

**Water and Environmental Research Institute of the  
Western Pacific  
Annual Technical Report  
FY 2015**

# Introduction

The University of Guam, Water and Environmental Research Institute (WERI) is one of 54 water research institutes set up by U.S. Congressional legislation. The institute is now in its 42st year of operation. The mission of WERI is threefold: (1) develop, through research and new technology, more efficient methods for solving regional water resource challenges; (2) train local water scientists, students, and local agencies; and, (3) facilitate water research coordination and application of research results through the dissemination of information and technology transfer.

The Institute provides its regional stakeholders Guam, Commonwealth of the Mariana Islands (CNMI), and the Federated States on Micronesia (FSM) with technical expertise in water resources related fields spanning the entire natural water cycle and spectrum of human water use, including tropical climatology, surface water hydrology, rainfall catchment systems, groundwater modeling and management, water distribution systems, soil erosion and mitigation strategies, watershed management, and various aspects of water quality. WERI faculty members contribute significantly to both undergraduate and graduate teaching programs at the University of Guam (UOG) and conduct vigorous research aimed at improving economic conditions and the quality of life for citizens of Guam and the regional island nations.

Currently, WERI has seven fulltime, and one emeritus, research faculty members, a water analysis laboratory manager and technician, two office staff, as well as six (6) graduate research assistants who are completing their MS degree in the UOG Environmental Sciences program. A WERI faculty member serves as the WERI Director on a rotational basis. WERI runs a state-of-the-art water quality laboratory that supports research and provides public service for water testing.

WERI administers and carries out research, training, and other information transfer programs under a variety of Federal and local funding sources, but the institute was created specifically to administer Department of Interior (US Geological Survey) funds under Section 104-B of the National Institute of Water Research Program. WERI has responsibility to manage 104-B base grants on Guam, in the Commonwealth of the Northern Marianas islands (CNMI), and in the Federated States of Micronesia (FSM).

In FY-2015, WERI faculty were involved as principal investigators and/or advisors on 24 research and training projects with a combined budget of approximately \$1,433,826. Of this, \$277,005 was awarded through the Water Resources Research, Institute Program administered by USGS under 104-B, while \$338,320 was received as a special appropriation from the Guam Legislature. The remainder came from other Federal and Private Sources awarded directly to the Institute, or indirectly through local Government Agencies.

## Research Program Introduction

The Water and Environmental Research Institute (WERI) Advisory Councils are the bodies which determine research goals and priorities for WERI in general and the USGS-104B program in particular. To determine each year's research goals, training, and information dissemination activities for the region, the Institute has three advisory councils. The Research Advisory Council (RAC) for Guam consists of representatives from all Guam governmental agencies involved with water resources development or regulation, members of U.S. Federal agencies, military organizations dealing with water resources issues, members of the university research community, and teachers. The RAC for the CNMI and the FSM consists of representatives from various government departments that deal with water resources, representatives from the local colleges, private sector engineers, environmental professionals, planners, and University of Guam research faculty. The duties of the advisory councils are to update/identify and prioritize the research and training needs for each region. Based on regional needs, the critical research needs will be updated/revised each year.

WERI holds RAC meetings in each island region from September through October of each year. The meetings provide a scientific forum for information exchange on new and recently completed projects. Each RAC group examines the research education and training priorities that were identified in past years and added or amended where appropriate.

In early November, a Request for Proposals (RFP) letter send out by e-mail to over two hundred (200) regional representatives in Guam, the CNMI and FSM. Recipients include all past and present RAC members, faculty members at the University of Guam, the Northern Marianas College in Saipan and the College of Micronesia in Pohnpei, and water resource professionals from several government agencies. Accompanying the RFP message are: a) a blank proposal form for submittal on the USGS Web Site, b) detail instructions on how to fill out the form, and c) the critical water resource research, education and training needs that they identify for Guam, the CNMI and FSM.

WERI has four (4) regional review panels, each composed of well qualified water resources professionals who are tasked with evaluating each proposal's regional relevance in accordance with the long-standing criteria listed in the RFP. The appropriate proposals that the Institute receives as the result of RFP, are e-mailed separately to each reviewer with the critical needs list for the region and a scoring form. The reviewers will be advised to work independently and within two weeks to submit their scores and comments to the WERI Director. The proposal scores will be tabulated and the projects rank in descending order of average score. Projects that will be approve for funding will be selected based on their regional ranking and availability of funds.

# Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2 implementation of a numerical model

## Basic Information

<b>Title:</b>	Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2 implementation of a numerical model
<b>Project Number:</b>	2015GU284B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Category:</b>	Groundwater, Hydrology, Hydrogeochemistry
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	John Jenson, Nathan C Habana, Mark Lander

## Publications

1. Habana, N.C., J.W. Jenson, and S.B. Gingerich, 2015, Abstracts and Program: Exploring Best-Practice Capacities for the Northern Guam Lens Aquifer in Second Conference on Water Resources Sustainability Issues on Tropical Islands. Honolulu: A7.
2. Simard, C.A., J.W. Jenson, and M.A. Lander, 2015, Analysis of Salinity in the Northern Guam Lens Aquifer in Proceedings of the 16th Symposium on the Geology of the Bahamas and other Carbonate Regions, Gerace Research Center, San Salvador Island, Bahamas, pp.243-253.

# PROJECT SYNOPSIS REPORT

**Project Title:** Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2—implementation of a numerical model

## Problem and Research Objectives

The Northern Guam Lens Aquifer (NGLA) provides 90% of Guam's drinking water. The anticipated addition of US Marine Corps activities will require additional production, while ongoing economic growth will increase demand as well. Policy-makers and water managers have begun asking "what is the absolute *maximum* volume of water that could be sustainably withdrawn from the aquifer?" Answering such a question requires identifying (1) the *natural limits* on aquifer recharge, storage, and water quality imposed by climatic and geologic conditions, but (2) doing it *for an ideal production system*, i.e., one constructed and operated so as to achieve the maximum possible production for a given standard of quality. This study is therefore directed at estimating the *maximum potential capacity* of the NGLA, i.e., the capacity that ultimately *could* be achieved by an ideal production system, given what we currently know or must assume about the natural limiting conditions. Recent modeling has incorporated the current state of knowledge regarding natural conditions and constraints. Estimates of maximum potential capacity can now be made by exploring scenarios in which hypothetical well depths, locations, and pumping rates are distributed so as to maximize the capacity for given upper limits of chloride. This study is thus helping to provide estimates of the absolute upper limits of production that could, in principle, be achieved by an optimum system. These will provide ultimate baselines against which to make long-term economic evaluations of future options for holistic sustainable management of the aquifer.

The objectives of the respective phases of this project were:

- (1) Data acquisition and literature review of published and emerging research on spatial and temporal distributions and trends of rainfall and salinity in the NGLA by WERI, USGS and others;
- (2) Study of meteorological and geological phenomena that might control or influence the observed rates and amounts of rainfall, infiltration, storage, flow, and salinity; and
- (3) Analyses of spatial and time-series data on rainfall, groundwater levels, specific conductivity, chloride concentrations, and production rates from existing wells within the NGLA; and
- (4) Application of a groundwater model to estimate the maximum production that could be attained from an optimum set of strategically spaced shallow-draft vertical wells producing at specified maximum acceptable values of salinity, under specified natural conditions (*e.g.*, long-term average rainfall, vs. historic wet and drought conditions)
- (5) Development of a production function that estimates the relationships between quantity and quality that might be produced by an ideal production system (i.e., one that would produce maximum quantity for a given quality or maximum quality for a given quantity).

## Methodology

The principal investigators are leading a research team composed of themselves, a WERI research associate trained in modeling, and WERI-based graduate and undergraduate research assistants (UOG environmental science MS candidate), working in collaboration with colleagues

at the USGS Pacific Islands Water Science Center (PIWSC) to assemble and prepare the data sets; identify climatic phenomena and geologic features that are most likely to exert significant control on rainfall amount and intensity, infiltration rates, aquifer storage, groundwater flow, and groundwater salinity on northern Guam; and apply statistical, geospatial, and other analytical tools to identify, characterize, and interpret past and present spatial patterns in rainfall, groundwater levels, specific conductivity, chloride concentrations, and production rates from existing wells within the NGLA. The team is developing scenarios to identify ideal configurations (i.e., configurations not limited by economic, social, legal, or other non-natural factors) of well distribution and spacing, depth, and pumping rates that could thus in principle maximize production from the aquifer for specified limits on saltwater content. Scenarios are examining how the ideal configuration might also respond to different long term climatic conditions.

### **Principal Findings and Significance**

Results to date suggest that a “picket fence” configuration of about 100 shallow (25-ft deep) wells pumping at 500 gpm throughout the para-basal zone of the aquifer might be able to capture 100% of supra-basal water descending to the para-basal zone, as well as drawing back a significant portion of the basal water otherwise down-gradient of the para-basal zone. Preliminary results indicate that in principal, an ideal system could thus extract up to 40% of annual recharge, while keeping average chloridity at less than 150 mg/liter chloride. Future scenarios will add wells to the basal zone to glean additional water from the basal zone and test what volume of water might be extracted for chloridity limits up to 250 mg/liter.

