FIJI

WATER AND SEWERAGE DEPARTMENT

NADI/LAUTOKA WATER SAFETY PLAN

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Water Supply and Sewerage Department, Lautoka, Fiji

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TABLE OF CONTENTS

LIST OF ACRONYMS

ADB	Asian Development Bank
C/E	Central Eastern
DoE	Department of Environment
EEC	Exclusive Economic Zone
EU	European Union
EC	European Commission
EIA	Environmental Impact Assessment
FAC	Free Available Chlorine
GIS	Geographic Information System
GDWQ	Guideline for Drinking Water Quality
GDP	Gross Domestic Product
HACCP	Hazard Analysis Critical Control Point
HTH	High Tensile Hypochlorite
H2S	Hydrogen Sulphide
IAS	Institute of Applied Science
IEC	Information, Education and Communication
IWRM	Integrated Water Resource management
km	Kilometers
LLEE	Live and Learn Environmental Education
ML	Mega Liters
MLD	Mega Liters per Day
MOH	Ministry of Health
NWQL	National Water Quality Lab
Mg/l	Milligrams per liter
NGOs	Non Governmental Organizations
NTU	Nephelometric Turbidity Unit
NZ-MOH	New Zealand Ministry of Health
NZDWS	New Zealand Drinking Water Standards
OHS	Occupational Health and Safety
PICs	Pacific Island Countries
PVC	Polyvinylchloride
pH	Acidity/Alkalinity
ppm	Parts per million
PWD	Public Works Department
RAP	Regional Action Plan
SOPs	Standard Operating Procedures
SOPAC	Pacific Islands Applied geo-science Commission
SCADA	Supervisory Control and Data Acquisition
TWL	Top Water Level
USA	United States of America
WHO	World Health Organization
WEDC	Water, Engineering and Development Centre
WSD	Water and Sewerage Department
WSP	Water Safety Plan

1. INTRODUCTION

The Fiji replication commenced after the interest shown by the Water and Sewerage Department of the Ministry of Local Government, Urban Development and Public Utilities. A request was made by the Director of Water and Sewerage via a letter to the Director of Pacific Islands Applied Geo-sciences Commission (SOPAC). Through the consultation with Director Water and Sewerage and the Divisional Water Engineer it was resolved that a workshop should be conducted to train and introduce the Water Safety Planning concept in Fiji for Western Division.

Nadi/Lautoka regional zone has a large population of about 140,000 which depend on the treated reticulated water supply from three sources of surface water catchments namely Nagado, Saru and Buabua. There is continuous increase in the urban population growth of Nadi and Lautoka due to expiry of agricultural land leases and greater demand for the treated piped water supply for tourism development. The major concern of the Water and Sewerage Department is the efficient supply of drinking water even though there are several constraints such as infrastructure, finance and human resources. The funds have been allocated from the government budget after realization of the extent of developments for both residential and tourism sectors in Nadi and Lautoka.

It is seen as an opportune time to incorporate the Water Safety Planning process in this venture. The expertise and resources will be made available from SOPAC/WHO to assist in the Water Safety Planning programme for Fiji. Greater commitment has been shown by the WSD after the successful completion of the water safety planning process for Suva/Nausori zone.

It is anticipated that with necessary training for the staff of Water and Sewerage and Ministry of Health it would greatly enhance the capabilities for formulating and implementing the Water Safety Planning process as a proactive measure in maintaining the drinking water quality and quantity.

The importance of safe drinking water for health and development in the Pacific Island Countries (PICs) has been reflected in many regional action plans and policies. Through the Regional Action Plan (RAP) on Sustainable Water Management (Sigatoka, Fiji, 2002) Pacific Island Countries outlined actions that were needed to achieve sustainable water management through collaborative efforts by water sector authorities and inter-sectoral partners.

The WHO workshop on Drinking Water Quality Standards and Monitoring in Pacific Island Countries (Nadi, Fiji, 2005) developed a Framework for Action on Drinking Water Quality and Health in Pacific Island Countries, designed to support the implementation of drinking water quality actions envisioned in the RAP. The Pacific Island Countries embraced the Water Safety Plan concept during the workshop and this was reflected in the Regional Framework. It was recommended that PICs should use Water Safety Plans to better manage their water supplies to ensure safe quality drinking water for Pacific communities.

1.1 BACKGROUND

The Fiji islands are located between 12 degree – 21 degree south latitude and 176 degree East – 178 degree West longitude (Refer to the Fiji islands Map Below). Fiji consists of more than 300 islands of which about one third are inhabited. With a land mass of 18.272 square km Fiji is third largest state in the region next to Papua New Guinea and the Solomon islands. The Exclusive Economic Zone (EEC) of the country Covers 1.3 million square Km. the two biggest islands , Viti Levu and Vanua Levu ,have the majority of the total population of about 900,000 ,with about 50%

living in urban areas such as Suva (177,000), Lautoka (45,000) and Nadi (33,000). The largest Islands account for 87% of the land area and 90% of the population.

The larger Islands such as Vitas Levu and Vanua Levu, Tavueni, Kadavu and the islands of the Lomaiviti group are rather mountainous and of volcanic origin. They rise more or less abruptly from the slow to impressive heights. The south east or the windward sides of the islands record the highest rainfall up to 4000mm annually. The western and northern parts of the major islands are in the rain shadow of the volcanic mountain ranges. They are therefore much drier and frequently threatened by droughts (Terry and Raj 2002)

The climate in Fiji is dominated by the southwest trade winds. Exposure and topography control the distribution of rainfall on the islands. Average annual precipitation over the Fiji group ranges from 1500 mm on smaller islands to over 4000 mm on the larger islands. Topographic effects mean however that much of this falls within the windward side of the islands'

The wet season from November to April is also the season of tropical cyclones. In the western parts of the bigger islands up to 80% of the annual total rainfall falls during this period. The western and northern parts of the major islands receive only 60-70% of the rainfall recorded in the eastern parts. Here drought conditions are more likely to occur, especially during El-Niño episodes. These drier parts of Viti Levu and Vanua Levu are the centre of Fiji's sugar cane production.

The Nadi/Lautoka water supply system comprises of the urban and rural areas of Nadi and Lautoka extending from Momi in Nadi to Teidamu Hill in Lautoka city. Between Nadi and Lautoka a number of larger settlements have come up during the last decade. Today more than 180,000 people live in the Nadi and Lautoka area, almost a quarter of Fiji's population. The water for the present population is mainly supplied by the Vaturu dam, Buabua and Saru catchments.

The demand for Nadi/Lautoka treated water is about 100 MLD out of which Nagado supplies about 91 MLD, Buabua -7 MLD and Saru – 5 MLD. Nagado reservoirs store 6 ML of treated water at an elevation of 166.7 meters and treated water from here is fed into the distribution system by gravity flow. The three treatment plants that supply water to the Nadi/Lautoka regional system are located at Nagado, Buabua and Saru. The water flows by gravity force to the distribution system and connected to the Buabua and Saru plants. Since Nadi and Lautoka are tourism town and fast developing, demand for treated water is always increasing.

Nagado Treatment Plant

Nagado Treatment Plant receives its raw water supply from Vaturu Dam via twin mains of 700 mm indiameter. The plant is operated in direct filteration through nine gravity sand filters, or with both clarification and filteration processes i.e full conventional treatment depending on the turbidity of incoming water from the dam.

Direct filteration is where the raw water flows directly to the filters with out any prior sedimentation stage. Low doses of alum (and possibly lime) are usually added to assist the filters to remove the solids and colour from the raw water. The captured solids are backwashed and removed on a periodic basis. When the raw water turbidity and/or alum dose required is high, the conventional water treatment process is implemented. This includes sedimentation(clarification) prior to filteration. Under this mode of operation ,the raw water is always dosed with alum and usually lime. And at much higher doses than for direct filteration.

Water for filter backwashing is stored in the wash water tanks at an elevated level close to the plant. These tanks are filled by the backwash supply pumps. During a backwash , air blowers provide air to scour the filter sand and dislodge the solids that have become captured within the filter beds. Water is then gravity fed from the wash water tanks to the filters. The wash water flows upwardly through the filter sand to flush out the solids to the site waste drainage system (sludge lagoons). Filtered water is dosed with chlorine and lime prior to entry to the clear water reservoirs. From the clear water reservoirs, water flows to the surrounding areas of Nadi/Lautoka via three outlet mains 500 -700 mm diameter.

1.2. Project Objectives:

The main objective of the Fiji Water Safety Plans Programme is to produce Water Safety Plan and Improvement Schedule for Nadi/Lautoka Water supply system involving the staff of Water and Sewerage Department and the operators of Nagado/Buabua/Saru Water Supply. At the end of the programme it is anticipated that the staff of the Department are well familiar in compiling the plans for other supplies by them.

1.3 What is a Drinking Water Safety Plan?

A Drinking Water Safety Plan (DWSP) is a comprehensive risk assessment and management tool that encompasses all stages in the drinking water supply from catchment to consumers. It draws on principles and concepts from other risk management approaches including Hazard Analysis Critical Control Point (HACCP) and the 'multi-barrier approach'. It is more of a pro-active approach whereby continuous monitoring and improvements are done to eliminate any hazard in the system.

The improvement Schedules are part of the Water Safety plans and compiled after the risk assessment and risk ranking in the water supply system for the specific plant.

The key objectives of a Drinking Water Safety Plan are to:

- Prevent the contamination of source waters;
- Treat water to reduce or remove contaminants; and
- Prevent re-contamination during storage, distribution and handling

1.4 Administrative Support

Administrative support was given by Lautoka Water Supply department for the logistics such as transportation for field work and office space for the consultant. A good commitment was shown by the department as the lead agency in the project. All information was made available with reference to reports, inspections and personal interviews during the consultancy.

1.5. Nadi/Lautoka (Nagado) Water Supply Description

Nadi/Lautoka urban water supply system flow diagram and locality plan can be seen in detail below. Since the water is from surface river catchment there is full conventional treatment system in place and thus sedimentation, filtration and chlorination is the necessary process to eliminate dissolved solids, micro-organisms and unwanted natural chemicals from water prior to public

consumption. It was informed that if the water from the dam was clear with less turbidity then direct treatment was preferred most of the time.

The pictures below show the horizontal clarifiers in use at the Nagado plant. The clear water is seen at the Vaturu dam as this is more common in dry season. The dam water may be coloured /turbid in rainy season though whereby full conventional treatment is required. The size of the Vaturu dam is quite large therefore it is necessary for regular inspection and monitoring. There is a provision of outboard motor boat for this purpose. The dam water quality is monitored by the national water quality lab staff once a while to detect abnormal presence of bacteria and hazardous chemicals.

Vaturu Dam Catchment

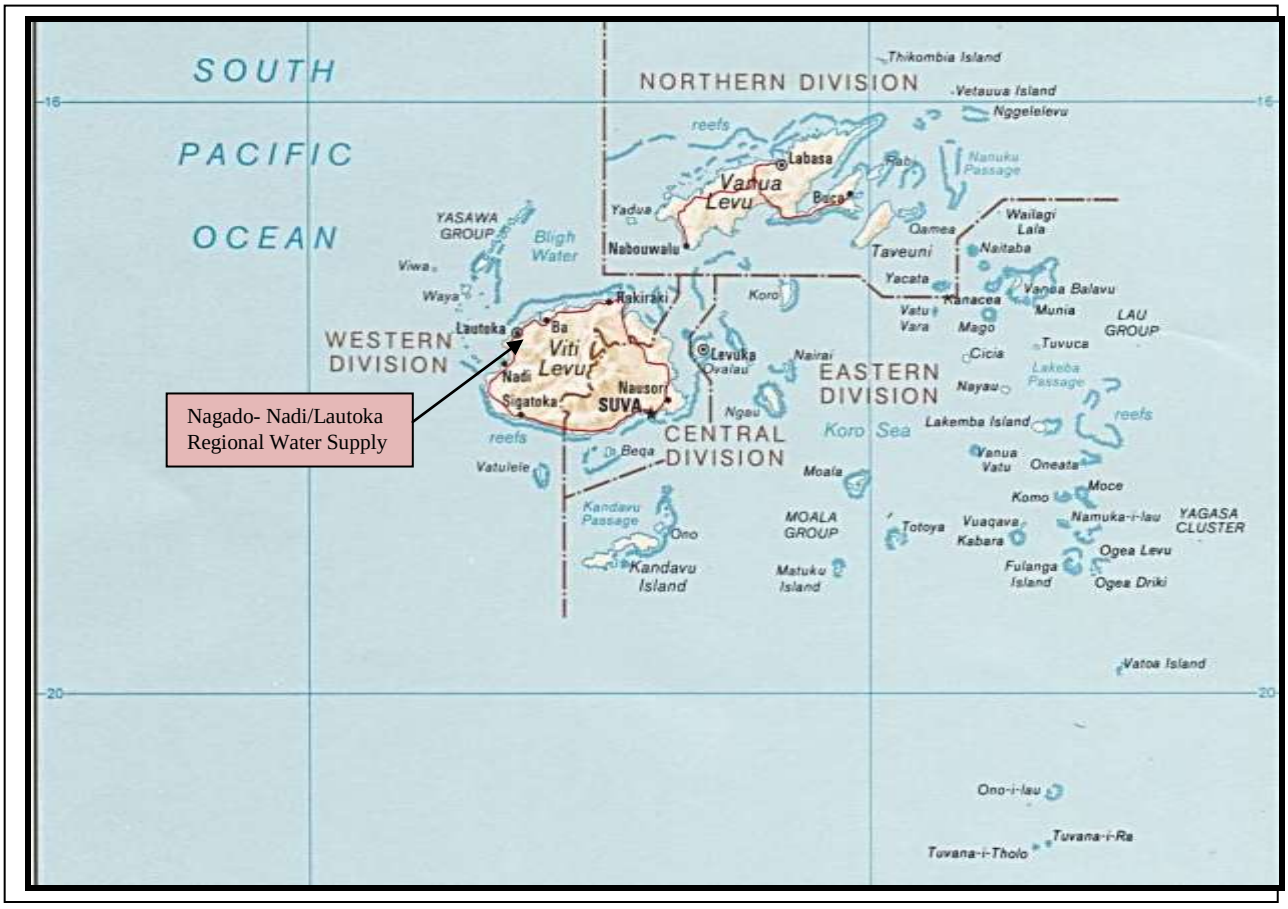
Horizontal Clarifier – Nagado Plant

Water Intake at Vaturu Dam

Electrical pumps – Nagado Plant

The map below shows that the Nadi/Lautoka (Nagado) water supply system is located in the western division where it is more prone to natural disasters. Secondly it is on the drier side of the country and water scarcity may be possible in drier seasons.

