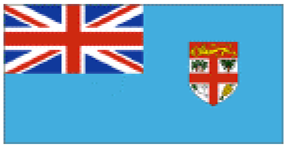


FIJI
WATER AND SEWERAGE DEPARTMENT

TAMAVUA WATER SAFETY PLAN

15-10-2008

Water and Sewerage Department, Suva, Fiji

Author/ Consultant: Davendra Nath – (SOPAC/WHO)

Acknowledgement

This is to acknowledge the contribution, support and commitment of the following:

Hon. Minister of Finance, National Planning, Sugar Industries and Public Utilities [Water and Energy]

AND

Mr. Taito Delana, Acting Director, of Water & Sewerage Department, Suva, Fiji

Without their support, the programme would not have been a success.

The Department also wishes to acknowledge the contribution of:

Mr. S.Yanuyanurua, Divisional Water Engineer, Central/Eastern, DWS
Mr. Poate Tabua, Production Manager/Supervisor, Water Supplies, C/E
Mr. Kamal Singh, Assistant Production Manager/Supervisor, Treatment Plants
Mr. Sher Singh, Senior Scientific officer, National Water Quality Laboratory, Kinoya
Mr. Tomasi V.Ledua , Senior Engineer, Maintenance and Operations, Suva

The author also thanks the Ministry of Health and Ministry of Agriculture and Primary Industries for their participation and support for this programme.

Special thanks to SOPAC/ WHO for providing the consultant Mr. Davendra Nath for this good course whereby Fiji will benefit from drinking water quality improvement.

Table of Contents

SECTION 1: TAMAVUA WATER SUPPLY SYSTEM DESCRIPTION

SECTION 2: WATER SAFETY PLANS - TAMAVUA

SECTION: 3 IMPROVEMENT SCHEDULE

SECTION: 4 NEEDS ASSESSMENT

SECTION: 5 RECOMMENDATION AND CONCLUSION

Table of Figures:

List of Tables:

LIST OF ACRONYMS

ADB	Asian Development Bank
AusAID	Australian Agency for International Development
C/E	Central Eastern
DoE	Department of Environment
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
MSR	Main Storage Reservoir
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
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
WTP	Water Treatment Plant
WEDC	Water, Engineering and Development Centre
WSD	Water and Sewerage Department
WSP	Water Safety Plan

SECTION 1: TAMAVUA WATER SUPPLY SYSTEM DESCRIPTION

1.1 INTRODUCTION

The Pacific Water Safety Plans Programme is a joint initiative of the Pacific Applied Geo-science Commission (SOPAC) and the World Health Organization (WHO), Suva Fiji. Funded by AusAID, the programme is a response to the regionally endorsed Framework for Action on Drinking Water Quality and Health and has been implemented in the Pacific Island countries since 2006. Water Safety Plans (WSP) as promoted by WHO in the Guidelines for Drinking Water Quality (Third Edition) ,are tools that allow for proactive measures to ensuring safety of a drinking water supply using risk assessment and risk management approaches to identify risk of contamination of water supply and allow for sufficient mechanisms to manage these risks. The primary objective of a Water Safety Plan is to minimise contamination of water sources, and prevent or remove contamination during treatment, storage and distribution. These objectives are equally applicable to large reticulated water supplies; smaller community managed systems and as well as for individual household systems

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 Central/Eastern it was resolved that a replication programme should be conducted to train and introduce the Water Safety Planning concept in Fiji for the Suva /Nausori area.

Suva/Nausori zone has a large population of about 300,000 people who depend on the treated reticulated water supply from two sources of surface water catchments. Due to the continuous increase in the urban growth there is greater demand for the treated piped water supply. The major concern of the Water and Sewerage Department (WSD) is the efficient supply of drinking water, though there are several constraints such as infrastructure, finance and human resources. Recently funds have been allocated by Asian Development Bank (ADB) to upgrade the Suva/Nausori water supply system and the work is in progress under the supervision of WSD.

It is seen as an opportune time to incorporate the Water Safety Planning process in this venture. The expertise will be made available from SOPAC/WHO to assist in the Water Safety Planning programme for Fiji.

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

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.

1.2 BACKGROUND

The Fiji islands are located between 16 degree – 21 degree south latitude and 176 degree west – 184 degree east 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 880,000 ,with about 50% living in urban areas such as Suva/Nausori(300,000), Lautoka (66,000) and Nadi (40,000). The larger Islands account for 87% of the land area and 90% of the population.

The larger Islands such as Viti Levu and Vanua Levu, Tavuni, 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 much 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. Topography of the islands effects mean rainfall however 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 urban agglomeration that comprises Fiji’s capital Suva and two smaller independent towns, Lami to the west of Suva peninsula and Nausori to the east at the Rewa River is at the south eastern side of the main island of Viti Levu. Between Suva and Nausori a number of larger settlements have come up during recent decades. Quite often the area therefore is called the Suva- Nausori corridor. Today about 300,000 people, a third of Fiji’s population live in the greater Suva urban area. The water for the present population is mainly supplied by the Waimanu and Tamavua rivers and the Savura creek.

The central piece of the greater Suva Water Supply system is the clear water reservoir at Tamavua. It is located at an elevation of 124 meters, and treated water from here is fed into the distribution system by gravity. The Tamavua plant is supplied by three gravity sources located in the headwaters of the Tamavua river catchment and two pumped sources on Savura creek and the upper Waimanu River. In addition water from the Tamavua Treatment plant is pumped to the Wainibuku reservoir at 81 meters height and to the other reservoirs in Suva area. The water is fed by gravity into the distribution system supplying Suva and Lami areas. The Tamavua Water Treatment plant purifies surface water pumped from the lower Waimanu River and the Savura Creek.

Clarifier- Tamavua Treatment Plant

Savura Headworks -3 Intake

Headworks 3 catchment Dam

Savura Creek - Dam

The above pictures of headworks 3 show ample water in storage as there were many rainy days but during dry spells the headworks dry up due to the siltation of the headworks. The intake of raw water is then supplemented from Savura creek dam and headworks 1 and 2. The headwork 3 also receives water from Waimanu river intake pumps and the water then flows to the Tamavua treatment plant by gravitational force for further treatment.

Figure 1 **Map- Fiji Islands**

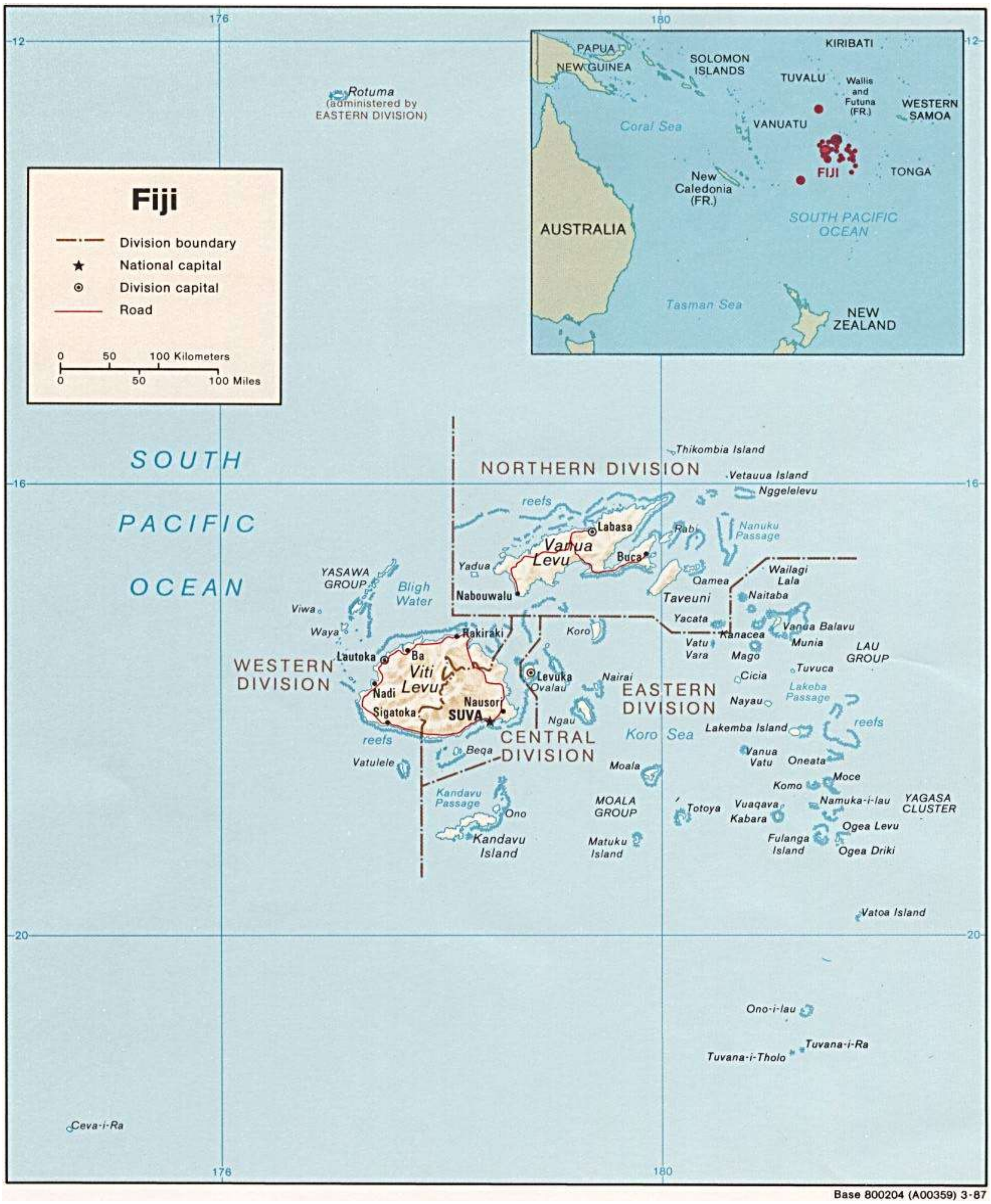
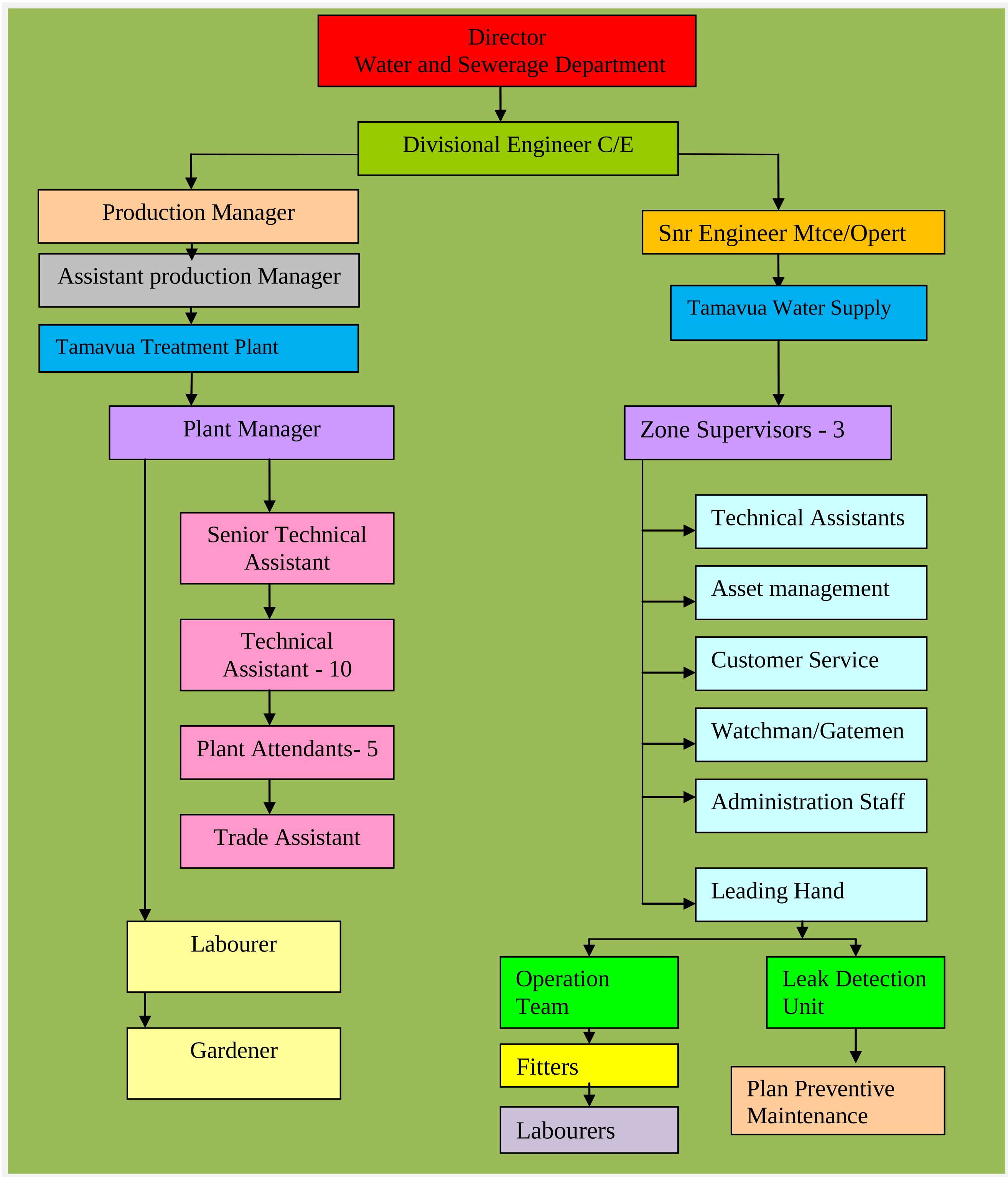


Figure 2: Tamavua Water Supply Operational Structure



1.3 Water Resource Management

Surface water is used as the main source of supply for all major towns on the larger, high islands of Fiji, as well as for industries and irrigation. Some small low lying islands rely exclusively on ground water and may or may not use rainwater. Rainwater harvesting is widespread in Fiji but improvements are required to sustain supply during droughts and prevent the stored water from contamination.

As a result of climate change flooding is currently a very high priority political issue for Fiji. In light of serious flooding which has occurred throughout various parts of the country over the last few years there is loss of life and damage to properties and infrastructure thus causing economic burden. On small low-lying islands, groundwater resources may be very vulnerable due to over-exploitation and contamination. Industrial pollution, urban drainage and sewage are cause of concern for water contamination on larger islands.

Even though 80% of the population has excess to treated, metered reticulated water, continuity of supply is not ideal and maybe in question, particularly in the drier months. Wells on many islands are contaminated with faecal coliforms due principally to a lack of sanitation and awareness amongst the community. The health of the near-shore environment is of particularly high importance, owing to tourism development along the coast. (IWRM Synopsis - Pacific Island Countries 2007)

Fiji identified the following water resource management barriers:

- A lack of water resources management technical capacity and responsibilities
- A lack of public awareness on water conservation and water pollution
- Land tenure and water rights
- Conflicting policies and unclear legislation
- A lack of effective formal coordination
- Inadequate planning mechanisms

Table 1- Fiji Essential Data - (Source-SPC data 2000)

Area	18,333 sq km
Population	850,000
Population Density	46 persons/ sq km
Urban Population	46%
Annual inter-census growth rate	2.6%
Annual inter-census national growth	1.6%
Rainfall	2000 – 4000 mm/year
GDP (Gross Domestic Product)	$5.6 billion
GDP/capita	$6,200
Land use	Arable land:11%;permanent crops ;4.6%
Water consumption	Urban:200 lpd;semi-urban;150 lpd; rural:100 lpd
Population access to treated water	80%
Island type	Volcanic, limestone, atoll, mixed
Type of water supply	Surface water, groundwater, rainwater, desalination
Key Economic Sectors	Agriculture, clothing, fisheries, sugar and tourism

1.4 Fiji Water Economics

Responsibilities for Fijis water resources falls within the jurisdiction of the Director of Water and Sewerage in the Public Works Department. The Fiji Public Works Department has responsibility to supply potable water to over 80% of the country's population. The consistent development of water resources and supply strategies in Fiji has been thwarted by a lack of clear and comprehensive legislation compounded by the number of government agencies that are mandated to deal with water at one level or another. These departments include the Ministry of Public Utilities, Ministry of Lands and Mineral Resources, Ministry of Health, Ministry of Regional Development, Housing and Squatter Settlement and Ministry of Agriculture Environment and Fisheries.

Hydrology falls within Public Works Department while the Ministry of Lands and Resources assists in the planning and assessment of ground water resources. Although Fiji is fortunate to have a plentiful supply of fresh water with high rainfall, droughts and floods over the last twenty years have caused major interruptions to the collection, treatment and reticulation of portable water. The symptoms of these impacts have been most noticeable in the towns and cities of Fiji where major water supply shortages and breakdowns have been the norm.

Legislation related to water resources in Fiji is outdated but has generally served the nation well until recent times. There is a need to review various water related legislation to reflect current policy constraints. The commercial use of water from groundwater supplies as well as resource management issues in catchments including logging underlies the need of comprehensive review of national policy followed by legislation. Many of these issues are politically and socially sensitive in Fiji, with the shortage of water supply in towns and cities and need for major infrastructure improvements. (SOPAC Misc Report 554-Carpenter& Jones)

The Water and Sewerage Department operates and maintains 32 Public water supply schemes nationwide comprising of 15 Water Treatment Plants, over 110 service reservoirs and over 2,200 km of reticulation system of 50 -900mm mains. It costs the WSD about $28 million per annum to produce and supply safe water to the nation. About $6 million is spent on electricity annually to operate motors and pumps. Chemicals used to purify the water costs about $2 million a year.

To be connected to government water supply the following fees is charged;

- New domestic connection - $21.95
- New commercial meter - $100.98
- Re-connections - $10.00

The average cost of producing 1,000 litres of water (equivalent to 1 unit on your water meter) is $1.98 but charges you less than 1 cent per litre. (Water Sewerage Dept 2008)

1.5 Water Quality Monitoring

It is recommended that before a monitoring programme is designed relevant agencies and professionals form a team and discus various aspects such as risk identification, parameter selection and risk management. A multidisciplinary approach is adopted to ensure that agencies with responsibilities for specific areas associated with water quality are involved. It is important to briefly but accurately describe the drinking water supply for which the monitoring plan is being set up.

