QUALITATIVE EXAMINATION OF GROUNDWATER FROM YAP AND SOME OF ITS NEIGHBORING ISLANDS

Murukesan V. Krishnapillai
Timothy Scheidt
Christina Fillmed

WERI
WATER AND ENVIRONMENTAL RESEARCH INSTITUTE
OF THE WESTERN PACIFIC
UNIVERSITY OF GUAM

Technical Report No. 115

May 2006

Qualitative Examination of Groundwater from Yap and some of its Neighboring Islands

by

Murukesan V. Krishnapillai
Timothy Scheidt
Christina Fillmed

Agriculture Experiment Station, College of Micronesia-FSM, Yap Campus
In collaboration with
Yap State Public Service Corporation
&
Yap State Environmental Protection Agency

Technical Report No. 115
May 2006

The work reported herein was funded, in part, by the Department of Interior via the Water Resources Research Institute Program of the U.S. Geological Survey (Award No. 01HQPA0010), administered through the Water and Environmental Research Institute of the Western Pacific at the University of Guam. The content of this report does not necessarily reflect the views and policies of the Department of Interior, nor does the mention of trade names or commercial products constitute their endorsement by the United States Government.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS

The project team appreciates the support and cooperation extended by the following individuals and institutions during the tenure of the project.

Professor Leroy Heitz, Director of WERI, is acknowledged for his interests in this research program by providing essential support to carry out the project objectives effectively. We are extremely thankful to Rick Wood, Laboratory Manager, for the advanced in-house training provided to the staff of YSPSC and Yap State EPA.

The project team is indebted to Dr. Singeru Singeo, Executive Director, and Ric Vera Cruz, Business Manager, of College of Micronesia Land Grant Programs for their administrative and accounts support for the project work.

The project team shows their appreciation to Lourdes Roboman, Director of College of Micronesia-FSM, Yap Campus, and Jim Currie, Vice President of Cooperative Research and Extension, College of Micronesia-FSM, for encouragement and access to college facilities to carry out the work.

Thanks are also due to Intertek Testing, Manila and Boni Francisco of Pamex International, for their help with the chemical analyses of water samples.

Leonard Yinug, the Executive Director of Yap State EPA, and John Mootmag, Chairman of Yap State Public Service Corporation, provided constant support and facilities to carry out the training workshop. The relentless efforts of Steven Chonmon, Mary Tided, Aloyius Wag (Public Health and Sanitation), Jim Ruetamngig, William Bamoon (Gagil-Tomil Water System), George Laman, Matthew Thigthen, Charles Falmeyog (YSPSC Water Division), Gregory Chem, Francis Gilpong (Southern Yap Water System), John Worswick (Yap State EPA) greatly contributed to the success of this project.

EXECUTIVE SUMMARY

This report presents the collaborative planning, analysis and capacity building efforts and achievements made by the project team to study the quality of drinking water sources on Yap and its neighboring islands.

Water has a major impact on human health, and the provision of adequate supply of good quality drinking water is vital to communities worldwide. The economic and social well being of small island states like Yap is greatly influenced by the quality of water and its effective management. However, infrastructure and trained human resource base constraints reflect in quality delivery of services. Although three large scale water systems have been serving the people of Yap for several decades, a qualitative study of its water resources have never been undertaken. With this in mind, the study described herein was initiated in 2004 to evaluate the chemical composition of water from three large scale systems on Yap proper, and some of its neighboring islands, with the following specific objectives:

1. To conduct a quality assessment of groundwater samples collected from different localities of Yap State including three of its main inhabited neighboring islands
2. To establish baseline information on the present condition of the vital resource, and
3. To train YSPSC and Yap State EPA personnel in carrying out various water qualities testing procedures

Representative samples analyzed from three large-scale systems of Yap proper and neighboring islands revealed the quality of water available for the population. Results demonstrated that the groundwater, in general, is of good quality based on the parameters tested.

Water samples from five sites (Lumpur –YSPSC, Gagil-GTWS, Old Airport-SYWS, Falalop-Ulithi and Woleai) were tested for various physical and chemical parameters including inorganic components and metals. Tests were also performed for volatile organic compounds and disinfection byproducts. No significant levels of contamination were noted in samples collected from the water systems of Yap. However, samples from neighboring islands fairly displayed high levels of chloride, indicative of contamination through salt-water intrusion.

Of the 179 water samples tested for bacteria in Yap proper, 37 were positive for fecal coliforms. In contrast, all water sources except rainwater tested positive for fecal coliforms on the neighboring islands visited. Poor sanitation prevalent in the neighboring islands is a serious impediment for delivering potable water to the communities.

The project team also gave importance to the capacity building component of the project and trained two personnel from Yap State Public Corporation and Yap State EPA in advanced water testing and bacterial testing procedures. A weeklong comprehensive workshop was also conducted for participants from various local bodies including water systems and Sanitation Department.

Based on the findings of this study, a set of recommendations is given for future follow-up programs.

INTRODUCTION

This project was initiated in 2004 as an effort to carry out a qualitative examination of the important surface and groundwater sources of Yap proper and some of its neighboring islands. The program was jointly implemented by the Agricultural Experiment Station of Yap Campus, College of Micronesia-FSM, Yap State Public Service Corporation (YSPSC) and Yap State Environmental Protection Agency (Yap EPA), with assistance and participation from personnel of Yap's public water systems. The project was driven by the lack of data pertaining to the quality of water used by the population from different distribution systems. Although Shade *et al*. (1992) analyzed water samples from different water systems as part of a reconnaissance study, much of the data is now outdated. This study marked the first major local effort at evaluating baseline water quality conditions across Yap.

In 2005, Southwest States and Pacific Islands Regional Water Program Coordinators conducted a region-wide survey to identify the high priority water issues of Pacific Islands. Respondents rated clean drinking water and household water supply as high priority issues. Results of this survey are currently being used to document public awareness, aptitudes, attitudes and actions toward water in many Pacific islands, including the Federated States of Micronesia. Despite being located in the largest body of water on Earth, the provision of potable water remains a considerable challenge in many Pacific Island States (Kingston, 2004). According to the 2005 Yap Annual Statistical Yearbook (2006), of the 1,541 housing units on Yap proper, 677 units still rely on water from catchments, individual tanks or drums, whereas in the neighboring islands of Yap, over 90 percent of the population remain dependent on water from various sources, the quality of which is not known.

Yap State Public Service Corporation, a non-profit entity responsible for water treatment and distribution within the State, has a mandate to supply potable water to the public. However, owing to economic constraints and poor treatment facilities, it runs only one plant near Colonia. This particular plant supplies approximately 500,000 gallons of water to a population of about 3500. Yap State EPA focus on safeguarding land, water and air quality of the State, and protecting natural resources and all living things from human and chemical pollution. Although Yap EPA's Water Quality Program is one of the thrust areas, laboratory facilities are insufficient to carry out extensive tests. Furthermore, a shortage of trained personnel makes it difficult to accomplish the stipulated tasks.

The population of Yap has increased considerably in the last ten years, leaving more demand for potable water. Yap State Public Service Corporation, as the prime body responsible for the distribution of potable water, has constraints in meeting the demand and combines with two other public water systems in order to meet the demands of consumers in rural parts of Yap proper.

In order to gain a better understanding of the types and extent of pollutants, if any, in surface and groundwater, as well as to address future regulatory requirements, the project team examined the drinking water quality of three large-scale water supply systems of Yap proper and water distribution systems of neighboring islands. The purpose of the sampling effort was to conduct a broad screening of current water sources to ascertain the level of contaminants. Once this is determined, a more informed approach could be made in the future for desired treatment and management practices.