Figure 1 Map- Fiji Islands- Nadi/Lautoka Regional Water Supply



2. WATER SAFETY PLANS – NAGADO

2.1. Risk Identification Worksheets

2.1.1 Catchment & Intake

List what could happen that may cause drinking-water to become unsafe (deterioration in water quality)	Is this under control?	If not, judge whether this needs urgent attention. Responsible agent/s for immediate action.
1. Easy access of wild animals (horses/pigs)to the Vaturu dam	No. No fencing or barrier to control animal access.	Yes/ Lautoka Water Supply to monitor and post security guards. Erect fence in areas near embankment and tower side. Awareness to public visiting the dam site
2. Siltation in the dam is likely due to soil erosion and decaying vegetation	No. No dredging of the Vaturu dam done for long time. Survey team to regularly monitor the dam bottom for siltation	Yes .Lautoka Water Supply. Prepare monitoring schedules for siltation and cleaning.
3. Sabotage / Vandalism	No. Possible intentional sabotage by chemical pollution. Security to be upgraded with provisions of caretaker, security locks and lights.	Yes/ Proper fencing is required at the Vaturu dam. Responsible-WSD. This is the major intake for Nadi /Lautoka Water Supply
4. Natural disaster makes source unsafe - massive occasional erosion.	No. Water catchment is large area uphill which has high annual rainfall and due to soil type erosion is common. High dissolved and suspended solids. Water colour changes to brown.	Yes. Use IWRM approach. WSD – hydrology section to monitor data of flooding.
5. Pollution from dead wild animals and decaying wood debris likely to happen.	No. - Public Awareness and liaison with authorities and surrounding villages	No. WSD/Plant managers/regular inspection of the dam site
6. Pipe breakage and exposure is common due to layout of the pipes in Natural Disaster	No. Expose pipe/leaking valves Regular monitoring is not done	Water Supply Lautoka/Dam Caretaker

2.1.2. Treatment

List what could happen that may cause drinking-water to become unsafe (deterioration in water quality) Risks: Include process/machinery failure	Is this under control?	If not, judge whether this needs urgent attention. Also, identify responsible agent(s) for immediate action.
1.Villagers entering the Nagado Treatment Plant area and use the plant water for drinking and domestic use when the supply pump to the village is malfunctioning	No. There is no security guards present at the Nagado Plant at all times. The main gates and perimeter fence needs improvement.	Yes. Plant operators/ Lautoka Water supply
2. Replace malfunctioning flow meters SCADA systems at plants and reservoirs.	No. Water measurement for the inflow will help in calculating the chemical dosing rate	Yes. –WSD /Design engineers Plant operators
3. Filter Failures **- Nagado has 9 rapid sand filters.** **- Filter media needs upgrading** **- Provision for flow meters to monitor backwash rate** **- Improper air scouring**	No. Due to cracking and mud balls noted all media to soak with caustic soda. This will eliminate slime build up and accumulation of mud-balls. - This will also increase the plant chlorine demand -No, flow meters can contribute to fast backwash rate which can result in loss of filter media. **–** can lead to mud ball accumulation. To provide redundant air scourers (machine)	Yes. WSD / Design and Structures – hydraulics. Plant managers/operator Filter media eeds upgrading/replacement.
4. Chlorine dosing rate may not counteract fluctuation in water quality accordingly.	Yes. Increase dosing rate during period of heavy rainfall. Ensure chlorinator servicing is done on time. Use of backup HTH dosing.	Treatment Section Plant Operators. Monitoring of residual chlorine at plant and consumer end.

List what could happen that may cause drinking-water to become unsafe (deterioration in water quality) Risks: Include process/machinery failure	Is this under control?	If not, judge whether this needs urgent attention. Also, identify responsible agent(s) for immediate action.
5. Free Available Chlorine (FAC) samples taken not randomly at the distribution system and treatment plant.	Yes, But need a monitoring program for distribution and treatment plant.	NWQL – chemist Plant Operators Senior Treatment Officer C/E Design proper monitoring programme with ata records.
6. Pre Chemical Dosing. **Due to plant size needs to be equipped with proper chemical dosing pump for copper sulphate/alum** **-Plant should maintain residual chlorine of 1.2 g/cubic meter; this will allow an acceptable residual in the reticulation system.** **- For effective chlorination –one chlorinator is installed at the plant** **- Provision of backup disinfection is provided by means of Calcium Hypochlorite (HTH)** **Failure of any above measures will lead to a total collapse of water quality.** **Soda Ash- is added for pH correction in treated water. Inadequate dosing can produce acidic water.**	No - There is a need to upgrade OHS requirements for handling chlorine. -One additional chlorinator to be installed. - There is an urgent need to install a new lime dosing mechanism. - No. the whole dosing system has to be replaced. Only one for each is working. Needs urgent repair for the other two.	Yes. WSD/ Engineer Plant managers
7. Lime Dosser	No. Needs to be replaced with a dry feeder mechanism to be more efficient and occupy less space	Yes , WSD- Plant operators Install additional dosser.
8. Manual Chlorine dozer	No. Should have two tanks and, one mixing tank and one drip tank. existing mixing compartment-.Ventilation Provide HTH powder chlorine at all times to supplement the dosing if the mechanical system breakdowns.	Yes, WSD – Plant Operators

2.1.3. Storage and Distribution

List what could happen that may cause drinking-water to become unsafe (deterioration in water quality) (Risks)	Is this under control?	If not, judge whether this needs urgent attention. Also, identify the responsible agency(s) for immediate action.
1. Rusted and missing reservoir inlet chamber lids. ▪ **Rodents ,birds and animals can enter the reservoir tanks**	No. -need to cut all trees nearby and remove discarded items from the reservoir. Repair all opening and inlets of the reservoir. - provide iron lids and cover all inlet chambers of the reservoirs. All main valves must be controlled from public access	Yes, WSD/Distribution manager Iron lids to be replace by lighter and rust resistance materials(aluminium)
2. Leakages within the distribution network could result in cross-contamination. ▪ **rusted and old pipes** ▪ **Breakages in underground pipeline from other activities such as digging for electrical/ telephone cables, construction etc**	Yes. A Leak detection programme has been mobilized by the DWS. No, Place warning sign and make information available. Use leak detector for underground seepage. About 40% is unaccounted water leakages through the system. Some direct connection without permission.	WSD/ Distribution manager Yes//Utility Companies Awareness. GIS /Maps Consent /Approval for development works. Regular Public awareness campaigns to be done.
3. Free available chlorine levels in the distribution system could be low due to increased turbidity after pipe breakages, old aged pipes and poor end mains.	No. - Current monitoring for FAC is sufficient but sampling points can be changed regularly. - Daily FAC testing to be done at the plant.	WSD/ Engineer –Lautoka /Nadi Distribution Section. Manager –Nagado Treatment Plant
4. Vandalism /sabotage.	No. Common as key valves damaged and iron lids are removed by public. - Reservoir is easily accessible by public so security, gates and fencing is required.	Yes/Police/WSD – Nadi/Lautoka Provide steel enclosure for key area/ access to reservoir

List what could happen that may cause drinking-water to become unsafe (deterioration in water quality) (Risks)	Is this under control?	If not, judge whether this needs urgent attention. Also, identify the responsible agency(s) for immediate action.
5. Water is contaminated as a result of repair works in the distribution system.	No. -insufficient flushing and chlorine wash after repair of broken mains. Few wash out system and hydrants available in the distribution system -Use appropriate backflow prevention devices, -No SOPs for repair of mains	Yes/ Lautoka-Distribution Section WSD - Engineer –Distribution Section Install non –return valves Monitoring of the distribution for bacteriological levels and residual chlorine.
6. Drop in water pressure due to high water demand disturbs sediments. ▪ **Sediments settle more in mains with low pressure.** ▪ **Need to clean the distribution system with swabs(pigs)**	No. - Numerous reports of insufficient water to parts of the network and dirty water seen at consumer taps. Wash out should be provided. This is a problem and water pressure should be constant to avoid sediments in the distribution.	Yes- Distribution Section. DE/W
7. Damages to the distribution network from natural disasters such as floods, landslides and earthquakes.	No. - Survey teams in place and activated after natural disaster. Establish and follow emergency contingency plans for natural disasters.	Yes WSD-consult with Disaster Management Office for emergency water supply.
8. Damage to exposed pipelines.	Yes. - Endeavour to bury/protect/encase all exposed pipelines. Have warning signs posted at reservoir and risk areas to inform the public.	Yes WSD-Lautoka/Nadi /Distribution Section. Train mechanical and maintenance teams.
9. Contaminated storage reservoirs	No, - Regular cleaning of storage tanks. - Mud sedimentation common in reservoir - Old reservoir needs structural maintenance	Yes WSD/ Distribution manager Upgrade and use modern cleaning equipments to remove silts and debris,
10. Asbestos pipes in use that can contaminate the water in the mains.	No. Some old mains pipes are of asbestos cement material, this can pose problem in water contamination if broken. Most pipes are old and need replacement.	Yes WSD/Distribution manager for the replacement of the existing damaged and old pipes. NWQL/MoH to analyse for asbestos content in drinking water.

2.2: Plan to Manage the 'Needs Urgent Attention'

2.2.1 Catchments & Intake

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed, reduced or remedied? Who needs to know and how quickly? Who can help?
1. Sabotage / Vandalism	- There is no fencing so access is possible by the public. - Possible intentional sabotage of electric pumps. - Caretaker /ranger to be allocated for monitoring at dam and intake pipes. - Security locks and lights needed	-Water smells looks or tastes abnormal. -Pump breaks down and there are signs of sabotage or vandalism, broken infrastructure and presence of offenders on water supply sites.	Existing dam managers should help. Responsible-WSD. Warn the public through the media. WSD/Police Dept Place public Notice at the intake and plant sites.
2. Natural disaster makes source unsafe - massive occasional flooding and erosion.	Water catchment is large area uphill which has high annual rainfall and lot of other smaller tributaries joins the river. - The system is hampered during natural disasters. Establish and follow emergency contingency plans for all repair works more so immediately after a natural disaster	Change in water colour/taste and suspended matter seen. Seek immediate help of emergency water supply from the Disaster Management Office. Water cartage to the affected public	Use IWRM approach. WSD – hydrology section to monitor data of flooding. WSD/MOH to make contingency plans. Collect all related data for actions when necessary. Monitoring of Water Quality by National Lab/Plant lab Boil water advice to Public given via media.
3. Public access and eco tourism likely to contaminate dam water.	- Public awareness of target population on river care. - use of proper human excreta disposal near catchment sites.	Water smells and solid waste visible in the river. Entry of contaminated water into the intake.	Educate the people visiting the Vaturu dam for picnicking. Local Health Authority to monitor and raise public awareness
4. Siltation in the dam causing loss of water storage capacity	Dredge the Vaturu dam of excessive sediments and silt	Water smells and the dam have low water capacity.	No plans in place. WSD engineers to design dredging plans and programme