It is important to know your role when designing a drinking water quality monitoring plan, whether you are a water supplier or a surveillance agency. The water supplier has a responsibility to ensure that the water they supply is fit for human consumption. Hence they are responsible for monitoring the quality of raw water, treated water and water at storages and distribution system. The surveillance agency is also expected to monitor the water supplied by the supplier to verify that the quality is indeed fit for human consumption. They are responsible for monitoring the water quality immediately after treatment and during storage and distribution. Occasionally they could monitor the source water quality to ensure that the supplier is doing its job of source water protection (SOPAC Tech Report 407, Hasan &Aalbersberg 2008)

Currently there are four major types of water quality monitoring programmes in Fiji, including those conducted by PWDs National Water Quality Laboratory (NWQL) for urban treated water and the Public Health Department for urban, rural and private supplies. The Institute of Applied Science (IAS-USP) also samples urban and rural water supplies and private bottling companies. There is no official exchange of information between agencies and results from WSD and USP are treated as confidential and not shared voluntarily with the Health Department.

The critical parameters in water quality monitoring are:

- **Microbial Organisms-**

Monitoring microbiological quality of drinking water is of principal importance because of the acute risk to health posed by bacteria and viruses in drinking water. Microbial organisms that are pathogenic (disease causing) make the largest contribution to water –borne diseases in developed and developing countries. The presence of pathogens in drinking water is usually due to human and animal waste entering the water sources. An indicator organism such as E.Coli is always present in large quantities in faecal matter, whether pathogenic organisms are present or not. A high level of indicator organisms in a water sample indicates a high risk that pathogenic organisms might also be present (Mosley et al, 2004)

The table below shows examples of population based sampling numbers and frequencies for microbiological parameters in distribution systems drawn from WHO Guidelines for Drinking –Water Quality (2004)

Table 2 - Water Samples per Population

Population	Sample per month
<5,000	1 sample
5,000 to 100,000	1sample per 5,000 population
>100,000	1 sample per 10,000 pop plus 10 samples

However if the population served is 30,000 then 6 samples are to be taken per month, this depends on the resources as well. It is advisable that the samples from a distribution system are collected randomly over the network instead of having fixed sampling points. This would ensure coverage of the entire network over time.

- **Turbidity**

Turbidity is the measure of “cloudiness” of the water and is often used as a simple substitute for suspended solids. Turbidity may cause rejection of water by consumers, but is also associated with bacteria survival, as adsorption onto suspended solids by microorganisms is common. Turbidity should always be tested whenever a sample is taken for water quality testing. High turbidity protects micro-organisms from chlorine and other disinfectants and interferes with the maintenance of residual chlorine. An increased turbidity during distribution may indicate leakage or breakage of piped system and therefore an increased likelihood of microbiological contamination (Howard 2002).

Residual Chlorine or Free Available Chlorine

Chlorine is a relatively cheap and readily available chemical that, when dissolved in clear water in sufficient quantities will destroy most disease causing organisms without being a danger to people. However chlorine is used up as organisms are destroyed. If enough chlorine is added, there will be some left in the water after the organisms have been destroyed, this is called free chlorine. Free chlorine will remain in the water until it is either lost to the outside world or used up destroying new contamination. Therefore, if we test water and find that there is still some free chlorine left, it proves that most dangerous organisms in the water have been removed and it is safe to drink. We call this measuring the residual chlorine or free available chlorine (FAC).

Residual chlorine or FAC of above 0.6 mg/L or more causes problems of acceptability for some consumers on the basis of taste, depending on local circumstances. Monitoring residual chlorine where the treated water leaves the plant indicated that the disinfection process is working properly. Measuring at different points in the distribution system is used to check that there is not an excessive chlorine demand that may indicate other problems in the system such as ingress of contaminants.

- **pH**

A common indicator pH is the measure of the hydrogen ions (H+) concentration in the water and is an important parameter for describing the likely state of other chemical process occurring. The pH of piped or reticulated drinking water supplies should be regularly monitored as low levels (<5-6) may cause corrosion of metal pipes and fittings, releasing metals into the water. Water with pH > 8.5 could indicate that the water is hard. pH is important as an operational parameter, particularly in terms of efficacy of chlorination or optimising coagulation. Where the pH is>8.5, the chlorination efficiency becomes impaired. The optimum ph for chlorination is between 6 .5 and 8.5. Wherever possible, the pH in water should be tested when residual chlorine is measured (Mosley et al 2004).

1.6 Water Quality Monitoring for Tamavua System

There is no on-line water quality monitoring instruments installed at Tamavua Treatment Plant and there is no automatic control of the chemical dosing pumps. If automatic adjustment of coagulant dose rate (g/m3) is required, some means of monitoring raw water conditions for controlling the alum and soda ash dosing pumps is also required.

Fiji has no water quality standards and no system for classifying receiving waters therefore ministries adopts their own standards in reference to the WHO standards. The National Water Quality Laboratory at Kinoya test a number of parameters including Free Available Chlorine (FAC) and bacteriological test weekly in the distribution and storage system and provides the results to the water treatment plant operators and the management.

The NWQL has adopted standards for its treated water. These standards have been adopted from a variety of sources and they are equal to or more stringent than, for example the current Australian and New Zealand Drinking Water Standards with the notable exception of Turbidity. However it needs to be noted that the adoption of standards has little effect meaning in the absence of a Non –compliance Procedure or Event Reaction procedure and /or an incentive to comply (ADB Report 1999).

At the Tamavua Treatment Plant test on the water quality are done at an interval of 4 hours and the result are recorded for adjustment if chemical dosing and availability of FAC at plant is to be maintained at the required standards. During manual testing, Hach chlorine colour comparator and turbidity meters are used. The plant operators monitor the water quality at various points at the plant and record the results.

Table 3-Treated Water Monitoring for NZDWS 2000 Compliance

Parameter	Method/Location	Frequency	Comments
Turbidity	Online turbidity meters on outlet of each filter	Continuous	Surrogate for protozoa contamination. Must be demonstrably less than 0.1 NTU for more that 95% 0f the time and must not exceed 0.2 NTU.
Copper Sulphate	Laboratory methods Drinking water leaving the plant	3 samples per calendar quarter	If dosing of copper sulphate continues: must not exceed 2 mg/l in any sample.
Chlorine	Online chlorine residual monitor	Continuous	Must be sampled after not less than 30 minutes contact time; monitoring plant must not be out of service for more than 1 hour per week; residual in drinking water leaving the plant must not be less than 0.2 mg/l with pH not greater than 8.0 and turbidity always less than 0.5 NTU
pH	Online monitor in drinking water leaving the plant.	Continuous	Required for verification of chlorine residual compliance

(Harrison & Grierson Report 2003)

Table 4-The table below summarizes the dose rates for chemicals at the plant:

Chemical	Solution Strength	Dose Range	Pump Rate (at 110 MLD)	Comments
Soda Ash	10%	2 – 30 mg/l	90 -1375 L/hr	High turndown rate- two operating pumps would be required to achieve range 2 pumps plus standby
Alum	10% 20%	10 – 50 mg/l	455 – 2290 L/hr 225 - 1145 L/hr	Turndown of 1:5 Difficult to prepare stronger (than20%) stock from alum kibble. Two simplex pumps or large duplex pump)to achieve capacity) plus standby if using 10% stock
Polyelectrolyte	0.1%	0.15 – 0.20 mg/l	255 – 920 L/hr	Turndown OK I pump plus standby
Lime	5%	Max dose of 1.0 mg/L	450 – 920 L/hr	Turndown ok 1 pump plus standby

(Harrison & Grierson Report 2004)

1.7 Social Analysis

Recent water shortages in Suva/Nausori areas have affected many residents as stoppages were unexpected. There are no alternatives for water supply when the main system is un-operational as few people have rainwater tanks and the nearby creeks and streams are polluted. During water cuts the water is catered in trucks to the residents as there are no water vendors or public standpipes. Those who experience the consequence most are the children and the elderly who rely on others for water.

Over the next five years, it is predicted that the Suva-Nausori population will increase to more than 300,000 people. Without intervention to improve the current water supply system, it will not be possible to cope with the increased demand. As many businesses rely on water supply as an essential element in their production, loss of water can mean significant economic disruption. There is also a social and non-monetary cost for the tourism, education and health services sectors when water is not available such as negative international reputation.

While the overall coverage of the water supply network is good in the area with 98% coverage of piped supply, the unreliability and unpredictability of the system affects virtually everyone.

In 2007 the greater Suva area including Nausori contained approximately 58% of Fiji's total urban population. The 2007 population is an increase of 17.43% over 1996 Census population as shown in Table below.

Table 5-Population Change 1996 – 2007 Suva- Nausori Area

Area	2007 Pop	1996 Pop	Change (number)	Change (%)
Lami Town	10,474	10,556	(82)	7.76
Lami Peri-Urban	9749	8,372	1377	16.44
Suva City Total	75,225	77,366	(2141)	2.76
Suva Ward	15,798	15,308	490	3.2
Maunikau	17,923	17,368	555	3.19
Samabula	18,634	18,053	577	3.08
Tamavua	27,486	26,637	852	3.19
Suva Peri- Urban	10,953	11,303	350	3.09
Nausori Town	24,630	23,842	788	3.30
Nausori Peri-urban	22,191	15,873	6318	39.8
Nausori Rural	11,729	10,073	1656	16.43
Rewa Delta and Nausori	25,284	26,380	(1096)	4.15

Source: Fiji Islands Bureau of Statistics –Press Release N0.53, 2007

Although the overall population growth rate of Fiji is 1.62% the areas which grew most rapidly during the last census period were the peri-urban areas of Suva and Nausori that is primarily the so called “Suva-Nausori corridor”. These area average growth rates were 3.24% and 5.74% respectively.

1.8 Health Status

Fiji enjoys a relatively high standard of health compared to many of its Pacific Islands neighbours. Comprehensive health care and immunisation programs, coupled with other initiatives undertaken by the Ministry of Health to promote healthy lifestyles, such as health education in schools, Healthy Islands Concept and health promoting communities project, have contributed to a high health standard.

The average life expectancy has increased from 61.4 to 70.6 years for males and from 65.2 to 74.9 for females for the period 1993-1997. The infant mortality rate is around 22 per 1000 live births (Bureau of Statistics 1999)

While general health indicators have improved, non-communicable diseases such as diabetes, heart diseases, cancer and respiratory diseases have been on the increase and are the main illnesses of concern in Fiji. These diseases are attributed to changes in lifestyle such as smoking, obesity and diet. Health reports indicate that the main illnesses in the greater Suva are diabetes, hypertension and asthma.

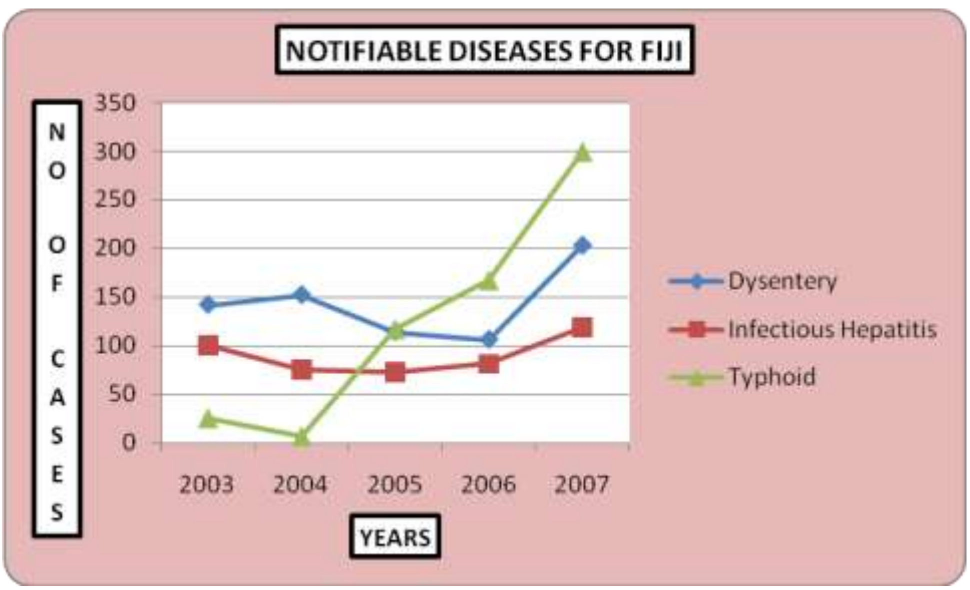
Some key diseases, which have been reported to health authorities for the whole of Fiji in the five year period from 2003 to 2007, are presented in table 6 below.

Table 6-Notifiable Diseases for Fiji

Name of Disease	2003	2004	2005	2006	2007
Acute Poliomyelitis	0	0	0	1	0
Dengue	2762	84	27	34	83
Diphtheria	0	0	0	0	0
Dysentery	142	152	114	106	203
Encephalitis	4	0	1	3	1
German Measles	2	2	0	7	0
Diarrhoea	6,103	5,844	6,309	11,411	7,625
Infectious Hepatitis	100	75	72	81	119
Malaria	12	3	5	2	1
Meningitis	47	63	118	107	120
Tetanus	0	4	1	0	0
Typhoid	26	7	117	167	299
Tuberculosis	188	135	133	93	54

Source: Ministry of Health, Fiji – 2007 Annual Report

Figure 3 - Notifiable Diseases for Fiji -2003-2007



The Central Board of Health was satisfied with the quality of mains water supply available in Suva-Nausori area. In year 2007 total water samples analysed were 166 and 123 of these were rated satisfactory. Health Authorities informed that the use of rivers and creeks for water is rare in Suva-Nausori area and there is a high level of awareness about polluted water and the need to boil before consumption. The media is used to notify the public about unsafe water condition if necessary.

Table 7- Bacteriological Water Sampling for Suva-Nausori Area - 2007

Sampling Area	Total samples taken	Number Satisfactory	Number Unsatisfactory	% Unsatisfactory
Suva	114	93	21	18.5
Nausori	52	30	22	42.3
Total	166	123	43	25.9

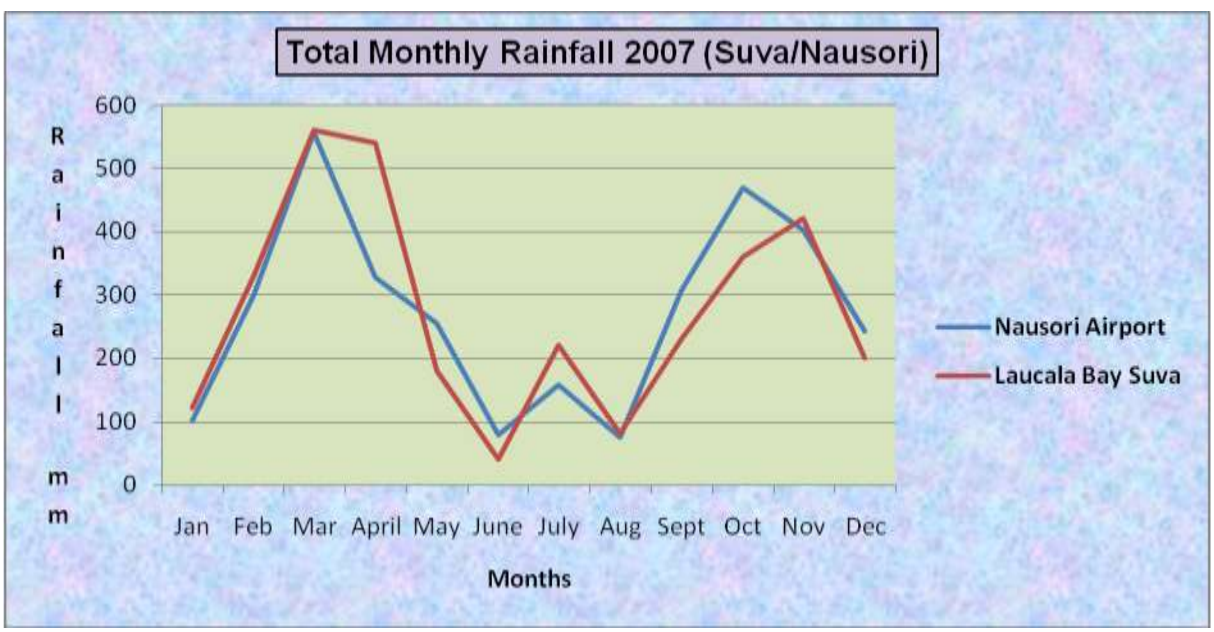
Source: Ministry of Health- Unsatisfactory samples are mostly from untreated supply.

1.9 Climate Data

The climate in Fiji is dominated by the South East trade winds. Exposure and topography control the distribution of rainfall on the islands. Average annual precipitation for Fiji group ranges from 1500 -4000mm.
Rainfall for the March to May 2008 period was predicted to be average to above average across Fiji. The confidence level of the forecast was generally moderate.

Most parts of the country experienced widespread rainfall with occasional heavy falls during the first three weeks as troughs of low pressure remained close to Fiji. Notable and significant one day rainfall of 200mm was recorded at Tokotoko in Navua and 103mm at Nausori Airport on May 15, 2008.

Figure 4 - Total Monthly Rainfall – Suva/Nausori for year 2007



Data Source: Fiji Metrological Services – 2008

1.10. SYSTEM DESCRIPTION TAMAVUA WATERSUPPLY

Water Supply Information Sheet

Catchments & Intake

Catchment

- Source: Waimanu River intake /Savura Creek (Surface water)
- Subsistence farming
- Wild animals and birds around the catchments
- Frequent flooding /erosion at the intake during rainy season

Intake

- Intake located on Waimanu River bank (Concrete Structure).
- Electrically operated submersible pumps (three)
- Intake situated about 6.7 km from the treatment Plant
- Water from the river/creek enters the intake chamber and flows through metal gratings/screens
- Savura pumping station pushes water from headworks 1,2 3. And Savura creek to the Tamavua plant

Treatment

- Each of the three electric pumps draws water from Waimanu River and five pumps are installed at Savura to pump the water to Tamavua Treatment Plant.
- Chemical mixing (Alum, Soda Ash, Copper Sulphate) is done at the Flash mixer
- Sedimentation and Coagulation is done at the two clarifiers.
- Rapid sand filtration is done by eight filter beds available.
- Chlorine and lime dosing is done via an injector at the main line, prior to distribution.

Storage and Distribution

- Distribution is by gravity feed and to the city of Suva and Lami Town
- Supply rate is 60 Mega Litres per day of treated water.
- Water is pumped and stored in 12 reservoirs along the distribution network and at clear water reservoir at Tamavua.
- Distribution of mains line is of 150-600 diameter iron and PVC pipes.
- All consumers are metered and water charges are imposed.
- Untreated water is also stored at MSR at Tamavua.