PROJECT OBJECTIVES

The project was implemented with the following three main objectives:

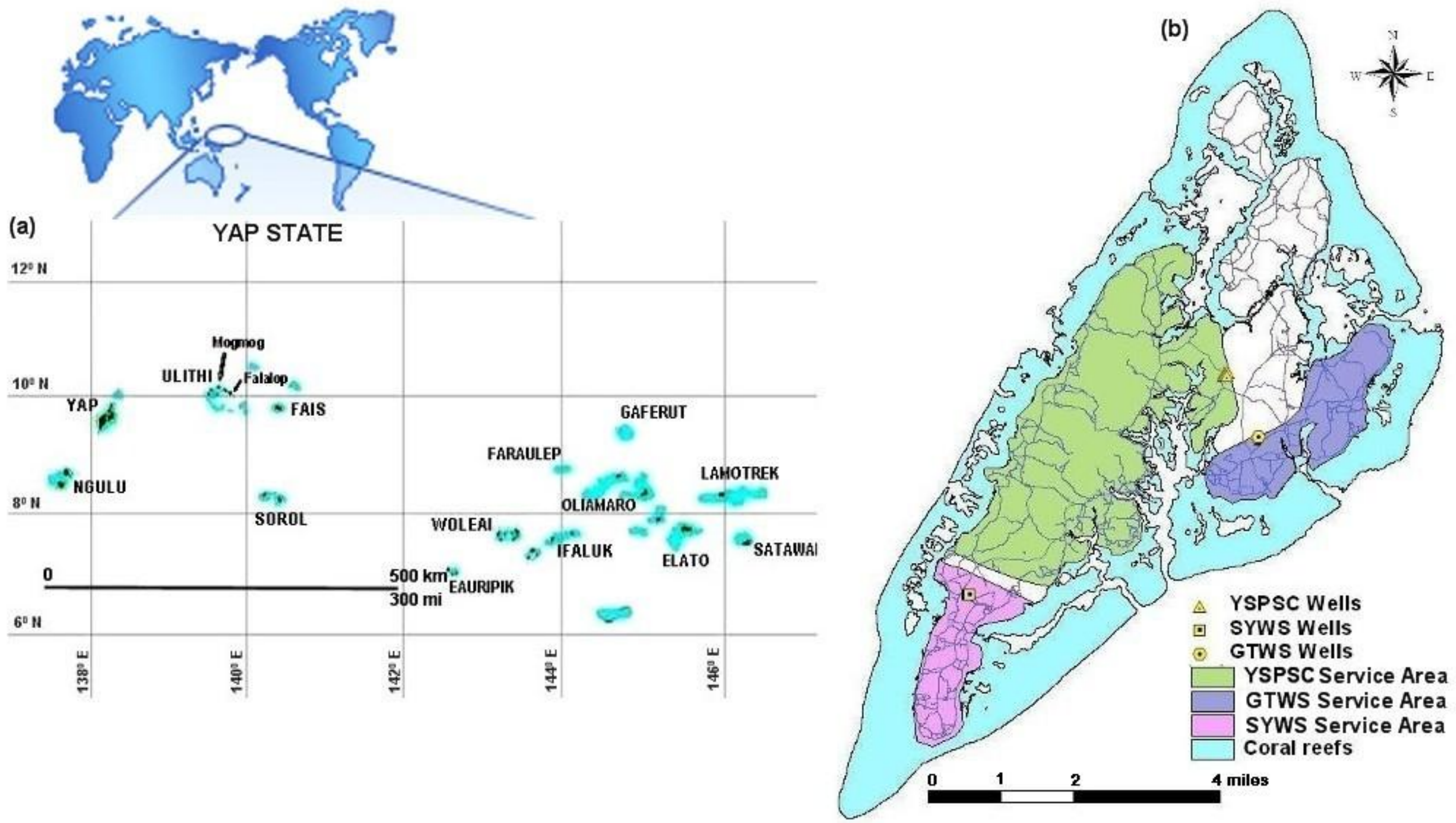
1. To conduct a quality assessment of groundwater samples collected from different localities of Yap State, including three of its main inhabited neighboring islands
2. To establish baseline information on the present condition of the vital resource, and
3. To train YSPSC and Yap State EPA personnel in carrying out various water qualities testing procedures.

OVERVIEW OF STUDY SITES

This study focused on the three large-scale water supply systems on Yap proper (Figure 1), namely Colonia Water System (YSPSC), Gagil-Tomil Water System (GTWS) and Southern Yap Water System (SYWS), and one lens well at Falalop, Ulithi. While the basic tests, including bacterial tests, have been carried out extensively on samples collected from different localities, detailed analytical tests were conducted primarily on samples collected from five sites – four from Yap proper and one from the neighboring island. Sites were selected based on populations served, the type of source water used, and whether chemical treatments were used. Chemical characteristics and/or contaminants to be tested were selected based on what is commonly found in these types of source waters, as recognized by US EPA.

Gitam Reservoir is the source of water supply for the first large-scale centralized Colonia Water System (now known as YSPSC water system) built in Yap. It consists of two raw water impoundments with a total capacity of about 30 Mgal. Current capacity of its treatment plant is 277gal/min. The water is distributed through a pipeline network that includes two 1.0 Mgal tanks. Inflow to the reservoirs is from Dalolaeb stream. Currently, YSPSC serves Colonia and adjacent villages in Weloy, Rull, Dalipebinau, Fanif and Tomil municipalities. Presently, a total of 914 households (this includes government, residential and commercial) are connected to the YSPSC water system. YSPSC bills on average 10-12 Mgal/month, which is close to about 400 gallons per residence per day. Treatment processes include chemically assisted (aluminum

Figure 1 Map showing (a) the location of study site and (b) area of coverage of three large-scale water systems on Yap (also called Yap proper)



sulfate) sedimentation, filtration and disinfection with chlorine. Relatively high turbid (7.0 to 19.0 NTU) water is generally what enters the treatment plant. The aluminum sulfate and the filtration process reduce this number to 0.3 to 0.9 in the finished water. The untreated water also consistently tested positive for the presence of coliform bacteria, thus disinfection is followed.

The Southern Yap Water System (SYWS) is supplied by groundwater developed near the old airport. This groundwater reservoir covers an area of about 0.36 mi^2 and is approximately 40ft thick (Shade *et al*., 1992). There are two wells in operation, capable of producing a combined yield of 86,000 gal/day. Today it serves about 400 households through a network of distribution pipelines. No treatment system is currently in place.

Groundwater from the central valley in Gagil-Tomil supplies the Gagil-Tomil Water System (GTWS). This system was completed in 1984, and currently provides potable water to the residents of Tomil and Gagil municipalities. The system derives its water from 4 wells drilled in Monguch, produces approximately 80,000 gallons of water per day, and serves about 300 households. The system is presently operating without chlorination capability and is tested for coliforms on a monthly basis by Yap EPA.

The freshwater lens of Falalop, Ulithi Island is managed by the YSPSC. This water is treated with chlorine prior to its entry to the distribution system. At this time, YSPSC provides non-potable water to residents via a pipeline that encircles the island. Nearly 20,000 gallons of water is available per day. Constraints of this system include poor quality of water and poor infrastructure for close monitoring.