2.2.2 Treatment - [Plan to Manage the 'Needs Urgent Attention]

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed or reduced? Who needs to know and how quickly? Who can help?
1. Villagers entering the Nagado Treatment Plant area and use the plant water for drinking and domestic use when the supply pump to the village is malfunctioning	There is no security guards present at the Nagado Plant at all times. The main gates and perimeter fence needs improvement. Provide additional supply pump at the plant for nearby villages/settlements.	Reservoir water is polluted with suspended solids and other foreign matter visible.	Policing by the plant operators and the Lautoka Water Supply supervisors. Post security personnel.
2. Replace malfunctioning flow meters at plants and reservoirs.	Water measurement for the inflow will help in calculating the chemical dosing rate. Residual Chlorine level inconsistence. Maintain SCADA system.	Public complains on chlorine taste/ No residual chlorine present when tested.	-Top priority should be given - WSD/ Engineers - Design and structures
3. Filter Failures **Nagado has 9 rapid sand filters.** **- Filter media needs upgrading** **- Provision for flow meters to monitor backwash rate** **- Improper air scouring**	Due to cracking and mud balls noted all media to soak with caustic soda. This will eliminate slime build up and accumulation of mud-balls. - This will also increase the plant chlorine demand -No, flow meters can contribute to fast backwash rate which can result in loss of filter media. **–** can lead to mud ball accumulation. To provide redundant air scourers (machine)	Turbid Water, High rate of dissolved and suspended solids. Chlorination is affected. Inspection reveals flowmeters not functioning.	Yes. WSD / Design and Structures – hydraulics. Plant managers/operator

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed or reduced? Who needs to know and how quickly? Who can help?
4. Chlorine dosing rate may not counteract fluctuation in water quality accordingly.	Increase dosing rate during period of heavy rainfall. Ensure chlorinator servicing is done on time. Use of backup HTH dosing. No residual chlorine when tested.	No residual chlorine at consumer end of 0.5 ppm as required by the WHO standard. Treatment Section Plant Operators test indicates less then1.2 ppm of residual chlorine.	WSD/mechanical section. - Higher chemical dosage is an option.
5. Free Available Chlorine (FAC) samples taken not randomly at the distribution system and treatment plant.	Need a monitoring program for distribution and treatment plant. Presently done in ad-hoc manner.	NWQL – chemist- test results not to required standards when tested by Plant Operators and Health Inspectors	- WSD / Design and Structures – hydraulics. - Higher chemical dosage is an option.
6. Lime Dosser (pre/post dosing)	Needs to be replaced with a dry feeder mechanism to be more efficient and occupy less space	Will affect coagulation and flocculation due lack of required pH medium. Turbid water will passes through the clarifiers (pre). Post dosing will correct ph to eliminate pipe corrosion. WSD-Plant operators	Plant managers NWQL-Analyst - Manual chemical dosing is used which promotes excessive chemicals in the distribution system.
7. Manual Chlorine dozer	Should have two tanks and, one mixing tank and one drip tank. existing mixing compartment-.Ventilation Provide HTH powder chlorine at all times to supplement the dosing if the mechanical system breakdowns.	FAC test that the treated water has no less than 1.2 ppm at plant and no less than 0.5 at consumer pipe. No taste of chlorine in treated water. WSD – Plant Operators	Additional testing resources needed at the Nagado plant such as turbidity meter and chemical detectors.

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed or reduced? Who needs to know and how quickly? Who can help?
8. Pre Chemical Dosing. Due to plant size needs to be equipped with proper chemical dosing pump for copper sulphate/alum **-Plant should maintain residual chlorine of 1.2 g/cubic meter; this will allow an acceptable residual in the reticulation system.** **- Provision of backup disinfection is provided by means of Calcium Hypochlorite (HTH)** **Failure of any above measures will lead to a total collapse of water quality.** **Soda Ash- is added for pH correction in treated water. Inadequate dosing can produce acidic water.**	- There is a need to upgrade OHS requirements for handling chlorine. -One additional chlorinator to be installed. - There is an urgent need to install a new lime dosing mechanism. The whole dosing system has to be replaced. Only one for each is working. Needs urgent repair for the other two.	Algal growth seen in treatment plant waters. Test at plant and consumer end indicate less residual chlorine then the required standard. WSD/ Engineer Plant managers	WSD/Plant managers. Visual inspection must be done.
9. Treatment facilities/storage tank/reservoir is damaged by natural disasters such as flooding, landslide, earthquakes.	Establish and follow emergency/contingency plans for all natural disaster events. Have standby power generators. Switch to manual dosing treatment if no other option permits. Follow the maintenance schedules for all repair works and ensure all maintenance is up to date	Inspection after natural disaster Water-borne diseases on the rise. Large amounts of water flowing out of the storage and distribution system.	Carting of treated water to the affected areas. Send out public health messages through local media informing consumers about possible risk of contamination. Advise them to take necessary precautionary measures e.g. boil or filter water. WSD-Engineers

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed or reduced? Who needs to know and how quickly? Who can help?
10. Chlorine dosing failure due to power outage.	During power outage, operators switch to manual dosing.	Low or zero residual chlorine in the clear/plant. Use manual chlorination methods to maintain required chlorine standards.	Manual dosing in place. Monitor for correct dosing rate. WSD, e.g. Engineer - Distribution Section
11. There is no treatment / barrier for protozoa, so it could be assumed that they are present in water.	Upgrade filters media. Soak filters in caustic solution to remove mud balls, slime growth and cracks.	Protozoa analysis of drinking water Upgrade sand filters to increase efficiency	Increase chlorine residual. Give boil water advice to the public. SWD/MOH
12. Free Available Chlorine (FAC) samples taken incorrectly.	Must provide appropriate training for staff to take samples and recording results. Establish. Sampling procedures and time schedules.	Residual chlorine level too low/high. Imprints a wrong nature of residual chlorine. Can result in presence of coliform in water samples.	NWQL – chemist Plant Operators to establish a set procedure for FAC sampling and record data.
13. Vandalism/sabotage.	Provide extra security lights and monitors. Put up a security fence to stop unauthorized access to the water storage tanks/post attendant/watchman at pump and reservoirs.	Low pressure/loss of water Abnormal objects in treatment plant water .other mechanical/electrical not correctly functioning, contaminated water samples.	Security persons posted. Install security alarms. WSD-Production/distribution Section
14. Entry Points in the Building for animals/birds	sealing of all entry points for insects ,birds and rodents Hygiene training to staff for up keep of the building and equipments	Entry of animals and birds into treated water. Water smells. Dead animals and birds seen -Contaminated chemical solutions	WSD/ Plant Operators

2.2.3Storage and Distributions [Plan to Manage the 'Needs Urgent Attention]

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed, reduced or remedied? Who needs to know and how quickly? Who can help?
1. There is not enough contact time with chlorine before the consumption, resulting in water not properly disinfected.	Have a right sized contact tank and time. Occasional cleaning/ flushing of contact tank.	Treated water analyzed at the plant and the closest consumer will reveal presence of high microbial organisms. Dosing should correspond with FAC result and water unsafe for public use. Mains can act as retention tank.	There is no current contingency plan. To do FAC at the plant and nearby consumer points. Regulate chlorination as required.
2. Illegal connections could lead to cross-contamination.	A regular monitoring / surveillance schedule for illegal connections. Allocate wardens in each zone/area/community.	Through Public complaints. Low water pressure in affected areas. High water demand.	The residual chlorine will provide protection (provided the levels of contaminants are low) until repairs are complete.
3. Rodents and animals getting into the storage reservoir tanks. - Rusted covers/lids of reservoirs.	Cut down trees growing close to the reservoir tanks and remove discarded items. All inlets to be sealed properly and rusted lids replaced. Regular inspection of reservoir.	Rodents die and excrete in and on the storage tanks. Ingress of animals and their excrement noticeable. Dead animals, birds and rodents seen in the storage tanks.	Close all inlets to the tanks Cover the openings with sacks or other flexible materials until repair works are done.
4. People have access to turn inlet and outlet keys at the reservoirs, cross contamination is possible	All turn keys wheels to be well secured and kept under lock and key. Provide security grills around reservoir chambers and turn keys.	Decrease in water pressure and cross contamination. Presences of bacteria and other dead organic matter when inspected and analysed.	Security checks. Place security alarms. Notice Board/signs. -Post caretaker.
5. Accumulation of sediments in storage tank.	Establish and follow a cleaning/maintenance schedule once a year. - Avoid ingress of dirt during repair of breakages in the mains.	Colour of water changes .water turbidity increases. Water smells. Presence of Bacteria when analysed.	-Drain storage tank water. - Clean the tank. - Improve filtration at treatment plant –Upgrade filter media

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed, reduced or remedied? Who needs to know and how quickly? Who can help?
6. Leakages within the distribution network could result in cross-contamination.	About 45 % water is lost due to leakage and abuse. A Leak detection programme is in place. Inform public on proper water use and water laws especially the villagers.	Analysis of mains water will indicate presences of pathogenic bacteria. Colour and turbidity is abnormal. Low water pressure in distribution pipes.	Close the distribution network and clean the system. WSD and distribution manager to act - Inform public to boil water through media/radio.
7. Free available chlorine levels in the distribution system could be too low.	Current monitoring for FAC is insufficient. The fluctuation could be due to water demand and major breakages. - Only selected areas tested regularly need to change the sampling point.	No FAC in treated water when tested. Presence of bacterial organisms in the treated water.	NWQL to monitor FAC/bacterial content regularly and provide report to plant operators to do appropriate chlorination.
8. Water is contaminated as a result of repair works in the distribution system.	Drain contaminated water before reconnection. Control back flaw of dirty water. Chlorine- washes of pipes and analyse water for bacterial contents prior to consumption. Refer to SOPs if available.	Water colour and turbidity changes. - Increased suspended and dissolved solids in treated water.	Distribution Section to monitor - Inform public to boil their drinking water. - Analyse water for bacterial content. -Formulate SOPs
9. Drop in water pressure due to main breaks and high demand disturbs sediments.	Keep supply constant to maintain pressure. Monitor usage, maintain average reservoir levels, and throttle supply. Provide additional reservoir.	Reports of insufficient water to parts of the network and dirty water seen at consumer taps. Water colour and turbid water seen at consumer end.	Distribution Section to monitor. Analyze water for bacterial content.
10. Damages to the distribution network from natural disasters such as floods, landslides and earthquakes.	Establish and follow emergency contingency plans for natural disasters during and after an event.	Low water pressure in distribution system. Consumer complains	WSD-consult with Disaster Management Office for emergency water supply. Analyse for bacterial content.

Risks that 'Needs Urgent Attention'	Improvement Schedule: How can you remove or reduce or remedy the cause and by when? Indicate where additional resources will be needed.	Until remedied, how will you know when this is actually causing deterioration towards unsafe drinking water?	What contingency management plan is in place until the cause is removed, reduced or remedied? Who needs to know and how quickly? Who can help?
11. Damage to exposed pipelines.	Endeavour to bury/protect/encase all exposed pipelines. Have warning signs posted to inform the public. Regular monitoring of intake and distribution pipes.	Low pressure Contaminated water found in the system on analysis Visible colour change of the water at consumer end	WSD-Distribution Section Inform the public Cover the pipelines. Install Signs
12. Mains scaling and sedimentation	Regular flushing of mains water (sections only). Provide washout valves at the lower end of the distribution system.	Water smells Water colour changes Increase in dissolved solids in treated water at consumer end Reduced water pressure at consumer end.	WSD/ Distribution Manager. Establish cleaning programme for the mains.
13. Vandalism/sabotage - **valve cover lids removed by people and metal dealers**	Cannot stop vandalism/sabotage but can reduce and prevent likelihood of both. If possible lock and secure tools, equipment, enclosures and parts. Upgrade cover method for chambers and reservoir. - Place notice/Sign boards/media information	Low pressure of water in pipes People seen around storage tanks drawing water or bathing in instances of water cuts	Police/WSD to monitor regularly. Provide steel enclosure for key area/ access to reservoir

SECTION: 3 IMPROVEMENT SCHEDULE

3.1 CATCHMENT AND INTAKE

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
1. Sabotage and Vandalism.	Secure intake at Vaturu dam to ensure that vandals do not get access to the intake pumps or piping by fencing and security measures. Post caretaker or ranger.	High	WTP/DWS	WSD Cost Fencing and Sign boards $30,400
2. Village / settlements close to Vaturu dam and people picnicking in the area.	People/tourist uses the area for picnicking. - Raise public awareness for people staying along riverside on pollution control.	High	WSD Public Awareness MOH Surveys and Workshops	Promote Health and Sanitation for settlements $15,000
3. Increase in soil erosion - in the areas immediately upslope from the source/intake causing siltation.	PWD and Provincial Councils to undertake awareness on land conservation and catchment protection. Dredge the Vaturu /Buabua dams to remove silts from erosion	High	WSD	Cost of dredging the dam. $15,000

3.2 TREATMENT [Improvement Schedule]

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
1.Villagers entering the Nagado Treatment Plant area and use the plant water for drinking and domestic use when the supply pump to the village is malfunctioning	There is no security guards present at the Nagado Plant at all times. The main gates and perimeter fence needs improvement. Provide additional supply pump at the plant	High	PWD NWQL WTP-operators PWD	Develop a regular (weekly) monitoring schedule for the supply pump at the Plant. Install additional pump. Cost; $18,000
2. Filter Failures Nagado has 9 rapid sand filters. **- Filter media needs upgrading** **- Provision for flow meters to monitor backwash rate** **- Improper air scouring**	Due to cracking and mud balls noted all media to soak with caustic soda. This will eliminate slime build up and accumulation of mud-balls. - This will also increase the plant chlorine demand -No, flow meters can contribute to fast backwash rate which can result in loss of filter media. **–** can lead to mud ball accumulation. To provide redundant air scourers (machine). Upgrade filter media (all size)	High	WSD WTP operators	Repair filters and upgrade filter media. Cost- $ 130,000
3. Lime Dosing	Provide one additional lime dosing pump to maintain the standard at all times and during the breakdown of one pump	High	WSD	Cost $16,000
4. Manual Chlorine dozing	Should have two tanks and, one mixing tank and one drip tank. existing mixing compartment-.Ventilation Provide HTH powder chlorine at all times to supplement the dosing if the mechanical system breakdowns. Provide manual chlorine tank and shed.	High	WSD	Cost $30,000