Figure 5: Tamavua Water Supply Schematic

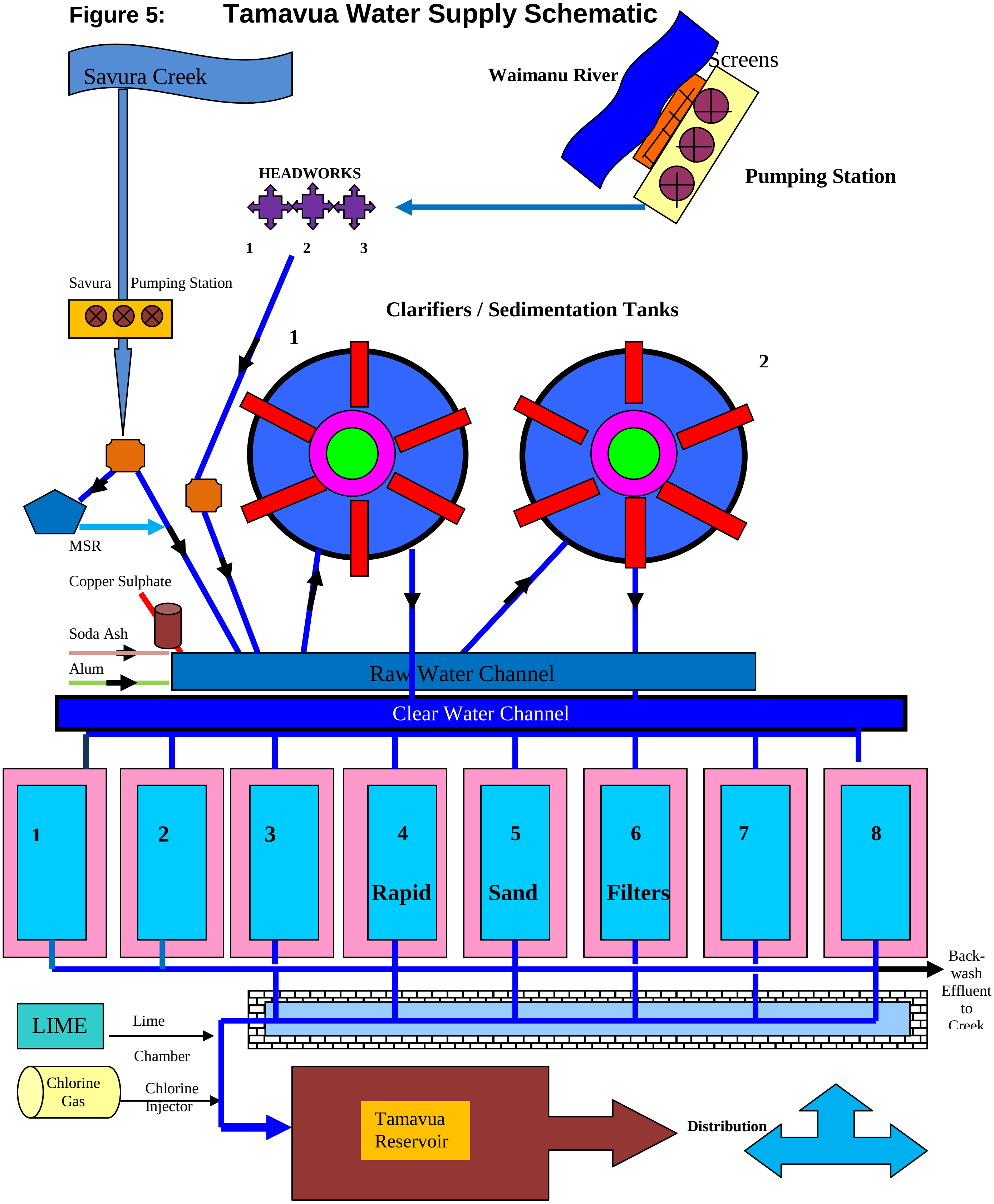
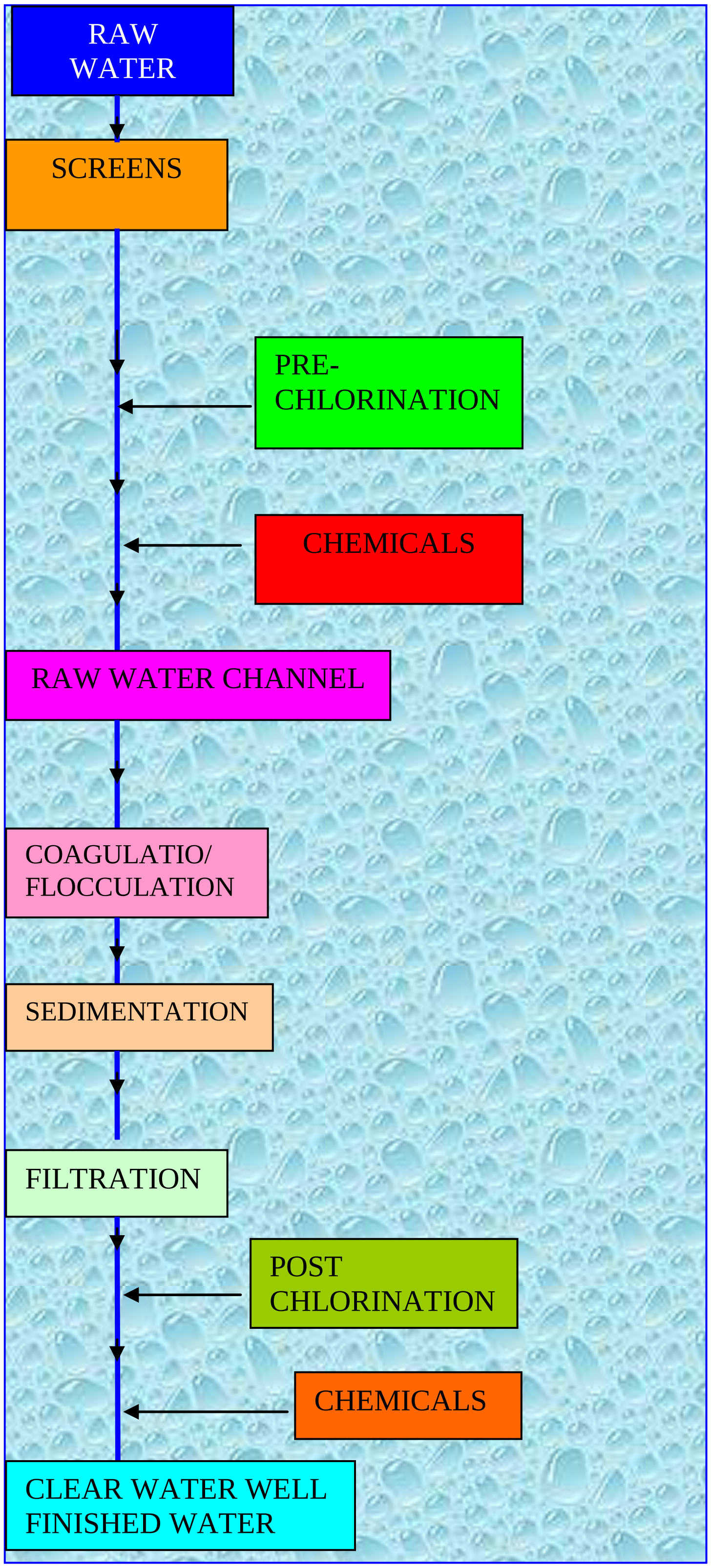


Figure 6 - TREATMENT PROCESS TAMAVUATREATMENT PLANT



Removes leaves, sticks, fish and other debris

Kills most disease causing organisms & Helps control taste and odour causing substances

Causes very fine particles to clump together into larger particles

Mixes chemicals with raw water containing fine particles that will not readily settle or filter out water

Gathers together fine, light particles (floc) to aid the sedimentation and filtration process.

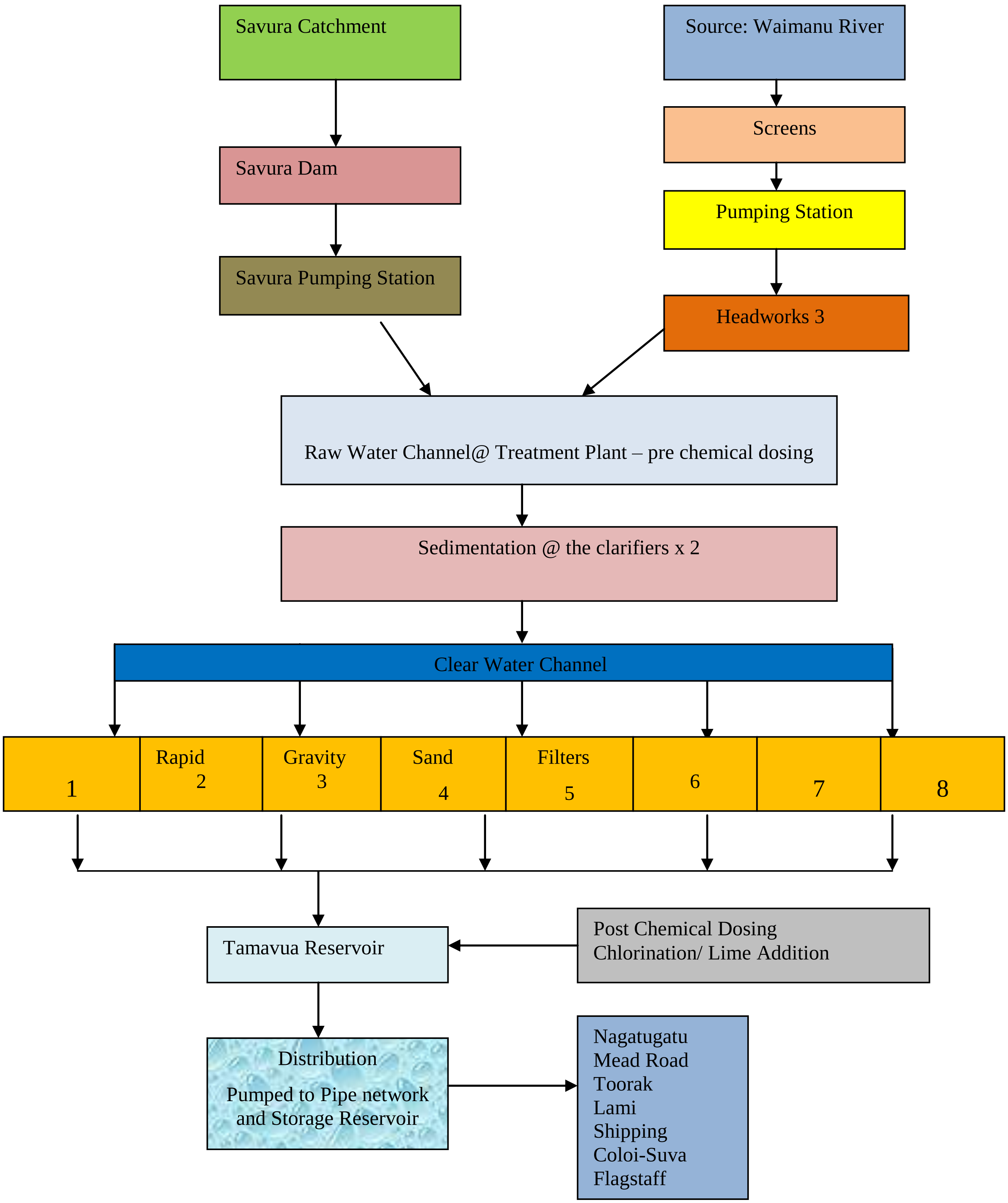
Settles out larger suspended particles.

Filters out remaining suspended particles

Kills disease causing organisms Provides chlorine residual for distribution system.

Provides chlorine contact time

Figure 7 - Flow Chart for Tamavua Water Supply System



1.10.1 Catchment and Intake

The source for the Tamavua water supply is the Waimanu River, which is a tributary of the Rewa River and Savura Creek and 3 headwork catchments.

- **Waimanu Catchment**

The Waimanu pumping station is located on the Waimanu River about 6.7 km from Tamavua Plant. The three electrical pumps are run continuously to pump the water to the Headworks 3 and from the Headworks the water flows by gravity to the plant. Some villages are situated along the river upstream from the Waimanu intake area. During periods of heavy rainfall, waste runoff and/or seepage into the Waimanu River is almost certain.

Farm runoff, especially fertilizer, pesticides and animal waste, are also a major concern within the Waimanu Catchment. Presently there is no catchment management plan and the stakeholders are not committed for the improvements due to lack of expertise and resource constraints.

Clearing of forest areas to convert land for farming is a contributor to increased sedimentation in the river. Increased sedimentation due to logging activities and large-scale deforestation within the catchment leads to periodic high levels of turbidity, which causes stress on the functions of the treatment plant.

Flooding events are quite common within the Waimanu River catchment. During periods of heavy rainfall, which is a common event in the Central-Eastern Division, the quality of raw water quickly deteriorates into heavily turbid (“muddy”) water.

Although drought is an uncommon event in the Central-Eastern Division, it can have a major impact on the quantity of water available for the water supply. One major problem noted is the siltation in the headworks that has blocked about 50% of the water holding capacity.

- **Savura Catchment**

The second source of water for Tamavua is the Savura creek and catchment from headwork 1 and 2. The main raw water intake is located approximately 3km from the Savura pumping station. Raw water pipeline runs for about 8 km from river and creeks and enters the intake chamber and flows through metal gratings/screens, which remove large debris and organic matter.

- **Savura Pumping Station**

The raw water pipelines come from the direction of Savura Creek Pumping Station and from the Main Service Reservoir (MSR) .There is also a pipe that goes out from the plant to fill the MSR. Presently the MSR is not fully utilised and is under improvement works.

Savura pumping station is located downhill about one km from Tamavua Treatment Plant and three electrical pumps are used to pump the water from Headworks 1, 2 and the Savura creek. The three pumps are continuously operated and if one breaks down then there is a short supply of water to the plant. A new 600mm pipe line has been laid from headwork three to the plant but the other existing pipes are 300 and 375 mm in use. An additional pump should be provided at Savura pumping station for emergencies.

1.10.2 Treatment

Tamavua Water Treatment Plant is a Peterson Filter Plant and was commissioned in two stages. The first in 1962 and the second in 1972 when four more filters were added to bring the capacity to 45 MLD. The plant is currently operated at 60 MLD due to the increased water demand.

Raw water is obtained from a number of sources as follows:

- Two small dams, called Headworks 1 and 2, the output of which are manifold together and flow in a common pipeline to the Water Treatment Plant (WTP). Due to limited pipeline capacity the flow is boosted by diverting the flow from these sources into the wetwell of Savura pumping Station, from where it is pumped to the WTP.

- The third dam, Headwork 3, which is fed by gravity to the WTP. Inflow to the headwork 3 is normally by gravity from the Headworks catchment but is supplemented at times by pumping from the Waimanu River, using upper Waimanu pumping station. Headwork 3 then provides services as a pre-settling pond and flow buffering tank.

- The cascades weir forms a low dam on Savura Creek and is the primary feed to Savura Creek Pumping Station wetwell, from where it is pumped to the WTP.

- The upper Waimanu pumping station draws water from the Waimanu River and pumps usually to Headworks 3. By operating line valves it is also possible to pump directly from upper Waimanu pumping station to the WTP; a surge tank on the delivery line facilitates this mode of operation.

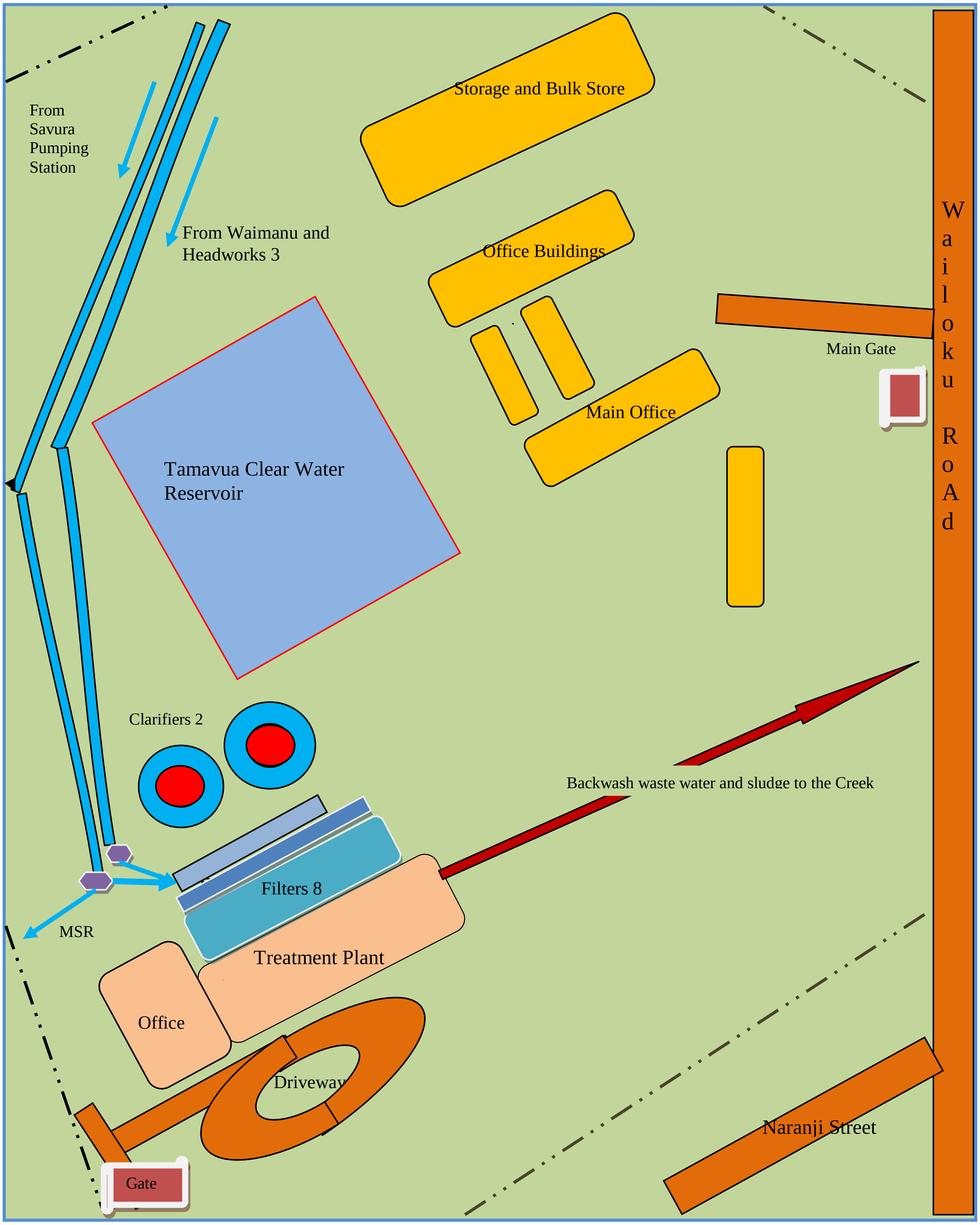
- At certain times, a supplementary supply is obtained by pumping directly from the low reaches of Savura Creek and into the wet well of Savura creek pumping station. The site of this source is tidal, often of low quality and susceptible to saline contamination.