METHODS

Collection, preservation and handling of water samples were based on the procedures of Clesceri *et al*. (1998) or Water Quality Skill Packages (Arasmith Consulting Resources, 2002). The project team carried out a thorough analysis of water samples collected from five different locations – four of which were from Yap proper and one from Falalop, Ulithi. In addition, basic water quality tests and coliform analyses were carried out on several samples collected from all over Yap proper and the neighboring islands. The water quality parameters chosen covered a broad spectrum of contaminants commonly found in wells and reservoirs affected by surface water runoff. A single water sample from YSPSC distribution line was analyzed for VOCs and disinfection byproducts. While basic analytical tests and bacterial tests were carried out at YSPSC or Yap EPA laboratory, more detailed analysis of inorganic components, VOCs and disinfection byproducts was carried at Intertek Testing Services, Inc., Philippines. Portable Laboratory Kit CEL/890 from Hach Company was used to carry out the basic tests such as turbidity, alkalinity, pH etc. Bacterial tests were conducted using Colilert and Enterolert kits from Idexx laboratories. Enterolert is an official American Society for Testing and Materials (ASTM) Method (#D6503-99).

Capacity Building
Prior to the detailed analysis of water samples and as part of the local capacity building, as envisaged in the objective, two personnel from YSPSC and Yap EPA were given advance training in water quality testing and bacterial testing procedures at WERI. Further, based on 'Water Quality Skill Packages' (Arasmith Consulting Resources, 2002), nine participants from Yap EPA, YSPSC, GTWS, SYWS and Sanitation Department of Yap State Health Services attended an intensive, weeklong workshop conducted by Tim Scheidt. This workshop comprehensively covered all aspects of water analysis and enabled the participants to learn the basics of water sampling, testing, compliance and reporting procedures.

RESULTS AND DISCUSSION

Neither Yap State nor the Federated States of Micronesia has any sort of accepted water quality standards. Hence our report and comparisons are based on US EPA Standards or Philippines National Standards.

A. Chemical Characteristics of Water
The chemical characteristics of surface and groundwater varied between locations. This likely reflects input differences in the amounts of organic matter and suspended material associated with surface runoff (Table 1-4). The overall test results indicate that water from the three large-scale systems of Yap Proper is acceptable for any use and complies with US EPA regulations (US EPA National Primary Drinking Water Regulations). However, tests for bacteria yielded variable results, which are discussed separately.

Source of water at Gitam reservoir is runoff from rainfall. The drainage area consists of open grassland in its lower part and forest in its upland area. The pH of water samples collected from Gitam reservoir and two wells of SYWS were slightly acidic, ranges between 6.4 and 6.7, which is probably related to acidic soils (Latosols as reported by Shade *et al*., 1992). Waters of GTWS and YSPSC well have a pH range of 6.9 – 7.3. Again, this can be attributed to the nature of parent material, high in silicate materials. A higher turbidity value for water from Gitam reservoir points to murkiness induced by heavy surface runoff to the reservoir.

Metals are ubiquitous in the environment. Anthropogenic sources of metals in Yap mainly include discarded junks including old automobiles, tire wear (steel belted tires), corrugated roofing materials and cans. Metals can be toxic in both solid and dissolved form and therefore warrant testing and monitoring. In this study, metals like arsenic, antimony, barium, cadmium, chromium, copper and lead were not detected in appreciable concentration in any of the samples tested. However, iron concentrations exceeding 0.3 mg/L were noted in two wells and one distribution line of GTWS.

Although such concentrations were not high enough to cause water quality problems, periodic monitoring would be beneficial. Its presence in water can stain plumbing fixtures in the long run. Iron also promotes the growth of bacteria. US EPA recommends a maximum contaminant level of 0.30 mg/L for iron (secondary standard).

A moderately high concentration of total dissolved solids was noticed in the water sample collected from the distribution line of SYWS. However, the TDS measurement was at acceptable levels in samples collected from SYWS wells. Nitrate and chloride levels were within the maximum permissible levels recommended for domestic use by the US EPA.

Nutrients are vital to the health of an aquatic environment. However, they can be detrimental to aquatic life in high concentrations. Nitrates were not detected in any of the samples tested.

The water treatment processes used for disinfection at YSPSC include chemically assisted (aluminum sulfate) sedimentation, filtration and disinfection with chlorine. Over the years, scientists have discovered that byproducts can form when these disinfectants react with natural organic matter (from decaying vegetation), or when certain compounds, such as bromide are present in the source water. Although studies are being conducted to determine what potential health effects these byproducts may have if consumed by humans over long periods of time, US EPA has set monitoring requirements and maximum contaminant levels for some of the more common byproducts. We tested one water sample from YSPSC distribution line for any potential byproducts. While chlorite and bromate were below the detection limit, chloroform exceeded the maximum contaminant limit of 80 μg/L established by US EPA for total trihalomethanes. Chloroform is one of the four tihalomethanes that is produced during chlorination (Ivahnenko and Zogorski, 2006). Prolonged exposure to trihalomethanes is associated with chronic human-health concerns, including cancer and damage to the liver, kidneys, and central nervous system (Zogorski *et al*., 2006). Relatively high level of chloroform in the sample from YSPSC distribution line indicates that continued monitoring is needed over long term.

Similarly, drinking water that contains Volatile Organic Compounds (VOCs) can increase risk for a variety of health problems. Some VOCs have been proven to cause cancer after prolonged exposure, while others are considered possible cancer risks. Hundreds of VOCs have been produced for use in a variety of products, including gasoline, dry cleaning solvents, and degreasing agents. When these products are improperly stored or disposed of, or when a spill occurs, VOCs can contaminate groundwater and drinking water supplies. Effective drinking water protection includes source protection and regular testing to ensure that the water is safe. Source elimination and proper well protection are the most effective methods for protecting ground water. In this study, 56 VOCs were tested for in the single sample taken from the YSPSC distribution line. None of these contaminants were detected in appreciable amounts. Only those contaminants that have established standard (maximum contaminant level) or health based screening level are listed in table 4.

When compared to the quality of water from three large-scale systems of Yap Proper, water from neighboring islands reveal a dismal picture. In as many samples collected from major islands such as Falalop- Ulithi, Woleai, Mogmog and Fais, concentrations of sodium and chloride were very high. This is an indication of salt water intrusion or salt water spray into the water bodies or groundwater lens due to over pumping of wells. High conductance of water samples from wells in Falalop-Ulithi. Mogmog and Fais may be because of tidal influence at the time of sampling.

Total Dissolved Solids (TDS) in drinking water originate from natural sources. Water from wells of Falalop-Ulithi, Fais, and Mogmog shows total dissolved solids well above the acceptable level of 500 mg/L. This is most likely an indication of seawater intrusion but could also reflect contributions from point and non-point wastewater discharges. An elevated TDS concentration is not a health hazard. US EPA considers TDS concentration as a secondary drinking water standard and therefore is regulated because it is more of an aesthetic concern rather than a health hazard.

