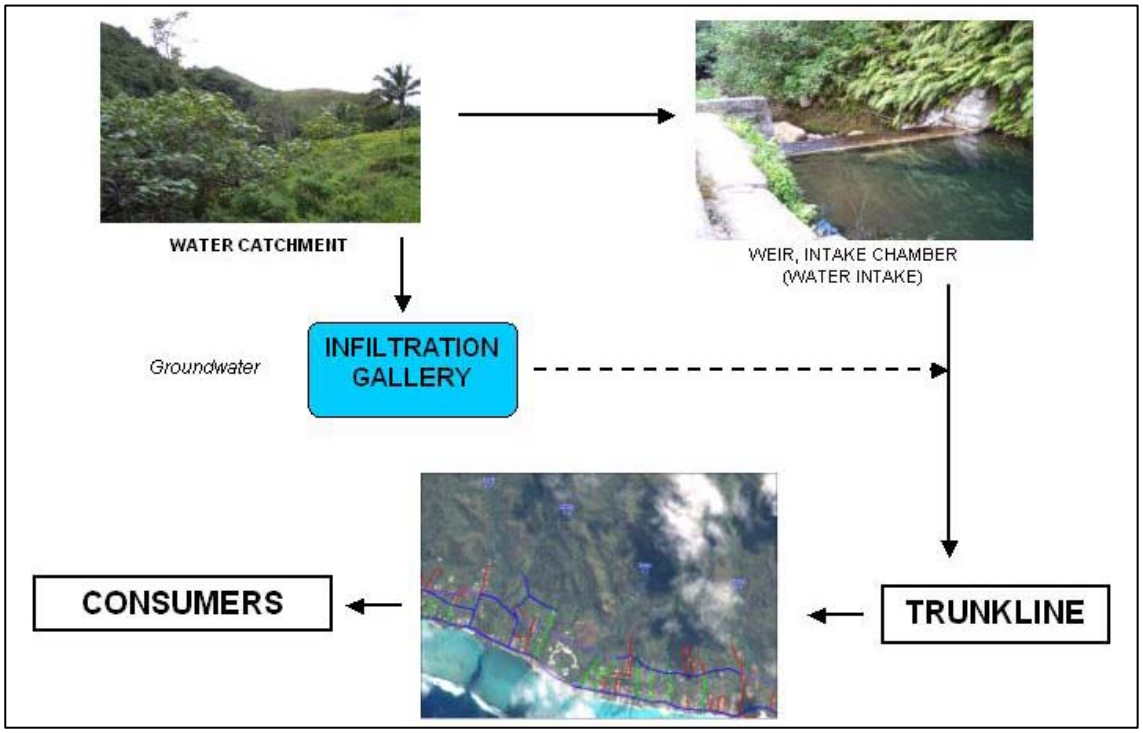


Figure 3: Schematic for Avana Intake

Feature	Details
Catchments area – ha	243
Intake Elevation – m	80.94
In-stream filter bed area – m^2	N/A
Concrete weir	Yes
Holding chamber volume – m^3	
Infiltration Gallery	Yes
Trunkline	
• Diameter (ID), mm	250
• Material	Asbestos

Tupapa Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	65m above sea-level
Production:	1,232 m3/day	**Date of Commissionh:**	Year 1992

Catchment & Intake

- Located in the Eastern part of the island, the intake for this supply is directly in the streambed. A small dam has been constructed to retain the water. A coarse screen has been placed at the mouth of the intake, which removes most large debris. This intake captures almost 90% of the stream flow.
- Extensive cultivation and farming activities within 100m of the intake
- Open access for people and animals
- Tourist Trekking through the Catchment
- The catchment is again steep bush covered hills.
- The Tupapa Stream is not known to dry up, and in times of flood the entire intake can be covered with debris.
- The intake is checked and cleared 3 times a week.

TUPAPA WATER INTAKE

Catchment Area: 101ha
Elevation: 65m
Production (Max) m3/day: 1,232

Plate 10: (a) Tupapa Intake; (b) Coarse screen removes large debris

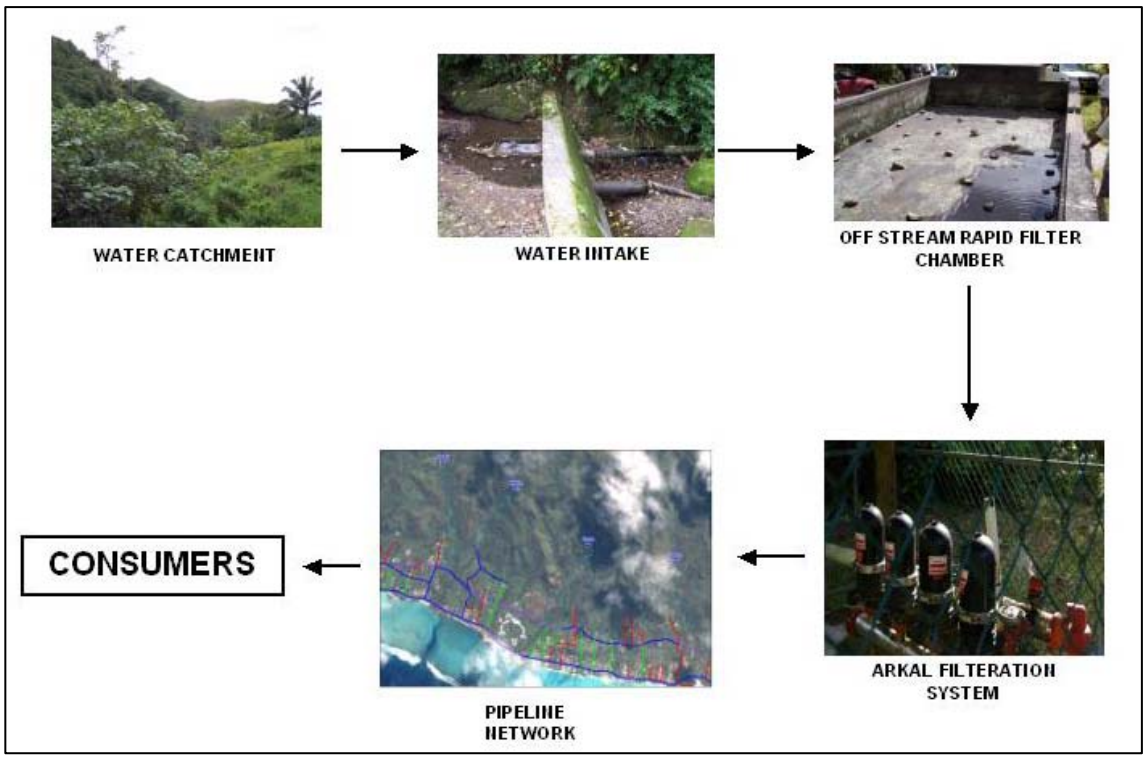


Figure 4: Schematic for Tupapa Intake

Treatment & Storage

- The intake point is enclosed in the small concrete dam located in the stream
- Water from here flows under gravity through a steel pipe into a concrete filtration chamber located on the stream bank down stream of the intake point. The filtration chamber is divided into two sections, settling and filtration sections. The filtration section has a geo-textile cloth and the water passes through the geo-textile cloth. The filtration chamber is cleaned every three months.
- Filtration through Geo-textile material
- Water then flows down to a four spine ARKAL ring filters. The filter system does not use external energy and the operation of the filters is based entirely on hydraulics. These filters contain a series of plastic rings, which act as filters (120 microns mesh). The output flow from the filter system is dependant on the down stream demand. The system can be set to self flush but is dependant on the upstream head pressure. An automatic timer can be set for backwash, but currently this is done manually.
- These filters are checked 3 times a week.

Plate 11: (a) Geo-textile bed at the filteration chamber; (b) Four spine ARKAL filteration system

Distribution

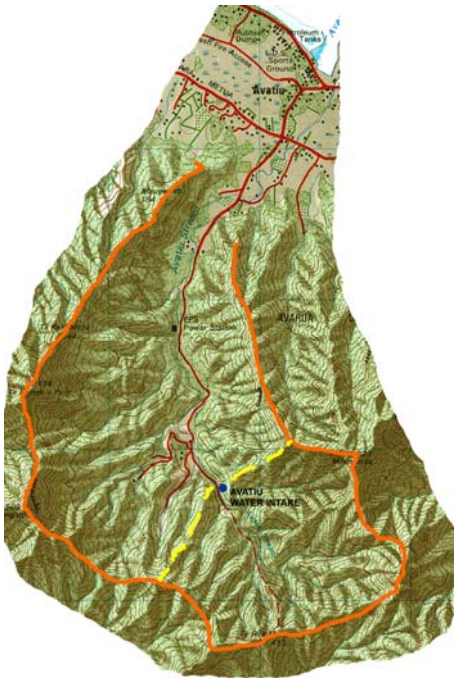
- Water is gravity fed into the distribution network
- The Tupapa intake coupled with the Matavera intake feeds the area from Turangi intake road on the back road and extends to Tupapa and stops at the back of John Tangi's resident. Also feeds the area between the back road and main road along the abovementioned route.
- The whole island is reticulated and the systems are interconnected.
- The sub-mains, cross-mains, loop-mains and branch-mains upgrading are complete in this area.
- Some Households supplement the reticulated supply with Rainwater Catchment.
- Some Households connects their holding tanks to the reticulation system to store reticulated water

Feature		Feature		Feature	
Catchment area – ha	110.6	*Filter media*		*Trunkline*	
Coarse screen	Yes	• Area (m^2)		• Diameter (mm)	200
Concrete weir	Yes	• Material	Crushed basalt aggregate	• Material	uPVC
Transmission line		*Intake pipes*		*Arkal Filteration System*	
• Diameter (mm)	200	• Diameter ID - mm	200	• Inlet size (mm)	100
• Material	Steel	•		• Number of spines	4
Filteration Chamber		• Material	uPVC		
• Volume (m^3)		Holding Chamber – Vol (m^3)			

Avatiu Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	80.30 m above sea-level
Production:	1668 m^3/day	**Date commissioned:**	1990

Catchment & Intake Description



- Located on the Northwest side of the island the catchment covers approximately 135 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- There are two (2) systems in Avatiu. The first system composed of a concrete weir bridging the stream, a rapid filter made up of crushed basalt aggregate, four intake pipes and a holding chamber.
- The second system is a gallery infiltration system which collects infiltering groundwater at about six (6.0) metre below ground level.
- The Avatiu catchment is an active trekking area, with several tourists and locals passing through the catchment and intake areas on a daily basis;
- There are no residential, commercial or industrial establishments upstream of the intake;
- There is extensive taro cultivation upstream and animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;
- Kids have historically used this small dam as a swimming hole, but this has been actively discouraged through community policing and warning signage.