- The original design of the plant provided for surplus incoming water to be diverted to storage in the Main Storage Reserve (MSR) situated on higher ground near princess road Tamavua. Water from MSR would then be drawn back into the plant as required to make for any shortfalls. The MSR has been out of service for some time due to leakages and maintenance.

The chemical quality and colloidal characteristics of raw water entering the Tamavua WTP is, therefore, highly variable and subject to rapid change. Pipes from Savura Creek pumping station, from Headworks 3 and from MSR all enter the plant at the head of the inlet channel. Some enters the channel directly and some via an inlet weir box.

There is full conventional treatment of water with pre and post chemical dosing. Continuous monitoring is done at plant to maintain the effective treatment of the water prior to human consumption.

Figure 8 - Site Plan - Tamavua Treatment Plant



Davendra Nath- 2008

1.10.3 Raw Water Inlet Channel

At the Raw Water Channel three chemicals namely Copper Sulphate, Sodiuam carbonate and Aluminium Sulphate are added to assist in the process of sedimentation. Alum is added as to facilitate coagulation, while copper sulphate is added to control algae growth and Soda Ash is added for pH correction.

There is manual mixing of copper sulphate (25kg) at the raw water channel by pouring of chemical into a plastic container. All the three chemicals are well mixed in the raw water channel through the water velocity. The water then enters the two clarifiers. Provision of a chemical mixing tank would enable coagulation and flocculation to be optimised and also provide improved mixing of the various source waters ahead of the process. No specialised flash mixing equipment is provided for at Tamavua plant. There is no plant inlet water flow measurement device at WTP. The Tamavua WTP has no purpose built flash mixer. All chemicals are dosed by free discharge from the open end of a pipe or hose and rely on general turbulence within the inlet channel to achieve dispersion. Dispersion in this manner is too slow for effective coagulation.

Jar Testing for Correct Chemical Dosing

Copper sulphate/Alum/Soda dosing at Raw Water channel

Rapid Sand Filters 8 –Tamavua Plant

One of the two clarifiers –Tamavua Plant

1.10.4 Chemical dosing

Table 8- Raw Water chemical dosing

Chemical	Solution Strength	Dosing Range	Pump Rate (at 60MLD)
Alum	10% 20%	10-50 mg/L	455- 2290 L/hr 225- 1145 L/hr
Soda Ash	10%	2 – 30 mg/L	90 – 1375 l/hr
Copper Sulphate		1-3 mg/L	Only if algae is present in the raw water

Chemical dosing is not automated at present at Tamavua. Dosing pumps have constant speed motors and the only adjustment is manual, on stroke length. Thus dosing rate turndown is less than about 6:1. The need for adjustment is determined largely by instinct and judgement of the plant operator in accordance to changes in flow rate and in raw water characteristics. Normally the dosing rate depends on 60 MLD of treated water outflow.

Dosing of alum and soda ash consists of dribbling chemical solutions onto the surface of the raw water as it enters the raw water channel. The practice is not appropriate as it prevents the coagulant reacting fully with the suspended solids and colloids in the raw water. It also leads to the formation of stable, quasi-floc species which are not able to react with polyelectrolyte and pass through clarifiers and filters. These un-reactable solids contribute to filter bed degradation through mud-balling and blinding as well as degrading final water quality. To avoid forming such uncreative flocs the method of dose injection requires upgrading to enable truly rapid dispersion to be achieved (Harrison Grierson Report 2003).

Table 9 - Chemicals added in the purification processes at Tamavua Treatment Plant:

Chemicals	Process Benefits
Aluminium Sulphate (Alum)	Helps in the process of Coagulation
Sodium Carbonate (Soda Ash)	Adjusts the Alkalinity and Acidity of Water
Hydrated Lime	pH and acidity of Water
Copper Sulphate	Controls the growth of Algae
Chlorine	Disinfectant – kills germs(bacteria)
Fluoride	Prevents tooth decay

Table 10 – TAMAVUA TREATMENT PLANT WATER SAMPLING RECORD

DATE SAMPLED- 30/06/08

Raw Water						
Parameters	**12 MN**	**4 am**	**8 am**	**1200 MD**	**4 pm**	**8 pm**
Plant inflow(m3/hr)	2516	1886	2540	2554	2517	2507
Colour	10	10	10	10	10	10
Alkalinity	3	3	3	3	3	3
Turbidity	2.36	2.45	2.39	2.21	2.32	2.64
PH	7.1	7.1	7.1	7.1	7.1	7.1
Temp *C	23	23	23	23	23	23
Chemical Dosing						
Alum (g/m3 0r ppm)	10	10	10	10	10	10
Soda Ash	2	2	2	2	2	2
Copper Sulphate	0.8	0.8	0.8	0.8	0.8	0.8
Filter Channel						
PH	6.7	6.7	6.6	6.6	6.7	6.7
Turbidity	2.09	2.15	2.11	2.08	1.96	1.78
Treated Water						
Colour	5	5	5	5	5	5
Alkalinity	3	3	3	3	3	3
Turbidity	1.78	1.91	1.91	1.78	0.94	0.82
PH - Plant	7.8	7.8	7.8	7.8	7.8	7.8
PH – Treated water	7.5	7.5	7.5	7.5	7.5	7.5
Temp *C	2.4	2.4	2.4	2.4	2.3	2.3
Lime Dose GM3	4.0	4.0	4.0	4.0	4.0	4.0
Chlorine Dose GM3	1.2	1.2	1.2	1.2	1.2	1.2
Plant Residual (Chlorine)	1.1	1.2	0.9	0.9	1.0	1.0
Reservoir Residual	0.9	0.9	0.9	0.9	0.8	0.8
Flouride	S/D					

Note: Samples taken by the Plant Operator during the Shift at 4 hour intervals – 31/08/08

Table 11 - Chemical test done at the Tamavua Treatment Plant

Type of Test	Equipments Used
Residual chlorine	Lovi Bond colour comparator with Plain test Tablets
Turbidity	HACH Brand 2100p Turbidity Meter
Jar test	One litre glass jars with alum solution
pH test	Screen methyl orange 10 drops, colour matching Lovi Bond (Nasselerise)

1.10.5 Clarifiers.

Water from the raw water channel flows directly into the two sedimentation tanks (clarifiers). Here, suspended and dissolved solids are extracted from the water. Flow to each clarifier is controlled by inlet valve located at the base of individual chambers.

There are two clarifiers of 26m diameter and 6.3 m depth with 45* sloping sides and level floor. Each clarifier has one central scraper drive system. Scrapper is a half-span suction type swivelling on a bush pivot embedded in the concrete floor. Sludge is sucked in through 18mm orifices under the suction pipe and directed through the bush pivot to the underground pipe and out via a 75mm telescopic valve. Each clarifier also has 2 units of flocculation drives placed off-centre. The flocculator paddles are steel plates in picket fence arrangement. Inlet is by a concrete pipe leading to a concrete ring channel. Raw water flows out of orifices 150mm diameter from the sides as well as bottom of the channel into the flocculation zone.

Both clarifiers are impeded by insufficient attention to sludge bleeding. Sludge collection in the clarifiers is by means of a rotating suction pipe, rather than the scrapper type. Although the operators refer to the sludge blanket, of these clarifiers are of not the sludge blanket type and have no means of removing sludge except from the bottom, through the bleed pipes. The clarifiers are set up for manual operation of the sludge bleeds but this should be done more frequently than it is now. Failure to attend to timely bleeding of sludge causes excessive strain on the sludge collector and associated drive mechanisms, and probably exacerbates floc carryover.

1.10.6 Filters

After the process of sedimentation, water is fed into a series of rapid sand filters, which removes fine solid particles and some micro-organisms such as protozoa (*Giardia* or *Cryptosporidium*) and certain bacteria as well. There are 8 constant-level type sand filters. The filters are 9.14 m x 4.57m filtration area with a fine sand depth of 610mm. The sand is reported to have never been replaced since commissioning.

The filters are backwashed manually, every eight (8) hours, or as required when highly turbid raw water is involved. High-pressure air is pumped into the filters, which dislodges the trapped materials, which are than flushed away by backwash water.

The water from the clarifiers enters the filter feed channel which runs along the front end of the rows of filters. Each filter is fed via two pneumatically –actuated butterfly valves enclosed by weirs in the channel. The weirs provide equal flow distribution to each filter provided they are not drowned.

- Channel is 0.62m wide by 1.68m deep at design water level

The filters were originally fitted with float-operated mechanisms to provide slow-start operation after backwash and to control filter throughput at a near-constant rate with a constant depth over the bed. Those mechanisms are no longer serviceable and operation is completely manual.

1.10.7 Clear Water Channel

Filtered water collected from each filter is directed along a channel below the filter gallery floor to the end of the corridor and then the channel turns around 90 degrees to a room where the backwash pumps are located.

Chlorine gas is added as a disinfectant (to eliminate any remaining microbiological agents in the water). Soda Ash is used for pH adjustment. Chlorine is dosed into the clear water at some point at this channel. The room is mostly enclosed and with no natural or forced ventilation which makes working in this compartment difficult.

- **Lift Pumps:**

The lift pumps take water from a compartment by the side of the clear water channel in the filter gallery and pumps up. The two pumps are Grundfos vertical multistage pumps.

- **Air Compressors**

The three air compressors are in a room in the central building. All three are Ingersoll-Rand three cylinder piston types and appear to be the same model with the same rated motor.

- 2 older units of Ingersoll-Rand three-piston air compressor model 15T with 15kW motors, no aftercoolers.
- I newer unit of Ingersoll- Rand model 15T as well.15kW motor, no aftercoolers.
- 2 units of horizontal mounted steel air receiver diameter 8 ft diameter x 10ft side wall.

1.10.8 Chemical Dosing:

Table 12 - Clear well chemical dosing

Chemical	Solution Strength	Dosing Range	Pump Rate (at 60 MLD)
Chlorine (gas)		1.5 - 2.0 mg/L	continuous
Lime	5%	2- 10 mg/L	180-920 L/hr
Fluoride	0.5 %	Max dose of 1.0 mg/L	450-920 hr

❖ Chlorination

Chlorination is done automatically and only if the dosage is low manual drip feeding method is used to top up the required dosage. The duty drum is a 920kg yellow chlorine drum containing liquid chlorine to disinfect the treated water and added automatically and lasts for about a month depending on the outflow of water. A 70 kg cylinder is used during change up.

The chlorinator room also has 1 unit of Wallace &Tiernan S10K chlorinator with manual flow adjustment mounted on a timber board. Also there is 1 unit PVC injector each connected via PE tube to each chlorinator. Both connected to service water pipeline.

Functioning Chlorinator – Tamavua

Gas chlorine cylinders -920 kg

Alum and Soda Mixing Chambers

Rapid sand filters-Tamavua Plant

❖ Copper Sulphate

Copper sulphate is dosed at the raw water inlet channel. Copper sulphate powder is in 25kg bags. One circular plastic container of about one cubic meter was seen placed at the inlet channel. The bag of Copper sulphate is opened and mixed into this container and the solution is drip fed into the raw water to control algae. There is a need for proper system of solution mixing and addition as the present system is inappropriate.

- **Chlorine Dosing Rate:**

Dose Rate Formula - $\dfrac{\text{Weight of Chemical x 1000}}{\text{Inflow per shift}}$ = Dose rate

Plant water inflow per shift = 33.600 litres

Method A - Gas Chlorination

- Chlorinator No.1 = 2kg
- Chlorinator No.2 = 4kg
- Total = 6kg/hr
- 6x8hrs per shift = 48kg per shift (Dose rate)

- $\dfrac{48 \times 1000}{33{,}600}$ = 1.375 ppm which gives 0.8 residual chlorine

Method B – HTH Powder Chlorine in 40kg Drum –Manual mixing and drip feeding (To Top up if gas chlorination is not providing the required residual chlorine)

-10 kg x 60% strength
= $\dfrac{6\text{kg} \times 1000}{33{,}600}$ = 0.18 ppm

Total dosing = Gas Chlorination - 1.375
HTH –Top up - <u>0.18</u>
<u>1.555</u> ppm which gives plant level dosing at 1.1 ppm
If the inflow water is dirty then plant dosing rate is increased to 1.5 ppm.

<u>Note: Calculation done by the Plant Operator</u>

- **Lime Dosing:**

Hydrated lime in 25kg bags are stored upstairs in the chemical room alongside other bags of powder chemical such as alum, soda ash, sodium silicofluoride and copper sulphate and charged to the treated water via 2 loading chutes. Lighting and ventilation is poor in the storage room. The loading method is manual into the mouth of the steel chutes on floor level. There is no dust extraction system or shields for loading the bags into the chutes.

Lime feeder and make up:

- Two (2) lime slurry tanks each 3.6 m x 2,13m with motorised horizontal paddle mixers.
- One metering system using a moveable plate to split the flow from a weir
- Dosing by gravity pipe.

There are two slurry tanks make –up concrete tanks located in the ground floor in front of the laboratory. One of the mixing tanks is only functioning. The tanks receive powder lime from the chutes with loading upstairs, and slurry is made up with service water. The tanks are rectangular but the bottom half is semi-circular in section. Powder lime from the chute enters through a covered compartment separated by a baffle wall. The arrangement is such that falling lime powder is contained within that compartment without dust escaping.

❖ Alum Dosing:

Aluminium Sulphate 17%Al in kibbles is stored in 50kg bags at the plant. Alum bags are stored in same storage area as other chemicals and have less dust problem as being in kibbles.

There are 2 concrete alum tanks (2.82 m x 2.03m) with propeller mixer (not functioning) for each of the tanks.

Each tank has two compartments, the front one about half a metre wide with a baffle wall extending to within about half a metre above ground. The front compartment has a stainless steel mesh supported on a timber frame covering the horizontal area of the compartment. Alum kibbles are poured here and rest on the mesh screen and the tanks filled with service water which dissolves the kibbles.

From below the tank, alum solution flows into PVC outlet pipes that lead to the dosing pumps downstairs.

Two units' duplex diaphragm dosing pumps by Us Filter –ENCORE 700.Both pump heads different size. The capacity is stated as 682/1300Lph.
The 2 pumps are located in the same room as the lime make up system. One pump has no connected piping and not being used. The other pump with piping connected only to the larger pump head and in operation.

❖ Soda Ash Dosing:

Soda Ash is kept in 50kg powder form bags at the plant and the storage room is same as for the other chemicals.

There are 4 concrete soda ash tanks (2.82m x 2.03m) by 1.38 fill depth. Each tank has two compartments, the front one about half a metre wide wait a baffle wall extending to within about half a meter above ground level. Soda ash is poured in the front compartment.
From below the tank, soda solutions flow into PVC outlet pipes that lead to the dosing pumps downstairs.

- 2 units double-headed diaphragm dosing pumps by US filters. Both pump heads different size. The capacity is stated as 682/1300lph. Presumably this means the rated capacity of each pump head.

❖ Fluoridation

At present there is no fluoridation done for the treated water even though there is a chamber available for the purpose. The chamber needs upgrading if fluoridation needs to recommence.

❖ Sludge Disposal

Sludge from the clarifier, wastewater from the filter backwash as well as drains from the Control Building are collected and directed in a deep underground drain pipe. The pipe leads out through a 6.9m deep manhole a few metres to the side of Clarifier No 2 and downhill, via Suva Water Supply office and depot, to the road alongside the treatment plant fence. From there the pipe leads further downhill and ends in a small stony creek covered by vegetation by the east side of Wailoku Road, close to the downhill corner of the plant.

1.10.9 Chemical Storage Room

The chemical storage room houses the bulk of the chemicals used at the plant and contains the chemicals; aluminium sulphate and soda ash, copper sulphate and hydrated lime.

There was no signage, labelling, material safety data sheets, health and safety or chemical handling instruction and no personal protective equipment evident in the chemical storage room.

A number of chemicals are stored in the same chemical store, including hydrated lime and aluminium sulphate (alum). All chemicals are stored in either 25 or 50 kg bags in high random piles. Extremely large quantities of most chemicals are held on the treatment plant site. Many of these piles appear unstable and are unprotected from spills and surface water and there is no clear separation between many of the chemicals.

It is recognised that this method of storage is borne of necessity as the quantities in storage far exceed the available safe storage capacity of the plant. The haphazard method of storage means that there is a high possibility for the incorrect chemical to be used in the treatment process. Clear segregation between the various chemicals should be maintained to ensure that chemicals are not incorrectly used and advertently mixed. The large piles of chemicals and the random method of storage present a very real threat of the piles collapsing possibly endangering the workers safety.

Hydrated lime is supplied in a fine powder which is poured into one of the three hoppers that feed to the volumetric screw feeding the lime mixing tank located on the floor below. There is no forced ventilation or dust extraction system to remove dust generated when it is being tipped into the lime feeder hopper.

The alum and soda ash day tanks are purpose designed, concrete tanks fitted with valves and mixers, located against one wall in the room. The tanks are accessed via a timber stair leading to each tank. Neither stair is adequately secured. Neither stair has the hand rails nor there is landing on the top of the day tanks. There are no safety rails provide around the day tanks to prevent a fall into the tank.

There is no safe access to the mixer units located in each tank. In order for maintenance to be undertaken it would necessitate walking along the dividing wall between the two tanks, presenting a fall hazard. There is no safe means to work on or remove the mixers. One of the tanks was functioning only.

There is no safety shower provided although a wash hand basin was available for emergencies. The storage building is seen corroded from the chemicals as the area lacks proper ventilation.

The quantity of chemicals stored in the main store should be significantly reduced to ensure 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 floor of the storage room should be cleaned and any damaged bags disposed of. Any spilled chemicals should be cleaned up and disposed of in an appropriate manner.

1.11 STORAGE AND DISTRIBUTION

The design capacity for the Tamavua Treatment plant is 45 MLD, but currently there is a high water demand due to the population increase and commercial and industrial developments. Consequently the plant is being operated at a production capacity of 60MLD.

From the Tamavua Plant the treated water is pumped to the clear storage Tamavua reservoir on site and flows by gravity to a number of storage tanks located on the distribution system. (Refer to Figure 10 Below). The Suva Water Supply has three zones and is headed by zone supervisors and managed by the Senior Engineer, Operations and Maintenance.

Metered domestic per capita water consumption varies across geographical regions from 73 lpd to more than 200lpd. The average metered domestic consumption recorded during 1998 was only 143 lpd. However when metering errors and suppressed demand are taken into account, the true average per capita consumption is calculated to be as 185 – 190 lpd.

Studies reveal that many of Suva water supply assets are in poor condition as a result of lack of maintenance, poor construction standards. The mains are of galvanised iron, PVC and some old pipes are of asbestos cement.

Due to old pipes there are leakages and, unaccounted for water is running at levels of about 50% compared to 33% about some years ago. The WSD has established a Leak detection programme and curbing on illegal water connections. The distribution system comprises of about 1900km of pipes larger than 50 mm diameter.