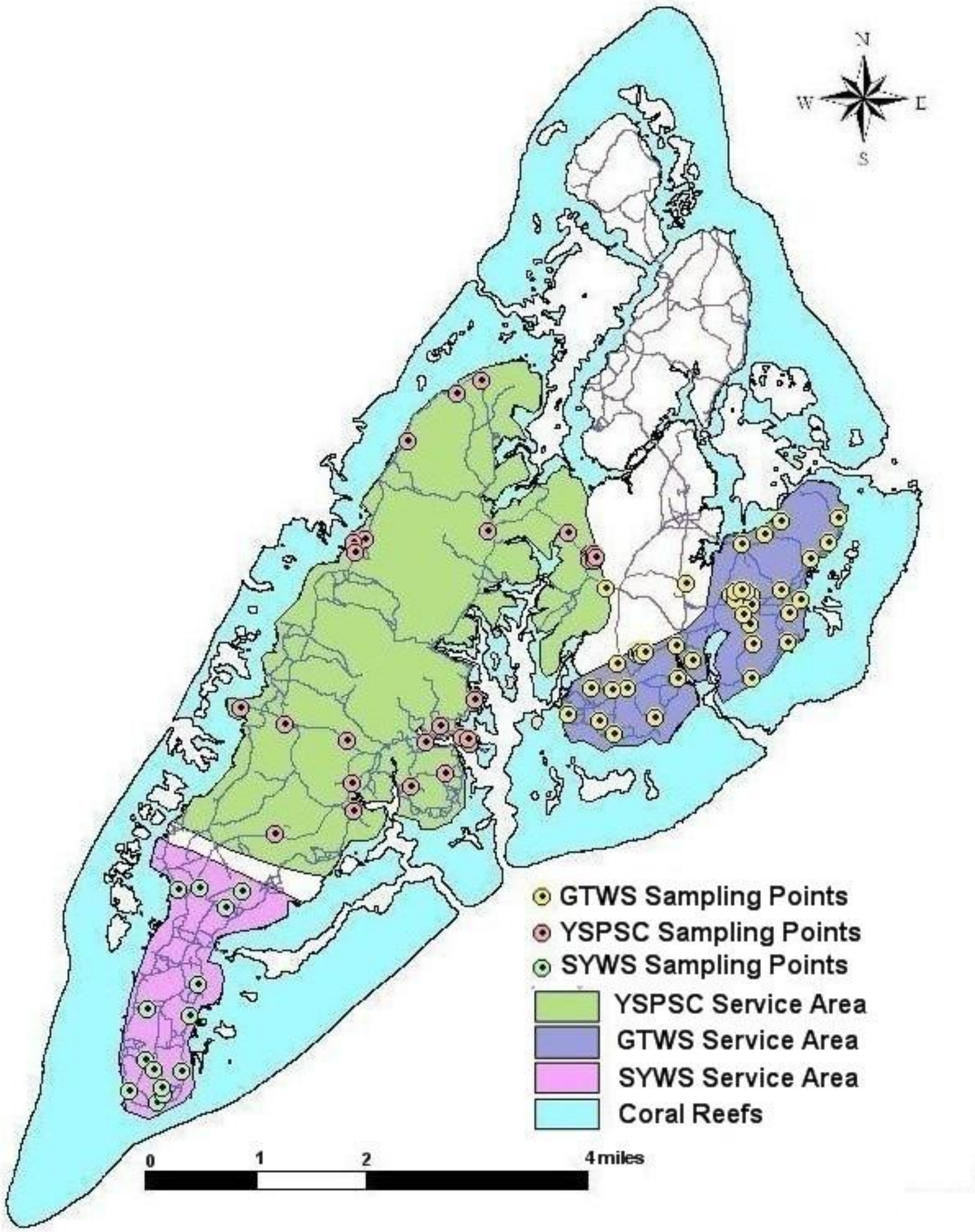
B. Tests for Bacteria

Current water quality testing methodologies rely on the usage of indicator organisms - total coliform, fecal coliform and enterococcus – as a measure of the potential for human pathogens to be present in the sampled waters. These indicator organisms are more readily detected than many human pathogens. Colilert test kits use Defined Substrate Technology® (DST®) to detect total coliforms and *E. coli* in water. As coliforms grow in Colilert media, they use ß-galactosidase to metabolize the nutrient indicator ONPG and change it from colorless to yellow. *E. coli* use ß-glucuronidase to metabolize MUG and create fluorescence. Since most non-coliforms do not have these enzymes, they are unable to grow and interfere. The few non-coliforms that do have these enzymes are selectively suppressed by Colilert's specifically formulated matrix. This approach minimizes false positives and false negatives.

Considering the current waste disposal mechanism prevalent on Yap proper and neighboring islands, we have given more importance to bacterial testing on water samples. Microbiological examination of water sources is also an ongoing program of Yap EPA. In this study, we have comprehensively surveyed all water sources representing all localities on Yap Proper (Figure 2) and neighboring islands. Although Yap's water systems are required to deliver safe and reliable drinking water to their customers, authorities face several impediments.

Table 5 shows the results of bacterial tests carried out on samples collected from all across Yap proper and neighboring islands of Ultihi, Woleai, Mogmog and Fais. Repeat

Figure 2 Water sampling locations for bacterial tests on Yap



tests were carried out at many locations. Our test results show a mixed trend in all sampling sites. In all, 179 bacteriological tests were conducted in this study. However, as mentioned earlier, water testing for bacteria is an ongoing program of Yap EPA and continues. In this instance, localities are randomly selected incorporating wells, reservoir, storage tanks, streams and distribution systems.

Water samples from all localities were primarily subjected to total coliform tests. Tests continued further for fecal coliform and *E. coli* when primary results turned positive. Of the 41 samples tested from YSPSC system, 12 were positive for total coliform, out of which only one raw water sample collected from YSPSC site was tested for fecal coliform. Forty-eight samples were tested from SYWS, out of which 11 tested positive for fecal coliform bacteria. The Malay Well, which had been unused for sometime but made temporarily operational to supplement wells serving Southern Yap, was the main source of positive fecal coliforms.

Figure 3 In house training at Water and Environmental Research Institute

Of the 78 samples collected from wells and distribution lines of GTWS, 25 tests were positive with sources that included a smaller water tank connected to the distribution system, storage tank, and a number of sites connected to the main distribution lines.

Figure 4 Training workshop

Figure 5 On- site training

Several rounds of follow-up testing to confirm results produced a lower number of sites positive for fecal coliform contamination. The workshop trainers took this opportunity to use these results as a case study and exercise in discussing and reviewing possible implications as they applied to public health. Thus, 'Public Notification' section of the skill package was reviewed in detail including the representative notice form provided. A plan of action was devised to address the problem of contaminated sites in addition to several preventive measures to help improve water quality in this system. The GTWA operators, who were participants in the workshop, were assigned to inform the board of directors about these findings and to present the suggested plan of action to address the matter of concern. The suggested plan discussed involve the following recommendations: (i) Inform the general public according to the procedures outlined in the skill package, (ii) Shut down #2 well and run the other three wells a bit longer each day to compensate the additional load, (iii) Disinfect the well according to proper well disinfection procedures, (iv) Drain, clean, inspect and disinfect the storage tank, (v) Flush the system with chlorinated water, and (vi) resample the system. The GTWS board of directors responded positively to these recommendations and undertook the necessary maintenance that was long overdue. The workshop participants reviewed a sample 'Consumer Confidence Report' and discussed the possibility of creating one for each water utility in Yap.

Except for the rain water sources, all the dip wells and pump wells of Ulithi, Woleai, Mogmog and Fais are heavily contaminated with fecal coliform. Our test results for bacteria address the dire need of improved sanitation and water storage and distribution mechanism in all these islands.

CONCLUSION

The data presented in this report is based on our detailed investigation on water from three large scale water systems of Yap proper and some of the populated neighboring islands. The water quality assessments yielded valuable information for the agencies involved, particularly the water service companies entrusted with providing water to the communities of the State. This information will be useful in planning improvements, and as a comparative value for future water quality monitoring programs.

RECOMMENDATIONS

Results of this exercise are encouraging, in that the analysis has established a benchmark for future operators and administrators to validate when evaluating the quality of their source water. Our recommendations based on this study are as follows:

- Although capacity development in terms of trained personnel in water quality management was an issue identified and subsequently addressed in this project, there remains a great deal of progress to be made. Further acquisition and development of water quality personnel, specifically at Yap State EPA and in relevant agencies or water authorities, should be considered to ensure safe water quality serving the citizens of Yap.