Storage & Treatment

- There is an in-stream rapid filter (39m^2), which removes coarse sediment and organic matter
- Within the filter-media at certain depth are four (4) 200mm diameter uPVC pipes which is perforate half the diameter. These pipes convey the water from the filter-media into the holding chamber.
- From the holding chamber the water under gravity flows through a trunk-main into the pipeline network.
- There is no storage facility in Avatiu.

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households connects their holding tanks to the reticulation system to store reticulated water

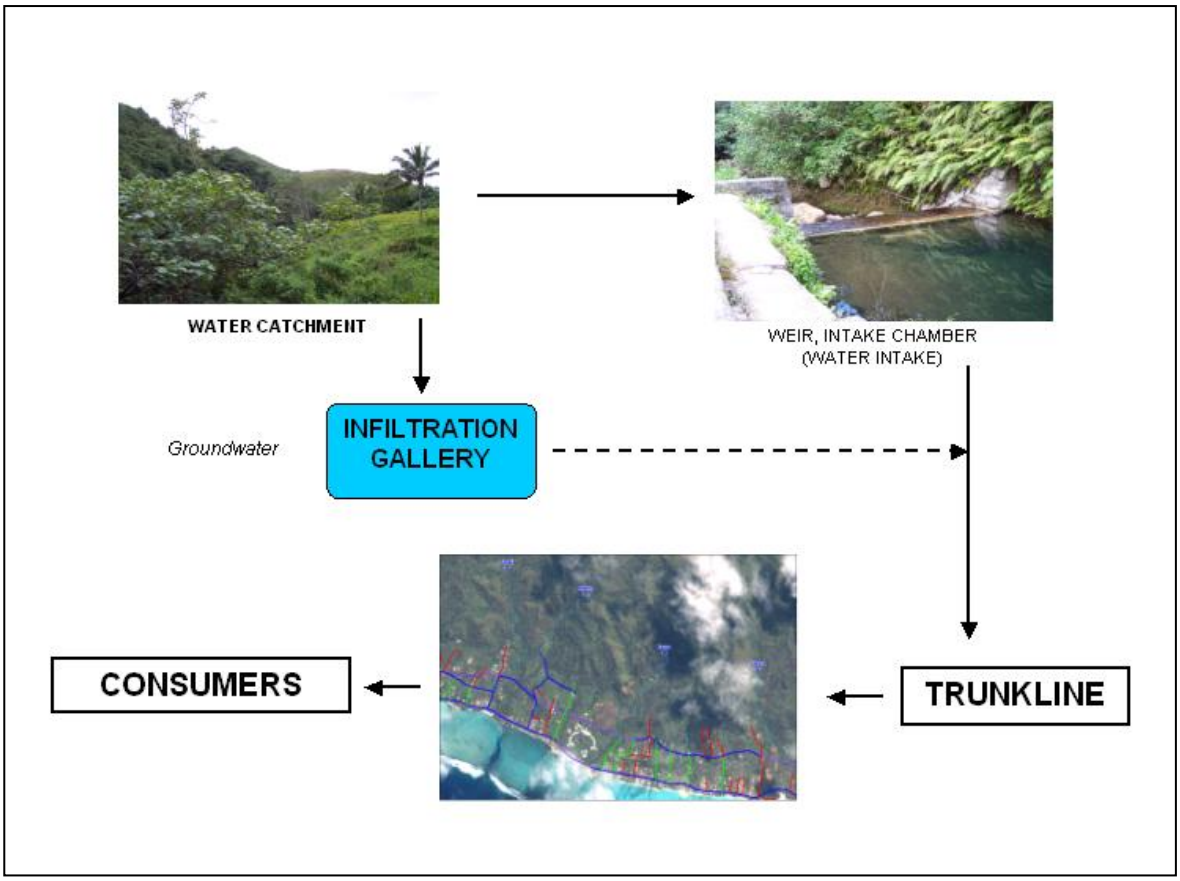


Figure 5: Schematic for Avatiu Intake

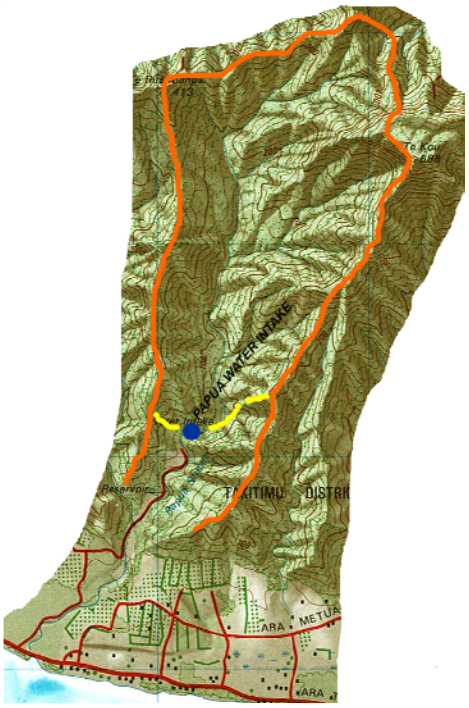
Feature	
Catchments area – ha	135
In-stream filter bed area – m^2	39
Intake pipes	
• Diameter (ID), mm	200
• Material	uPVC
Concrete weir	Yes
Holding chamber volume – m^3	
Infiltration Gallery	Yes
Trunkline	
• Diameter (ID), mm	150
• Material	Asbestos

Papua Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	49 m above sea-level
Production:	2000 m^3/day	**Date of Commission:**	1965

Catchment & Intake Description

- Located on the Southern side of Rarotonga, the catchment covers approximately 163 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Papua catchment is an active trekking area, with several tourists and locals passing through the catchment ('cross-island trek') and intake areas on a daily basis;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;
- Locals and visitor use this small waterfall as a swimming pool.



Storage & Treatment

- There is no treatment or storage

Distribution

- Water is gravity fed into the distribution network
- The gallery system is not thought to be functioning.
- A 450,000 litres concrete tank exists as part of the system but it is presently isolated from the system until further investigation is carried out to determine the possibility of using this distribution tank to a provide water to nearby sector of the network.
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households connects their holding tanks to the reticulation system to store reticulated water

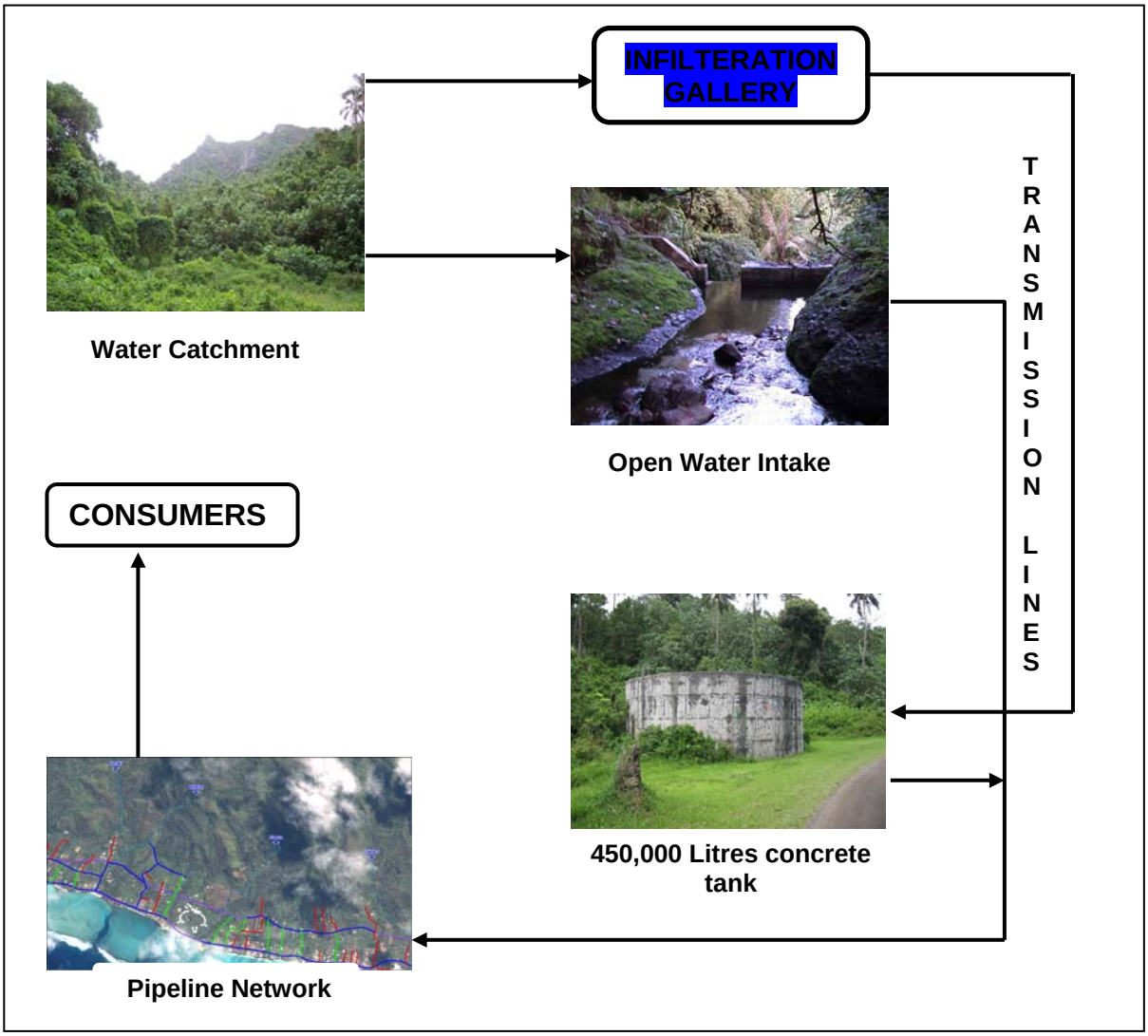


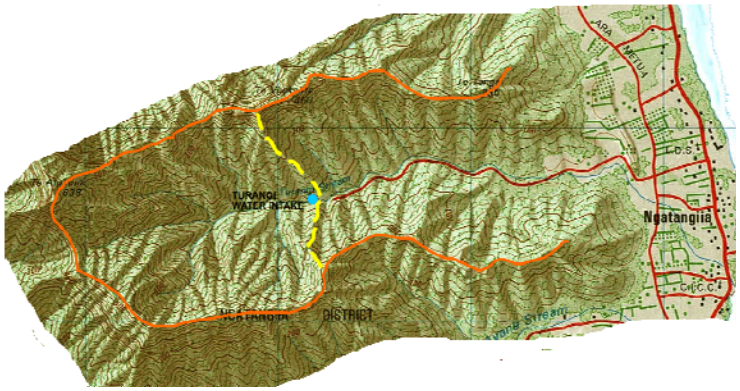
Figure 6: Schematic for Papua Intake

Feature	
Catchments area – ha	163
Intake pipes	
• Diameter (ID), mm	200
• Material	Steel
Concrete weir	Yes
Infiltration Gallery	Yes
Trunkline	
• Diameter (ID), mm	150
• Material	Asbestos, steel