Most of the reservoirs in the system are of concrete structure but some new galvanised and steel tanks are constructed. The common problems noted were the missing cover lids and the monitoring of the water level. Reservoirs are located at ground level thus chance of recontamination of the treated water is high. Some reservoirs had electrical measurement system but others needed manual measuring. Due to the remoteness of the reservoirs accessibility was a major problem. There is no stipulated schedule of the reservoir cleaning and maintenance as this largely depends on the annual budget. Most of the allocated funds are exhausted in the middle of the year or utilised on other important services.

Even though there is a maintenance team at Suva Water Supply working to maintain the distribution system, the constrained resources and old infrastructure cause many problems. It was informed that it is necessary to establish proper staff recruitment and training procedures for the efficiency of the services.

The figures below show the location of reservoirs and pump stations within Suva-Nausori distribution system. Most of the reservoirs were seen unmaintained and public access was possible. Due to rusted covers at reservoirs entry of rodents into the finished product and recontamination of treated water is possible.

Figure 9 - Suva/Nausori Water Supply Distribution System

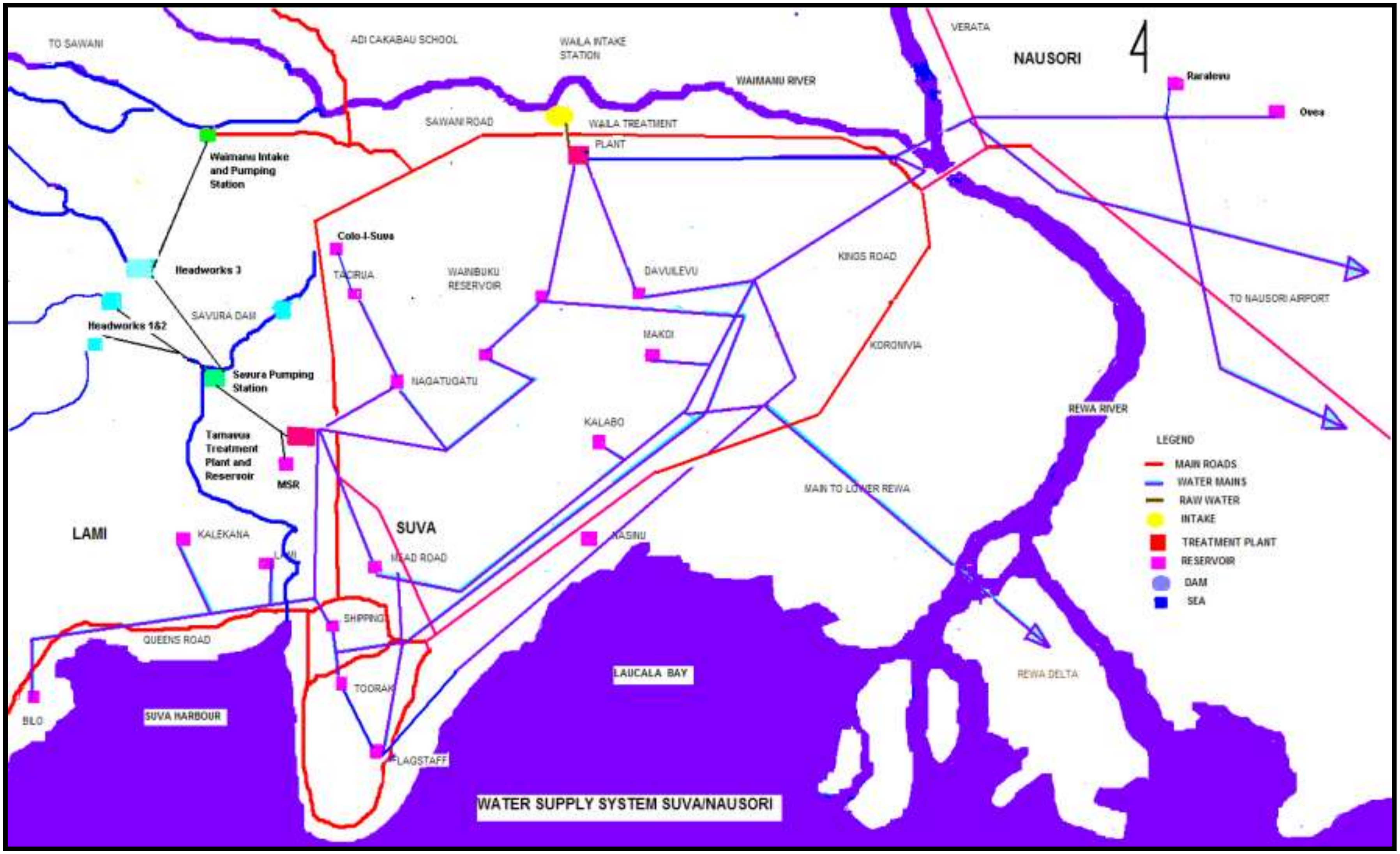


Figure 10 - TAMAVUA WATER DISTRIBUTION RESERVOIR NETWORK

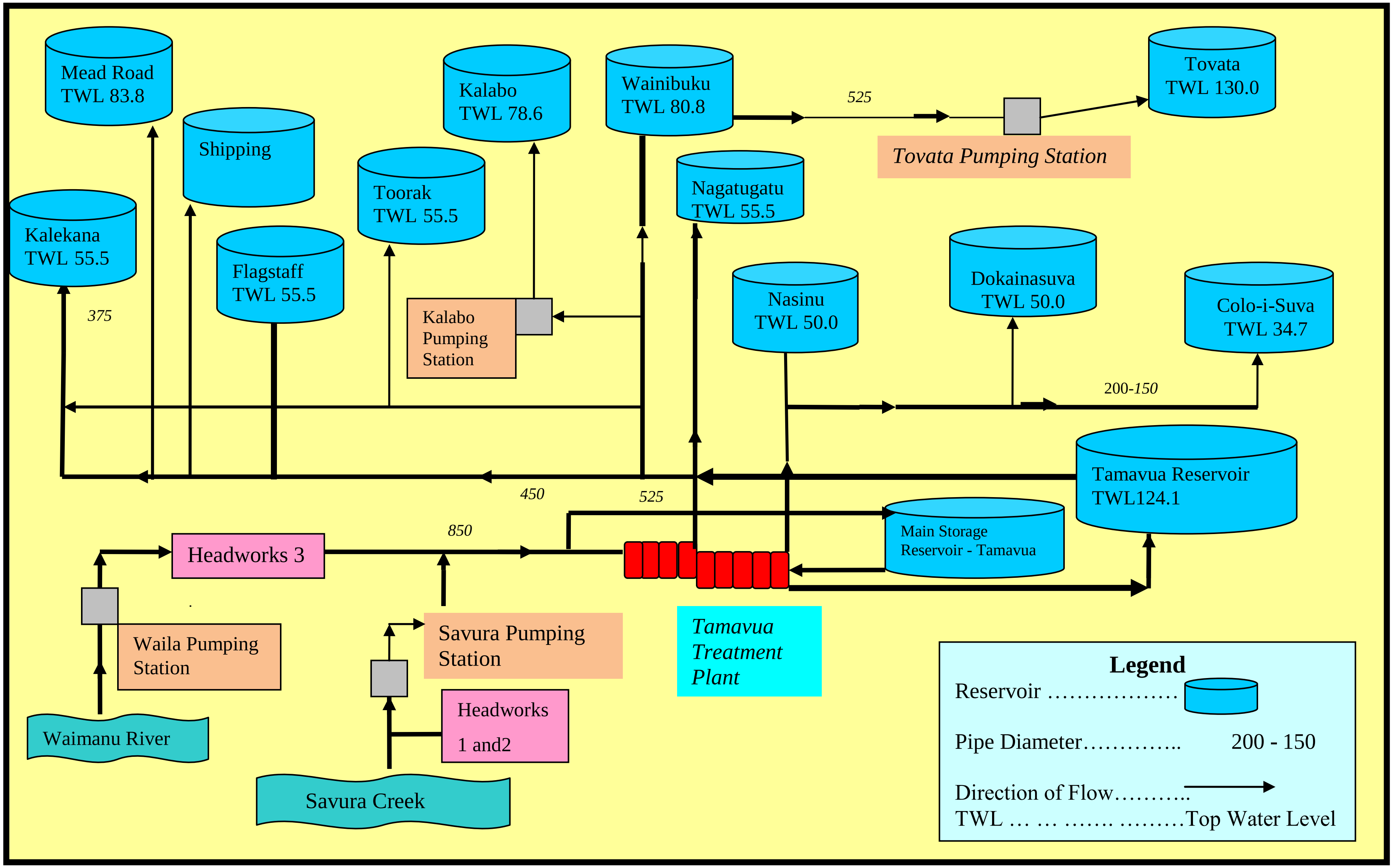


Table 13 - Reservoir Type and Capacity-Suva Water Supply

Reservoir Location	Type of Tank	Risk Assessment	Capacity Mega litre (ML)	Top Water Level (TWL)m
1. Wainibuku	Concrete//galvanised	Reservoir receives treated water from Waila and gravity supplies to other reservoirs. Reservoir was 60% full. There were two other galvanised tanks on site for future storage. Inlet chambers, vents unprotected and rusted. Fence/gates damaged and unlockable.-main valves not locked and prone to sabotage.	13.6	80.8
2. Kalabo	Concrete	Inlet lids rusted, old pipes lying around, large trees around the tank.	2.25	78.6
3. Toorak	concrete	Inlet chamber damaged easy access for rodents and small domestic animals into the tank. Ground level, needs drainage	2.56	55.5
4. Flagstaff	concrete	Partly below ground level. Compound overgrown with grass. Needs drainage. Chamber was seen left open and rusted.	3.5	55.5
5. Nasinu	galvanised	Well secured and maintained	6.0	55.5
6. Mead Road	concrete	Below ground level. Overgrown grass. Inlet chamber open and rusted. Easy access for rodents and domestic animals.	3.64	83.8
7. Kalekana	concrete	Inlet open and rusted, tank empty and not in use. Needs cleaning of silts and fencing.	6.0	60.0
8 Shipping	Galvanised-steel	New tank not commissioned yet.	3.0	n/a
9. Raralevu	concrete	Fencing is good. Needs storm water drainage Office/caretaker shed needs improvement	4.5	50.0
10. Nagatugatu	concrete	Overgrown grass, drainage needs improvements. Open inlets, rusted lids.	1.2	185
11. Ovea	concrete	Overgrown grass, drainage needs improvements. Open inlets, rusted lids.	3.6	34.7
12. Tovata	Galvanised steel	Overgrown grass, drainage needs improvements. Open inlets, rusted lids.	3.6	n/a
13. Colo-i –Suva	Galvanised-steel	Well secured and maintained	1.2	n/a
14, Dokainaisuva	Galvanised steel	Overgrown grass, drainage needs improvements. Open inlets, rusted lids.	3.65	n/a
15. Tamavua	Concrete	Underground concrete tank. Drainage needs improvements.	27.0	124.1

Source: Water and Sewerage Department – Tamavua

Table14 - Reservoir Condition Assessment-Suva Water Supply

Reservoir Location	Type of Tank	Risk Assessment					
		Fence	Gate	Compound	Chambers	Water level Indicators	Ladders
1. Wainibuku	Concrete/ galvanised	Needs repair	nil	Need cleaning of grass and shrubs	Rusted needs replacement	manual	Unsecure Rusted
2. Kalabo	Concrete	Good	Good	Needs cleaning of debris /old pipes and trees	Rusted/ missing	manual	Unsecure
3. Toorak	concrete	Needs repair	Needs repair	Compound needs drainage	Rusted/ broken inlet	manual	Ground level
4. Flagstaff	concrete	Needs repair	good	Needs cleaning of grass and drainage	Needs cover	manual	Needs repair
5. Nasinu	galvanised	good	good	Needs cleaning of grass	good	Indicator on tank	good
6. Mead Road	concrete	good	good	Needs cleaning of grass	Missing/ rusted	Indicator on tank	good
7. Kalekana	concrete	Needs repair	nil	Need cleaning of grass and shrubs	Rusted needs replacement	manual	Unsecure Rusted
8 Shipping	Galvanised - steel	Needs repair	nil	Need cleaning of grass and shrubs	Rusted needs replacement	manual	Unsecure Rusted
9. Nagatugatu	concrete	Needs repair	nil	Need cleaning of grass and shrubs	Rusted needs replacement	manual	Unsecure Rusted
10. Tovata	Galvanised steel	Needs repair	nil	Need cleaning of grass and shrubs	Rusted needs replacement	manual	Unsecure Rusted
11. Colo-i –Suva	Galvanised -steel	Needs repair	good	Needs cleaning of grass and drainage	good	manual	Needs repair
12.Dokanaisuva	Galvanised steel	Needs repair	good	Needs cleaning of grass and drainage	Needs cover	manual	Needs repair
13. Tamavua	Concrete	Needs repair	good	Needs cleaning of grass and drainage	Needs replacement	manual	Needs repair
14,Main Storage Reservoir	Concrete/ Soapstone	Needs Repair	good	Needs cleaning of grass and drainage	Open pond	manual	Needs repair

1.11.1 Tamavua Water Supply Distributions

The maximum storage capacity of the Tamavua reservoir is 27.0 ML. From the Tamavua reservoir, treated water is distributed to Lami town and Suva urban and peri-urban areas. Tamavua reservoir is located about 5 km from Suva city and with 450 mm mains the supply is distributed from the Tamavua Plant. Tamavua reservoir also supplies water to Wainibuku reservoirs via 150, 200, and 300 mm mains. The distribution mains are laid alongside the roads and across the farm lands where necessary. Most of the reservoirs need major improvements such as fencing and provisions of lids and covers.

Discussion with Suva Water Supply staff and field inspection reveals that many mains turn-key chambers are not properly constructed and recontamination is possible in such cases where leaks are present and chamber lids missing. It was revealed that some chamber lids were removed by vandalism. It is important to upgrade these reservoirs as it stores the treated water for residential, commercial and industrial use.

Interviews with a number of residents of Suva and Lami area revealed that they receive the pipe water but the low pressure is a common problem, secondly when there is a breakage then fine silts are seen in the treated water. The distribution team confirmed this as a problem due to the fact that there is no drain out chambers in the lower part of the system. The dirty water at the consumer end is normally due to the siltation in the pipes which are not cleaned. It is also the possibility that some dissolved solids may have passed through the filtration system. This events signal that there is a need to improve the treatment and distribution systems immediately to improve the water quality and avoid the recontamination of treated water.

Nagatugatu Reservoir - easy public access

Nagatugatu Reservoir – Manual Measuring

Most of the reservoirs in the Suva Water Supply are noted to be unmaintained and have easy public access due to dilipitated condition of fence and gates. There are no proper measuring device and manual measuring is done by dipping a PVC pipe to monitor the water level as can be seen in the above pictures.

Leaking Turn Key Chambers at roadside

Concrete Chamber Not provide for Turn Key

It was also noted that two 2.7 million litres galvanised tanks newly constructed at Wainibuku and Nagatugatu for future storage and supply to the system.

The design capacity for the Tamavua Treatment plant is 45 MLD, but currently the demand is high therefore the need to increase the plant capacity to meet the future demand which may rise to 60 MLD. The pictures below reveal the dilapidated state of the reservoirs and the unprotected inlet and inspection chambers.

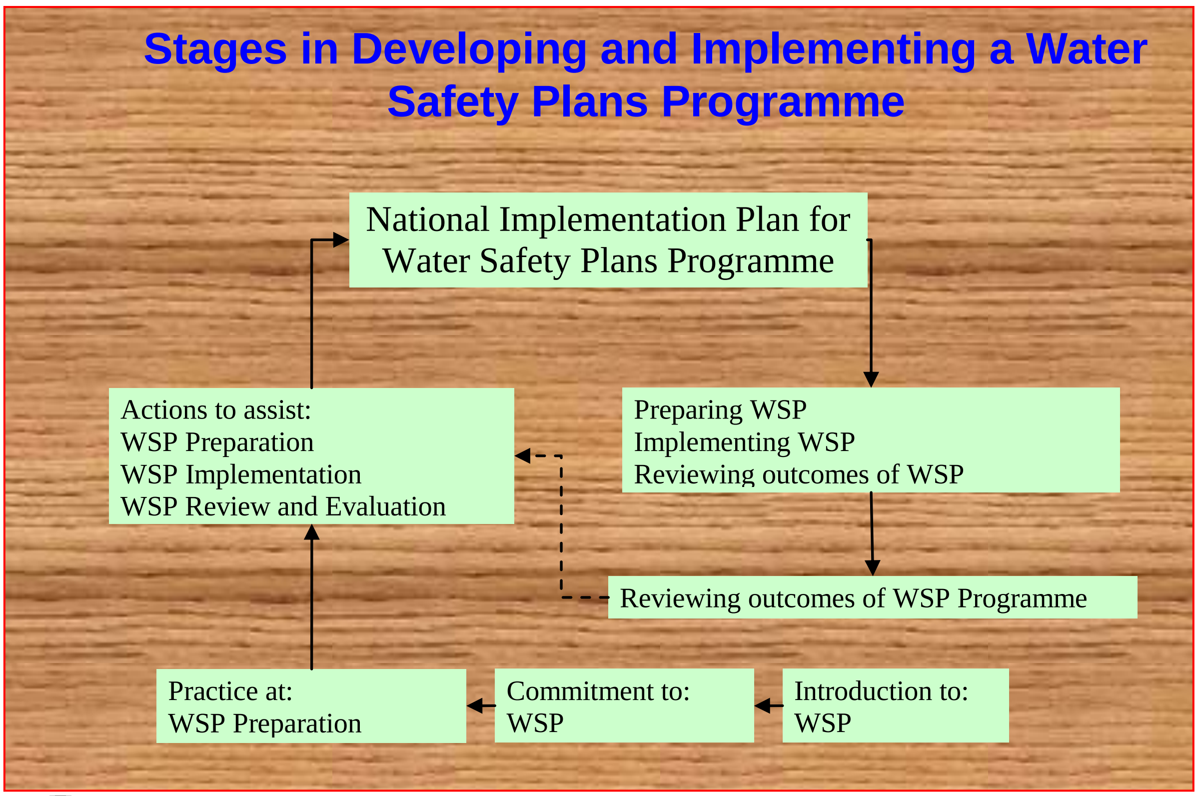
Concrete Reservoir- Nagatugatu -unmaintained

Reservoir inlet lids are missing

1.12. WATER SAFETY PLANNING

Water Safety Plans (WSP) is the nameplate for WHO's new risk-assessment / risk-management approach to ensuring safe drinking water. This approach was introduced to Pacific island countries in a workshop, Nadi, Fiji, February 2005. The 18 countries and territories present completed a 'Framework for Action on Drinking Water Quality and Health in Pacific Island Countries' to guide future activities and gather donor support. The meeting of Pacific Islands Health Ministers in Apia, Samoa, endorsed this 'Framework' two months later with a statement in the 'Samoa Commitment'. Three Pacific-wide water quality programmes have since been proposed and funded.