- Relevant environmental legislation and policy should be reviewed to better support water quality monitoring efforts, specifically targeting the development of practical State water quality standards in line with national goals and priorities.
- An assessment targeting the needs of the public water authorities should be considered to improve overall capacity and management of water sources, placing special focus on developing water authorities' capacity to better identify and correct problems encountered with distribution systems and improving water quality to consumers.
- Each agency should raise public awareness programs about the quality of water they provide. It is important to safeguard the health through management of the environment, and in particular, the water environment.
- Although analysis shows that all source waters from Yap proper are free from any harmful chemical or mineral contaminants, some form of disinfection process is suggested to prevent the possible ill effects of waterborne human pathogens.
- Operators should eliminate the concern of bacterial contamination by using appropriate practices, such as use of chlorine, and by undertaking routine maintenance practices of water distribution system. Yap State Public Service Corporation is using chlorine as a disinfectant and the system has consistently tested negative for the presence of bacteria.
- The wells of the neighboring islands have a salt water intrusion problem that could be alleviated by a reduction in pumping rates. Further, rainwater catchments facilities should be improved to alleviate any water shortages.
- Steps should be quickly taken to address the issue of poor water quality in the neighboring islands. A more comprehensive evaluation of water sources there should be considered with a complementary outreach campaign to raise awareness of water quality issues.
- Sanitation facilities of outer island communities are substandard and threaten the health of their residents; concerned authorities should initiate appropriate waste treatment methods for the atoll island communities. Waste disposal practices that were once the norm are no longer adequate to effectively deal with the waste, and need to be revised to fit current conditions.
- Modern toilet/shower/laundry facilities with appropriate on-site treatment of the wastewater (septic tanks, featuring secondary treatment of effluent prior to discharge to the ground) should be constructed to accommodate the needs of the people and to protect the environment. Those communities that have very little water to use for wastes would use a composting process that would effectively contain and treat toilet waste, and produce a soil conditioner as by-product of the process.

- Follow-up training and/or similar projects addressing water quality issues in the State should be pursued to further enhance capacity.
- Repeat monitoring of water sources is recommended at least in every five years.

REFERENCES

Arasmith Consulting Resources. 2002. *Water Quality Skill Packages*, originally written for the US Department of Interior funded project "Micronesian Water and Wastewater Operators Training Program." www.omip.org

Clesceri, L.S., A.E. Greenberg and A.D. Eaton. 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. American Water Works Association.

Ivahnenko, Tamara and J.S. Zogorski. 2006. Sources and occurrence of chloroform and other trihalomethanes in drinking water supply wells in United States. 1986 – 2001: U.S. Geological Survey Scientific Investigations Report, 2006-5015, 13 p.

Kingston, P.A. 2004. Surveillance of Drinking Water Quality in the Pacific Islands: A Situation Analysis and Needs Assessment. A Report based on Western Pacific Region 'Workshop on Drinking Water Quality Surveillance and Safety' held at Nadi, Fiji from 29 October to November 1, 2001, and the 'Pacific Regional Consultation on Water in Small Island Countries, held in Sigatoka, Fiji, from 29 July to 3 August 2002. Pp. 86.

Shade, P.J., S.S. Anthony and K.J. Takasaki. 1992. Ground-water Resources Reconnaissance of the Yap Main Islands. Water Resources Investigations Report 90-4074, U.S. Geological Survey, Honolulu, Hawaii. Pp. 71.

US Environmental Protection Agency. National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations. http://www.epa.gov/OGWDW/mcl.html

Yap State Census Report (2002). *2000 FSM Census of Population and Housing*. Yap Branch Statistics Office, Division of Statistics, Department of Economic Affairs, National Government, Colonia, Yap 96943.

Zogorski, J.S., J.M Carter, T. Ivahnenko, W.W. Lapham, M.J. Moran, B.L. Rowe, P.J. Squillace, and P.L. Toccalino. 2006. Volatile organic compounds in the nation's ground water and drinking-water supply wells. U.S. Geological Survey Circular 1292, 101 p. (http://pubs.usgs.gov/circ/circ1292/).

2005 Annual Statistical Yearbook, Yap State. 2006. Yap Branch Statistics Office, Division of Statistics, Department of Economic Affairs, National Government, Federated States of Micronesia.

Table 1: Results of analytical tests[1] conducted on water samples collected from three large scale systems (four sites on Yap Proper) and one lens well from Falalop, Ulithi

Parameter	Locality[2]					Method	Reporting limit	PNS Limit	US EPA limit
	YSPSC LW-FU	SYWS	GTWS	YSPSC LUM	YSPSC M1				
Antimony, mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	AAS	0.005	0.005	0.006
Arsenic, mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	AAS	0.003	0.01	0.01
Barium, mg/L	<0.70	<0.70	<0.70	<0.70	<0.70	AASpec Phot	0.7	0.7	2.0
Boron, mg/L	0.12	<0.03	<0.03	<0.03	<0.03	UV-Vis Spec	0.03	0.3	n/a
Cadmium, mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	AASpec Phot	0.003	0.003	0.005
Chromium total, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	AASpec Phot	0.01	0.05	0.1
Cyanide, mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	Spec. Col	0.002	0.07	0.2
Fluoride, mg/L	0.31	<0.10	0.1	0.11	0.12	Spec. Col	0.1	1	4.0
Lead, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	AASpec Phot	0.01	0.01	0.015
Mercury, mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	AASpec Phot	0.001	0.001	0.002
Selenium, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	AASpec Phot	0.01	0.01	0.05
Aluminum, mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	AAS	0.2	0.2	0.2
Chloride, mg/L	970.93	12.64	7.25	11.21	78.43	Arg. Tit	0.05	250	250
Copper, mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	AASpec Phot	0.05	1	1.0
Total Hardness, mg $CaCO_3$/L	659.6	89.27	44.63	61.99	44.63	EDTA Titration	0.05	300	n/a
Hydrogen sulfide (as sulfide), mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	Iodometric method and calculation	0.05	0.05	n/a
Iron, mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	AAS	0.3	1	0.3
Manganese, mg/L	<0.006	<0.006	<0.006	<0.006	<0.006	AASpec Phot	0.006	0.5	0.05
Sodium, mg/L	342.28	5.72	4.35	4.16	4.13	AASpec Phot	0.006	200	n/a
Sulfate (asSO_4), mg/L	126.77	<2.46	<2.46	<2.46	<2.46	Gravimetric with ignition of residue	2.46	250	250
Total Dissolved Solids, mg/L	1946	142	64	80	78	Drying to constant wt. at 180 ^{0}C	5	500	500
Zinc, mg/L	<0.015	<0.015	<0.015	<0.015	<0.015	AASpec Phot	0.015	5.0	5.0
Oil & Grease, mg/L	<0.60	<0.60	<0.60	<0.60	<0.60	Pet. Ether Extraction	0.6	nil	n/a

[1] Tests carried out at Intertek Testing Services, Philippines

[2] Sampling locations: YSPSC LW-FU: Water from YSPSC Lenswell, Falalop, Ulithi; SYWS: Water from supply source, Southern Yap Water System; GTWS: Water from supply source, Gagil-Tomil Water System; YSPSC-LUM: Water from supply source YSPSC, Lumpur; YSPSC M1: Water from supply source, YSPSC main line.