Turangi Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	71.60 m above sea-level
Production:	3,680 m^3/day	**Date of Commission:**	1990

Catchment & Intake Description



- Located on the Eastern side of the island the catchment covers approximately 118 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Turangi catchment is not an active trekking area, with very minimal tourists and locals passing through the catchment and intake areas;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;

Storage & Treatment

- There is some in-stream filtration
- As the water enters the intake chamber, it passes through a coarse wire netting (mesh) which removes any remaining debris and large solids or suspended matter

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

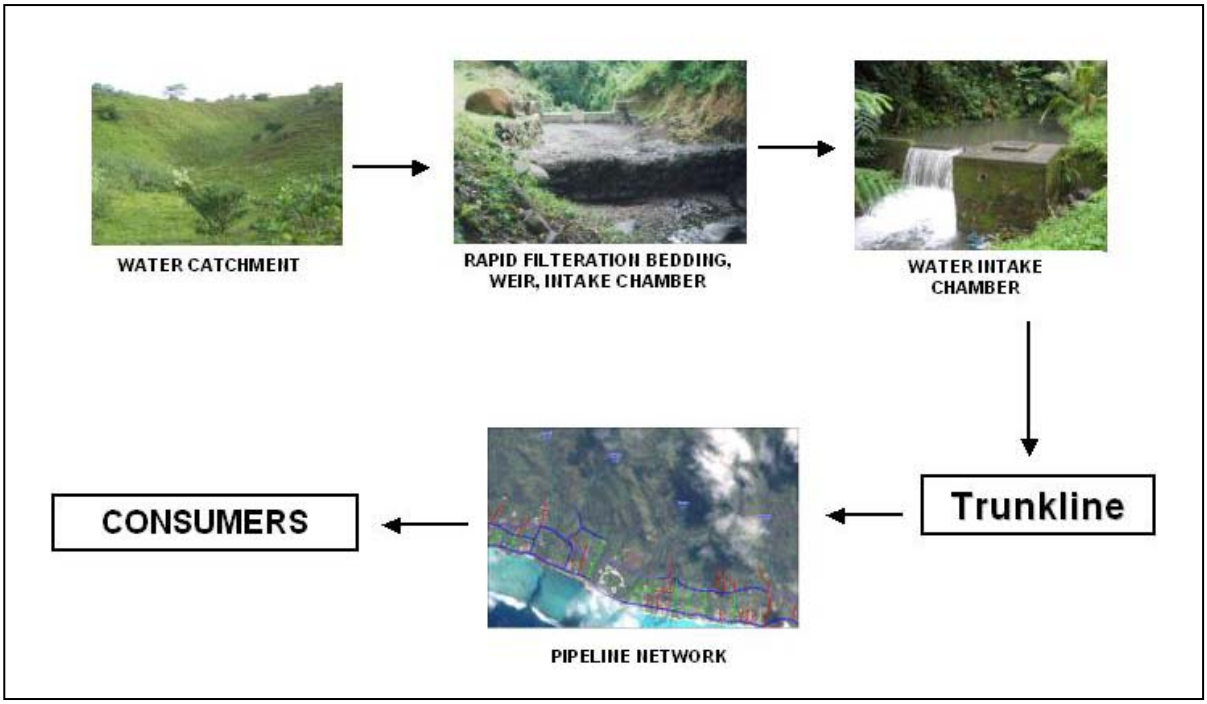


Figure 7: Schematic for Turangi Intake

Feature		Feature	
Catchment area (Ha)		*Trunkline*	
In-stream filter bed		• Diameter (ID), mm	200
Filter bed area – m^2		• Material	Mild Steel
Filter media	Crushed basalt	*Intake Lines*	
Concrete weir	Yes	• Number	4
Holding chamber – vol (m^3)	-	• Diameter (ID), mm	200
Flush out line		• Material	uPVC
• Diameter (ID), mm	200		
• Material	Mild steel		

Rutaki Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	51 m above mean sea-level
Max. Production:	1838 m^3/day	**Date Commissioned:**	1989

Catchment & Intake Description

- Located in the South west side of the island, the catchment covers approximately 109 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Rutaki catchment is not an active trekking area, with very few (if any) tourists and locals passing through the catchment and intake areas;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;

Storage & Treatment

- There is some in-stream rapid filtration, but no storage

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

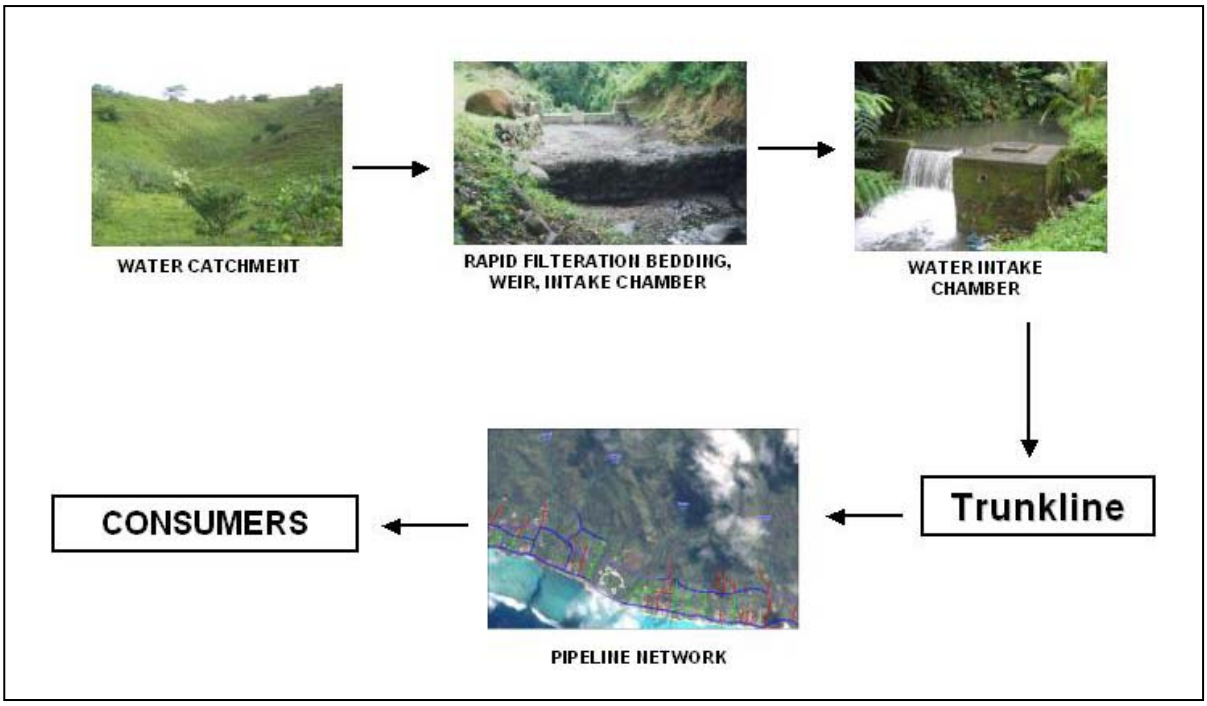


Figure 8: Schematic for Rutaki Intake

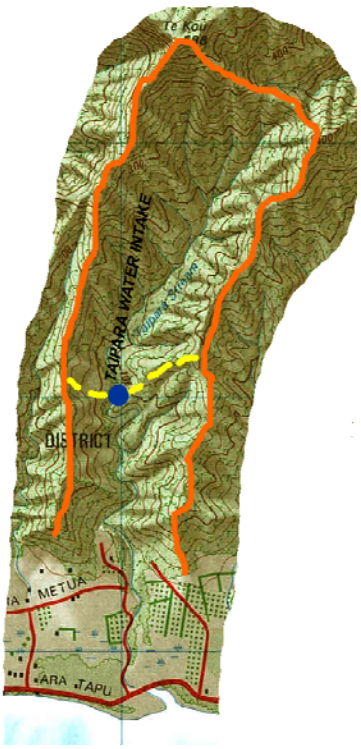
Feature		Feature	
Catchment area (Ha)	109	*Trunkline*	
Instream filter bed		• Diameter (mm)	150
Filter bed area – (m^2)	33	• Material	Mild steel
Filter media – Crushed basalt	Yes	*Intake Lines*	
Concrete weir	Yes	• Number	4
Holding chamber – vol (m^3)	-	• Diameter (mm)	200
Flush out line		• Material	uPVC
• Diameter (ID), mm	150		
• Material	Mild Steel		

Taipara Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	49.5 m above sea-level
Production:	2177 m^3/day	**Date Commissioned:**	1988

Catchment & Intake Description

- Located on the Southern side of the island, the catchment covers approximately 84.3 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Taipara catchment is not an active trekking area, with very few tourists and locals passing through the catchment and intake area;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;