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
5. Chlorine dosing rate does not counteract fluctuation in water quality accordingly. Nagado Plant Lab needs Upgrading.	Follow monitoring procedures for FAC measurements to confirm a chlorine residual of no less than 0.2 mg/L. Increase measurements during period of heavy rainfall. Need to have a lockable lab.	High	WTP operators	Upgrade Existing lab with provision of necessary equipments such as clear glass etc. Cost- $10,000
6. Inefficient alum dosing.	Upgrade – reflux valves, motorised valves, pump remote controls- both intake and high lift. Provide a additional alum pump	High	WSD/WTP operators	Provide alum pump Cost- $16,000
7. Entry Points in the Building for rodents/birds	Sealing and repairing of all entry points for insects, birds and rodents. Provide enclosure /lids for clear well to exclude entry of solid and liquid waste. Upgrade sanitation of the plant	Medium	WSD/WTP operators	Upgrade grills and screens in the Plant building and hygiene aspects. Cost- $40,000
8.Chlorinator and safety equipments	Upgrade chlorination equipments and provide post chemical dosing shed	High		Cost $10,000
9Siltation in the Clear water storage reservoirs- Nagado Plant	Provide washout drain valve for No.3 reservoir	high		Cost $18,000
10.Clarifier upgrading	Replace trident pipes Cleaning of lamella plates Need for heavy duty water blasters for removing of floccs.	high		Cost $14,000

3.3 STORAGE AND DISTRIBUTION - [Improvement Schedule]

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
1. Vandalism/Sabotage There is easy access for the public into the reservoir compounds.	Install security lights and steel grills for the inlet and inspection chambers Fencing and upgrading of gates for the reservoirs	High	WSD/WTP operators	Upgrade Security at all time. Cost $30,000
2.Illegal connections could lead to cross-contamination	A regular monitoring / surveillance schedule for illegal connections. Allocate wardens in each zone community. Raise public awareness And enforce Water legislation	Moderate	WSD/WTP operators	Inform via media. Public awareness materials. Brochure- Cost $20,000
3. Rodents and animals getting into the storage reservoir tanks. Rusted covers/manhole lids for the inlet storage tanks has openings	Remove old pipes and fittings which can pose breeding grounds for rodents and animals. Repair damaged intake chambers. All inlets to the storage reservoir to be sealed properly. Rusted lids to be replaced. All ladders to be upgraded	High	WSD/WTP operators	Cost $20,000
4.Trees and shrubs around the reservoir provides presence of rodents and birds	Cut down all trees /shrubs growing close to reservoir. Remove shrubs/grass and landscape to keep the sites clean All valve wheels at the storage reservoirs to be well secured and kept under lock and key. Provide signboards for all reservoirs	Moderate	WSD/WTP operators/PWD	Cost- $40,000

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
5. Rate of free available chlorine levels in the distribution system.	Current monitoring for FAC is insufficient. Design a more rigid monitoring programme with identified sampling points and time period.	High	WSD WTP operators NWQL	Upgrade the existing testing procedures
6. Water is contaminated as a result of repair works in the distribution system.	Drain contaminated water before reconnection. Control back siphonage of dirty water. Chlorine washing of pipes and analyse water for bacterial contents. Establish written procedures e.g. SOPs for fixing distribution problems, including hygiene procedures.	High	WTP distribution section	Train staff and use SOPs $10,000
7. Danger of backflow during breakages and low pressure	Use appropriate backflow prevention devices, double check valve and ensure air gaps. Education programme for new and existing industry which pose a significant threat if backflow occurred. Backflow prevention devices installed if required valves and valve house	Moderate	WTP distribution section	Cost of valve replacement $10,000
9. Drop in water pressure due to high demand disturbs sediments in mains.	Numerous reports of insufficient water to parts of the network and dirty water seen at consumer taps. Install inlet/outlet meters for all reservoirs.	High	WSD WTP operators Distribution Section	Increase the mains size in the areas affected. National Budget

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
11. Damages to the reservoir and exposed pipes from floods, landslides and earthquakes.	Establish and follow emergency contingency plans for natural disasters during and after an event. Endeavour to landscape and upgrade reservoir access.	Moderate	WSD WTP operators PWD Regional Development	Cost $10,000
12.Dirty Contaminated storage tanks with silt and debris	Regular cleaning of storage tanks of sediments and chlorine washing before refill. - install floater gauges to measure the water level in the reservoir tanks. Install Water level indicators	High	WSD WTP operators	Costs- $ 25,000
13. Breaks, leaks or damage to pipes during natural disasters and human activities allowing contaminants to enter treated water.	-Unintentional pipeline damage by companies should be repaired by them. -Formulate M.O.U with PWD, Telecom and FEA to repair damages done during their operations -Establish leakage detection measures Encourage public to report for damaged pipes.	High	WSD WTP operators Distribution section	Public awareness Sign boards. $10,000
14. Interrupted distribution or contamination of water due to accidental damage. Mains scaling and sedimentation.	-Public notices to stress importance of pipelines that are buried or exposed to stop damage. - provide wash out valves at the lower areas of the distribution system to flush out deposited silts. - regular flushing of mains water to eliminate sediments in distribution	Moderate	PWD & Municipal, Provincial councils PWD	Provide wash out valves and chambers Cost – $25,000
15. Drop in Water Level in the reservoirs. Leakage in underground pipelines within houses and properties.	Provide water level measuring gauge. Encourage upgrading of old pipelines within houses/properties. Advise property owners on advantages of using standardised pipes	High	DWS to install measuring devise and train staff PWD	Cost of installation and training on data recording $25,000

3.4 SUMMARY FOR THE IMPROVEMENT SCHEDULE FOR THE NAGADO WATER SUPPLY SYSTEM

IMPROVEMENT REQUIRED	COMPONENT IMPLIED	ETIMATED COST
Catchment and Intake		Fiji Dollars
1.Public awareness campaign	Surveys and Workshops	15,000
2.Provide security fencing /signboards at Vaturu Dam	Fencing/signboards at the main entrance	30,400
3.Dredging of Vaturu/Buabua Intake	Dam dredging and removal of large debris.	15,000
Treatment	COST	**$60,400**
4. Provide fencing/gates/supply pump at Nagado plant	Upgrade fence / gates and supply pump	18,000
5. Rehabilitation of Horizontal Clarifiers	Cleaning and upgrading of clarifier	14,000
6. Repair filters and upgrade filter media (all size)	Replace filter media	130,000
7. Upgrade existing lab with equipments/consumables	Upgrade existing water lab at Nagado	10,000
8. Provide additional lime dosing pump	Lime dosing pump –Nagado Treatment Plant	16,000
9. Upgrade manual chlorine dosing methods	Mixing Tanks/Shed	30,000
10. Provide additional Alum dosing pump	Aluminium dosing pump	16,000
11.Upgrade Treatment Plant building	Repair bird/rodent opening/upgrade sanitation	40,000
12.Chlorination system -upgrade	Chlorination equipment	10,000
13.Cleaning siltation in reservoir tanks-	Provide washout drain valve ,No.3 reservoir	18,000
14.Filteration upgrade - filter valves	Provide filter penstock valves	40,000
Storage and Distribution	COST	**$342,000**
15.Maintenance and upkeep of reservoirs	Security lights, fence /gates and grills	30,000
16.Carry out Public awareness campaign	Workshop, media, IEC materials/water usage	20,000
17.Cleaning and landscaping of reservoir compound	Grass cutting, landscaping, removing trees	20,000
18.Upgrade and replacement of cover lids, manhole	Replace rusted lids / inspection covers/ ladders	40,000
19.Backflow /contamination control measures	Prepare SOPs /train staff/monitoring	10,000
20. Replacement of valves at distribution network	Sluice valves on the main pipelines	10,000
21.Cleaning of Silts and debris in the reservoirs	Remove silts and debris from reservoirs	25,000
22.Damage of pipes and storage system in Disasters	Cover pipes/post signboards	10,000
23.Provision of water level measuring gauge	Install measuring device (SCADA system)	25,000
24.Provision of washout valves and chambers	Install measuring device (flow meters)	25,000
	Cost	**215,000**
TOTAL	**COST**	**FJD$617,400**

4 NEEDS ASSESSMENT

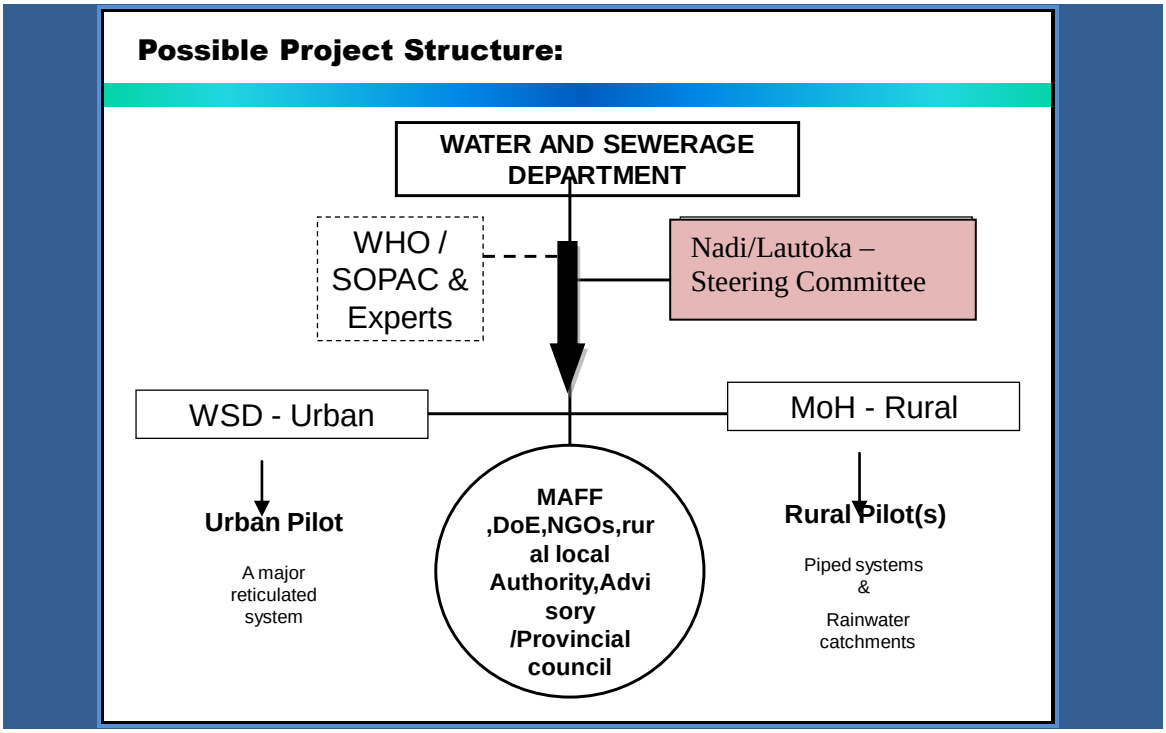
4.1 INTRODUCTION

The importance of safe drinking water for health and development in the Pacific Island Countries has been reflected in many regional action plans and policies. Through the Regional Action Plan (RAP) on Sustainable Water Management (Sigatoka, Fiji, 2002) Pacific Island Countries (PICs) outlined actions that were needed to achieve sustainable water management through collaborative efforts by water sector authorities and inter-sectoral partners.

The WHO workshop on Drinking Water Quality Standards and Monitoring in Pacific Island Countries (Nadi, Fiji, 2005) developed a Framework for Action on Drinking Water Quality and Health in Pacific Island Countries, designed to support the implementation of drinking water quality actions envisioned in the Regional Action Plan. The Pacific Island Countries embraced the Water Safety Plan concept during the workshop and this was reflected in the Regional Framework. It was recommended that PICs should use Water Safety Plans to better manage their water supplies to ensure safe quality drinking water for Pacific communities.

Fiji was chosen as one of the replication countries for the Water Safety Plans programme after the interest was shown by the WSD. An introductory workshop was conducted in December 2008 in Lautoka to train Water Supply staff of the Western division on the formulation of Water Safety Plans and improvement schedules for Nadi /Lautoka regional supply. There was good commitment shown from Lautoka Water and Sewerage Department (WSD) Fiji. It was initially decide that the Water Safety Plans will be formulated for Nagado Water Supply System and a steering committee and lead agency was identified. Below is a possible functional structure indicating the position of the steering committee.