AAS: Atomic absorption spectrometry; AASpec Phot: Atomic absorption spectrophotometry; UV-Vis Spec: UV Visible Spectrophotometry; Spec. Col: Spectroquant Colorimetry; Arg. Tit: Argentometric Titration. PNS: Philippine National Standards; US EPA: United States Environmental Protection Agency; n/a: Not available

Table 2. Results of on-site and laboratory tests (using Hach Kit) conducted on water samples from various locations of Yap Proper and neighboring islands

Source	Location	pH	Conductivity µmhos/cm	TDS mg/L	Hardness $mgCaCO_3/L$	Alkalinity $mgCaCO_3/L$	Turbidity NTU	Iron mg/L	Chloride mg/L	Nitrate mg N/L
YSPSC Well #1	Eyeb	6.9	341	57	28	45	2.2	0.14	15	0.12
YSPSC Well #2	Eyeb	7.1	350	67	35	60	1.7	0.29	35	0.18
YSPSC Well #3	Eyeb	6.9	309	38	30	55	1.4	0.19	30	0.23
YSPSC Well #4	Eyeb	7.0	321	36	70	60	1.0	0.16	30	0.1
YSPSC Well #5	Eyeb	6.9	320	45.8	70	40	1.6	0.8	35	0.17
YSPSC Well #6	Eyeb	7.0	380	135	65	45	1.1	0.7	35	0.23
YSPSC Well #7	Eyeb	7.2	360	105.9	80	45	1.3	0.5	40	0.2
YSPSC Well A	Gitam	7.3	390	78	200	50	1.8	0.13	25	0.4
YSPSC Reservoir	Gitam	6.7	280	90	53	5.0	7.9	0.15	23	0.44
YSPSC Distribution	Colonia	6.9	300	95	50	60	0.9	0.18	20	0.01
GTWA	Well #1	7.2	358	42	25	40	1.3	0.22	30	0.56
GTWA	Well #2	7.2	335	56	32	35	0.7	0.27	35	0.43
GTWA	Well #3	7.0	320	57	60	35	0.9	0.39	35	0.6
GTWA	Well #4	7.3	305	45	65	45	1.1	0.3	30	0.23
GTWA	Distribution	7.0	325	60	50	50	1.0	0.35	35	0.21
SYWS	Well #1	6.4	280	45	80	40	0.43	0.17	20	0.31
SYWS	Well #2	6.5	300	60	40	40	0.76	0.14	25	0.12
SYWS	Distribution	7.0	310	55	45	40	1.0	0.17	25	0.18
Falalop	Rain	7.9	106	54	7.0	1.0	0.9	n/d	0	0
Falalop	Dip well	7.4	4430	813	80	45	0.9	n/d	325	0.84
Falalop	Pump well	7.2	1627	2200	175	60	1.0	n/d	1250	0.67
Mogmog	Dip well	7.0	1256	627	52	50	1.0	n/d	190	0.33
Mogmog	Rain	8.0	106	23	5.0	1.0	0.9	n/d	0	0.01
Mogmog	Pump well	7.0	1043	525	63	51.5	0.9	n/d	187	0.23
Fais	Dip well	6.8	2113	1064	50	40	1.0	n/d	52	0.76
Woleai	Dip well	7.3	605	304	8.0	30	0.9	n/d	35	0.11
Woleai	Pump well	7.0	689	344	10	32	1.0	n/d	37.5	0.18
US EPA limit		6.5 - 8.5	4.7 - 5.8 µS/cm (pH dependent)	500 mg/L	No limit set	No limit set	0.3 NTU	0.3 mg/L	250 mg/L	10mg/L

YSPSC: Yap State Public Service Corporation; GTWA: Gagil-Tomil Water Authority; SYWS: Southern Yap Water System
n/d: Not detected

Table 3 Results of tests[a] carried out for disinfection by-products on water sample from YSPSC distribution line

Parameter	Result	Method Detection Limit	PNS Allowable Limit	US EPA Allowable Limit
Chlorite, mg/L (By Colorimetric-Titrimetric Method)	<0.20	0.20	0.20	1.0
Bromate, mg/L (By Colorimetry Method)	<0.01	0.01	0.025	0.010
Total Trihalomethanes, µg/L (By Gas Chromatography)				80[b]
Bromodichloromethane	<1.0	1.0	60	-
Bromoform	<1.0	1.0	100	-
Chloroform	96	1.0	200	-
Dibromochloromethane	<1.0	1.0	100	-

[a] Analytical tests by Intertek Testing Services, Philippines Inc.
[b] US EPA Drinking water standard (maximum contaminant level) for the summed concentration of all four compounds.
PNS: Philippines National Standards
US EPA: United States Environmental Protection Agency

Table 4: Results of tests[a] carried out for Volatile Organic Compounds on water sample from YSPSC distribution line

Parameter (By Gas Chromatography-MS) µg/L	Result	Method Detection Limit	US EPA Allowable Limit
Benzene	<1.0	1.0	5
Bromobenzene	11	1.0	4000[b]
Bromomethane	<1.0	1.0	100[b]
Carbon tetrachloride	<1.0	1.0	5
Chlorobenzene	<1.0	1.0	100
Chloromethane	<1.0	1.0	30[b]
1,2-Dichlorobenzene	<1.0	1.0	600
1,3-Dichlorobenzene	<1.0	1.0	600[b]
1,4-Dichlorobenzene	<1.0	1.0	75
Dichlorodifluoromethane	<1.0	1.0	1000[b]
1,1-Dichloroethane	<1.0	1.0	7
1,2-Dichloroethane	<1.0	1.0	5
1,1-Dichloroethene	<1.0	1.0	7
cis-1,2-Dichloroethene	<1.0	1.0	70
Trans-1,2 Dicholoroethene	<1.0	1.0	100
1,2-Dichloropropane	<1.0	1.0	5
Ethylbenzene	<1.0	1.0	700
Hexachlorobutadiene	<2.0	2.0	1[b]
Isopropylbenzene	<1.0	1.0	700[b]
Methylene Chloride	<1.0	1.0	5
Naphthalene	<1.0	1.0	100[b]
Styrene	<1.0	1.0	100
1,1,1,2-Tetrachloroethane	<1.0	1.0	70[b]
Toluene	<1.0	1.0	1000
1,2,4-Trichlorobenzene	<2.0	1.0	70
1,1,1-Trichloroethane	<2.0	1.0	200
1,1,2-Trichloroethane	<1.0	1.0	5
Trichloroethane	<1.0	1.0	5
Trichlorofluoromethane	<1.0	1.0	2000[b]
1,2,3 Trichloropropane	<1.0	1.0	40[b]
Vinyl Chloride	<2.0	2.0	2
Xylenes (Total)	<2.0	2.0	10000
Semi-Volatile Organic Compounds			
2-Chlorophenol	<1.0	1.0	40
2,4-Dimethylphenol	<1.0	1.0	100[b]
2,4-Dichlorophenol	<1.0	1.0	20[b]
2-4-6-Trichlorophenol	<1.0	1.0	3[b]
2,4-Dinitrophenol	<1.0	1.0	10[b]

[a] Analytical tests by Intertek Testing Services, Philippines Inc.