Storage & Treatment

- There is some in-stream rapid filtration, but no storage

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

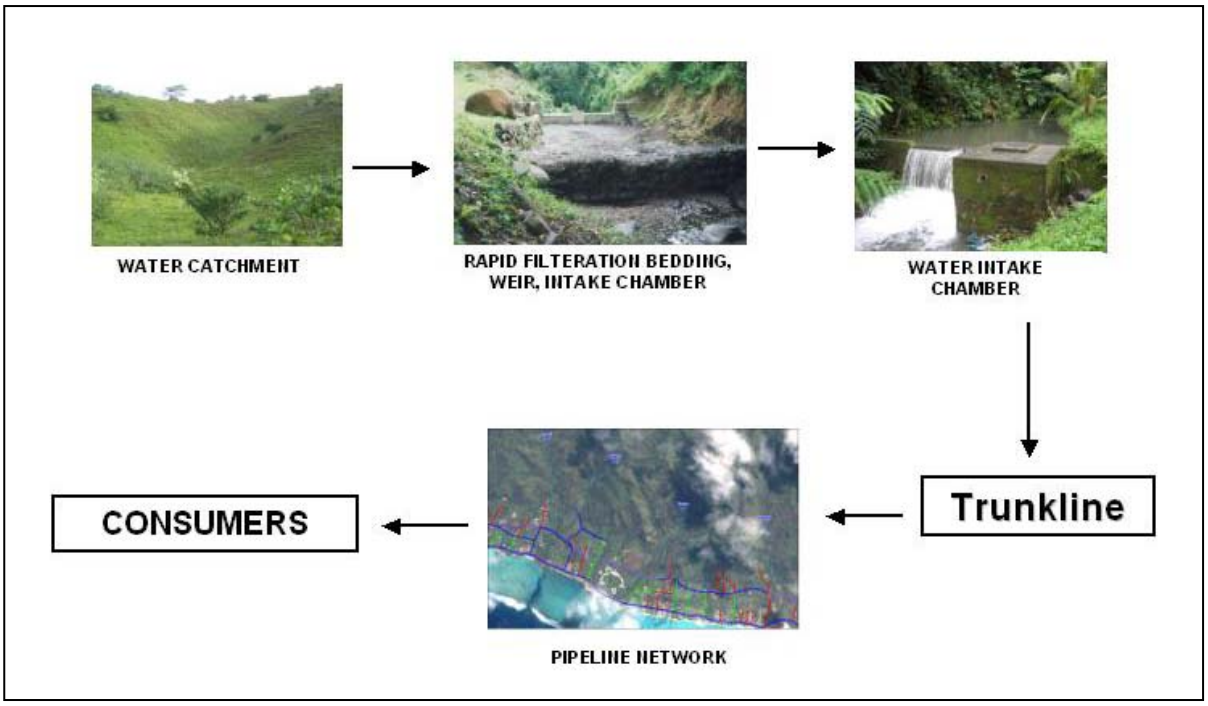


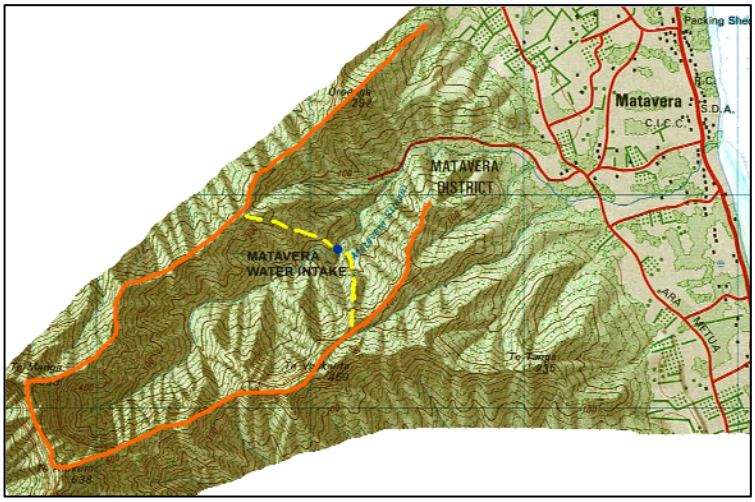
Figure 9: Schematic for Taipara Intake

Feature		Feature	
Catchment area (Ha)	84.3	*Trunkline*	
In-stream filter bed		• Diameter (mm)	200
Filter bed area (m^2)	31	• Material	Mild steel
Filter media – Crushed basalt	Yes	*Intake Lines*	
Concrete weir	Yes	• Number	4
Holding chamber – vol (m^3)	-	• Diameter (mm)	200
Flush out line		• Material	uPVC
• Diameter (mm)	200		
• Material	Mild Steel		

Matavera Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	65 m above sea-level
Max Production:	1369 m^3/day	**Date Commissioned:**	1992

Catchment & Intake Description



- Located on the Eastern side of the island the catchment covers approximately 83 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Matavera catchment is not an active trekking area, with very few tourists and locals passing through the catchment and intake area;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;

Storage & Treatment

- There is some off-stream filtration (45m^2) but no storage

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

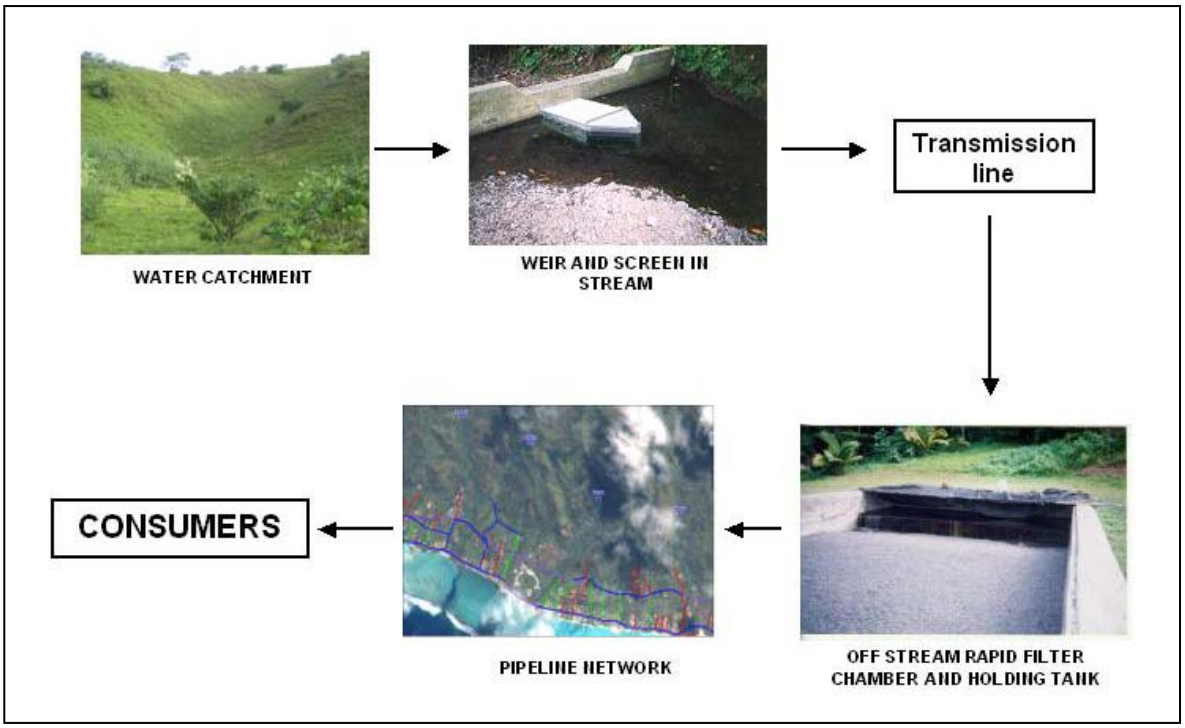


Figure 10: Schematic for Matavera Intake

Feature		Feature		Feature	
Catchment area (ha)	82.8	*Filter Media*		*Trunkline*	
Coarse screen	Yes	• Area – m^2		• Diameter (ID), mm	200
Concrete weir	Yes	• Material	Crushed basalt aggregate	• Material	uPVC
Transmission line		*Intake pipes*			
• Diameter (ID), mm	200	• Number	One		
• Material	Steel	• Diameter (ID), mm	200		
Filteration Chamber		• Material	uPVC		
• Volume – m^3		Holding Chamber – Vol (m^3)			

Ngatoe Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	65 m above sea-level
Production:	2000 m^3/day	**Date Commissioned:**	1993

Catchment & Intake Description

- Located on the South-western side of the island the catchment covers approximately 98 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Ngatoe catchment is not an active trekking area, with very few tourists and locals passing through the catchment and intake area;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;

Storage & Treatment

- There is some off-stream filtration (45m^2) but no storage

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

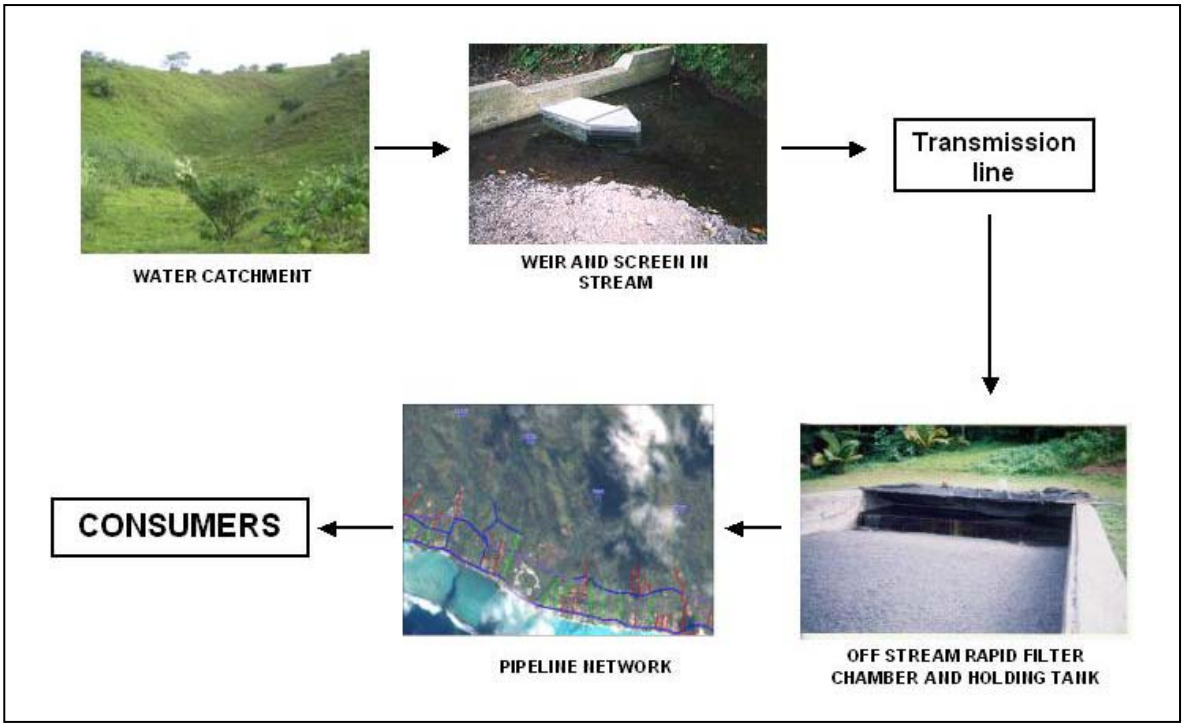


Figure 11: Schematic for Ngatoe Intake

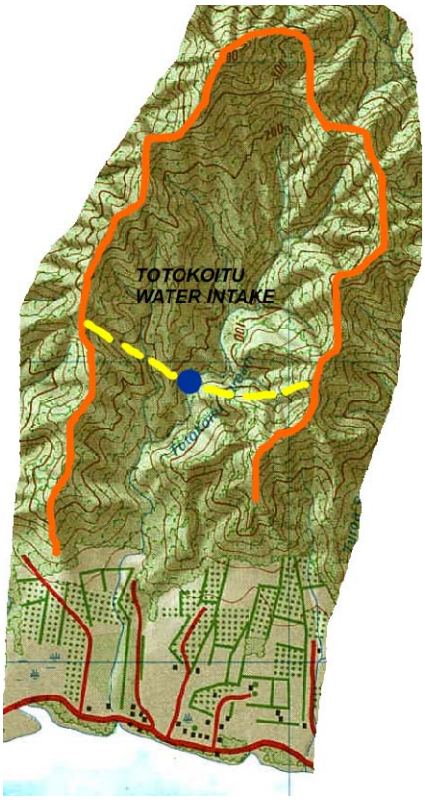
Feature		Feature		Feature	
Catchment area (ha)	98.10	*Filter Media*		*Trunkline*	
Coarse screen	Yes	• Area – m^2		• Diameter (ID), mm	200
Concrete weir	Yes	• Material	Crushed basalt aggregate	• Material	uPVC
Transmission line		*Intake pipes*			
• Diameter (ID), mm	200	• Number	0ne		
• Material	Steel	• Diameter (ID), mm	200		
Filteration Chamber		• Material	uPVC		
• Volume – m^3		Holding Chamber – Vol (m^3)			