# Impact of Multiple Mercury Sources on Edible Quality of Fish from American Memorial Park Nearshore Waters, Saipan, CNMI

## Basic Information

<b>Title:</b>	Impact of Multiple Mercury Sources on Edible Quality of Fish from American Memorial Park Nearshore Waters, Saipan, CNMI
<b>Project Number:</b>	2015GU285B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/28/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Water Quality
<b>Focus Category:</b>	Toxic Substances, Water Quality, Non Point Pollution
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Gary Denton

## Publications

There are no publications.

## PROJECT SYNOPSIS REPORT

**Project Title:** Impact of Multiple Mercury Sources on Edible Quality of Fish from American Memorial Park Nearshore Waters, Saipan, CNMI.

### Problems and Research Objectives

The American Memorial Park (AMME) in Saipan was created in 1978 and commemorates US soldiers who lost their lives in the CNMI during WWII. The seaward boundary of this 33 acre property extends from Micro Beach in the village of Garapan to the southeastern corner of the Puerto Rico Dump (Fig.1), a shoreline distance of approximately 2 km.

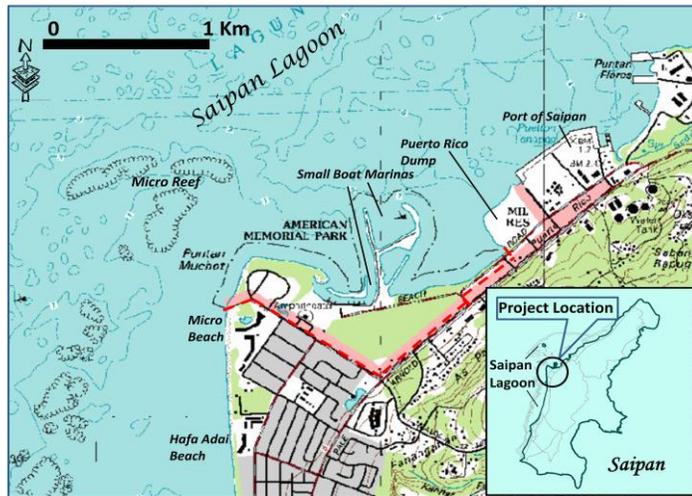
The property was occupied by US Marines immediately after WWII and served as a motor pool and vehicle maintenance/repair facility as well as a refueling station for military and civilian personnel (Ogden 1998). It was also used as a primary storage and detonation site for residual munitions stockpiled during the subsequent clean-up and rebuilding effort. In 2004, hundreds of high explosive artillery shells were unearthed during the construction of the AMME Visitor

Center car park. A magnetometer sweep of the area suggested hundreds more lay buried outside of the construction area (AMPRO 2005).

The widespread use of mercury in primers and detonators of WWII artillery shells (US Navy 1947), and electrical switches in certain types of wartime rockets and projectiles (US Navy 1946) thus raises environmental concerns that are justified in light of recent findings of mercury enrichment in runoff, soils and sediments on the island (Environet Inc. 2007; Denton *et al* 2014, 2016). The study reported here examined mercury levels in sediments and fisheries from nearshore waters adjacent to AMME with a view towards identifying and delineating mercury contributions from potential land-based sources in the park and other facilities nearby.

### Methodology

Surface sediment samples were collected at discrete intervals (50-100 m) along the entire coastal boundary of AMME. Samples were scooped up in clean, polypropylene vials and dried to constant weight at ~30°C. Following disaggregation, the samples were sieved through a 1-mm nylon screen and wet digested in nitric acid (1g/10ml) at 100°C for ~3 hours. Upon cooling the digests were made up to 30 ml with deionized water and allowed to stand overnight to permit settlement of any suspended solids.