[b] Values are based on US EPA's formula for Lifetime Health Advisory

Table 5 Results of tests conducted for bacteria

Test #	Method	System	Source	Location	Total Coliform	Fecal/E.Coli
1	COL	YSPSC	Raw	WTP - RAW	**POSITIVE**	**POSITIVE**
2	COL	YSPSC	Dist	YAP HIGH SCHOOL	NEGATIVE	
3	COL	YSPSC	Catch	YFA	**POSITIVE**	NEGATIVE
4	COL	YSPSC	Catch	PMA	**POSITIVE**	NEGATIVE
5	COL	YSPSC	Dist	AIRPORT	NEGATIVE	
6	COL	YSPSC	Finished	WTP	NEGATIVE	
7	COL	YSPSC	Dist	DB - HIGH FIVE	NEGATIVE	
8	COL	YSPSC	Dist	LEGISLATURE	NEGATIVE	
9	COL	YSPSC	Dist	HOSPITAL	NEGATIVE	
10	COL	YSPSC	Dist	BALABAT	NEGATIVE	
11	COL	YSPSC	Dist	NIMAR	NEGATIVE	
12	COL	YSPSC	Dist	NGOLOG	NEGATIVE	
13	COL-P/A	YSPSC	WELL	EYEB - WELL 2	**PRESENT**	NEGATIVE
14	COL-P/A	YSPSC	WELL	EYEB - WELL 5	**PRESENT**	NEGATIVE
15	COL-P/A	YSPSC	WELL	EYEB - WELL 6	**PRESENT**	NEGATIVE
16	COL-P/A	YSPSC	WELL	EYEB - WELL 7	**PRESENT**	NEGATIVE
17	COL-P/A	YSPSC	WELL	EYEB - WELL 3	**PRESENT**	NEGATIVE
18	COL-P/A	YSPSC	Dist	SDA	ABSENT	
19	COL-P/A	YSPSC	Dist	FANIF	**PRESENT**	NEGATIVE
20	COL-P/A	YSPSC	Dist	OKAW	ABSENT	
21	COL-P/A	SYWS	WELL	MALAY	**PRESENT**	**POSITIVE**
22	COL-P/A	SYWS	WELL	MALAY	**PRESENT**	**POSITIVE**
23	COL	SYWS	WELL	MALAY	**POSITIVE**	**POSITIVE**
24	COL	SYWS	WELL	MALAY	**POSITIVE**	**POSITIVE**
25	COL	SYWS	WELL	MALAY	NEGATIVE	
26	COL	SYWS	WELL	MALAY	NEGATIVE	
27	COL	SYWS	WELL	MALAY	**POSITIVE**	**POSITIVE**
28	COL	SYWS	WELL	MALAY	**POSITIVE**	**POSITIVE**
29	COL	SYWS	WELL	MALAY	**POSITIVE**	**POSITIVE**
30	COL	SYWS	Dist	SWS PLANT	NEGATIVE	
31	COL	SYWS	Dist	SWS PLANT	NEGATIVE	
32	COL	GTWS	WELL	MONGUCH	**POSITIVE**	NEGATIVE
33	COL	GTWS	WELL	MONGUCH	**POSITIVE**	NEGATIVE
34	COL	GTWS	Dist	MAA	**POSITIVE**	NEGATIVE
35	COL	GTWS	Dist	TAMILANG SCHOOL	**POSITIVE**	NEGATIVE
36	COL	GTWS	Dist	BUGOL	**POSITIVE**	NEGATIVE
37	COL	GTWS	Dist	DOMCHUY	**POSITIVE**	NEGATIVE
38	COL	GTWS	Dist	THOL	**POSITIVE**	NEGATIVE
39	COL	YSPSC	Dist	NGOLOG	NEGATIVE	
40	COL	YSPSC	Dist	STATION 4 TANEYBOCH	NEGATIVE	
41	COL	YSPSC	Dist	BALABAT	NEGATIVE	
42	COL	YSPSC	Dist	MARINA	**POSITIVE**	NEGATIVE
43	COL	YSPSC	Dist	MPC	NEGATIVE	
44	COL	YSPSC	Dist	LEGISLATURE	NEGATIVE	
45	COL	YSPSC	Dist	GARGEY	**POSITIVE**	NEGATIVE

46	COL	YSPSC	Dist	YSPSC MAIN OFFICE	NEGATIVE	
47	COL	YSPSC	Dist	YHS	NEGATIVE	
48	COL	YSPSC	Dist	BILEYUW	NEGATIVE	
49	COL	YSPSC	Dist	SIDE PAPAYA BEACH	**POSITIVE**	NEGATIVE
50	COL	YSPSC	Dist	GATUMOON	NEGATIVE	
51	COL	YSPSC	Dist	GILYAL ARNGEL DB	NEGATIVE	
52	COL	YSPSC	Dist	SDA	NEGATIVE	
53	COL	YSPSC	Dist	YYIN	NEGATIVE	
54	COL	YSPSC	Dist	PAPAYA BEACH	NEGATIVE	
55	COL	YSPSC	Dist	OKAW	NEGATIVE	
56	COL	SYWS	WELL	MALAY	NEGATIVE	
57	COL	SYWS	WELL	MALAY	NEGATIVE	
58	COL	SYWS	WELL	MALAY	NEGATIVE	
59	COL	SYWS	WELL	MALAY	NEGATIVE	
60	COL	SYWS	WELL	MALAY	NEGATIVE	
61	COL	SYWS	WELL	MALAY	NEGATIVE	
62	COL	YSPSC	Dist	PAPAYA BEACH 1	NEGATIVE	
63	COL	YSPSC	Dist	PAPAYA BEACH 2	NEGATIVE	
64	COL	YSPSC	Dist	GARGEY	NEGATIVE	
65	COL	YSPSC	Dist	MARINA	NEGATIVE	
66	COL	GTWS	Dist	LEBNAW	**POSITIVE**	**POSITIVE**
67	COL	GTWS	Dist	RIKEN	**POSITIVE**	**POSITIVE**
68	COL	GTWS	Dist	GAGIL ELEM SCHOOL	**POSITIVE**	**POSITIVE**
69	COL	GTWS	Dist	TENFAR	**POSITIVE**	**POSITIVE**
70	COL	GTWS	Dist	WILNGIR ST RES 9	**POSITIVE**	**POSITIVE**
71	COL	GTWS	Dist	WILNGIR ST RES 4	**POSITIVE**	**POSITIVE**
72	COL	GTWS	Dist	PAA GACHPAR	**POSITIVE**	**POSITIVE**
73	COL	GTWS	Dist	WILNGIR ST RES 1	**POSITIVE**	**POSITIVE**
74	COL	GTWS	Dist	WILNGIR ST RES 6	**POSITIVE**	**POSITIVE**
75	COL	GTWS	Dist	WILNGIR ST RES 7	**POSITIVE**	**POSITIVE**
76	COL	GTWS	Dist	WILNGIR ST RES 8	**POSITIVE**	**POSITIVE**
77	COL	GTWS	Dist	FMI	NEGATIVE	
78	COL	GTWS	TANK	WILNGIR ST RES 1	**POSITIVE**	**POSITIVE**
79	COL	GTWS	Dist	OUTSIDE TAMOR 2	NEGATIVE	
80	COL	GTWS	Dist	WILNGIR ST RES 4	**POSITIVE**	**POSITIVE**
81	COL	GTWS	STREAM	THOL STREAM	**POSITIVE**	**POSITIVE**
82	COL	GTWS	Dist	MAY	**POSITIVE**	**POSITIVE**
83	COL	GTWS	WELL	GTWS WELL 1	NEGATIVE	
84	COL	GTWS	WELL	GTWS WELL 2	**POSITIVE**	**POSITIVE**
85	COL	GTWS	WELL	GTWS WELL 3	NEGATIVE	
86	COL	GTWS	WELL	GTWS WELL 4	NEGATIVE	
87	COL	GTWS	Dist	MAA	NEGATIVE	
88	COL	GTWS	Dist	TAMILANG ELEM SCH	**POSITIVE**	**POSITIVE**
89	COL	GTWS	Dist	DECHMUR	**POSITIVE**	**POSITIVE**
90	COL	GTWS	Dist	BUGOL	NEGATIVE	
91	COL	GTWS	Dist	AFF	NEGATIVE	
92	COL	GTWS	Dist	STORE	NEGATIVE	
93	COL	GTWS	Dist	DOMCHUY	**POSITIVE**	**POSITIVE**
94	COL	GTWS	Dist	MEERUR	NEGATIVE	
95	COL	SYWS	WELL	MALAY	NEGATIVE	
96	COL	SYWS	WELL	MALAY	NEGATIVE	
97	COL	SYWS	WELL	MALAY	NEGATIVE	
98	COL	SYWS	WELL	MALAY	NEGATIVE	
99	COL	SWS	Dist	DULKAN PENTA	**POSITIVE**	NEGATIVE
100	COL	SWS	Dist	THABETH	**POSITIVE**	NEGATIVE
101	COL	SWS	Dist	NGOFF M'ON HOUSE	NEGATIVE	
102	COL	SWS	Dist	LUWECH PIPE 1	NEGATIVE	