Figure 2 -Possible Project Structure



4.2 WHO Guidelines for Drinking Water Quality

Drinking-water quality control is a key issue in public health policies. From 1950 to 1970 the World Health Organization (WHO) published standards for drinking-water quality that served as a scientific basis for monitoring the quality of the water produced and delivered by water suppliers. Later on, other legislative and regulatory approaches were published by the WHO and the European Union (EU): WHO Guidelines for Drinking Water (1st edition, 1984, and 2nd edition, 1993), and EU Directives 80/778/EC, and 98/83/EC (EC, 1998). This legislation was strongly focused on standards for treated drinking water and on compliance monitoring. Water quality was guaranteed by the so-called end product testing, based on spot sampling of the water produced. With this procedure it was possible to bring the very widespread water-borne diseases under control, especially those of bacterial origin.

Over the years, and after several shortcomings and limitations of the end-product testing, the methodology has been reviewed. Some findings related to the following aspects:

a) There is a multitude of water-borne pathogens that cannot be detected or they can be detected insecurely with the classical indicators such as *E. coli* Coliforms and *Enterococci*, and particularly viruses and protozoa. There are examples of water-borne disease outbreaks (*e.g.*, Milwaukee - U.S.A., in 1993) that occurred through water supply systems that met the standard for absence of indicator microorganisms.

b) Often, monitoring results are available out of time of intervention needed to maintain the safety of a supply system. End product testing only allows checking if the water delivered was good and safe (or unsafe) after distributed and consumed.

c) End-product testing hardly can be considered a sound method for representative water quality status. A very small fraction of the total volume of water produced and delivered is subject to microbiological and chemical analysis. Moreover, the monitoring frequency does not guarantee representative results in time and space, as well.

d) End-product testing does not provide safety in itself. Rather is a mean of verification that all the supply system components and installed control measures are working properly.

In recognition of these limitations, primary reliance on end-product testing is presently considered not to be sufficient to provide confidence in good and safe drinking-water. Thus moving towards a process monitoring by introducing a management framework for safe water is necessary (Bartram *et al.*, 2001). The 3rd edition of the WHO Guidelines for Drinking-water Quality, (GDWQ) proposes a more effective risk assessment and risk management approach for drinking-water quality control. The GDWQ emphasize the multi-barrier principle, establishing a systematic process for hazards identification and effective management procedures for their control through the application of a preventive Water Safety Plan (WSP) that comprises all steps in water protection, from catchments to the consumer.

4.3 WATER SAFETY PLAN

Water Safety Plans Workshop Lautoka - 2008

A Water Safety Plan (WSP) is an improved risk assessment and management tool designed to ensure the delivery of safe drinking water to consumers. It identifies:

- hazards that the water supply is exposed to and the level of risk associated with each;
- how each hazard will and/or can be controlled;
- how the means of control will be monitored;
- how the operator can tell if control has been lost;
- what actions are required to restore control
- how the effectiveness of the whole system can be verified.

The development of a WSP involves a systematic approach for:

- preventing the contamination of source waters
- treating water to reduce or remove contaminants; and
- preventing re-contamination during storage, distribution and handling of treated water

In order to do this, the water authority or supplier needs to:

- assemble a team that understands the system;
- identify risks, hazards and hazardous events;
- identify means for controlling these risks, hazards and hazardous events;
- establish a monitoring system to ensure consistent supply of safe drinking water; and
- periodically review the Water Safety Plan.

To develop and establish a WSP, some essential prerequisites are required such as getting commitment from Government officials, Managers and Executive Officers of all stakeholders.

Once commitment is achieved, a WSP steering committee is established (consisting of relevant stakeholders such as health and environment professionals as well as the water supplier). The water supply system is described and risks and control measures are identified and monitoring systems developed.

4.4 ORGANISATIONS INVOLVED

Water and Sewerage Department

The Water and Sewerage Department (WSD) is the agency responsible for planning, installation, operation and maintenance of public water systems in selected urban areas of Fiji. WSD was identified as the lead implementing agency for the Nadi/Lautoka Water Safety Plan Programme. The steering committee formed with the members of other stakeholders will carry out activities under the direction of the WSD and liaise with regional and donor agencies. WSD is the water supplier and owns the infrastructure and carriers out the management and maintenance as well.

Ministry of Health

The Ministry of Health (MOH) is the agency responsible for regulating and monitoring the water quality and the infrastructure conditions. MOH also implements and manages some of the rural water supply schemes and conducts monitoring and surveillance of the biological quality of public water supply schemes. There are existing programmes for regular water quality monitoring of public supplies as well as sanitary surveys and monitoring of village water supplies. These could be strengthened through Water Safety Plan pilot projects in rural areas. The MoH also have awareness programmes for communities on health issues including water-borne diseases and could play a key role in developing awareness programmes for water quality issues. At district levels there are duly appointed local health authorities by the Minister of Health to carry out all health monitoring activities.

Ministry of Lands, Survey and Natural Resources

The Ministry of Lands, Survey and Natural Resources is the agency responsible for assessment and monitoring of water resources throughout Fiji and for advise on future development and management of water resources. The department directly responsible for this task is Mineral Resources Department.

Rural Local Authorities/Advisory Councils/Provincial Councils

The local Authorities/Advisory and Provincial councils provide expertise and assist in the implementation and management of rural water supplies within the villages and settlements. Since they already have an established role in village water supplies, they have a key role in the Water Safety Plan Planning especially in awareness raising and monitoring.

Live and Learn Environmental Education

The Live and Learn Environmental Education (LLEE) is a major Non-Government Organisation in Fiji and has various community-based programmes. They have a strong relationship with communities in Fiji and therefore have a key role in the Water Programme and river care especially in developing awareness materials and conducting community workshops.

Ministry of Finance

The Ministry of Finance is the agency responsible for preparing the national budget and thus have an impact on capital and recurrent funding for water supply projects. Their involvement in the Nadi/Lautoka Water Supply upgrading Programme is vital, as some improvements will need small-scale capital works that could be Government funded rather than donor funded. The ministry is also monitoring the deployment of Asian Development Bank funds for Nadi/Lautoka water supply upgrading.

Department of Environment

The Department of Environment is the agency responsible for environmental issues and concerns including pollution, conservation, waste management, climate change and EIAs. The Department has assisted in formulating the new Environmental Management Act which will assist in the protection of water resources from contamination.

Table 1: Nadi/Lautoka Water Safety Plan Team

Name	Position	Organization	Responsibility	Phone/E-Mail
S.Tubui	Divisional Water Engineer-Western	Department of Water and Sewerage, (WSD) Lautoka	Overall Supervision of Engineering and Infrastructure for Western Division Water Production and distribution.	PH: 6660563 tubui@connect.com.fj P.O. Box 56, Lautoka
Peceli Ravasua	Senior Technical Officer	Lautoka Water Supply	Overall supervision of all treatment Plants and distribution	PH: 6660563
Govind Naicker	Treatment Supervisor, Western	Lautoka Water Supply	Supervision of treatment Plants for Western Division	PH: 6660563
Sher Singh	Senior Scientific Officer	Lautoka Water Supply	Supervisor for the Plant treatment process – Western Division	PH: 3392133 shersinghh@connect.com.fj
Inoke Rauga	Manager-Nadi/Lautoka Bulk supply	Lautoka Water Supply	Supervisor Nadi/Lautoka Distribution System	PH: 3321099
Rusiate Waqa	Officer In-charge Nagado	Lautoka Water Supply.	Plant Supervisor Nagado	Ph: 6660563
Mereseini Mataluvu	Project Officer	Lautoka Water Supply	Project Planner – Western Division	PH: 6660563
Simione Radakua	Senior Health Inspector	Ministry of Health (HQ) – Western Division	Water and Sanitation	Ph:6660411 P.O. Box 45, Lautoka
Kalisito Biaukula	Principal Agricultural Officer (W)	Dept of Agriculture Lautoka	Supervisor Western Division – farming technology	PH: 6661000 kbiaukula@yahoo.com P.O Box 264, Lautoka

4.5 NEEDS ASSESSMENT FOR NADI/LAUTOKA WATER SUPPLY

When preparing to provide a new water supply, consider all the likely water sources and the costs of bringing the water from each source up to a safe standard. Treatment costs and overall safety are greatly improved by choosing sources well away from potential contaminants. Water testing is almost always used to see what the problems are. When testing the water, it is important to think about the range of water conditions that may occur and what land use activities or situations can affect the water quality. Integrated water resource management approach should be adopted in order to involve all stakeholders in decision making and implementation process.

The world's freshwater resources are under increasing pressure due to population growth, increased economic activity and improved standards of living. This phenomena leads to increased competition and conflicts over the limited fresh water resource. The world's population has increased by a factor of about three during the 20th century whereas water withdrawals have increased by a factor of about seven. It is estimated that currently one third of the world's population live in countries that experience medium to high water stress. This ratio is expected to grow to two thirds by 2025(Global Water Partnership TAC Report 2000).

4.5.1 RESOURCE AND TRAINING

As pressure on resources increases, governments need to consider water as a resource in its own right and manage it accordingly. Policies are the framework within which water resources are managed, and thus a framework within which to develop a water resource management should be adopted. To integrate water resources management policies must mesh with overall national economic policy and related national sectoral policies.

Water Safety Plan Workshop-2008 Lautoka

Since the multiple users of water are competing, and the pressure on resources is increasing because of growing pollution, it is crucial to have the participation of as many different stakeholders and authorities as possible in the management of water resources. Environmental concerns, the ways in which water policies may have an impact on other environmental media and vice versa, must be recognised. At the same time, economic and social policies need to take account of possible water resource implications. Developments outside the water sector for example national energy and food policies should be evaluated for possible impacts on the water resource. Water is a core developmental issue; its development and management therefore affects almost every activity within the wider economy and society, including migration, land use and settlement growth and changes in the industrial activity.

It was noted that the water treatment plant operators had the basic knowledge of all the aspects of the plant's operations that they have mostly learned from the job site training and with number of years of work experience. Bearing in mind the extensive operational procedures involving machines and chemicals the operators should have the sufficient knowledge to operate the plant. There is a request for further training of the operators and technicians with

issuances of necessary certificates and water operator's licence. Presently the operators are taking study course from OPUS – New Zealand based trainers as arranged by the Department.

Recommendation:

- It is recommended that further training and workshop should be conducted on the health aspects and water quality, the safe plant operation and importance of chemicals used for the purification of the water.
- Operator training should be done to upgrade the operator's knowledge to use necessary procedures such as right chemical dosage and use of the necessary equipments.
- Trained staff should be available to monitor the mechanical aspects of the plant operations. Presently there is a lack of mechanical plant operators for the western division.
- Standard Operating Procedures should be formulated for every Treatment Plant and the distribution network in the division.

4.5.2 Infrastructure

The Nagado Treatment Plant was commissioned in 1982 and all necessary provisions were made for the efficient operations but over the years due to the lack of maintenance and upgrade efficiency of the plant is questionable. There was an upgrade of the plant in 2001-2002 to lift the production capacity to 90 ML/day.

Nagado Treatment Plant Filters

Recommendation

- Minor upgrading as railings, signage, fencing and painting is important to protect the facility and workers and these should be immediate improvements as major cost are not involved.

- It was revealed that the allocated funds from the national budget is normally utilised elsewhere such as on staff salary and maintenance in the distribution and storage sections. Due to the lack of management skills and policies there is little control on expenditure and keeping proper data records is a problem.

- The quantity of chemicals stored in the main storage should be kept in a manner that the chemicals remain fresh, clean and dry. The chemicals that are required to be stored should be restacked in separate distinct and clearly labelled areas. The usage should be in the manner of first come last using method so the storage should be done accordingly. The quality of the chemicals should be test certified.

- The floor or the store should be cleaned and damaged bags disposed of first. All spilled chemicals should be cleaned immediately. Appropriate chemical hazard and handling instructions, appropriate personal protective equipments and emergency procedures should be provided in the chemical storage areas.

Laboratory at Nagado Treatment Plant

- The whole plant structure should be kept clean at all times with minimum of leakages to avoid any recontamination of treated water at the plant.

- There has been no Environmental Impact Assessment (EIA) done on the extraction of water from the Vaturu dam after the completion of the project to monitor the impacts and its mitigation factors. It is important to have an EIA done In order to formulate necessary policies to protect the water resource and the natural ecosystem of the area it's necessary to conduct an EIA.

4.5.3 Equipments

The Treatment plant lacked the modern communication technologies such as from Vaturu Dam and the plant. Recorders and telephones for efficient communications during emergencies and disasters are also necessary.

The operators are using old techniques to monitor the water qualities at the plant. Measuring tools as water meter/checker should be provided for efficient and time saving methods.

Due to the lack of a proper enclosed laboratory, analysis is difficult and chemical storage is not safe.

- There are no written SOPs for the plant laboratory.
- Training should be provided to the staff on the proper use of equipments and chemicals that is used in the plant operation.
- It was noted that some of the existing equipments and chemicals are outdated thus giving invalid results. The laboratory at the Nagado Treatment Plant needs immediate improvement.
- Leak detection equipments are needed as the division has a large distribution system.

4.5.4 Mobility/Transport

At present transport is provided by the department but recommendation that each plant has a full time vehicle and the plant operators should be allocated the vehicle with the authority to drive. It was noted that the transport is available on request and the drivers reach to their destination after long delay as such much work time is lost while waiting. Hired transport is also available on request and there is the chance for misuse of the vehicles.