Figure 11 - Stages in Development of Water Safety Plans



Prepared during the Pacific Water Safety Training and Planning Workshop 2006

In contrast with other Pacific countries Fiji has a complete conventional water treatment system with all process involved and chemical disinfection is done where necessary at a cost to maintain an efficient supply. Though there are necessary infrastructures and human resources, by adopting a more professional approach as Water Safety Plan many risks can be identified and managed by the responsible persons.

Figure 12 - Stages in Implementation of Water Safety Plan

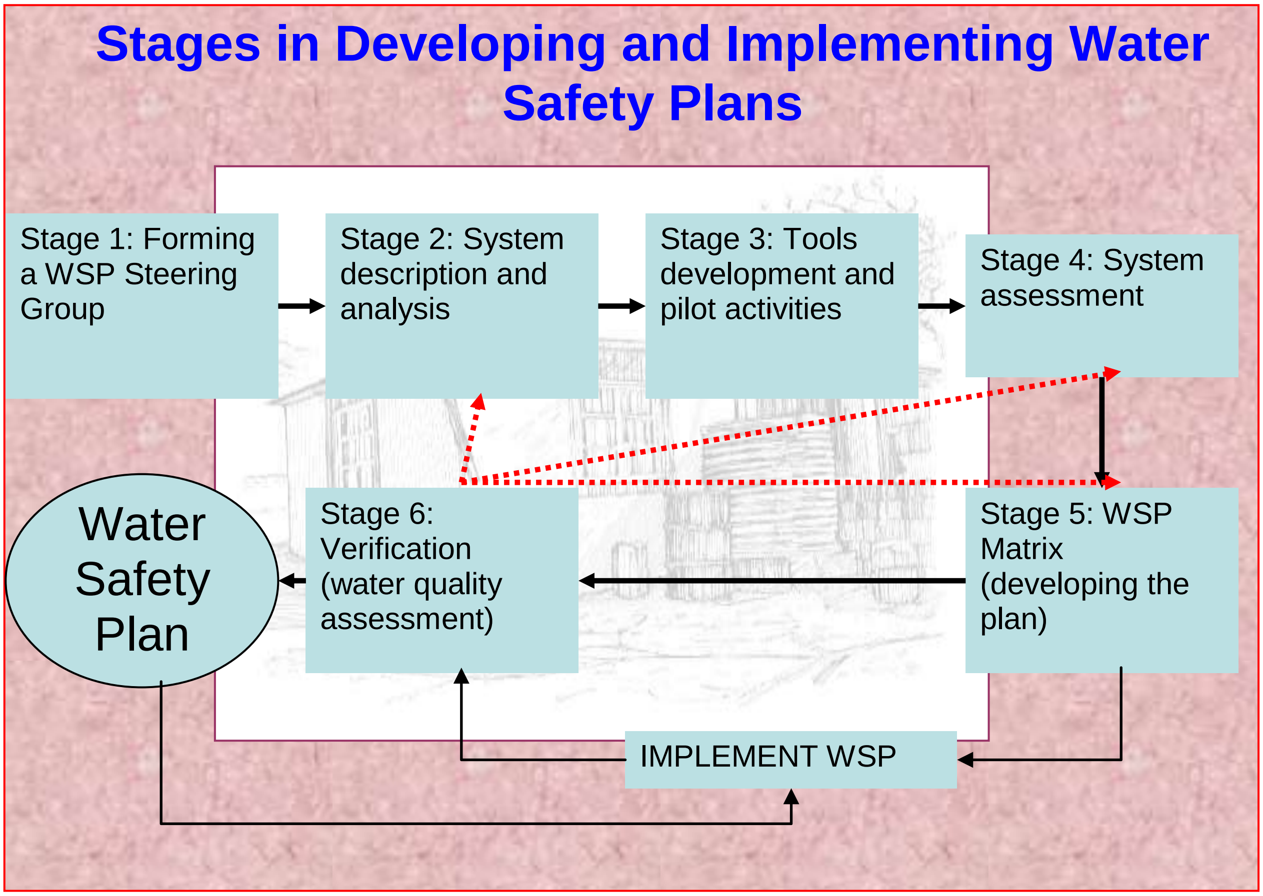


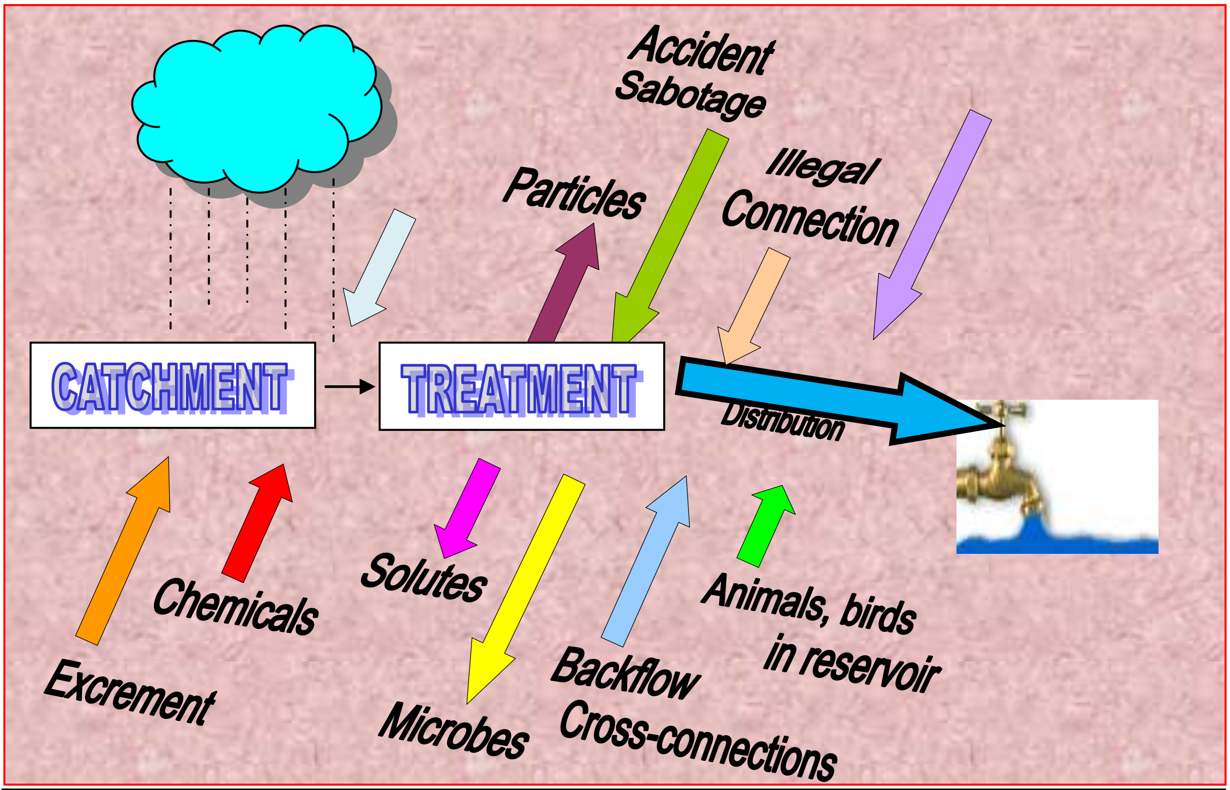
Figure: 9 WEDC Publications 2005

There is a lack of legislation, rules and standards in the water sector and the responsibilities and powers of the authorities are not clearly defined. The Ministry of Health, normally the surveillance agency, has not vigorously conducted any surveillance activity to gather sufficient data. A microbiology laboratory has been set up at Mataika House, Tamavua with necessary equipments but it is under utilised as field samples are not arriving. The field staffs, the Health Inspectors are unable to perform water quality work due to the constrained resources with their ministry. There is little or no co-operation, collaboration or exchange of information between relevant authorities. It is recommended that the Government should establish Fiji Water Authority at the earliest so that necessary strategies are formulated and appropriate management practices are in place. The tax payers are suffering due to mismanagement and high rate of corruption in many of the government ministries. The relevant authorities should establish a monitoring and surveillance scheme to which all of the authorities agree and enforce as this is important due to the re-emergence of such diseases as laptospirosis and typhoid in Fiji.

The Health Department should be responsible for surveillance activities and the overall supervision of the water quality aspects, and should develop a monitoring scheme for the short term including the chemical parameters to be monitored, sampling frequency and inspection regimes. National Drinking Water Quality Standards are required; this will include bacteriological, physical, and chemical quality parameters, and other acceptable levels for drinking water.

Standardised sampling methods, sampling frequency and analysis methods should be derived through inter-agency studies.

Figure 13 - Risks in the Water Supply System



Trucks are used for Water Cartage

Unclean tanks can cause contamination

During water cuts in the Suva distribution network private trucks are hired to cart the water to the residence. This is an additional cost to the department and usually the water cartage commences after much public concern.

SECTION 2: WATER SAFETY PLANS - TAMAVUA

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 to the Headworks(dams)	No. No fencing or barrier to control animal access.	Yes/ Water and Sewerage dept to monitor and post security guards
2. Siltation in the Headworks	No. 50 % of Headworks covered with silt No dredging done for long time. The headworks are unable to hold sufficient water and occasionally it dries up.	Yes .WSD
3. Sabotage / Vandalism	No. Possible intentional sabotage of electric pumps and pipes. Caretaker /ranger to be allocated for monitoring. Security to be upgraded with provisions of caretaker, security locks and lights	Yes/ Proper fencing is required at the Headworks Responsible-WSD. This is the major intake for greater Suva Water Supply
4. Natural disaster makes source unsafe - massive occasional flooding and erosion.	No. Waimanu river watershed is large area uphill Naitasire which has high annual rainfall. Lot of other smaller tributaries joins the Savura creek.	Yes. Use IWRM approach. WSD – hydrology section to monitor data of flooding.
5. Some villages alongside Waimanu River. Pollution from waste water and solid waste likely to happen.	No. -enforcement of pollution control legislation. - Awareness and liaison with authorities.	No. WSD/Plant managers Health Authority(Suva/Nausori)

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. Chemical Injection Points **- to be done at designated points prior to flash mixing**	No. - Dosing is done at raw water channel. - can be a cause for improper coagulation process. - Use of proper dosing pump - Not recommended to use drip feeding for this big plant (as is the case of copper sulphate).	Yes. - WSD/ Design Engineers
2. Inflow meters to be installed	No. Water measurement for the inflow will help in calculating the chemical dosing rate	Yes. –WSD /Design engineers Plant operators
3. Overloading of Clarifiers **- causes loss of retention time** **- improper sedimentation process.**	No. - Plant s demand capacity warrants provision of additional clarifier for the treatment of water to maximum capacity of 60 MLD. Only two clarifiers in existence. Which are designed to handle only 45 MLD	Yes. -Top priority should be given - This plant is designed for clear water treatment but water is turbid during rainy season. - WSD/Design and structures
4. Mixing Impellers **- Clarifiers designed to have slow mixing impellers. This greatly helps during coagulation in the mixing chambers of clarifiers – failure will cause improper floc formation.**	No. -Clarifiers No 1 and 2 are not Fully functional.	Yes. WSD/mechanical section/Plant operators

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.Sludge Extractors	Aging structures, usually collapses during operation. Needs replacement and re-doing for clarifiers 1 & 2	WSD- Design Engineers /plant operators
6. Filter Failures **-Tamavua has eight 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 soakwith 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
7. Main Storage Reservoir **a. All entry points to be closed and well secured.** **b. Provision of wash out valve to remove any accumulation of sediments.**	No -the MSR is not maintained at fully utilised. It is sufficiently large enough to hold water in reserve and supply in emergencies. The reservoir needs cleaning and improvement. Water quality test to be done of the water prior to use in the plant for treatment	Yes. WSD/Engineers/Plant managers

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.**
8. Post Chemical Dosing. **Due to plant size Tamavua needs to be equipped with proper chemical dosing facilities** **-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
9. 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
10. 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

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.
11. Lime Dosser	No Needs to be replaced with a dry feeder mechanism to be more efficient and occupy less space	WSD-Tamavua/Plant operators
12. Manual Chlorine dozer	No mprove existing mixing compartment-.Ventilation Provide HTH powder chlorine at all times to supplement the dosing if the mechanical system breakdowns.	WSD – Tamavua/Plant Operators
13. Filter Waste Water	No. Provide settling tank for waste water and sludge drying beds. The water can be recycled by pumping back to the clarifiers. The silt can be used for land reclamation	WSD – Tamavua/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
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
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 –Tamavua Distribution Section. Manager –Tamavua Treatment Plant
4. 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/ Tamavua-Distribution Section WSD - Engineer – Tamavua Distribution Section

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. 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- Tamavua Distribution Section. DE/C
6. 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 Provide steel enclosure for key area/ access to reservoir
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.	WSD-Distribution Section
9. Contaminated storage reservoirs	No, - Regular cleaning of storage tanks. - Mud sedimentation common in reservoir - Old reservoir needs structural maintenance	WSD/ Distribution manager
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.	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 and headworks. - Security to be upgraded with provisions of caretaker, security locks and lights	-Water smells looks or tastes abnormal. -Pump breaks down and there are signs of sabotage or vandalism	Proper fencing is required at land and river levels Responsible-WSD. This is the major intake for greater Suva/Nausori area 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.	-- Waimanu river watershed is large area uphill Naitasire 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	Seek immediate help of emergency water supply from the Disaster Management Office	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.
3. Village/Settlement alongside Waimanu River.	- Public awareness of target population on river care. - Due to illiteracy people use river for waste disposal and bathing	Water smells and solid waste visible in the river. Entry of contaminated water into the intake.	Educate the people residing alongside the river on proper waste disposal and sanitary conditions. Local Health Authority to monitor and raise awareness
4. Siltation in the Headworks causing dry ups and loss of water storage capacity	Dredge the Headworks of excessive sediments and silt	Water smells and the headworks dry up.	No plans in place. WSD engineers to design dredging plans and programme

2.2.2 Treatment

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. Chemical Injection Points ▪ **Dosing to be done at designated points prior to flash mixing**	- Dosing is done at raw water channel which can be a cause for improper coagulation process. - Use of proper dosing pump - Not recommended to use drip feeding for this big plant (as is the case of copper sulphate).	Overloading of dam. -poor coagulation and sedimentation process. Dissolved solids passing into filtration media. - leads to high turbidity of treated water.	Mixing is done manually atraw water channel - WSD/ Design Engineers
2. Overloading of Clarifiers **- causes loss of retention time** **- improper sedimentation process.**	- Plant is operating at a maximum rate of 60 MLD so three clarifiers are needed. - Additional one clarifier to be provided.	Less retention time. Incomplete sedimentation. Dissolved solids entering filter media and treated water.	-Top priority should be given - WSD/ Engineers - Design and structures
3. Sludge Extraction **- Plant design to operate on a timed basis sludge extraction/disposal.** **- Will cause sludge accumulation, sludge decomposition and eventually lead to anaerobic actions causing taste and odour problems.**	- Automatic sludge disposal system is defunct. - System is presently manually control – leads to inefficient sludge disposal. - Upgrade the system	Sludge accumulation seen in the Sedimentation tanks. Decomposition and anaerobic actions creates smell in water	- WSD/Design structural section- hydraulics. - Remove sludge manually at appropriate intervals.

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.Mixing Impellers **Clarifiers designed to have slow mixing impellers. This greatly helps during coagulation in the mixing chambers of clarifiers – failure will cause improper floc formation.**	-Clarifiers No 1 and 2 are defunct and needs immediate upgrading.	Reduced or no floc formation. Dissolved solids entering the filter media and treated water.	WSD/mechanical section. - Higher chemical dosage is an option.
5. Filter Failures **-Tamavua has eight rapid sand filters.** **-Most filters noted with dam-Breakdown of backwash controls – this leads to improper filter backwash.**	- provide additional sand filters - upgrade filtration media - This the major cause of high turbidity in treated water? - This will also increase the plant chlorine demand	Dissolved solids entering the treated water. Presence of micro-organisms/protozoa in treated water.	- WSD / Design and Structures – hydraulics. - Higher chemical dosage is an option.
6.Clear Water Storage Reservoir **a. Existing entry points for animals and rodents.** **b. Manual measuring device requires operators to enter the well.** **c. No wash out valve to remove any accumulation of sediment**	-the main inlet to clear well to be further secured from entry of birds/rodents and intentional sabotage. Install water level measuring device - Upgrade filter media, occasional soaking of filter media with caustic soda.	- high water demand - loss of well volume due to increased volume of sludge/media deposits, media deposits sand/gravel from damaged filters can affect pump performance. -Dead and live rodents seen in the reservoir	WSD/Plant managers. Visual inspection must be done.

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?**
7. Post Chemical Dosing. **Due to plant size Tamavua needs to be equipped with proper chemical dosing facilities** **-Plant should maintain residual chlorine of 1.2mg/l; this will allow an acceptable residual in the reticulation system** **- Lime/Soda Ash- used for pH correction in treated water. Inadequate dosing can produce acidic water.**	-There is a need to upgrade OHS requirements for handling chlorine - For effective chlorination –two chlorinators are installed at the plant - Provision of backup manual chlorine disinfection is provided by means of Calcium Hypochlorite (HTH) during chlorinator failure. - - There is an urgent need to install a new lime dosing mechanism.	Water sampling will indicate presence of coliform bacteria. Public complains on taste, odour and turbidity of treated water.	Plant managers NWQL-Analyst - Manual chemical dosing is used which promotes excessive chemicals in the distribution system.
8. Residual Chlorine levels in distribution system are too high or too low.	Develop a regular (weekly) monitoring schedule for residual chlorine at different points in the distribution system. Ensure end mains are flushed regularly.	Increase in Public complains about taste, appearance or smell of water.	Additional testing resources needed at the Tamavua plant such as turbidity meter and chemical detectors.
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.	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	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

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 TAC result and water unsafe for public use. Mains can act as retention tank.	There is no current contingency. 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
6. Sediment accumulation in the mainline at lower areas.	Wash out valves required at the lower areas of the distribution system to eliminated deposited silt.	Low pressure in consumer taps and blockage in the consumer supply. Low chlorine residuals.	Keep constant supply of water and flush out during blockage repair. Distribution section –Suva water Supply.