Totokoitu Intake Water Safety Plan

Source:	Freshwater Stream	**Elevation:**	65 m above sea-level
Production:	1933 m^3/day	**Date Commissioned:**	1963

Catchment & Intake Description

- Located on the Southern side of the island, the catchment covers approximately 70 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Totokoitu catchment is not an active trekking area, with very few tourists and locals passing through the catchment and intake area;
- There are no residential, commercial or industrial establishments upstream to the intake;
- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;



Storage & Treatment

- There is screening using metal grates, but no storage

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

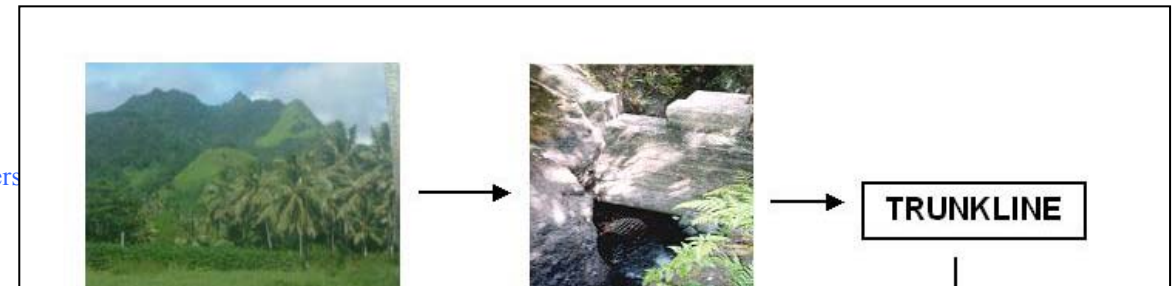


Figure 12: Schematic for Totokoitu Intake

Feature	
Catchment area (Ha)	
Coarse screen	
Concrete weir	
Flush out line	
• Diameter (mm)	
• Material	
Trunkline	
• Diameter (mm)	
• Material	

Muriavai Intake Water Safety Plan

Source:	Freshwater Stream

Elevation:	64 m above sea-level

Max Production:	760 m^3/day

Date Commissioned:	1967

Catchment & Intake Description

- Located on the Western side of the island the catchment covers approximately 144 hectares of forest, dense bush and tall grass;
- The intake is located in a valley surrounded by high, steep mountains;
- The Muriavai catchment is not an active trekking area, with very few tourists and locals passing through the catchment and intake area;
- There are no residential, commercial or industrial establishments upstream of the intake;

- Animals such as poultry, goats and pigs have access to the catchment and intake;
- This can have a potential effect on the water quality;

Storage & Treatment

- There is screening using metal grates, but no storage

Distribution

- Water is gravity fed into the distribution network
- Some Households supplement the reticulated supply with Rainwater Catchment
- Some Households also have holding tanks to store reticulated water

Ve

Figure 13: Schematic for Muriavai Intake

Feature	
Catchment area (Ha)	
Coarse screen	
Concrete weir	
Flush out line	
• Diameter (mm)	
• Material	
Trunkline	
• Diameter (mm)	
• Material	

WSP Risk Table Explanation

Risks have been identified and characterised into 3 aspects of the water supply:

- Source and catchment
- Treatment, storage and distribution
- Other (including staff and laboratory)

Risk Table 1 shows for each water supply component:

Item, Risk, Cause, Likelihood, Consequence, Priority and control measure in place.

Risk Table 2 shows for each water supply component:

Item, Risk, Cause, Likelihood, Consequence, Priority and critical limits (divided into target and trigger).

Risk Table 3 shows for each water supply component:

Item, Risk, Cause, Likelihood, Consequence, Priority and monitoring (divided into what, when and who).

Risk Table 4 shows for each water supply component:

Item, Risk, Cause, Likelihood, Consequence, Priority, corrective action and verification.

Further explanation included on the next page.

WSP Risk Table Key

Risk What the problem or issues with the water supply is

Cause What could cause the risk to be present

Likelihood Chance of the risk happening

Likelihood score	Possible Descriptions
Almost Certain	• Occurs like clockwork, Occurs every week, month, or season.
Likely	• Has occurred more than once before, Expected to occur every year.
Possible	• Has occurred before, Expected to occur every 2 – 5 years.
Unlikely	• Has never occurred before, but expected to occur every 5 - 10 years.
Rare	• Has never occurred before, and expected to occur less than once every 10 years.

Consequence Impact of the risk on people's health or the water supply system in general

Consequence score	Possible Descriptions
Insignificant	• No illness expected in the community, no impact on water supply system.
Minor	• Very few of the community ill, low impact on water supply system.
Moderate	• Some of the community ill, moderate impact on the water supply system
Major	• Most of the community ill., major impact on water supply system
Catastrophic	• All of the community ill, anticipate some deaths. Complete failure of water supply system

Priority Priority for improvement (based on the following table)

Likelihood	**Consequence**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	medium	high	Very high	Very high	Very high
Likely	medium	medium	high	Very high	Very high
Possible	very low	low	medium	Very high	Very high
Unlikely	very low	very low	low	high	Very high
Rare	very low	very low	low	high	high

Control measure in place Outlines what is currently in place to control risk

Critical Limit
Target Ultimate goal to control risk
Trigger When risk becomes a problem, early warning signs

Monitoring
What What to monitor to ensure control is in place and effective
When Frequency of monitoring
Who Which organisation will undertake monitoring actions

Corrective Action What needs to be done

Verification How you know when risk is controlled

Rarotonga Water Safety Plan risk tables:

Source and Catchment Risk Table 1

Item	Risk	Cause	Likelihood	Consequence	Priority	Control Measure in place
1	No water	Land issues	Likely	Major	Very high	Written agreement on supply assurance
2	No water	Streams drying out during drought	Possible	Major	Very High	Monitoring of rainfall and stream flows (trending). When flow <50% then initiate **SOP**.
3	Poor water quality (blocks off stream filters)	High sediment load from heavy rain	Likely	Major	Very High	Some sedimentation tanks, cleaning of off stream filters **(SOP)**
4	Poor water quality	High sediment load from heavy rain	Likely	Major	Very High	Takuvaine has catchment management plan (catchment zoning)
5	Chemical contamination of water	Chemicals used in catchment	Possible	Minor	High	Takuvaine has catchment management plan (catchment zoning), unknown chemical use in other catchments
6	Blocked intakes	Sediment and gravel blocks intakes	Likely	Major	Very High	Inspection and cleaning of intakes after heavy rain **(SOP)**
7	Poor water quality or damage to structures	Human activities in catchments	Likely	Major	Very High	Water Works ordinance, catchment management plan enforced (Takuvaine only)
8	Damage to infrastructure, pipe breakage, intake damage	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Contingency plans and **SOP's** in place. (Some pipes made of metal where cross stream so when knocked off they can easily be put back on)
9	Unable to access intakes after extreme weather event	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Clear tracks to intakes asap after extreme weather event. (SOP for access track clearing)

Source and Catchment Risk Table 2

Item	Risk	Cause	Likelihood	Consequence	Priority	Critical limit	
						Target	Trigger
1	No water	Land issues	Likely	Major	Very high	Access to water source	Water source / intake access is blocked
2	No water	Streams drying out during drought	Possible	Major	Very High	Stream flow is sufficient	Stream flow insufficient (<50%)
3	Poor water quality (blocks off stream filters)	High sediment load from heavy rain	Likely	Major	Very High	Turbidity? Filter not blocked	Turbidity exceeds standard Algae and silt
4	Poor water quality	High sediment load from heavy rain	Likely	Major	Very High	Turbidity?	Turbidity exceeds standard, intakes blocked
5	Chemical contaminatio n of water	Chemicals used in catchment	Possible	Minor	High	Chemical levels comply with WHO standards	Chemical levels do not comply with WHO standards
6	Blocked intakes	Sediment and gravel blocks intakes	Likely	Major	Very High	Intakes functioning	Intakes blocked or not functioning
7	Poor water quality or damage to structures	Human activities in catchments	Likely	Major	Very High	Controlled access to catchment	Uncontrolled access
8	Damage to infrastructur e, pipe breakage, intake damage	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Mitigation efforts identified for quick recovery of system from extreme weather damage	Mitigation efforts not in place
9	Unable to access intakes after extreme weather event	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Intakes accessible	Intakes inaccessible

Source and Catchment Risk Table 3

Item	Risk	Cause	Likelihood	Consequence	Priority	Monitoring		
						What?	When?	Who?
1	No water	Land issues	Likely	Major	Very high	Catchment Management plan agreement	Annually	DWW Management
2	No water	Streams drying out during drought	Possible	Major	Very High	Stream flows	Biweekly monitoring and bi-monthly analysis	DWW and Met office
3	Poor water quality (blocks off stream filters)	High sediment load from heavy rain	Likely	Major	Very High	Turbidity and visual inspection	Monthly? Weekly	DWW?
4	Poor water quality	High sediment load from heavy rain	Likely	Major	Very High	Turbidity and visual inspection Stream flows	Weekly	DWW? NES
5	Chemical contaminatio n of water	Chemicals used in catchment	Possible	Minor	High	Chemical use in catchments	During catchment inspection	DWW? NES Agriculture
6	Blocked intakes	Sediment and gravel blocks intakes	Likely	Major	Very High	Visual inspection of intakes, high rainfall, no water complaints	3 times per week and after heavy rain	DWW
7	Poor water quality or damage to structures	Human activities in catchments	Likely	Major	Very High	Visual inspection of structures. Tourist activities monitored	3 times per week and after heavy rain.	DWW
8	Damage to infrastructur e, pipe breakage, intake damage	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Mitigation Plan (based on experiences from the past). Weather patterns	Based on climatic patterns.	DWW, Met Office, Emergency Office and Cabinet
9	Unable to access intakes after extreme weather event	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Stream flows, weather patterns and access to intakes	Based on climatic, weather patterns, past history	DWW, Met Office