Transport is used for the movement of staff, chemicals and machinery parts and as such it is vital to have transport available during emergencies. Presently there is no routine timely inspection and monitoring schedules and inspection for the plants and reservoirs, it only eventuates when there is an emergency in one of the treatment plants in the division.

Hired transport (truck) is used for water cartage in case of emergency break downs. It was informed that the department has few water cartage tanks and trucks. There was no plan in place for the emergency cartage and manual purification of water.

4.6 Lautoka Water Supply

Lautoka water supply is located in Lautoka city close to other administrative centre. It has its own set up and structure and managed by the Lautoka Water Supply Engineers and technical and administrative staff. The main functions of the Lautoka water supply are to maintain the storage and distribution system for the treated water supply for the consumers. The households on the system are from part of the Nadi/Lautoka area. Saru and Buabua water supplies are also connected to the Nadi/Lautoka regional supply provide about 12 MLD of treated water. There are a number of operational teams divided in two zones with specific roles.

The major function is of the new household connection and handling consumer complains of water cuts and low pressure. The management revealed that it manages to handle all the complaints on time and also able to provide for new water connections. Illegal connection is one of the major problems in the area and a team has been established to curb the problem by monitoring and public awareness.

Lautoka Water Supply -Office

- **Human resources.**

The management informed that there is need for the proper training for the distribution and management staff. Staff should be recruited on merits and qualifications and preferably training should be provided from Fiji Institute of Technology and Training and productivity Authority of Fiji. Training is requested for plumbers and fitters and on water safety and leak detection. Since there is a lot of interaction with the public, the staff to be trained on customer relations record keeping and stores and financial management. There is a need for competent staff due to the expansion of the system. It was informed that the leak detection unit needs more trained staff. Presently there is two staff and one of them is a Japanese volunteer. Leakages are a common problem in the area and due to financial constraint improvement is slow.

- **Infrastructure**

The Lautoka Water Supply has its own office building as seen in the picture above. The treatment chemicals are stored at Navutu Sewerage treatment plant and distributed to other plants in the Western division on request. The office buildings and the storage facilities need immediate improvement and renovations. The existing Buabua and Saru catchment areas also need improvements. This system once upgraded will solve the major problem of the Nadi/Lautoka Water Supply system.

Rusted open inspection chambers

Unfortunately there has been less funding allocation from the national budget and improvement to the system is slow. It is difficult to maintain some of the reservoirs and re-contamination may be possible if improvements are prolonged.

It is difficult to keep the reservoir compounds clean as there are no set work procedures. This was evident during the inspection as trees in the surrounding the reservoirs contributed to the access of rodents and birds. Most of the reservoir inspection chambers were rusted or left open.

The distribution network which mainly comprises of galvanised pipes is quickly deteriorating due to aging. Locating leakages are difficult and leaking mains siphon the ground contaminated water. This in turn contaminated the treated mains water as people are unaware of the health consequences they are least appreciative to take corrective measures or inform the authorities in time.

It was informed by the project officer that in Lautoka area there is a need to increase the size of service pipes. There is much public complain due to water limits during dry periods of the year and again this is a health concern. The proposal has been made for budget allocations annually but unfortunately funds are constrained and improvements are lagging behind the schedules.

Nadi Water Supply

Nadi Water supply has its own operation and maintenance team which operates from Navakai Deport. There is 33 staff headed by a supervisor, the teams are involved in reservoir maintenance, fixing the broken mains and doing new water meter connection in Nadi area. Nadi area expends from Sabeto to Momi. The project officer, Lautoka informed that their major project is in Nadi area i.e. the extension of mains towards Momi and other rural settlements.

The census of 2007 indicates a high population growth for Nadi and secondly due to tourism development there is ever increasing demand for treated water. The Principal Agricultural Officer (Western) informed that there may be greater need for treated water as people are using it for backyard gardening and commercial production of hydroponic vegetables in Nadi. Since Nadi area is mainly flat the sewerage effluent overflow is common and in turn this can re-contaminate treated mains water during breakages and repair works.

Table 2: STAFF ESTABLISHMENT

	Total Number	Supervisor	Pump Attendants	Trade Assistant/Labours
Nagado Treatment Plant	19	1	12	9
Saru Treatment Plant	11	1	3	7
Buabua Treatment Plant	11	1	2	8
Lautoka Water Supply	143	4	28	41
Nadi Water Supply	33	1	2	30
National Water Quality laboratory	16	1	15	-

❖ Equipments

- It was noted that there were field equipments available with Lautoka Water Supply and was made available to other water supplies on demand. Each station should have its own set of equipments as sharing and transportation becomes a hassle and time consuming.

- Administrative equipments such as computers, filing system and records of maps and charts are necessary for efficient services. The communication needs improvement especially in case of emergencies.

Equipment storage – in use

- The upgrading of SCADA system is also necessary and where possible solar or electrical power to be used for the system.

❖ Mobility

There are trucks and vans for mobility and they are hired private vehicles. There is a request for full time two tonne trucks and 4x4 twin cab vehicles for Nadi/Lautoka water supply.

Being a large reticulation area its time consuming during travel and inspections. Some reservoirs are accessible by driveways which needs maintenance. Consequently this contributes to the problem of maintenance and upkeep of the reservoirs and distribution mains in these areas.

Once again transportation cost is the major financial constraint from the annual budget allocation. There being no inspection programme for the reservoirs so it is done randomly.

Turn Key – Holika Reservoir -Nadi

The distribution staffs have to visit storage reservoirs either to close or open the reservoir keys to maintain the water level at each reservoir. This will in turn maintain the constant supply to the consumers.

Holika Reservoir - Nadi –overgrown grass/trees

Nadi Farming Area – Regional Supply

4.7. DEVELOP RELEVANT TOOLS FOR RISK ASSESSMENT

The team should gather relevant resources and expertise to assist with identification of risks in the water supply system. These resources could include:

- Photos and maps of the water supply
- Risk assessment guidelines (e.g. NZ- MoH and WHO guidelines)
- Videos on risk assessment (e.g. NZ- MoH DVDs)
- Reports (of previous studies)
- Experts (e.g. mechanics, plumbers, operators, civil engineers, hydrologists, soil scientists, laboratory personnel, health officials and others as needed)
- Funding (national budget, donor)
- Establish and strengthen the National Steering Committee by including all agencies that have a role (or responsibility) in the management of drinking water quality in Nadi/Lautoka Area.

Conduct public consultations and workshops to consult relevant agencies on issues and concerns relating to drinking water quality and health and improve sharing of information among agencies. Establish a working group that would collate data and prepare annual reports on the drinking water quality of various supplies.

The membership of this working group should include agencies that are directly responsible for water quality monitoring or health surveillance such as Fiji Water Authority, Ministry of Health and Department of Environment. The NGOs and village water committees should also be represented in this working group.

Inter & intra governmental relationships and networks should be strengthened to improve information sharing by adopting a collaborative approach.

4.8 MONITORING AND INSPECTION PROGRAMME

There is a need to develop new or strengthen existing water quality monitoring and health surveillance programmes and review current monitoring programmes to identify gaps and weaknesses. Collate past water quality monitoring and health surveillance data (including customer complaints records and disease statistics). Conduct public consultations and organize

workshops for key agencies to discuss a strategy to improve coordination between existing monitoring programmes.

Identify resources (e.g. finance, experts etc) that would be needed to strengthen existing monitoring programmes and establish means for securing those resources. Complete the Water Safety Plans to identify areas that need improvement. Rank the improvements based on the resources (funding, capital works, infrastructure development, human resources) and time needed to complete them.

Table 3: Activity & Responsibility Matrix for the Development of WSP

	Actions	WSD	MoH	DoE	L&S	NGO	Fin	Legal	MAPI	NPO	LLEE	AC/PC
1	Assemble a team of people who have good knowledge of the system	R	I	I	I	I	A	A	I	A	I	R
2	Develop checklists for describing a water supply system	R	I	I	I	I	A	A	I	A	I	R
3	Carry out surveys do describe a water supply system	R	I	I	I	I	A	A	I	A	I	R
4	Develop relevant tools for risk assessment of the water supply system	R	I	I	I	I	A	A	I	A	I	R
5	Strengthen stakeholder collaboration	R	R	R	I	I	I	I	I	I	I	I
6	Conduct public consultations and workshops to consult relevant agencies on issues and concerns relating to drinking water quality and health.	R	R	I	I	I	A	A	I	A	I	R
7	Improve sharing of information among agencies	R	R	R	I	I	I	I	I	I	I	I
8	Develop new or strengthen existing water quality monitoring and health surveillance programmes	R	R	R	I	I	A	I	I	A	I	R
9	Identify resources (e.g. finance, experts etc) that would be needed to strengthen existing monitoring programmes and establish means for securing those resources.	R	R	I	I	I	I	I	I	I	I	I
10	Complete Water Safety Plans to identify areas that need improvement.	R	R	I	I	A	A	A	A	A	I	R
11	Rank the improvements based on the resources (funding, capital works, infrastructure development, human resources).	R	R	R	I	I	A	A	I	A	I	R

Key: **R – Responsible** **I – Involved in the action** **A – Aware of action**

L&S – Lands and Survey
Fin – Finance Dept
Legal – Legal Affairs
MAPI – Ministry of Agriculture and Primary Industries
NPO- National Planning Office
AC/PC – Advisory Council and Provincial Council

4.9. ACTIONS FOR IMPLEMENTATION OF WATER SAFETY PLANS

- Develop awareness programmes by establishing a working group for community awareness & education that would be responsible for developing IEC materials for awareness rising on drinking water quality and health issues.

- The Awareness Working Group should engage in public consultations to identify issues and concerns of the public in relation to drinking water and health. Conduct workshops to empower village communities to take more ownership and responsibility of their drinking water.

- Promote the linkages between drinking water quality and health issues through village workshops. Promote better understanding of water supplies by training village water supply operators and managers on technical aspects of water supply management including plumbing, pump maintenance and treatment options.

- Empower communities to maintain safe quality water by training them on simple water quality tests and sanitary surveys e.g. H2S test kits and WHO sanitary survey forms.

- Conduct studies to establish the extent of underground aquifers (including area, quality and quantity) that is the main source of water. Identify resources (including experts, finance etc) needed for such studies and experts and/or agencies to assist with the studies. Develop funding proposals for donor funding of such studies if experts are not locally available

- Establish strategies for sustaining the quality and quantity of water resources and strengthen monitoring of drinking water quality. Strengthen MoH surveillance and monitoring of drinking water supplies (including urban and rural supplies). Strengthen National Water Quality Laboratory monitoring procedures of public water supplies.

- Establish strategy for sharing of data among agencies and prepare annual reports on drinking water quality status.

Institutional Arrangements

- It is vital for capacity building for agencies in developing and implementing of the WSPs. An ongoing Capacity Building and Training programme needs to be established to ensure local expertise is available to assist with WSP development & implementation.

- Conduct training workshops to train staff from other agencies on development and implementation of WSPs. A strategy for maintaining expertise within agencies needs to be developed (e.g. staff passing on their knowledge to successors).

- The membership of this working group should include agencies that are directly responsible for water quality monitoring or health surveillance such as Water and Sewerage Department, Ministry of Health and Department of Environment. The NGOs and advisory and provincial councils should also be represented in this working group.

- Intra governmental relationships and networks should be strengthened to improve information sharing. Establish a network between all stakeholders that have or are in the process of developing and implementing WSPs to share lessons learnt.

- Strengthen monitoring of drinking water quality by strengthening MoH surveillance and monitoring of drinking water supplies (including urban and rural supplies). Strengthen NWQL for monitoring of public water supplies. Establish strategy for sharing of data among agencies and prepare annual reports on drinking water quality status.

- Establish a National WSP Working Group *(*Expert group that will help other supplies prepare a WSP). Assemble a working group that would assist operators of other supplies (e.g. rural and outer island supplies) in developing and implementing WSPs. Organize a training of trainers' workshop on Water Safety Planning for this working group.

- Enforce existing legislation or draft new legislation to address national water supply concerns such as water theft, illegal connections or cross connections between reticulated and rainwater systems.

- Conduct a legislative review of various acts and regulations that regulate water resource, water supply or water quality management. Make amendments to existing legislation to address key issues in water resource, water supply and water quality management. Formulate Water Quality Standards and incorporate it into one of the related legislations.

- Villages and Squatter settlements do have illegal communications and unaccounted water use. Most household have taps running all the time and a lot of water is wasted. Public awareness is necessary and some subsidy of funding programme may be implemented to do tap/ shower maintenance work with the village/squatter community.

Financing

Agencies need to identify sources (national budget and donor aid) for funding WSP implementation. Reviewing of current and projected budgets to identify funding for needed capital or institutional improvements for implementation of WSPs is necessary. Establishing an advisory service for preparation of funding proposal will enhance accountability and transparency.

Allocation of funding for needed improvements (capital works or institutional arrangements) or capacity building is needed. The Completed Water Safety Plans for water supplies can be used as justification for funding or donor support for needed improvements. Preparing an Improvement Schedule with a budget will assist in identifying (prioritize) those improvements that can be made with existing funding and those that will need additional funding from Government or donor support.