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?
7. 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.	Analysis of mains water will indicate presences of pathogenic bacteria. Colour and turbidity is abnormal	Close the distribution network and clean the system. WSD and distribution manager to act - Inform public to boil water.
8. 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.
9. 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- wash of pipes and analyse water for bacterial contents prior to consumption.	Water colour and turbidity changes. - Increased suspended and dissolved solids in treated water.	Yes/ -Distribution Section to monitor - Inform public to boil their drinking water. - Analyse water for bacterial content.
10. 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, throttle supply. provide additional reservoir.	W 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.	YES- Distribution Section to monitor. Analyze water for bacterial content.
11. 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 pressure Consumer complains	Yes/WSD-consult with Disaster Management Office for emergency water supply. Analyse water 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?
12. Damage to exposed pipelines.	Endeavour to bury/protect/encase all exposed pipelines. Have warning signs posted to inform the public.	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
13. 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
14. 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/media information	Low pressure of water in pipes People seen around storage tanks drawing water or bathing in instances of water cuts	Yes/Police/WSD 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 and Headworks 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 $60,000
2. Natural disasters makes source unsafe –massive occasional flooding and erosion	Inspection and advice the owners of the commercial activities. Provide screens at the intake Care taker needed to monitor the situation.	High	DWS/Health Department	Public Awareness PWD, Local Authority $15,000
4. Village / Settlement alongside Waimanu river.	People use river water for waste disposal and bathing. - Raise public awareness for people staying along riverside on pollution control.	High	WSD Public Awareness MOH	Promote Health and Sanitation for Villages and settlements
5. Increase in soil erosion - in the areas immediately upslope from the source/intake	PWD, and Provincial Councils to undertake awareness on land conservation and catchment protection. Dredge the Headworks to remove silts from erosion	High	WSD	Cost of dredging the heardworks $30,000
6.Siltation in the Headworks	Dredging of the headworks 1,2 and 3	High	WSD-Engineers	Regular inspection

3.2 TREATMENT

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
1. Chemical injection points **- to be done at the designated points prior to flash mixing**	- Install proper dosing pump for copper sulphate, alum, soda, chlorine - Investigate method for monitoring FAC in process following 30 minute disinfection contact time - Install chemical injection points ,delivery lines and checker plates	High	PWD NWQL WTP-operators PWD	Develop a regular (weekly) monitoring schedule for residual chlorine. Install dosing pumps – Cost- $ 60,000
2. Sludge extraction **- plant designed to operate on a timed basis sludge extraction/disposal** **- Will cause sludge accumulation and decomposition leading to anaerobic actions** **Mixing Impellers** **- Clarifiers designed to have slow mixing impellers. This greatly helps during coagulation in the mixing chambers of clarifiers.** **- Failure will cause improper floc formation**	Clarifier 1&2 rehabilitation - Upgrade automatic sludge removal system - Impellers for clarifiers No.1 and 2 to be repaired to operational level	High High	WSD Plant Operators WSD WTP operators	Upgrade Sludge remover Cost- $100,000
3.Filter failure **-Tamavua has eight rapid sand filters.** **-Filter media needs upgrading and cleaning with caustic soda**	- Repair damaged control nozzles of the sand filters. - Replace and upgrade filter media (sand) - Repair backwash control Overloading of filters due to water demand - Soaking in caustic soda	High	WSD WTP operators	Repair filters and upgrade filter media. Cost- $ 20,000

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
4. Chlorine dosing rate does not counteract fluctuation in water quality accordingly. Tamavua 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- $30,000
5. Upgrade major pumps controls.	Upgrade – reflux valves, motorised valves, pump remote controls- both intake and high lift. Provide a additional pump at Savura Pumping Station.	High	WSD/WTP operators	Provide backup generator and pump Cost- $60,000
6. Entry Points in the Building for animals/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.	High	WSD/WTP operators	Upgrade grills and screens in the Plant building. Cost- $20,000
7.Chlorinator and safety equipments	Upgrade chlorination equipments and pumps/safety device	High		Cost $30,000

3.3 STORAGE AND DISTRIBUTION

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
1. There is easy access for the public into the reservoir compounds.	Install security lights and steel grills for the inlet and inspection chambers	High	WSD/WTP operators	Upgrade Security at all time. Cost $36.000
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. Awareness materials. Brochure- Cost $10,000
3.Rodents and animals getting into the storage reservoir tanks	Cut down trees growing close to the reservoir tanks and remove discarded items. Remove old pipes and fittings which can pose breeding grounds for rodents and animals. Repair damaged intake chambers. Clean the compound of grass and shrubs.	High	WSD/WTP operators	Cost $54,000
4.Rusted covers/manhole lids for the inlet storage tanks has openings	All inlets to the storage reservoir to be sealed properly. Rusted lids to be replaced. Provide plastic lids where possible. All ladders to be upgraded.	High	WSD/WTP/PWD	Cost - $90,000
5.People have access to turn inlet and outlet keys at the reservoirs, cross contamination is possible	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- $28,000

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
6. 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 procedures
7. 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 wash 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
8. 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. Low Pressure could result in some communities being deprived of water.	Numerous reports of insufficient water to parts of the network and dirty water seen at consumer taps. Keep supply constant. Install inlet/outlet meters for all reservoirs	High	WSD WTP operators Distribution Section	Cost of meters 114,000

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
10. Vandalism/sabotage.	Lock and secure tools, equipments and turn keys at reservoirs. Provide enclosures for inlet chambers. Post caretakers and security alarms at reservoirs. Provide fencing around the reservoir compounds. Upgrade All reservoirs. Provide fixed chamber lids for existing valves.	Moderate	WSD/WTP operators	Reservoirs. Security and fencing. 123,000
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	Upgrade access 90,000
12.Dirty Contaminated storage tanks and contamination by plant operators during the checking of reservoir water levels	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	Provide water level measurements gauges. Costs- $ 25,000
13. Breaks, leaks or damage to pipes during earthworks, farming and logging 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. -Advice public on the consequences of unauthorised water tapping from fire hydrants.	High	WSD WTP operators Tamavua. Distribution section	Public awareness Sign boards.

Risks Identified	Improvement	Priority	Responsibilities and Timeline	Comments and Costs
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 – $40,000
15. Drop in Water Level in the reservoirs. Leakage in underground pipelines within houses and properties.	Recommend to install telemetry system SCADA for immediate data collection on water level Encourage upgrading of old pipelines within houses/properties. Advise property owners on advantages of using standardised pipes	High	DWS to install and train staff PWD	Cost of installation and training on data recording 270,000

3.4 SUMMARY FOR THE IMPROVEMENT SCHEDULE FOR THE TAMAVUA 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 at Intake and Headworks	Fencing/watchman	60,000
3.Dredging of Headworks 1,2 and 3	Removing of silts from Headworks 1,2 and 3	30,000
Treatment	COST	$105,000
4. Install chemical dosing pump	For copper sulphate, alum, Soda, chlorine	60,000
5. Rehabilitation of Clarifiers 1&2	Mechanical mixer	100,000
6. Repair filters and upgrade filter media	Wash filter media	20,000
7. Upgrade existing lab with equipments	Upgrade existing water lab at Tamavua	30,000
8.Provide backup generator and pump	Savura pumping station and treatment plant	60,000
9.Upgrade grills and screens in the Plant building	Entry point of Birds rodents and insects	20,000
10. Improve chlorine mixing chamber	Manual Chlorination area	10.000
11.Upgrade chlorination system	Chlorinators, detectors, safety gear	30,000
Storage and Distribution	COST	$330,000
12.Provide security lights and grills at the reservoirs	Security lights, fence and grills	36,000
13.Carry out Public awareness campaign	Workshop, media, IEC materials	10,000
14.Cleaning and landscaping of reservoir compound	Grass cutting, landscaping, removing trees	54,000
15.Upgrade and replacement of cover lids, manhole	Replace rusted lids and inspection covers	90,000
16.Upgrade of Reservoir Turn Keys	Lids and covers/locks	28,000
17.Cleaning of Storage tanks of silts and debris	Remove dirt from storage tanks/reservoir	20,000
18.Replacement of valves at distribution network	Gate valve on main lines	10,000
19.Installation of flow meters for the reservoirs	Flow meters	114,000
20.Fencing,upgrade of gates and security at reservoirs	Fence and gates	123,000
21.Upgrade of Access/driveway to reservoirs	Upgrade existing access for inspection	90,000
22.Provision of water level measuring gauge	Install measuring device	25,000
23. Provision of washout valves and chambers	For the distribution network	40,000
24.Installation of Telemetry SCADA system	Install at all reservoir	270,000
TOTAL	**COST**	**FJD$910,000**

SECTION: 4 NEEDS ASSESSMENT

4.1 INTRODUCTION

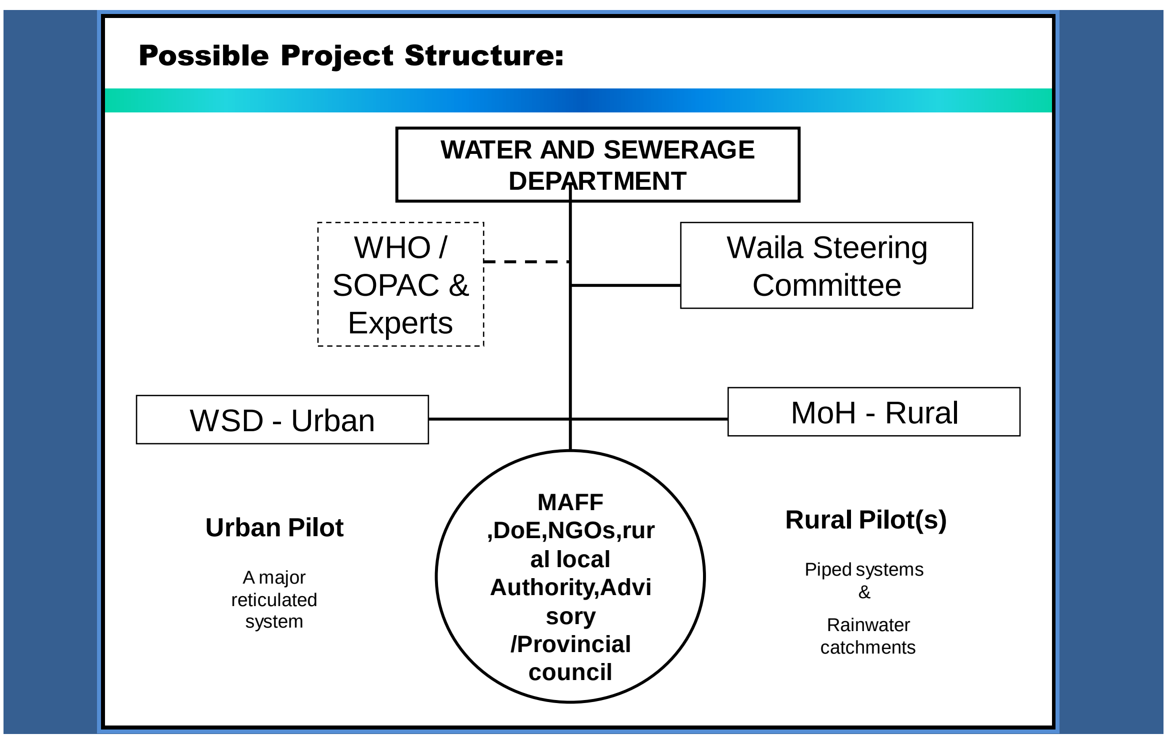
The importance of safe drinking water for health and development in the Pacific Island Countries has been reflected in many regional action plans and policies. Through the Regional Action Plan (RAP) on Sustainable Water Management (Sigatoka, Fiji, 2002) Pacific Island Countries (PICs) outlined actions 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. An introductory workshop was conducted in December 2007 to train Water Supply and Ministry of Health staff on the formulation of Water Safety Plans for rural and urban areas. There was good commitment shown from Water and Sewerage Department (WSD) and Ministry of Health, Fiji. It was initially decide that the Water Safety Plans will be formulated for Suva/Nausori Water Supply System and a steering committee and lead agency was identified. Below is a possible work structure indicating the position of the steering committee.

Figure 14 -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

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:

Water Safety Plans Workshop - 2007

- 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 Suva /Nausori 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.

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. 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 and carries 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 /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 Suva/Nausori 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 Suva/Nausori 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. It has formulated the new Environmental Management Act which will assist in the protection of water resources from contamination.

Table 14: Tamavua Water Safety Plan Team

Name	Position	Organization	Responsibility	Phone/E-Mail
S.Yanuyanurua	Divisional Engineer-C/E	Department of Water and Sewerage, (WSD) Suva	Overall Supervision of Engineering and Infrastructure for Suva/Nausori Water Production and distribution.	PH: 3321099 syanu@fijiwater.gov.fj
Poate Tabua	Production Manager	WSD, Tamavua Treatment Plant, Suva	Overall supervision of all treatment Plants in central Division.	PH: 3321099 pltabuaniviti@yahoo.com
Kamal Singh	Plant Manager	WSD, Wailoku Treatment Plant, Tamavua Suva	Assistant Production manager	PH: 3321099 PH: 3477716
Sher Singh	Senior Scientific Officer	WSD NWQL Kinoya	Chemical/Bacteriological Analysis – NWQL, Kinoya, Suva	PH: 3391194 PH: 3392133
Bobby Dave	Tamavua Plant Manager	WSD Tamavua Treatment Plant	Plant supervisor, Tamavua treatment plant	PH: 3321099
Tomasi .V. Ledua	Distribution Manager	WSD –Suva Water Supply.	Distribution Supervisor Suva Water Supply	PH: 3321099 Ext: 203
Deo Narayan	Health Inspector	Ministry of Health, Suva Rural Local Authority	Surveillance/water sampling.	PH: 3372546
Francis Wele	Assistant Health Inspector	Ministry of Health, Nausori	Surveillance/water sampling.	PH: 3478027 Fax: 3477233
William Magnus	Senior Research Officer	Fiji Agriculture Chemistry Lab Koronivia- Nausori	Chemical Analysis for Water	William.magnus@govnet.gov.fj

4.5 NEEDS ASSESSMENT FOR TAMAVUA 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.

The world's freshwater resources are under increasing pressure. Growth in population, increased economic activity and improved standards of living lead to increased competition for 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).

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 be integrated, water resources policy must mesh with overall national economic policy and related national sectoral policies.


Water Safety Plan Workshop-2007 Suva

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 ministry. It is recommended that further training and workshop should be conducted on the health aspects and water quality and the safe plant operation.

Infrastructure

The Tamavua Treatment Plant was commissioned in 1962 and all necessary provisions were made for the efficient operations but over the years due to the lack of maintenance and upgrade the technology at the plant needs major overhaul. There is room for expansion of the plant and it's an urgent need to provide additional clarifiers, upgrading of filters and provision of sludge drying beds.

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 records and data correlation is a problem.


Tamavua Treatment Plant

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 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.

The plant should have a sludge settling tank which can hold filter wash water and recirculate it to the clarifiers. The dried silt should be used for land filling rather than disposing into the streams and endangering aquatic life forms.

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 done on the extraction of water from the Waimanu River and the disposal of waste water from the plant. 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.

Equipments

The Treatment plant lacked the modern communication technologies such as from the pump station and the plant. There is lack of computers, telemetry
Recorders and telephones for efficient communications during emergencies and disasters

There operators are using old and manual 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 Tamavua Treatment Plant needs immediate improvement.

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.

Laboratory at Tamavua Treatment Plant

4.6 SUVA WATER SUPPLY

Suva water supply is located on the same site as the Tamavua treatment plant alongside Wailoku road. It has its own set up and structure and managed by the Suva Water Supply Distribution Engineer. The main functions of the Suva 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 Suva/Lami and Nausori corridor. Some areas of Lami are facing problem of low pressure and siltation in the mains due to an extensive flat area. There are a number of operational teams divided in three zones with specific roles. Their major function is of the new connection due to increased population and addressing 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

- **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.

Suva Water Supply -Office

- **Infrastructure**

The Suva Water Supply has its own office building, a storage building and offices as seen in the picture above. The treatment plant building and the storage facilities need immediate improvement and renovations. There is an existing Main Storage Reservoir (MSR) which should be upgraded and maintained. The Distribution engineer informed that to improve the constant water supply MSR should be maintained. The water from the MSR can be utilised during pump and mains breakdown. The existing Savura pumping station to be improved and one additional pump to be provided. This system once upgraded will solve the major problem of the Suva Water Supply area.

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 recontamination may be possible if improvements are prolonged.

It is difficult to record the Top Water Level (TWL) from all the reservoirs in the system and it was stressed by the engineers that a Supervisory Control and Data Acquisition (SCADA) system would greatly assist the WSD in improving its performance in operating and maintaining the system. It is recommended that SCADA system be implemented that would allow significant information from water infrastructure to be monitored and controlled by radio telemetry from the various locations determined by WSD ,with a view to improving system reliability, operational efficiency, system planning and customer relation.

Solar water measuring Device

Table 15: STAFF ESTABLISHMENT

	Total Number	Supervisor	Technicians	Trade Assistant/Labours
Tamavua Treatment Plant	19	3	7	9
Suva Water Supply	143	4	28	41
National Water Quality laboratory	16	1	15	-

❖ **Equipments**

- It was noted that there were field equipments available with WSD and was made available to Suva water supply on demand. The station should have its own set of equipments as at presently it is shared by Rewa Water Supply as well.

- 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.

- As mentioned above the installation of SCADA system is also necessary and where possible solar or electrical power to be used for the system.

Government/Private Vehicles – in use

❖ **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 Suva Water Supply.

Due to a large reticulation area its time consuming during travel and some reservoirs are accessible by roads 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 is the major financial drain from the budget allocation. There should be better control and usage of the available transport. There is no inspection programme for the reservoirs due to lack of mobility.

Kalabo Reservoir – discarded items on site **Nasinu Residential Area – Tamavua Supply**

4. 7. NATIONAL WATER QUALITY LABORATORY

- **Human resources**

There is need for staff training on analytical methods of water quality analysis.

- It was also suggested by the senior scientific officer that the treatment plant operators should receive training and are graded by their qualifications and experience for the respective positions.
- The laboratory staffs needs training on writing down the SOPs for the treatment plants water quality monitoring.
- The recommendation is for training and setting up of E-Coli 0157.Giardia cryptosporidium monitoring system and procedures.
- The plant and Laboratory staff need training on the use of chemical disinfectants and the effects of their by products.

- **Infrastructure**

Water and Sewerage Department has constructed a new building at Kinoya for the office space and laboratory facilities and the NWQL will be soon shifting in this building once water connection is made to the building.

- It was recommended that online instrumentation be done for the distribution system so that monitoring can be made easy and time saving.

- **Equipments**

- NWQL requires some new instruments for the testing of the disinfectants and their by-products.
- Equipments are also required for Giardia and cryptosporidium protozoa testing.

- There is a need of testing equipment for bacterial E-Coli 0157 as the lab is engaging in testing for this very dangerous of bacterial strain capable of causing disease through water contamination.