Source and Catchment Risk Table 4

Item	Risk	Cause	Likelihood	Consequence	Priority	Corrective Action	Verification
1	No water	Land issues	Likely	Major	Very high	Consultation process initiated, strengthen partnerships with landowners	Water source / intake is readily available
2	No water	Streams drying out during drought	Possible	Major	Very High	Investigate feasibility of groundwater abstraction. Public advisory. Increased storage	Stream flow is sufficient
3	Poor water quality (blocks off stream filters)	High sediment load from heavy rain	Likely	Major	Very High	Increased storage an shut off intake	Turbidity complies with standard, filters are clear of algae and silt
4	Poor water quality	High sediment load from heavy rain	Likely	Major	Very High	Increased storage and shut off intake	Turbidity complies with standard and intakes clear
5	Chemical contamination of water	Chemicals used in catchment	Possible	Minor	High	Catchment inspections. Advice to landowners on chemical use in catchments above intakes.	Chemical levels comply with standard, chemicals used appropriately in catchment.
6	Blocked intakes	Sediment and gravel blocks intakes	Likely	Major	Very High	Intake modification investigations. Increased storage investigation	Intake not blocking or intake cleared ASAP
7	Poor water quality or damage to structures	Human activities in catchments	Likely	Major	Very High	Enforcement of Water Works Ordinance and replication of Takuvaine catchment management plan. Investigate new legislation (IWRM Act?). Advice to tourist operators. Signage improved. Better understanding of risks.	Controlled tourist activities. Signage present. Catchment management plan in place.
8	Damage to infrastructure, pipe breakage, intake damage	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Assessment and review of mitigation / contingency plan, liaison with Emergency office.	Mitigation Plan effective
9	Unable to access intakes after extreme weather event	Effects of cyclone, hurricane and extreme weather events.	Likely	Major	Very High	Improve access to intakes where possible.	Intakes accessible after extreme weather event, access cleared ASAP

Treatment, Storage and Distribution Risk Table 1

Item	Risk	Cause	Likelihood	Consequence	Priority	Control Measure in place
10	Poor water quality in distribution zone	Increased turbidity and runoff after heavy rain	Likely	Major	Very high	Sedimentation tanks in place for Takuvaine & Papua. Hospital, tourist resorts and licensed premises have own treatment
11	Poor water quality in distribution zone	Increased due to low flow	Likely	Moderate	High	As above
12	Poor water quality in distribution zone	Microbiological contaminants not removed as no treatment	Likely	Major	Very High	Arkal filter reduces microbes (1 intake) sedimentation tanks reduces microbes (2 intakes)
13	Poor water quality in distribution zone	Failure of treatment due to high turbidity water from storage tanks	Likely	Major	Very High	Sectorising the network (configuration into an area and flush). SOP for flushing?
14	Pathogens in water supply	Contaminated water, lack of effective treatment	Likely	Major	Very High	Testing for E-coli, Collaboration with Ministry of Health (disease stats) possibly a MOU
15	Suspended particles not removed from water	Not sufficient time in tanks, lack of tanks, insufficient particle removal.	Likely	Major	Very High	Some tanks and Arkal filter present but may not be sufficient to remove suspended particles.
16	Poor water quality	Secondary contamination of the network	Likely	Major	Very High	Non-return valves in domestic and agriculture connections (non-return valves only on domestic where upgraded)
17	Poor water quality	Secondary contamination after repair works on the mains	Likely	Major	Very High	(Ensure all efforts were made to control secondary contamination) **SOP**
18	Low pressure / flow	High demand, weak network, leakage	Lilkey	Major	Very High	Water meters, pressure loggers (water demand management), 70% complete of network
19	Disruption to flow	Damage to pipeline network from earthworks, uncontrolled civil works	Likely	Major	Very High	Database mapping of network. Inform DWW of intended civil works at least 24 hours in advance
20	Disruption to flow	Damage to pipeline network from natural hazards	Likely	Major	Very High	Contingency plan? Emergency Plan
21	Pump failure	Lack of maintenance, power supply, age	Possible	Moderate	Medium	Regular checks of pumps when manually switched on/off

Treatment, Storage and Distribution Risk Table 2

Item	Risk	Cause	Likelihood	Consequence	Priority	Critical limit	
						Target	Trigger
10	Poor water quality in distribution zone	Increased turbidity and runoff after heavy rain	Likely	Major	Very high	Turbidity meets standard. Reference: WHO standard	Turbidity exceeds standard
11	Poor water quality in distribution zone	Increased due to low flow	Likely	Moderate	High		
12	Poor water quality in distribution zone	Microbiological contaminants not removed as no treatment	Likely	Major	Very High	Faecal coliforms <10 (WHO standard)	Faecal coliforms >10
13	Poor water quality in distribution zone	Failure of treatment due to high turbidity water from storage tanks	Likely	Major	Very High	Low turbidity	Elevated turbidity
14	Pathogens in water supply	Contaminated water, lack of effective treatment	Likely	Major	Very High	Report of tests are available: No reported cases of any pathogens	Case of water borne disease (inform DWW if suspected cause is drinking water)
15	Suspended particles not removed from water	Not sufficient time in tanks, lack of tanks, insufficient particle removal.	Likely	Major	Very High	TSS, turbidity (WHO)	TSS and /or turbidity exceeds standard
16	Poor water quality	Secondary contamination of the network	Likely	Major	Very High	Secondary contamination is controlled	Consumer complaints
17	Poor water quality	Secondary contamination after repair works on the mains	Likely	Major	Very High	Quality of repair works conforms to standard repair procedures ./ checklist	
18	Low pressure / flow	High demand, weak network, leakage	Lilkey	Major	Very High	Balanced system (normal pressure and flow) No consumer complaints	Pressure and / or flow drop, consumer complaints
19	Disruption to flow	Damage to pipeline network from earthworks, uncontrolled civil works	Likely	Major	Very High	Controlled works	Consumer complaints, disruption to water supply
20	Disruption to flow	Damage to pipeline network from natural hazards	Likely	Major	Very High	Reduced vulnerability and continuous flow	Disrupted flow
21	**Pump failure**	**Lack of maintenance, power supply, age**	**Possible**	**Moderate**	**Medium**	**Pumps operating satisfactorily**	**Pumps not working**

Treatment, Storage and Distribution Risk Table 3

Item	Risk	Cause	Likelihood	Consequence	Priority	Monitoring		
						What?	When?	Who?
10	Poor water quality in distribution zone	Increased turbidity and runoff after heavy rain	Likely	Major	Very high	Turbidity Treatment systems for Hospital, tourist resorts and Licensed premises operating satisfactorily.	Monthly? Annually?	DWW MoH
11	Poor water quality in distribution zone	Increased due to low flow	Likely	Moderate	High			
12	Poor water quality in distribution zone	Microbiological contaminants not removed as no treatment	Likely	Major	Very High	Faecal coliforms	Monthly	DWW MoH?
13	Poor water quality in distribution zone	Failure of treatment due to high turbidity water from storage tanks	Likely	Major	Very High	Turbidity	Ongoing	DWW
14	Pathogens in water supply	Contaminated water, lack of effective treatment	Likely	Major	Very High	Cases of illness which may be caused by water borne diseases	Ongoing	MoH in collaboration with DWW
15	Suspended particles not removed from water	Not sufficient time in tanks, lack of tanks, insufficient particle removal.	Likely	Major	Very High	TSS, turbidity	Monthly	DWW
16	Poor water quality	Secondary contamination of the network	Likely	Major	Very High	Complaints	Ongoing	DWW, MoH
17	Poor water quality	Secondary contamination after repair works on the mains	Likely	Major	Very High	Recurrence (failure if repair works)	After repair works	DWW
18	Low pressure / flow	High demand, weak network, leakage	Likely	Major	Very High	Flow, pressure Consumer complaints	Ongoing	DWW
19	Disruption to flow	Damage to pipeline network from earthworks, uncontrolled civil works	Likely	Major	Very High	Consumer complaints	Ongoing	DWW
20	Disruption to flow	Damage to pipeline network from natural	Likely	Major	Very High	Indicators for natural hazards	Ongoing	Met Office, Emergency

		hazards						Office, DWW
21	**Pump failure**	**Lack of maintenance, power supply, age**	**Possible**	**Moderate**	**Medium**	**Pump hours, energy consumption**	**??**	**DWW Ops staff**

Treatment, Storage and Distribution Risk Table 4

Item	Risk	Cause	Likelihood	Consequence	Priority	Corrective Action	Verification
10	Poor water quality in distribution zone	Increased turbidity and runoff after heavy rain	Likely	Major	Very high	Investigation into continuous turbidity meters at each intake. Investigation into additional settling tanks at each intake which may allow for shutting off intakes (Tukevaine & Papua have them). Promote rainwater harvesting use to public. Regular system for inspection / audit of treatment facilities for hospital, Tourist resorts and Licensed premises.	Turbidity in distribution zone complies with standard. No complaints from the public. Hospital, Tourist resorts and Licensed premises treatment systems operating satisfactorily.
11	Poor water quality in distribution zone	Increased due to low flow	Likely	Moderate	High	As above	
12	Poor water quality in distribution zone	Microbiological contaminants not removed as no treatment	Likely	Major	Very High	Investigate filtering options to reduce coliforms. Investigate sedimentation tanks for all intakes. Investigate other treatment options if filtration not sufficient.	Effective treatment processes installed and faecal coliforms comply with standard.
13	Poor water quality in distribution zone	Failure of treatment due to high turbidity water from storage tanks	Likely	Major	Very High	Investigate primary and secondary tanks with control mechanisms. Supplement source from the network. Demand Management?	Turbidity, optimal treatment
14	Pathogens in water supply	Contaminated water, lack of effective treatment	Likely	Major	Very High	Contingency plan. Consider testing water supply for pathogens if supply implicated.	Contingency plan in place, no water borne disease.
15	Suspended particles not removed from water	Not sufficient time in tanks, lack of tanks, insufficient particle removal.	Likely	Major	Very High	Investigate filtering options to reduce suspended particles. Investigate sedimentation tanks for all intakes, can they remove	TSS, turbidity or effective treatment processes installed.

						suspended particles?	
16	Poor water quality	Secondary contamination of the network	Likely	Major	Very High	Remedy Plan for network. Backflow prevention (high risk areas) identified eg. Resorts, manufactures, industry.	No complaints, high risk areas have backflow installed and monitored. Health care
17	Poor water quality	Secondary contamination after repair works on the mains	Likely	Major	Very High	Quality control on repairs (create checklist and inspection guidelines) Training refresher courses on standard procedures	Quality of repair works meets standard and no secondary contamination
18	Low pressure / flow	High demand, weak network, leakage	Lilkey	Major	Very High	Water Demand Management Plan and completion of network upgrade	Balanced system and no low pressure complaints. Network upgrade fully complete.
19	Disruption to flow	Damage to pipeline network from earthworks, uncontrolled civil works	Likely	Major	Very High	Application forms, public awareness on uncontrolled activities	Continuous flow, DWW notified of all actions which may effect water supply
20	Disruption to flow	Damage to pipeline network from natural hazards	Likely	Major	Very High	Contingency Plan recorded, Emergency Plan	Continuous flow after an event, prompt repair after event
21	**Pump failure**	**Lack of maintenance, power supply, age**	**Possible**	**Moderate**	**Medium**	**Pump maintenance and inspection programme. Spare pumps and parts. Service agreement**	**Pumps operating ok. Maintenance identifies any problems**