103	COL	SWS	Dist	LUWECH PIPE 2	NEGATIVE	
104	COL	SWS	Dist	GILMAN HEAD START	**POSITIVE**	NEGATIVE
105	COL	SWS	Dist	SWS PLANT	NEGATIVE	
106	COL	SWS	Dist	ANOTH	**POSITIVE**	NEGATIVE
107	COL	SYWS	WELL	MALAY WELL 1	**POSITIVE**	**POSITIVE**
108	COL	SYWS	WELL	MALAY WELL 2	**POSITIVE**	**POSITIVE**
109	COL	SWS	Dist	MALAY	**POSITIVE**	NEGATIVE
110	COL	SWS	Dist	GUROR	NEGATIVE	
111	COL	SWS	Dist	LAMAER	**POSITIVE**	NEGATIVE
112	COL	SWS	Dist	KANIFAY ELEM SCHOOL	NEGATIVE	
113	COL	SWS	Dist	NEFF	NEGATIVE	
114	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
115	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
116	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
117	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
118	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
119	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
120	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	**POSITIVE**
121	COL	GTWS	TANK	WILNGIR TANK	NEGATIVE	
122	COL	GTWS	Dist	WANYAN 1	NEGATIVE	
123	COL	GTWS	Dist	WANYAN 2	NEGATIVE	
124	COL	GTWS	Dist	GAGIL ELEM SCHOOL	NEGATIVE	
125	COL	GTWS	Dist	TENFAR	**POSITIVE**	NEGATIVE
126	COL	GTWS	Dist	WILNGIR ST RES 4	NEGATIVE	
127	COL	GTWS	Dist	PAA GACHPAR	NEGATIVE	
128	COL	GTWS	Dist	WILNGIR ST RES 1	**POSITIVE**	**POSITIVE**
129	COL	GTWS	Dist	OUTSIDE TAMOR 2	NEGATIVE	
130	COL	GTWS	WELL	GTWS WELL 2	NEGATIVE	
131	COL	GTWS	Dist	TAMILANG ELEM SCH	NEGATIVE	
132	COL	GTWS	Dist	DECHMUR	NEGATIVE	
133	COL	GTWS	TANK	WILNGIR TANK	NEGATIVE	
134	COL	GTWS	Dist	GAGIL ELEM SCHOOL	NEGATIVE	
135	COL	GTWS	Dist	TENFAR	NEGATIVE	
136	COL	GTWS	Dist	WILNGIR ST RES 4	NEGATIVE	
137	COL	GTWS	Dist	PAA GACHPAR	NEGATIVE	
138	COL	GTWS	Dist	WILNGIR ST RES 1	**POSITIVE**	**POSITIVE**
139	COL	GTWS	Dist	OUTSIDE TAMOR 2	NEGATIVE	
140	COL	GTWS	WELL	GTWS WELL 2	NEGATIVE	
141	COL	GTWS	Dist	TAMILANG ELEM SCH	NEGATIVE	
142	COL	GTWS	Dist	DECHMUR	NEGATIVE	
143	COL	GTWS	Dist	WILNGIR ST RES 4	NEGATIVE	
144	COL	GTWS	Dist	WILNGIR ST RES 1	**POSITIVE**	**POSITIVE**
145	COL	GTWS	Dist	WILNGIR ST RES 3	**POSITIVE**	**POSITIVE**
146	COL	GTWS	Dist	WILNGIR ST RES 2	**POSITIVE**	**POSITIVE**
147	COL	GTWS	Dist	WILNGIR ST RES 5	**POSITIVE**	**POSITIVE**
148	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	NEGATIVE
149	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	NEGATIVE
150	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	NEGATIVE
151	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	NEGATIVE
152	COL	SYWS	WELL	MALAY WELL	**POSITIVE**	NEGATIVE
153	COL	FAIS	WELL	FAIS DIP WELL	**POSITIVE**	**POSITIVE**
154	COL	FAIS	TANK	FAIS RAIN TANK	**POSITIVE**	NEGATIVE
155	COL	ULITHI	WELL	ULITHI PUMP WELL	**POSITIVE**	**POSITIVE**
156	COL	ULITHI	WELL	ULITHI YSPSC WELL	**POSITIVE**	**POSITIVE**
157	COL	ULITHI	WELL	ULITHI DIP WELL	**POSITIVE**	**POSITIVE**
158	COL	MOGMOG	WELL	MOGMOG RAIN WELL	NEGATIVE	
159	COL	MOGMOG	WELL	MOGMOG DIP WELL	**POSITIVE**	**POSITIVE**

160	COL	MOGMOG	WELL	MOGMOG PUMP WELL	**POSITIVE**	**POSITIVE**
161	COL	WOLEAI	TANK	WOLEAI RAIN TANK	**POSITIVE**	NEGATIVE
162	COL	WOLEAI	WELL	WOLEAI PUMP WELL	**POSITIVE**	**POSITIVE**
163	COL	WOLEAI	WELL	WOLEAI DIP WELL	**POSITIVE**	**POSITIVE**
164	COL	ULITHI	TANK	ULITHI RAIN TANK	NEGATIVE	
165	COL	GTWS	Dist	WANYAN	NEGATIVE	
166	COL	GTWS	Dist	GAGIL ELEM SCHOOL	**POSITIVE**	NEGATIVE
167	COL	GTWS	Dist	RIKEN	**POSITIVE**	NEGATIVE
168	COL	GTWS	Dist	LENG	**POSITIVE**	NEGATIVE
169	COL	GTWS	Dist	TENFAR	**POSITIVE**	NEGATIVE
170	COL	GTWS	Dist	MEEYUB	**POSITIVE**	NEGATIVE
171	COL	GTWS	Dist	THOL	**POSITIVE**	NEGATIVE
172	COL	GTWS	Dist	LEEBNAW	**POSITIVE**	NEGATIVE
173	COL	GTWS	Dist	MAA	NEGATIVE	
174	COL	GTWS	Dist	DECHMUR	**POSITIVE**	NEGATIVE
175	COL	GTWS	Dist	TAMOR	NEGATIVE	
176	COL	GTWS	Dist	BUGOL	NEGATIVE	
177	COL	GTWS	Dist	AFF	NEGATIVE	
178	COL	GTWS	Dist	DOMCHUY	**POSITIVE**	NEGATIVE
179	COL	GTWS	Dist	MEERUR	NEGATIVE	

COL: Colilert
P/A: Presence/Absence
Catch: Catchment
Dist: Distribution line
YSPSC: Yap State Public Service Corporation
GTWS: Gagil-Tomil Water System
SYWS: Southern Yap Water System