- **Mobility**

  - The WSD is providing transport to NWQL for water quality monitoring and inspection in the division. The transport is made available on demand and there is a restriction of private transport use due to lack of funds. There is a request of fulltime transport allocation to NWQL for its field operations and monitoring at national level.

4.8. DEVELOP RELEVANT TOOLS FOR RISK ASSESSMENT OF THE WATER SUPPLY SYSTEM

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 Suva/Nausori 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.

4.9 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 16: 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
Legal – Legal Affairs
NPO- National Planning Office
Fin – Finance Dept
MAPI – Ministry of Agriculture and Primary Industries
AC/PC – Advisory Council and Provincial Council

4.10. 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 raising 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 NWQL monitoring 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).

- Improve sharing of information among agencies by establishing a working group that would collate data and prepare annual reports.

- 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.

FINANCING

Agencies need to identify sources (national budget and donor aid) for funding WSP implementation. Review current and projected budgets to identify funding for needed capital or institutional improvements for implementation of WSPs. Establish an advisory service for preparation of funding proposal.

Allocate funding for needed improvements (capital works or institutional arrangements) or capacity building. Complete Water Safety Plans for water supplies to use as justification for funding or donor support for needed improvements. Prepare an Improvement Schedule to identify (prioritize) those improvements that can be made with existing funding and those that will need additional funding from Government or donor support.

APPROPRIATE TECHNOLOGY

Develop National Guidelines for Septic Tank construction. Determine the restrictions that need to be applied to construction in rural areas to protect groundwater resources Review the National Building Code to identify areas that need to be enforced or strengthened for septic tank installations

Conduct studies to determine if septic tanks are affecting groundwater quality. Develop maps showing locations of septic tanks in rural areas. 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

Improve farming practices to reduce reliance on chemical fertilizers and pesticides.
Encourage NGOs and Community-based organizations to promote organic farming.

Develop an education and awareness programme for farmers on risks to drinking water quality from agricultural chemicals. Develop national policies and guidelines for best practice for sustainable farming. Establish a National Registry for agricultural chemicals

Clear Water Reservoir Tamavua below ground level

Addition of Copper sulphate /Alum/Soda

Table 17: 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

Fin – Finance Dept
MAPI – Ministry of Agriculture and Primary Industries
AC/PC – Advisory Council and Provincial Council

4.11 Products & Outputs of the 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 Suva/Nausori 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 Suva/Nausori area
15. Improvement schedule completed for Suva/Nausori area
16. National guidelines for sustainable farming developed
17. Standard Operating procedures and contingency plans formulated for the respective water supplies.

4.12 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 18: 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

4.13 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

REPLICATION

Replication strategy to be complete by the steering Committee, Water and Sewerage Department and Ministry of Health for the water supplies in urban and rural areas.

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 there is to have water authority for the efficient management of the water supply system in relation to human and capital resources.

2. There is a need for the training of staff on raising public awareness in the departments and 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. Functioning of the established steering committee is vital with the involvement of all stakeholders such as MOH and Ministry of Agriculture, Fisheries and Forest.

4. Suva Water Supply has a large workforce therefore there is the need to improve the existing office building, bulk stores and other facilities for the staff.

5. 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.

6. The Tamavua 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. There should be provided sludge retention tank so that the waste water can be recycled and the sludge will not enter the natural water course.

7. Communication and mobility to be improved and maintained for field works and for administrations activities.

8. Modern laboratory with equipment to be set at the Tamavua Treatment Plant and a field monitoring , distribution system should be upgraded with maintenance of the existing reservoirs and replacement of old pipes.

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

10. Most of the financial constraints are due to the use of electricity therefore new methods of generating electricity to run the pumps should be explored. Such options as use of boreholes and desalination plants to supplement the water demand should be investigated in terms of viability and cost.

11. Data and record keeping should be improved in order to monitor the resource, demand and water wastage.

12. De-silting of distribution pipes, chlorine wash and flush outs is necessary to avoid re-contamination of treated water.

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

14. The WSD should continuously involve trainers, experts and technicians to train the water supply staff at all sectors.

15. Ministry of Health as regulators should formulate a monitoring plan for the drinking water quality for bacterial and chemical parameters.

16. Due to the increase in the population and industrial activities in Suva/Nausori corridor there is increase in water demand so reserve supply to be maintained and upgraded. The MSR at Tamavua is seen unmaintained and not fully utilised to solve the problem of water shortages.

17. It is likely that water safety planning programme would synergistically fit into the ADB project focusing on the water quality improvement. There is a good functional structure and facilities with WSD to facilitate the programmes efficiently.

18. There are a number of reservoirs in the Suva/Nausori water scheme 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 lids or inlets. Ingress of rodents and small animals are possible. The turn key chambers are unmaintained and usually damaged by vandalism.

19. Measuring of water level method is improper whereby the plant attendants enter the reservoirs to take measurements thus there is likely chance of the re-contamination of treated water.

20. Siltation of dissolved solids 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 and water cuts.

21. There needs to be a good public awareness programme implemented by the major stakeholders as WSD and Ministry of Health on water use at resource and distribution levels (control of leakages and contamination of water source).

22. There is a lack of effective formal coordination with major stakeholders. Networking and information sharing is necessary to promote more collaborative approach in water resource management at watershed and service level.

23. There is a general lack of good infrastructure and communication technology at administrative and distribution areas. Upgrading of existing reservoirs and distribution mains are necessary. Mode of mobility and administrative centres needs improvement as well.

24. Extensive improvements to the human resource are needed due to the increase in the service demand. Therefore there is a need for up skilling the staff through on-job and institutional training. Focus should be on workshops and training on new field technology.

25. Alternative options to supplement the water demand by exploring the opportunities for desalination plants for salty water and use of borehole system to tap into ground water source is necessary.

26. Environmental Impact Assessment should be done on the use of surface water from the Waimanu River and on the sludge disposal methods for Tamavua Treatment Plant.

27. Latest statistics from Ministry of Health reveals an increase of the water borne diseases such as diarrhoea, typhoid and laptospirosis. Therefore it is necessary for capacity building for human resource and technology. Ministry of Health should organise more public awareness campaigns on water and sanitation methods.

28. It is vital to enforce Environmental Management Act and Public Health Act to maintain a healthy watershed through elimination of pollution from human activities.

29. Periodical chemical analysis of source water is necessary to monitor the chemicals present in the drinking water as many environmental persistent chemicals are used in the agricultural activities.

30. With reference to the Harrison and Grierson report and ADB Report it is imperative to carry out the recommendation of the reports in totality in order to improve the water quality and manage the water demand efficiency.

31. Financial reports on the operation of the Tamavua Treatment Plant reveal that much of the expenditure is incurred in the use of electricity to run the pumps. Options should be investigated on provision of alternative power supply as mini-hydro or use of solid waste for power generation.

32. There is lack of data on water resource management and surveillance with major stakeholders such as WSD 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).

33. Fiji is facing a number of problems as large population and poor economy, so there remains major obstacle in the upgrading of the fast deteriorating water services. Therefore human and capital resources needed require international support.

34. 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.

5.2 Conclusion

The Water Safety Plan was finalized through the assistance of the Tamavua Water Supply staff and reference was also made to the outcome of the WSP workshop held at Tamavua Water Treatment Plant in December 2007. Tamavua Water Safety Plan 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 steering committee is also requested to provide the cost of the improvements in local currency. 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 Suva Water Supply is under much pressure due to high demand of treated water for consumption by the increasing population in the Suva /Lami area. The Suva Water Supply has authority and capacity to maintain the distribution system for Suva and Lami areas but many constrains 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 establish Water Safety Plans for the Tamavua Water Supply system and replicate for the other areas in future. Cooperation between these agencies is necessary to achieve the outcomes they have expressed for this programme at the commencment.

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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

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

INTAKE / PUMPING STATION

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

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)	Likely 4	Major 4	Very High 16
Algae in water	Algae in raw water	Increase dosing of copper sulphate	Unlikely 2	Minor 2	Low 4
Scraper breakdown	Electrical Failure	none	Rare 1	Major 4	Low 4
Malfunctioning	Damage to structure	Preventative maintenance in place	Rare 1	Major 4	Low 4
Filters					
Filter overload	High turbidity	None	Likely 4	Major 4	Very High 16
	Clarifier failure	Preventative Maintenance in Place	Possible 2	Major 4	Moderate 8
	Insufficient Backwash	Trained operators	Rare 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

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	Unlikely 2	Major 4	Moderate 8

STORAGE AND DISTRIBUTION NETWORK

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

WATER AND SEWERAGE DEPARTMENT

NATIONAL WATER QUALITY LABORATORY

P. O. BOX 3850, SAMABULA

CHEMICAL AND BACTERIOLOGICAL ANALYSIS OF WATER

Sample from	Nausori/ Suva [Reservoirs]	Sampled by	Raijeli	Weather	Fine	Laboratory Ref. No.	WSR 001/08
Sample date	15/04/08	Sample time	0900-1600hrs				

DETERMINANDS		UNITS	SAMPLE LOCATION 4	5	6	Standards For T/W
ANALYSIS	Temperature	°C	25.3	25.1	25.0	
	pH	0-14	6.3	6.5	6.5	6.5 to 8.5
	Conductivity	uS/cm	96.5	102.5	99.6	1000µS/cm
	Colour	TCU	0	0	0	5TCU
	Turbidity	NTU	2.37	1.12	2.35	5 NTU
ALKALINITY HARDNESS	Alkalinity	mg/L	23.0	20.4	22.1	
	bicarbonate	mg/L	23.0	20.4	22.1	
	Carbonate alkalinity	mg/L	0	0	0	
	Total Hardness	mg/L	30.5	33.9	23.7	200mg/L
	Calcium Hardness	mg/L	20.3	22.6	15.8	
	Magnesium Hardness	mg/L	10.2	11.3	7.9	
SOLIDS	Total Solids	mg/L				
	Total Dissolved Solids	mg/L	65.2	68.9	66.8	500mg/L
	Suspended Solids	mg/L				
DISSOLVED GASES	Carbon dioxide	mg/L				
	Dissolved Oxygen	mg/L				
OTHER CHEMICAL ANALYSES	BOD 5-day @ 20°C	mg/L				
	Total Nitrogen	mg/L				
	Ammonia Nitrogen	mg/L				
	Nitrate	mg/L				
	Salinty	ppt	0	0.1	0	50mg/L
	Total Phosphorus	mg/L				
	Ortho-phosphates	mg/L				
	Total Sulphates	mg/L				250mg/L
	Chlorides	mg/L	7.00	7.00	6.10	
	Cynades	mg/L				0.07mg/L
	Fluorides	mg/L	<0.05	<0.05	<0.05	1 mg/L

DETERMINANDS		UNITS	SAMPLE LOCATION 4	5	6	Standards For T/W
METALS	Iron (Total)	mg/L				<0.3mg/L
	Iron (Soluable)	mg/L	<0.05	<0.05	<0.05	<0.3mg/L
	Manganese (Total)	mg/L				<0.1mg/L
	Manganese (Soluable)	mg/L	<0.05	<0.05	<0.05	<0.1mg/L
	Aluminium	mg/L	<0.02	<0.02	<0.02	<0.2mg/L
	Calcium	mg/L	8.20	9.10	6.30	
	Magnesium	mg/L	2.50	2.70	1.90	
	Sodium	mg/L				<180mg/L
	Potassium	mg/L				
HEAVY METALS	Copper	mg/L	<0.05	<0.05	<0.05	<1.0mg/L
	Lead	mg/L				0.01mg/L
	Barium	mg/L				0.7mg/L
	Lithium	mg/L				
	Zinc	mg/L				3mg/L
	Cadmium	mg/L				0.003mg/L
	Chromium	mg/L				0.05mg/L
	Nickel	mg/L				
	Selenium	mg/L				0.01mg/L
	Arsenic	mg/L				0.01mg/L
	Mercury	mg/L				0.01mg/L
	Silica	mg/L				
CHLORINE RESIDUALS	Total Available	mg/L	0.64	0.08	0.86	
	Free Available	mg/L	0.58	0.04	0.80	0.5mg/L
MICROBIO-LOGICAL *in Col/100mL*	Standard Plate Counts					
	Total Coliforms		0	14	0	0
	Faecal Coliforms		0	8	0	0
	Faecal Streptococci					

REMARKS

[4] Wainibuku Reservoir
[5] Raralevu Reservoir
[6] Flagstaff Reservoir

Senior Scientific Officer

WATER AND SEWERAGE DEPARTMENT
NATIONAL WATER QUALITY LABORATORY
P O Box 3850, Samabula

RESULT OF WATER ANALYSIS
WATER SUPPLY RETICULATION SYSTEM

Sample From: Nausori Area
Date Sampled: 26/05/08

Time Sampled: 0930-1530Hrs
Laboratory Ref No: WRT 165/08
Weather: Fine

	LOCATION OF SAMPLE	TEMP in °C	pH units 0-14	TRBDTY in NTU	AVAILABLE CHLORINE in milligrams per Litre		MICROBIOLOGICAL Coliforms in Col/100mL	
					TOTAL	FREE	TOTAL	FAECAL
1	Lab Sterile Water	23.0	6.8	0.10	N/A	N/A	0	0
2	Government Printing	25.0	7.2	1.12	0.66	0.62	0	0
3	USP Lower Campus	25.5	7.2	1.66	0.46	0.40	0	0
4	Suva Grammar School	26.0	7.0	2.79	0.42	0.38	0	0
5	Valelelvu market	26.2	7.2	1.99	0.78	0.72	0	0
6	Makoi Residence	26.0	7.2	0.92	0.58	0.52	0	0
7	Koronivia Research Station	26.0	7.2	0.98	0.60	0.54	0	0
8	Market	26.5	7.2	1.10	0.68	0.64	0	0
9	Wanibokasi Hospital	26.0	7.2	1.78	0.70	0.64	0	0
10	Naitalasese	26.0	7.2	1.22	0.72	0.66	0	0
11	Kasavu Shop	26.0	7.2	1.50	0.74	0.70	0	0
12	Waimanu River	25.5	7.0	3.45	N/A	N/A	360	155

REMARKS

Treated Water quality meets bacteriological purity of drinking water.

(Reccommeded chlorine dose- 0.5mg/l after 30min. contact period.)

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

Singh
Senior Scientific Officer

DEPARTMENT OF WATER AND SEWERAGE **ANNEX: 5**

MONTHLY PRODUCTION REPORT
STATION: WAILA TREATMENT REPORT
MONTH: AUGUST- 08
DESIGNED PRODUCTION: 45 MEGA LITRES
CURRENT PRODUCTION: 60 MEGA LITRES

	This Month	Corresponding Month last year
A. TOTAL INFLOW TO PLANT	1634.49	1751.85
B.TOTAL PLANT USE	92.09	122.70
C.TOTAL TREATED WATERTO RESERVIOR	1542.42	1629.15
D.B" AS % OF A"	5.63%	7.0%
E.EXPRESSED AS CUB. MWTRES/DAY	53.09	54.31

CHEMICALS

	Av. Nominal Dose	Total Used (Kg)	Actual .Av Dose	Chemical Unit Cost ($)	Total Cost ($)
Chlorine (920kg)	1.50	1840	1.19	2.48	4563.20
Chlorine (70kg)	-	70	0.04	4.66	326.20
Aluminium Sulphate	10.0	19,200	11.74	0.70	13,440.00
Sodium Carbonate	2.0	1950	1.19	0.90	1755.00
Calcium Hydroxide	4.0	6575	4.26	0.43	2827.25
Copper Sulphate	0.80	600	0.36	4.96	2976.00
Sodium Silico Fluoride		-	-	-	-
Calcium Hypochlorite	1.0	320	0.20	3.93	1257.60
TOTAL COST (CHEMICAL)				**$27,145.25**	

ELECTRICITY CHARGES

STATIONS	VALUE($)
Treatment Plant	20,543.53
Savura Pumping Station	101,416.56
Waimanu Pumping Station	132,438.29
TOTAL	**254,398.38**

ADMINISTRATIVE COST

ITEM	COST ($)	ITEM	COST($)
Salay (Established)	3800.00	Safety	3,000.00
Wages (Unest)	10,622.00	Tools& Equipments	-
Plant Hire	2,500.00	Urgent Maintenance	-
Stationery/telephone	370.00	Maintenance and Operation	-
Savura Pump	4,500.00	Waimanu pump	4,500
TOTAL COST		**29,292.00**	

WAIMANU WATER PUMPS

	Hours Run	Total (hrs) Run	Volume Pumped *10^3M^3
Pump No .1			BREAKDOWN
Pump No. 2	588.50		
Pump No. 3	542.50	-	-
Pump No.4			
GENERATOR		1131.00	Breakdown

SAVURA WATER PUMPS

	Hours Run	Total (hrs) Run	Volume Pumped *10^3M^3
Pump No .1	-	-	Breakdown
Pump No. 2	-	-	-
Pump No. 3	741.15		
Pump No.4	739.0		
Pump No.5	563.10		

PRODUCTION COST

1.CHEMICALS	$ 27,145.25
2. ELECTRICITY	254,398.38
3. ADMINISTRATIVE COST	29,292.00
TOTAL	310,835.63
PRODUCTION COST/MEGA LITRE	**201,52**

PEAK DAILY FLOWS

Week -ending	Day of Highest Flow	Flow * 1000Cub .M.
7/8	WED	62.26
14/8	FRI	62.13
21/8	THURS	58.49
31/8	FRI	61.78

REMARKS

1. Lime feeder No.1 still under repair
2. Both clarifiers sludge mechanisms still under repair.
3. Wash out valve No.3 under repair by f/shop
4. Compressor No.2 and chlorine pump still not fixed by electrical

……Signed…- Bobby Dave………………...
Plant Manager, Tamavua Treatment Plant

……Signed…-Poate Tabua...................
Production Manager
Source; Tamavua Treatment Plant records

ANNEX: 5

World Health Organisation (WHO) Drinking Water Quality Guidelines

Parameter	WHO Guideline value
Faecal coliform or E. coli	Not detectable in a 100 ml sample
Aluminium	0.2 mg/L*
Arsenic	0.01 mg/L
Ammonia	1.5 mg/L*
Cadmium	0.003 mg/L
Arsenic	0.01 mg/L
Chloride	250 mg/L*
Colour	15 TCU*
Copper	2 mg/L
Fluoride	1.5 mg/L
Hydrogen Sulphide	0.05 mg/L*
Iron	0.3 mg/L*
Lead	0.01 mg/L
Manganese	0.1 mg/L*
Nitrate	10 mg/L
Sodium	200 mg/L*
Sulphate	250 mg/L*
Turbidity	5 NTU*
Total dissolved solids	1000 mg/L*
Zinc	3 mg/L

* May not be toxic but could result in consumer complaints

Source: WHO Guideline for Drinking Water Quality Standards 3rd Edition