Other Risk Table 1

Item	Risk	Cause	Likelihood	Consequence	Priority	Control Measure in place
22	Contamination of samples	Sampling procedure	Likely	Moderate	High	Two staff can undertake sampling
23	Samples not taken	Not enough staff	Likely	Moderate	High	Two staff can undertake sampling
24	Samples not Analysed	Not enough trained staff and inadequate laboratory facilities	Likely	Moderate	High	One staff member can do analysis. DWW has small area set aside for sample analysis, although not a proper lab.
25	Work not done	Staff motivation, training and supervision	Likely	Major	Very High	Foreman supervises work

Other Risk Table 2

Item	Risk	Cause	Likelihood	Consequence	Priority	Critical limit	
						Target	Trigger
22	Contamination of samples	Sampling procedure	Likely	Moderate	High	No contaminated samples	Unusual results
23	Samples not taken	Not enough staff	Likely	Moderate	High	Enough trained staff to undertake sampling	Cannot take samples, frequency of sampling not followed.
24	Samples not Analysed	Not enough trained staff and inadequate laboratory facilities	Likely	Moderate	High	All samples analysed within timeframes. Enough and appropriate laboratory space and facilities.	Samples not analysed within timeframes. Lab space not allowing timely analysis of samples.
25	Work not done	Staff motivation, training and supervision	Likely	Major	Very High	All work requested by Director of DWW done in a timely manner	Work not done within requested timeframes.

Other Risk Table 3

Item	Risk	Cause	Likelihood	Consequence	Priority	Monitoring		
						What?	When?	Who?
22	Contamination of samples	Sampling procedure	Likely	Moderate	High	Sample results	Ongoing	DWW
23	Samples not taken	Not enough staff	Likely	Moderate	High	Sample frequency adhered to	Ongoing	DWW
24	Samples not Analysed	Not enough trained staff and inadequate laboratory facilities	Likely	Moderate	High	Samples analysed. Lab space and facilities appropriate	Ongoing	DWW
25	Work not done	Staff motivation, training and supervision	Likely	Major	Very High	Quality and quantity of work completed	Ongoing	Director DWW

Treatment, Storage and Distribution Risk Table 4

Item	Risk	Cause	Likelihood	Consequence	Priority	Corrective Action	Verification
22	Contamination of samples	Sampling procedure	Likely	Moderate	High	Training of additional sampling staff. SOP's for sample taking. Additional sampling equipment.	Appropriate sampling technique. No contaminated samples.
23	Samples not taken	Not enough staff	Likely	Moderate	High	Training of additional sampling staff. SOP's for sample taking. Additional sampling equipment.	Sample frequency adhered to and enough trained staff to take samples
24	Samples not Analysed	Not enough trained staff and inadequate laboratory facilities	Likely	Moderate	High	Additional Staff trained on sample analysis. SOP's for sample analysis New Laboratory space	All samples analysed in agreed timeframes. Additional staff trained. Appropriate laboratory space identified and implemented.
25	Work not done	Staff motivation, training and supervision	Likely	Major	Very High	Job sheets for activities. DWW database	Work done, job sheets used and audited.

WSP Improvement Schedule Table Key

Improvement List or break down of activities that need to be done as identified by the corrective action

Responsible Agency responsible for undertaking the improvement

Rarotonga Water Safety Plan Improvement Schedule:

Source and Catchment Improvement Schedule

Risk	Cause	Priority	Control Measure in place	Corrective Action	Improvement	Responsible
No water	Land issues	Very high	Written agreement on supply assurance	Consultation process initiated, strengthen partnerships with landowners	1. Strengthen partnerships with landowners	DWW, NES
No water	Streams drying out during drought	Very High	Monitoring of rainfall and stream flows (trending). When flow <50% then initiate **SOP**.	Investigate feasibility of groundwater abstraction. Public advisory to conserve water. Investigate increased storage	2. Investigate feasibility of groundwater abstraction. 3. Public advisory to conserve water. 4. Investigate increased storage 5. Written Standard Operating procedure when stream flows <50% of normal.	DWW DWW, NES, Agriculture DWW DWW, MoH
Poor water quality (blocks off stream filters)	High sediment load from heavy rain	Very High	Some sedimentation tanks, cleaning of off stream filters **(SOP)**	Increased storage an shut off intake	4. Investigate increased storage, to allow for shut off of intake. 6. Written Standard Operating Procedure for cleaning of off stream filters. Investigate use of air compressor and modification of filtration system	DWW DWW
Poor water quality	High sediment load from heavy rain	Very High	Takuvaine has catchment management plan (catchment zoning)	Catchment inspections. Increased storage and shut off intake	7. Conduct catchment inspections 4. Investigate increased storage, to allow for shut off of intake.	DWW, NES DWW
Chemical contamination of water	Chemicals used in catchment	High	Takuvaine has catchment management plan (catchment zoning), unknown chemical use in other catchments	Catchment Inspections. Advice to landowners on chemical use in catchments above intakes.	7. Conduct catchment inspections 8. Advice to landowners on chemical use in catchments above intakes.	DWW, NES, Agriculture DWW, NES, MoA
Risk	**Cause**	**Priority**		**Corrective Action**	**Improvement**	**Responsible**

			Control Measure in place			
Blocked intakes	Sediment and gravel blocks intakes	Very High	Inspection and cleaning of intakes after heavy rain (SOP)	Intake modification investigations. Increased storage investigation	10. Intake modification investigations 4. Investigate increased storage, to allow for shut off of intake 11. Written Standard Operating procedure for inspection and cleaning of intakes	DWW DWW DWW
Poor water quality or damage to structures	Human activities in catchments	Very High	Water Works ordinance, catchment management plan enforced (Takuvaine only)	Enforcement of Water Works Ordinance. Investigate new legislation (IWRM Act?) Advice to tourist operators. Signage improved. Better understanding of risks. Replication of Takuvaine Catchment Management Plan	12. Enforcement of Water Works Ordinance. Investigate new legislation (IWRM Act) 13. Advice to tourist operators 14. Signage improved 14a. Investigation of Catchment Management Plan	DWW, NES DWW, NES, TA DWW, NES DWW, NES
Damage to infrastructure, pipe breakage, intake damage	Effects of cyclone, hurricane and extreme weather events.	Very High	Contingency plans and SOP's in place. (Some pipes made of metal where cross stream so when knocked off they can easily be put back on). Emergency Plan	Assessment and review of mitigation / contingency plan and liaison with Emergency office and cabinet	15. Written contingency plans and Standard Operating procedures for repair of broken infrastructure. Liaison with Emergency office	DWW, EO
Unable to access intakes after extreme weather event	Effects of cyclone, hurricane and extreme weather events.	Very High	Clear tracks to intakes asap after extreme weather event. (SOP for access track clearing)	Improve access to intakes where possible.	16. Improve access to intakes where possible 17. Written Standard Operating procedure for access track clearing.	DWW DWW

Treatment, Storage and Distribution Improvement Schedule

Risk	Cause	Priority	Control Measure in place	Corrective Action	Improvement	Responsible
Poor water quality in distribution zone	Increased turbidity and runoff after heavy rain	Very high	Sedimentation tanks in place for Tukevaine & Papua. Hospital, tourist resorts and licensed premises have own treatment	Investigation into continuous turbidity meters at each intake. Investigation into additional settling tanks at each intake which may allow for shutting off intakes (Tukevaine & Papua have them). Promote rainwater harvesting use to public. Regular system for inspection / audit of treatment facilities for hospital, Tourist resorts and Licensed premises.	18. Investigation into continuous turbidity meters at each intake. 4. Investigate increased storage, to allow for shut off of intake. 19. Promote rainwater harvesting use to public 20. Develop regular system for inspection / audit of treatment facilities for hospital, Tourist resorts and Licensed premises.	DWW DWW DWW, MoH, NES MoH
Poor water quality in distribution zone	Increased due to low flow	High	As above	As above	As above	
Poor water quality in distribution zone	Microbiological contaminants not removed as no treatment	Very High	Arkal filter reduces microbes (1 intake) sedimentation tanks reduces microbes (2 intakes)	Investigate filtering options to reduce coliforms. Investigate sedimentation tanks for all intakes. Investigate other treatment options if filtration not sufficient.	21. Investigate filtering options to reduce coliforms. 4. Investigate increased storage, to allow for shut off of intake 22. Investigate other treatment options if filtration not sufficient, such as disinfection.	DWW DWW DWW
Poor water quality in distribution zone	Failure of treatment due to high turbidity water from storage tanks	Very High	Sectorising the network (configuration into an area and flush). SOP for flushing.	Investigate primary and secondary tanks with control mechanisms. Supplement source from the network. Water Demand Management	23. Investigate primary and secondary tanks with control mechanisms. 24. Consider supplementing source from the network 25. Written Standard Operating Procedure for flushing of distribution zone.	DWW DWW DWW

Risk	Cause	Priority		Corrective Action	Improvement	Responsible

			Control Measure in place			
Pathogens in water supply	Contaminated water, lack of effective treatment	Very High	Periodic tests for E-coli. Collaboration with Ministry of Health (disease stats) possibly a MOU	Contingency plan. Consider testing water supply for pathogens if supply implicated.	26. Written contingency plan for detection of pathogens in water supply. 27. Consider testing water supply for pathogens if supply implicated	DWW, MoH DWW, MoH
Suspended particles not removed from water	Not sufficient time in tanks, lack of tanks, insufficient particle removal.	Very High	Some tanks and Arkal filter present but may not be sufficient to remove suspended particles.	Investigate filtering options to reduce suspended particles. Investigate sedimentation tanks for all intakes, can they remove suspended particles	28. Investigate filtering options to reduce suspended particles. 4. Investigate increased storage, to allow for shut off of intake (can they remove suspended particles?)	DWW, MoH DWW
Poor water quality	Secondary contamination of the network	Very High	Non-return valves in domestic and agriculture connections. Domestic completed in upgraded areas.	Remedy Plan for network. Backflow prevention (high risk areas) identified eg. Resorts, manufactures, industry. Health care.	29. Develop Remedy Plan for network. 30. Identify high risk backflow areas and encourage backflow devices where appropriate.	DWW DWW. MoH
Poor water quality	Secondary contamination after repair works on the mains	Very High	(Ensure all efforts were made to control secondary contamination). SOP	Quality control on repairs (create checklist and inspection guidelines) Training refresher courses on standard procedures	31. Create checklist and inspection guidelines for repair work on mains. (SOP) 32. Look into training refresher courses on standard procedures.	DWW, MoH DWW
Low pressure / flow	High demand, weak network	Very High	Water meters, pressure loggers, Water Demand Management Plan	Water Demand Management Plan and completion of network upgrade	33. Instigate Water Demand Management Plan 33a. Complete network upgrade 33b. Leak detection surveys	DWW
Disruption to flow	Damage to pipeline network from earthworks, uncontrolled civil works	Very High	Database mapping of network. Inform DWW of intended civil works at least 24 hours in advance	Application forms, public awareness on uncontrolled activities	34. Create application forms for civil works near water main and make available. 35. Public awareness on activities which may effect water mains	DWW DWW