Appropriate Technology

Buabua Treatment Plant- Pressure sand Filter

Sedimentation/Clarifier –Buabua Treatment Plant

Development of National Guidelines for septic tank construction and imposing policies and restrictions would protect groundwater resources from contamination. The National Building Code and other related Acts such as Public Health and Environment Management Acts will strengthened the pollution control measures.

Regular monitoring of effluent quality from septic tanks, waste disposal pits and sewer lines will indicate the groundwater quality. Maps showing locations of existing point source pollution will assist in designing improvements in the system and punishing the offenders. Identify appropriate infrastructure and equipment to strengthen on-going monitoring of drinking water quality (e.g. purchase of appropriate equipment for measuring residual chlorine in distribution system)

Sustainable Agricultural Practices

Improvement in the farming practices in the watershed can considerably reduce reliance on chemical fertilizers and pesticides. The NGOs can play a good role in promoting organic farming through community education. Appropriate policies for non-point source contamination of water resources are common in farming areas and there is a need to control this. It is important to develop an education and awareness programme for farmers on risks to drinking water quality from agricultural chemicals.

Lautoka Cane farm area

Lautoka Reservoirs –overgrown trees/grass

Table 4: Activity & Responsibility Matrix for Programme Sustainability

	Actions	WSD	MoH	DoE	L&S	EDO	Fin	Legal	MAPI	NPO	LLEE	AC/PC
1	Develop awareness programmes	I	R	R	I	I	A	A	I	A	R	I
2	Conduct workshops to empower village communities to take more ownership and responsibility of their drinking water	I	R	R	I	I	A	A	I	A	R	R
3	Conduct studies to establish the extent of underground aquifers (including area, quality and quantity) that is the main source of water for the people.	R	A	I	R	A	A	A	R	A	A	I
4	Establish strategies for sustaining the quality and quantity of water resources.	I	I	I	R	I	A	A	R	A	I	I
5	Strengthen monitoring of drinking water quality	R	R	R	I	I	A	A	I	A	I	I
6	Capacity Building for agencies in developing and implementing WSPs	R	R	R	I	I	A	I	I	I	I	I
7	Strengthen monitoring of drinking water quality	R	R	R	R	A	A	A	I	I	I	I
8	Establish a National WSP Working Group (*Expert group that will help other supplies prepare a WSP*)	R	R	R	I	I	A	A	I	I	I	I
9	Enforce existing legislation or draft new legislation to address national water supply concerns such as water theft, illegal connections or cross connections between reticulated and rainwater systems.	R	R	R	I	I	A	R	I	I	I	I
10	Identify funding sources	R	R	R	I	I	R	A	I	A	I	I
11	Allocate funding for needed improvements (capital works or institutional arrangements) or capacity building	R	R	R	R	I	R	A	I	A	I	I
12	Develop National Guidelines for Septic Tank construction	R	R	R	I	I	I	R	I	I	I	I
13	Conduct studies to determine if septic tanks are affecting groundwater quality	R	R	R	R	I	R	I	I	I	R	I
14	Identify appropriate infrastructure and equipment to strengthen on-going monitoring of drinking water quality (e.g. purchase of appropriate equipment for measuring residual chlorine in distribution system)	R	R	R	I	A	I	A	I	A	I	I
15	Improve farming practices to reduce reliance on chemical fertilizers and pesticides.	R	R	I	I	I	A	A	R	A	I	R
16	Improve farming practices to reduce reliance on chemical fertilizers and pesticides.	A	A	I	I	A	A	I	I	A	R	I

Key: **R - Responsible** **I – Involved in the action** **A – Aware of action**

L&S – Lands and Survey
Legal – Legal Affairs
NPO- National Planning Office
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MAPI – Ministry of Agriculture and Primary Industries
AC/PC – Advisory Council and Provincial Council

4.10 PRODUCTS & OUTPUTS OF THE WATER SAFETY PLANS PROGRAMME:

1. National Policy promoting Water Safety Plans formulated
2. National Steering Committee established
3. Drinking water quality monitoring working group established and improved Water quality programmes by NWQL/MOH
4. Awareness programme(s) established
5. Education & Awareness materials introducing WSPs are developed and distributed.
6. Strategy for information sharing developed including water resource, status reports, water quality monitoring data and health surveillance statistics.
7. Capacity building and training workshops completed on Water Safety Planning
8. Drinking water quality surveillance and monitoring programme established by Ministry of Health
9. Source water and drinking water quality monitoring programme established by Water and Sewerage Department and Mineral Resources Department.
10. Annual reports on drinking water quality status of all supplies in Nadi/Lautoka Area.
11. National WSP Expert Group established
12. Necessary legislation reviewed and new ones formulated.
13. National Plans and policies reviewed to include WSPs and checklist /maps developed
14. Water Safety Plans completed for Nadi/Lautoka area
15. Improvement schedule completed for Nadi/Lautoka area
16. National guidelines for sustainable farming developed
17. Standard Operating procedures and contingency plans formulated for the respective water supplies.

4.11 REVIEW AND EVALUATION

Indicators of success of the programme

1. Safe drinking water for all communities including reticulated and rainwater supplies.
2. Sufficient drinking water for communities (Quantity).
3. Less number of water-borne diseases reported
4. Improved water quality monitoring
5. Improved sanitation and health surveillance
6. Improved collaboration between key agencies
7. Improved sharing of water quality monitoring data among agencies
8. Improved quality of source water
9. Less reliance on rainwater
10. Better sanitary services, surveillance and monitoring
11. Less bottled water imported
12. Active community participation in water supply management.

Table 5: WHO BENEFITS

	Indicators	WSD		MoH		DoE		L&S		NGOs	
		U	R	U	R	U	R	U	R	U	R
1	Safe drinking water for all communities including reticulated and rainwater supplies (Quality)	P	S	P	P	P	P	S	S	P	P
2	Sufficient drinking water for communities (Quantity)	P	S	S	P	P	P	P	P	P	P
3	Less number of water-borne diseases reported	P	S	P	P	P	P	S	S	P	P
4	Improved water quality monitoring	P	S	S	P	P	P	P	P	P	P
5	Improved sanitation and health surveillance	P	S	P	P	P	P	S	S	P	P
6	Improved collaboration between key agencies	P	P	P	P	P	P	P	P	P	P
7	Improved sharing of water quality monitoring data among agencies	P	P	P	P	P	P	P	P	P	P
8	Improved quality of source water	P	P	P	P	P	P	P	P	P	P
9	Less reliance on rainwater	P	S	S	P	P	P	P	P	S	S
10	Better sanitary services, surveillance and monitoring	P	S	P	P	P	P	P	P	P	P
11	Less bottled water imported	P	P	P	P	P	P	P	P	P	P
12	Active community participation in water supply management (especially rural water supplies	P	P	P	P	P	P	P	P	P	P

Key: **P – Primary benefit** **S – Secondary benefit** **U – Urban** **R - Rural**

4.12 Verification

	Indicator	Means of Verification
1	Safe drinking water for all communities including reticulated and rainwater supplies (Quality)	Water quality test results for bacteriological and chemical parameters
2	Sufficient drinking water for communities (Quantity)	Less water cuts with ample water pressure at the consumer end
3	Less number of water-borne diseases reported	Check medical statistics
4	Improved water quality monitoring	Formulated plans in place by the supplier and the regulator. Increased complying data
5	Improved sanitation and health surveillance	Number of staff engaged and samples taken
6	Improved collaboration between key agencies	Improved information sharing, regular meetings and workshops. Active steering committee.
7	Improved sharing of water quality monitoring data among agencies	Available data
8	Improved quality of source water	Improved collaboration with stakeholders and the rural community
9	Less reliance on rainwater	Reduced number of water tanks and others means of storage
10	Better sanitary services, surveillance and monitoring	Use of toilets and use of hand washing facilities
11	Less bottled water imported	Importation and sales record
12	Active community participation in water supply management (especially rural water supplies	Community empowerment, increase and upgrading of the supplies in the community

4.13 REPLICATION

After gaining the sufficient knowledge on the formulation of Water safety Plans Process, the replication strategy for other water supplies may be complete by the leading agency (Water Supply Department) and assisted by the Steering Committee in a collaborative effort. The Water and Sewerage Department and Ministry of Health may lead the process in their respective jurisdictions. During replication, Water Safety Plans, Improvement Schedules and Standard Operating Procedures (SOPs) may be formulated for each supply system. Offcourse this will largely depend on the commitment of each stakeholder.

SECTION: 5 RECOMMENDATIONS AND CONCLUSION

5.1Remarks and Recommendations

1. There is a need for the improvements in water resource management and land use planning in the water shed; therefore it is necessary to have a water authority for the efficient management of the water supply system in relation to human, capital and natural resources.

2. There is a need for the training of staff on raising public awareness in the departments and in the community levels. It is necessary for the continuous up-skilling of staff at all sectors of the organisation due to the advent of new technology and quick staff turnover.

3. Since most of the staff are field workers occupational health and safety provisions should be made for efficient work performance especially in the treatment plant where hazardous chemicals are used.

4. The Nagado Treatment Plant to be upgraded and improved (filters, clarifiers, chemical mixing and sludge disposal). The request of such improvement in seen in the monthly reports. The plant building also needs improvement and hygiene upgrade.

5. Modern laboratory with equipment to be set at the NagadoTreatment Plant and a field monitoring system for residual chlorine and leak detection procedures.

6. All plant operators should be suitably qualified, graded to operate the plants. The department should arrange for the necessary training for the respective staff.

7. Data and record keeping should be improved in order to monitor the resource, demand and water wastage. SCADA telemetry system to be improved where necessary.

8. Existing management plans and strategies to be continuously reviewed with the formulation of contingency plans and standard operating procedures (SOPs).

9. Ministry of Health as regulators should formulate a monitoring plan for the drinking water quality for bacterial and chemical parameters and make relevant information available to Water department.

10. Due to the increase in the population, tourism and industrial activities in Nadi/Lautoka there is increase in water demand, therefore storage and distribution system to be maintained and upgraded urgently.

11. There are a number of reservoirs in the Nadi/Lautoka water supply; unfortunately the inspection reveals that they are not well maintained. Contamination of treated water is likely as most reservoirs are seen with over growth of grass and broken manhole lids /inlets. Ingress of rodents and small animals are possible. The turn key chambers are unmaintained and usually damaged by vandalism. This to be addresses immediately as per the WSP/Improvement Schedules.

12. Remove siltation of dissolved solids which is common in the reservoirs and distribution mains as filtration process at the treatment plant is in-efficient. There are no flush out device for the mains at low lying areas. Siltation also occurs due to the low water pressure during water cuts.

13. Coordination with major stakeholders and networking and information sharing is necessary to promote more collaborative approach in water resource management at watershed and service level.

14. It is vital to enforce Environmental Management Act and Public Health Act to maintain a healthy watershed through elimination of pollution from human activities (point and non-point source).

15. There is lack of data on water resource management and surveillance with major stakeholders such as WSD, Mineral Resources Department and Ministry of Health. This impedes in making proper decisions in many cases such as water demands in specific zones and water loss through leakages (unaccounted water). Department sections to improve data recording and formulating improvement proposals.

16. Proper chemical storage areas should be provided to store different chemicals in confined areas in order to maintain them in good condition and provide efficient methods of application of chemicals without endangering the health of workers and quality of chemicals.

5.2 Conclusion

The Water Safety Plan was finalized through the assistance of the Lautoka Water Supply staff and reference was also made to the outcome of the WSP workshop held at Lautoka Water Treatment Plant in December 2008. Lautoka Water Safety Plans steering committee is formed which would monitor the future activities necessary for implementing the plan. The Water Safety Plans documents will be presented to the Steering Committee and the Water and Sewerage Department for their initial endorsement as the final document. It is realized that this document is very important for the implementation of the plan and to carry out the improvements in order to remove risks in the water supply system and create a holistic management approach from catchment to consumer. The document would assist in future planning and for the fund allocation in specific areas as per the improvement schedule. The completed Water Safety Plan is an ideal reference document for staff and the decision markers.

The Improvement Schedule was finalised with the assistance of Water and Sewerage Department during the consultancy process. The national budgetary allocation in reference to this document is important for the country to divert further funding in this area. It is anticipated that Fiji Water Safety Plan programme will assist and train the staff of the department in improving the water quality by eliminating the risks in the system. The Steering committee also requested that staff from WSD should be further trained in risk assessment and management in the water supply system. The WSP replication programme for Fiji is well progressing due to the commitment shown by the stakeholders and especially Water and Sewerage Department.

The Lautoka Water Supply is under much pressure due to high demand of treated water for consumption by the increasing population in the Nadi/Lautoka area. The Nadi/Lautoka Regional Water Supply has authority and capacity to maintain the treatment and distribution system but many constraints such as lack of capital and human resources and deteriorating infrastructure hinders the progress. There are many benefits of improved water quality and quantity such as

improved human health and the economic status of the country. And it is anticipated that Fiji will surely gain through implementation of this programme.

It is envisaged that Water and Sewerage Department, the Ministry of Health and the Department of Public Works will work together to implement Water Safety Plans for the Water Supply system and replicate the process for the other areas in Fiji. Cooperation between various agencies is necessary to achieve the outcomes, as they have expressed commitment for this programme at the commencement of the Regional Action Plan (RAP) for the Pacific island countries and endorsed by the ministers.