Risk	Cause	Priority	Control Measure in place	Corrective Action	Improvement	Responsible
Disruption to flow	Damage to pipeline network from natural hazards	Very High	Emergency Plan	Emergency Plan recorded	36. Ensure Emergency plan developed for natural hazards and link into Ministry of Works disaster plan.	DWW, MoW
Pump failure	Lack of maintenance, power supply, age	Medium	Regular checks of pumps when manually switched on/off	Pump maintenance and inspection programme. Spare pumps and parts. Service agreement	37. Create inspection and maintenance programme. (SOP) 37a. Purchase spare parts and backup pump with service agreement.	DWW, MoW DWW, MoW

Other Improvement Schedule

Risk	Cause	Priority	Control Measure in place	Corrective Action	Improvement	Responsible
Contamination of samples	Sampling procedure	High	Two staff can undertake sampling	Training of additional sampling staff. SOP's for sample taking. Additional sampling equipment.	38. Train additional staff on sampling technique. 39. SOP for sampling. 40. Get additional sampling equipment.	DWW -NZDWA DWW -NZDWA DWW
Samples not taken	Not enough staff	High	Two staff can undertake sampling	Training of additional sampling staff. SOP's for sample taking. Additional sampling equipment.	38. Train additional staff on sampling technique.	DWW
Samples not Analysed	Not enough trained staff and inadequate laboratory facilities	High	One staff member can do analysis. DWW has small area set aside for sample analysis, although not a proper lab.	Additional Staff trained on sample analysis. SOP's for sample analysis New Laboratory space	41. Train additional staff on sample analysis. 42. SOP's for sample analysis. 43. Investigate and get new lab.	DWW DWW DWW/MoW
Work not done	Staff motivation, training and supervision	Very High	Foreman supervises work	Job sheets for activities. DWW database	44. Create job sheets for DWW operations staff activities. 45. DWW database	DWW DWW

WSP Improvement Summary Table Key

Improvement	List or break down of activities that need to be done as identified by the corrective action
Improvement Schedule Activity	Identifies whether improvement is: capital expenditure (**C**), an investigation (**I**), operational procedure (**O**), additional monitoring (**M**), Action (**A**), training (**T**).
Responsible	Agency responsible for undertaking the improvement
Timeframe	When activity or improvement is to be done by

Source and Catchment Improvement Summary

Improvement	Category	Responsible	Timeframe
1. Strengthen partnerships with landowners	A + I	DWW, NES	
2. Investigate feasibility of groundwater abstraction. 3. Public advisory to conserve water. 4. Investigate increased storage 5. Written Standard Operating procedure when stream flows <50% of normal.	I A I A + O	DWW DWW, NES, Agriculture DWW DWW, MoH	
4. Investigate increased storage, to allow for shut off of intake. 6. Written Standard Operating Procedure for cleaning of off stream filter, Arkal 6a. Investigate use of air compressors and modification of filters	I A + O I	DWW DWW DWW	

7. Conduct catchment inspections	A	DWW, NES	
7. Conduct catchment inspections 8. Advice to landowners on chemical use in catchments above intakes.	A I	DWW, NES DWW, NES, Agriculture	
10. Intake modification investigations 4. Investigate increased storage, to allow for shut off of intake 11. Written Standard Operating procedure for inspection and cleaning of intakes	I I A + O	DWW DWW DWW	
12. Enforcement of Water Works Ordinance. Investigate new legislation (IWRM Act) 13. Advice to tourist operators 14. Signage improved 14a.Investigate replication of Takuvaine Catchment Management Plan and development of Catchment Zoning	A A A + C A	DWW, NES DWW, NES, Tourism Authority DWW, NES DWW, NES	
15. Written Emergency plans and Standard Operating procedures for repair of broken infrastructure.	A + O	DWW, EO	
16. Improve access to intakes where possible 17. Written Standard Operating procedure for access track clearing.	A A + O	DWW	

Treatment, Storage and Distribution Improvement Summary

Improvement	Category	Responsible	Timeframe
18. Investigation into continuous turbidity meters at each intake. 4. Investigate increased storage, to allow for shut off of intake. 19. Promote rainwater harvesting use by public 20. Develop regular system for inspection / audit of treatment facilities for hospital, Tourist resorts and Licensed premises.	I I A A + M + O	DWW DWW DWW, MoH, NES MoH	
21. Investigate filtering options to reduce coliforms. 4. Investigate increased storage, to allow for shut off of intake 22. Investigate other treatment options if filtration not sufficient, such as disinfection.	I I I	DWW, MoH DWW DWW, MoH	
23. Investigate primary and secondary tanks with control mechanisms. 24. Consider supplementing source from the network 25. Written Standard Operating Procedure for flushing of distribution zone.	I A + O A + O	DWW DWW DWW	
		DWW, MoH	

26. Written contingency plan for detection of pathogens in water supply. 27. Consider testing water supply for pathogens if supply implicated	A + O M	DWW, MoH	
28. Investigate filtering options to reduce suspended particles. 4. Investigate increased storage, to allow for shut off of intake	I I	DWW, MoH DWW	
29. Develop Remedy Plan for network. 30. Identify high risk backflow areas and encourage backflow devices where appropriate.	A + O A + I	DWW DWW, MoH	
31. Create checklist and inspection guidelines for repair work on mains. 32. Look into training refresher courses on standard procedures.	A + O T	DWW, MoH DWW	
33. Instigate Water Demand Management Plan 33a. Complete network upgrade 33b. Leak detection surveys	A C + A A + O + C	DWW DWW DWW	
34. Create application forms for civil works near water main and make available. 35. Public awareness on activities which may effect water mains	A A	DWW DWW	
36. Ensure Emergency plan developed for natural hazards and link into Ministry of Works disaster plan.	A + O	DWW, MoW	
37. Create inspection and maintenance programme. (SOP) 37a. Purchase spare parts and backup pump with service agreement.	A + O C + A	DWW, MoW	

Other Improvement

Improvement	Category	Responsible	Timeframe
38. Train additional staff on sampling technique. 39. SOP for sampling. 40. Get additional sampling equipment.	T O C	DWW -NZDWA DWW -NZDWA DWW	Done
38. Train additional staff on sampling technique.	T	DWW -NZDWA	Done
41. Train additional staff on sample analysis. 42. SOP's for sample analysis. 43. Investigate and get new lab.	T O I + A + C	DWW DWW DWW/MoW	
44. Create job sheets for DWW operations staff activities. 45. DWW database	A + M + T A	DWW DWW	

Monitoring Plan

Monthly – Analytical Tests

Parameters	Avana	Avatiu	Matavera	Muriavai	Ngatoe	Papua	Rutaki	Takuvaine	Tupapa	Totokoitu	Turangi	Taipara
Micro-bio												
Faecal Coliform	√	√	√	√	√	√	√	√	√	√	√	√
Total Coliform	√	√	√	√	√	√	√	√	√	√	√	√
E-coli	√	√	√	√	√	√	√	√	√	√	√	√
Physical												
Turbidity	√	√	√	√	√	√	√	√	√	√	√	√
TDS	√	√	√	√	√	√	√	√	√	√	√	√
pH	√	√	√	√	√	√	√	√	√	√	√	√
Chemical												
Nitrate	√	√	√	√	√	√	√	√	√	√	√	√

Insert number and location of sites table in here

Location and number of samples

	SAMPLING SITES				
	Intake Sampling	**Intake Site Qty**	**Network Site Qty**	**Total Qty**	**Details**
1	Avatiu Intake	1	1	2	Collection Chamber, Network
2	Takuvaine Intake	3	2	5	Collection Chamber, Kia Oana Tank, Reservoir Outlet, Network x 2 (including Tauae)
3	Tupapa Intake	2	1	3	Collection Chamber, Outlet Filter Unit,Network
4	Matavera Intake	1	1	2	Collection Chamber, Network
5	Turangi Intake	1	1	2	Collection Chamber, Network
6	Avana Intake	1	1	2	Collection Chamber, Network
7	Totokoitu Intake	1	1	2	Intake, Network
8	Taipara Intake	1	1	2	Collection Chamber, Network
9	Papua Intake	1	1	2	Intake, Network
10	Ngatoe Intake	1	1	2	Collection Chamber, Network
11	Muriavai Intake	1	1	2	Intake, Network
			Total Sampling	**26**	

Quarterly (*These additional parameters will be monitored in addition to Monthly parameters*)

Parameters	Avana	Avatiu	Matavera	Muriavai	Ngatoe	Papua	Rutaki	Takuvaine	Tupapa	Totokoitu	Turangi	Taipara
Physical												
EC	√	√	√	√	√	√	√	√	√	√	√	√
Chemical												
Phosphate	√	√	√	√	√	√	√	√	√	√	√	√
Nitrite	√	√	√	√	√	√	√	√	√	√	√	√
Ammonia	√	√	√	√	√	√	√	√	√	√	√	√
Sulfate	√	√	√	√	√	√	√	√	√	√	√	√
Tot. Iron	√	√	√	√	√	√	√	√	√	√	√	√
Ferrous Iron	√	√	√	√	√	√	√	√	√	√	√	√
Aluminium	√	√	√	√	√	√	√	√	√	√	√	√
Magnesium	√	√	√	√	√	√	√	√	√	√	√	√
Calcium	√	√	√	√	√	√	√	√	√	√	√	√
Hardness	√	√	√	√	√	√	√	√	√	√	√	√

Physical Checks

	Avana	Avatiu	Matavera	Muriavai	Ngatoe	Papua	Rutaki	Takuvaine	Tupapa	Totokoitu	Turangi	Taipara	Frequency
Visual Checks													
Structure - weir	√	√	√	√	√	√	√	√	√	√	√	√	
Structure - tanks	n/a	n/a	n/a	n/a	n/a	√	n/a	√	n/a	n/a	n/a	n/a	
Structure – Off stream filters				√	√				√				
ARKAL Filters	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	√	n/a	n/a	n/a	
Sediment deposits in weir	√	√	√	√	√	√	√	√	√	√	√	√	
Others													
Rainfall	√	√	√	√	√	√	√	√	√	√	√	√	
Stream flow	√	√	√	√	√	√	√	√	√	√	√	√	