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ANNEX: 1

Drinking Water Risk Assessment Table

Judging Priorities – systematic risk assessment

i. For each hazard event, decide on the likelihood of the event happening

Likelihood	Score	Possible Descriptions
Almost Certain	5	• Occurs like clockwork • Occurs every week, month or season
Likely	4	• Has occurred more than once before • Expected to occur every year
Possible	3	• Has occurred before • Expected to occur every 2-5 years
Unlikely	2	• Has occurred before • Expected to occur every 5-10 years
Rare	1	• Has never occurred before and unlikely to occur less than every 10 years

ii. *For each hazard event, decide on the consequence to people's health if it did happen*.

Consequence	Score	Possible Descriptions
Insignificant	1	• No illness expected in the community or interruption to water availability
Minor	2	• Very few of the community ill, or some interruption to water availability
Moderate	3	• Some of the community ill
Major	4	• Most of the community ill
Catastrophic	5	• Most (or all) of the community ill with anticipation of some deaths

iii. *For each hazard event, look up the likelihood and consequence scores in this table to find the corresponding priority (very low, low, medium, high, very high)*

Likelihood	Consequence				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Almost Certain 5	Medium 5	Medium 10	High 15	High 20	very high 25
Likely 4	Medium 4	Medium 8	Medium 12	High 16	high 20
Possible 3	very low 3	Low 6	Medium 9	High 12	High 15
Unlikely 2	very low 2	very low 4	Low 6	Medium 8	High 10
Rare 1	very low 1	very low 2	low 3	medium 4	medium 5

(Adapted from NZ MoH, 2007)

Instruction: Using either of the methods outlined above, consider each of the hazard events separately and determine the priority for each. Enter the priority rating into the third column of the DWSP matrix.

ANNEX: 2

RISK ASSESSMENT – NAGADO

Risk assessment was conducted using the following steps:

i. Identify risks (at each stage of the water supply system)
ii. Identify control Measures (or barriers)
iii. Prioritize Risks which are not under control

Semi-quantitative ranking – using the "likelihood" and "consequence" matrices, a semi-quantitative way of prioritizing risks was developed as in the tables below.

Intake/Catchment

RISK	CAUSE	CONTROL MEASURE IN PLACE?	LIKELIHOOD	CONSEQUENCE	PRIORITY
High levels of Faecal Coliform in raw water	Animal/bird feaces and/or seepage	None	Almost Certain 5	Moderate 3	High 15
High turbidity due to Increased sedimentation and soil erosion	Deforestation / logging	None	Almost Certain 5	Minor 3	High 15
	Farming – land clearing	None	Likely 4	Minor 2	Moderate 8
	Flooding	None	Likely 4	Moderate 3	High 12
Not sufficient water, low water level	Drought	None	Possible 3	Major 4	High 12
Algae in raw water	High nutrient levels in water	None	Likely 4	Minor 2	Moderate 8
Head Works drying up	Increased siltation in the Headworks	None	Possible 3	Moderate 3	Medium 9

Pumping Station/Intakes – Buabua/Saru

RISK	CAUSE	CONTROL MEASURE IN PLACE?	LIKELIHOOD	CONSEQUENCE	PRIORITY
Pump Failure	Electrical blackout	None	Possible 2	Major 4	High 8
	Mechanical Problems	Preventative Maintenance programme in place	Possible 2	Major 4	Moderate 8
Vandalism and Sabotage	Low security	None	Likely 4	Major 4	Very High 16
	Easy access to site	None	Unlikely 2	Major 4	Moderate 8
Contamination from Storm water and flooding	Damaged infrastructure (leaking buildings)	None	Possible 3	Major 4	High 12
Low water Intake	Smaller diameter intake pipe	None	Likely 4	Major 4	Very High 16

Treatment Plant -Nagado

RISK	CAUSE	CONTROL MEASURE IN PLACE?	LIKELIHOOD	CONSEQUENCE	PRIORITY
Raw Water Channel					
Sabotage and/or vandalism	Low security	None	Likely 4	Major 4	Very High 16
	Easy access to site	None	Unlikely 2	Major 4	Moderate 8
Solution strength inaccurate	Chemical strength can be affected if not stored properly and by manual mixing	None	Unlikely 2	Major 4	Moderate 8
Chemical Under-dosing	Equipment Failure (e.g. improper jar-test or old balance etc)	Calibration by trained technicians and audited by NWQL	Possible 2	Major 4	Moderate 8
	Fluctuations in turbidity	None	Likely 3	Major 4	High 12
	Fluctuations in flow rate	Flow meters	Possible 2	Moderate 3	Moderate 6

	Improper mixing (low concentration)	Trained Technicians required	Rare 1	Moderate 3	Low 3
Chemical Over-dosing	Equipment Failure (e.g. improper jar-test or old balance etc)	Calibration by NWQL	Possible 2	Major 4	Moderate 8
	Fluctuations in turbidity	None	Likely 3	Major 4	High 12
	Fluctuations in flow rate	Flow meters	Possible 2	Moderate 3	Moderate 6
	Improper mixing (high concentration)	Trained Technicians required.	Rare 1	Moderate 3	Low 3
Contamination from operational activities	Improper safety mechanisms – no railing, slippery surface, poor lighting, poor ladder etc	None	Possible 2	Moderate 3	Moderate 6
Clarifiers					
Overload	High turbidity	Increased dose of coagulant (jar test)	Rare 1	Moderate 3	Low 3
Algae in water	Algae in raw water	Increase dosing of copper sulphate	Unlikely 3	Moderate 3	Moderate 9
Malfunctioning	Damage to structure	Preventative maintenance in place	Rare 1	Major 4	Low 4
Filters					
Filter overload	High turbidity	None	Rare 1	Moderate 3	Low 3
	Clarifier failure	Preventative Maintenance in Place	Possible 2	Major 4	Moderate 8
	Insufficient Backwash	Trained operators	likely 1	Major 4	Low 4
	Filter Medium expired (sand)	Changing filters prior to expiry	Rare 1	Major 4	Low 4
Protozoa presence in treated water	Protozoa barrier	Sand filters	Possible 3	Major 4	High 12

Disinfection					
In-sufficient Chlorination	Chlorinator failure/manual dosing	Preventative Maintenance	Possible 3	Major 4	High 12
	High turbidity/less time for the settlement of flocs	None	Possible 3	Major 4	High 12
Pumps					
Pump failure	Electrical Failure	None	Possible 3	Major 4	High 12
	Power board exposed	None	Possible 3	Major 4	High 12
Flow Meters	Not functioning	none	Possible 3	Major 4	High 12
Clear Well Storage					
Sedimentation	Improper filtration ,reduced filter media	none	Likely 4	Major 4	Very High 16
Accumulation of Filter Media	Damaged filter nozzle allows filter media to enter clear well	none	Likely 4	Major 4	Very High 16
Easy entry of rodents and birds	Open inlets above clear well	none	Possible 3	Major 4	High 12
Sabotage /Accidents	Open Inlets	none	Possible 3	Moderate 3	Moderate 9
Entry by Operators to check water level	No mechanical measuring device	none	Possible 3	Major 4	High 12
Chemical Storage					
Chemicals react with air and lose strength	Improper Storage	None	Possible 3	Major 4	High 12
Unventilated Chambers	Distract workers	none	Possible 3	Moderate 4	High 12

Post Treatment Storage - Nagado

RISK	CAUSE	CONTROL MEASURE IN PLACE?	LIKELIHOOD	CONSEQUENCE	PRIORITY
Accidental contamination	Rusted covers and other components	None	Possible 3	Major 4	High 12
	Cracks allow for bacterial access	None	Likely 4	Major 4	Very High 16
	Sedimentation at the bottom of the tank	None	Likely 4	Major 4	Very High 16
Security	Low security	None	Likely 4	Major 4	Very High 16
	Easy access to site	None	likely 4	Major 4	Very High 16

Storage and Distribution network – Nadi/Lautoka Supply

RISK	CAUSE	CONTROL MEASURE IN PLACE?	LIKELIHOOD	CONSEQUENCE	PRIORITY
Distribution Pipe Breakages	Old pipes	Leak detection and replacement	Likely 4	Major 4	Very High 16
	Earth Works	None	Possible 3	Major 4	High 12
	Disasters	None	Possible 3	Major 4	High 12
Sedimentation and Scaling in storage tanks and Distribution pipes	Pipe breakages	none	Likely 4	Major 4	Very high 16
	Inefficient filtration	none	Possible 3	Major 4	High 12
Rodents, Birds and animals entering the reservoir tanks	Rusted cover and inlets	none	Possible 3	Major 4	High 12
	Remove tall trees and discarded pipes / fitting	Casual workers	Possible 3	Major 4	High 12
Cross Contamination of treated water	Illegal connections	Meter reading	Possible 3	Moderate 3	Moderate 9
Low water pressure	High demand and low treatment plant capacity	Increase water intake through catchments improvement.	Possible 3	Moderate 3	Moderate 9

ANNEX;3

NATIONAL WATER QUALITY LABOROATORY

WATER AND SEWERAGE DEPARTMENT

SERVICE RESERVOIRS SANITARY SURVEY

Sample Time: 1120Hrs
Inspected By: Marica

Date: 5/02/09
Water level: 0.9m

a) Name/Location: **Buabua [Lautoka].**

b) Are the overflows and vents properly screened **Yes**/No

c) Is the reservoir free of major structural problems (cracks, etc) **Yes**/No

d) Is the above ground reservoir corrosion free **Yes**/No

e) Is there any trees and roots in the vicinity of the ground reservoir? Yes/**No**

f) Is the Reservoir cleaned/ Not Covered with Silt, etc. Provide Details
The reservoir is silt free.
Everything -water flow through filter , no bypass.
Is there any records showing when the reservoir was last cleaned Yes/**No**
Provide Details:
Reservoir has never been cleaned since commissioning.

g) Is the reservoir fenced and locked **Yes**/No

h) The reservoir compound is : Poorly maintained/ **well maintained**
Observation: **neat and Tidy.**

i) Any other observation that could affect water quality:
If drip-feed HTH , could react with metal the steel ladder inside the reservoir.

k) Who is responsible for the maintenance of the reservoir?
Buabua Treatment Plant

B) Actions

C) Suggested remedial actions (in order of priorities)

b) Note down any other observations made.

ANNEX: 4

MINISTRY OF HEALTH

Shaping Fiji's Health

BACTERIOLOGICAL ANALYSIS OF WATER

Sender	Collected	Received	Reported
HEALTH INSPECTOR, NADI AIRPORT.	Analysed	20/10/2008	24/10/2008

Lab No.	Sample No.	Sample Decalls	Coliforms	Faecal Coliforms
196	47/08	ATS CATERING KITCHEN	< 3	N/A
197	48/08	ATS ENGINEERING AC WATER TANK	< 3	N/A
198	49/08	NAMAKA H/CENTRE STANDING PIPE	< 3	N/A
199	50/08	NAMAKA MARKET STANDING PIPE	< 3	N/A

Remarks

All the above samples are bacteriologically safe.

DEPARTMENT OF WATER & SANITATION Date 24/10/08 WESTERN

Analyst

c.c. Central Board Of Health
Western Engineer Western
Divisional Health Inspector

Lautoka Hospital
P.O.Box 65, Lautoka, Fiji Islands
Phone (679) 6660399, 6662399 Fax (679) 6665423

ANNEX: 5

WATER AND SEWERAGE DEPARTMENT

NATIONAL WATER QUALITY LABORATORY

P O Box 3850, Samabula

RESULT OF WATER ANALYSIS
WATER SUPPLY RETICULATION SYSTEM

SAMPLE FROM: Nadi
DATE SAMPLED: 02/12/08
TIME SAMPLED: 1015 - 1121 Hrs
Laboratory Ref No.: WRT 476/08
Weather: Fine

	LOCATION OF SAMPLE	TEMP in C	pH units 0 - 14	TURBDTY in NTU	AVAILABLE CHLORINE in milligrams per Litre		MICROBIOLOGICAL Coliforms in Col/100ml	
					TOTAL	FREE	TOTAL	FAECAL
1	Lab Sterile Water	25.0	6.8	0.10	N/A	N/A	0	0
2	Nawaicoba Police Post	30.5	9.4	0.39	0.18	0.14	0	0
3	Sonaisali Resort	29.5	7.8	1.25	0.58	0.54	0	0
4	Korovuto Shop	30.0	7.6	1.16	0.66	0.62	0	0
5	Mobil Service Station	29.5	7.4	1.50	0.68	0.64	0	0
6	Navakai STP	30.0	7.4	1.20	0.86	0.82	0	0
7	Namaka Market	29.0	7.8	1.45	1.14	1.10	0	0
8	Airport	30.0	7.6	1.34	1.02	0.98	0	0

Analysis By: Vilimaimai Kirifi Kavita *Checked By: Marica Korai*

REMARKS

Treated Water quality meets bacteriological purity of drinking water.

[Reccommeded chlorine dose- 0.6mg/l after 30min. contact period.)

Sample number (1) as blank and to check against possible contamination during sampling, filtration and incubation.

Senior Scientific Officer

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ANNEX: 6

Nadi Water Supply Structure 2009