**Figure 1: Map of Saipan (inset) showing project location. The American Memorial Park inland boundary delineated by dashed red line**

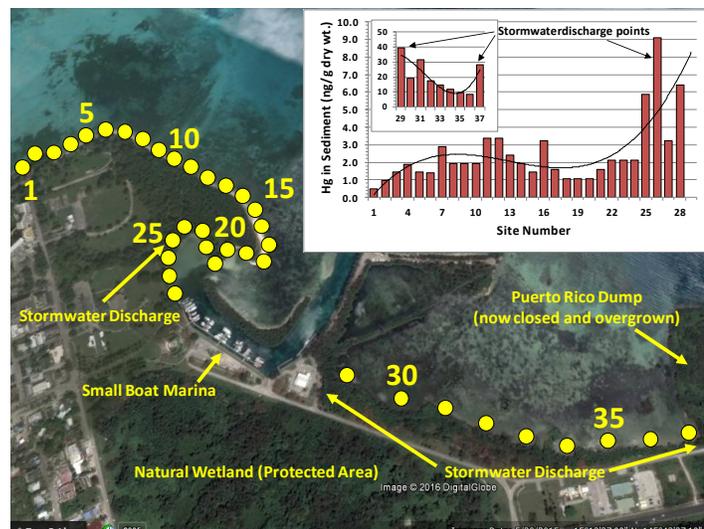
Nearshore fish were collected from four locations in Saipan Lagoon adjacent to AMME (Mirco Beach, Micro Reef, the Puerto Rico Dump) as well as from two relatively clean, remote locations at the northern end of Saipan Lagoon (Fig. 1). Dominant representatives ideally suited for such monitoring purposes included the blue-line surgeonfish, *Acanthurus lineatus* (herbivore), soldierfish, *Myripristis* spp. (planktivore), and the thumb-print emperor, *Lethrinus harak* (carnivore). All three fish types have limited foraging ranges and are popular table fish among local fishers. Mercury levels were determined in axial muscle taken from immediately below the dorsal fin of all captured specimens. Complete digestion of this tissue was achieved in a 2:1 nitric-sulfuric acid mixture at 100°C, for 3 hours.

All samples were analyzed by flameless atomic absorption spectroscopy using the syringe techniques described by Stainton (1971). Calibration standards (5–20 ng/L) were made up in 10% nitric acid containing 0.05% potassium dichromate as a preservative (Feldman, 1974). QA/QC procedures included blanks, matrix spikes, and accuracy and precision verifications using appropriate standard reference materials consistently yielded recoveries better than 95%.

## Principle Findings and Significance

### *Sediments:*

Mercury levels encountered in intertidal sediment were generally low with the great majority of samples yielding values of less than 10 ng/g. Profiles along the southern perimeter of the park showed mildly increasing mercury enrichment between sites 1 and 12 followed by a gradual return to baseline (1 ng/g) at site 20. The highest levels encountered along this stretch of coastline were associated with freshwater inflows from an artificial lake on the western side of the park (site 25). The lake receives drainage from adjacent roads and commercial premises in Garapan and over the years has become a repository for heavy metals and other contaminants washed into the park in urban runoff. Mercury levels in bottom deposits from this structure ranged from 49 ng/g at the head end to 16 ng/g ~150 m downstream (Denton, unpublished data).



**Figure 1: Map of sediment sampling sites along seaward boarder of AMME with graphical representations of mercury data obtained (inset).**

Mercury profiles in nearshore sediments from the northern perimeter of the park, while generally higher than in the southern section, were only mildly enriched by local standards (Denton *et al.* 2014) and well below threshold levels (130 ng/g) associated with adverse biological effects (MacDonald *et al.* 1996). They were, however, probably sufficient to exert some influence on mercury levels in resident fish species as indicated below.

### **Fish:**

The success of this part of the program was somewhat constrained by unfavorable weather conditions associated with four major storms in the area between May and October, 2015. Nevertheless sufficient samples were obtained to get a reasonable picture of site-specific difference in fish mercury levels and make a preliminary assessment of any potential health risks associated with their unrestricted consumption.

The findings of the study are summarized in Table 1 and illustrated graphically in Figure 3. As expected mercury levels in axial muscle were clearly trophic level dependant with lowest and highest levels generally encountered in herbivorous and carnivorous representatives respectively. Mercury levels in axial muscle of fish from non-polluted waters typically range between 0.001-0.100 µg/g wet weight depending upon age and trophic level (Holden, 1973). Several of the larger specimens of *Myripristis* sp. and *Lethrinus harak* captured here exceeded this range.

USEPA fish consumption guidelines for the general population recommend that fish with mercury concentrations in their muscle tissue above 0.088 µg/g wet weight (as methyl mercury) should not be eaten on an unrestricted basis (USEPA, 2000).

Based on this assumption, 8-oz meals of the larger emperor fish (~25 cm) from the study area should probably not be eaten more than once or twice a week for the general population and once every two weeks for women of childbearing age, nursing mothers, or sensitive individuals (USEPA, 2000).

Because of uncertainties associated with the formulation of USEPA risk-based consumption limits for mercury in fish, risk managers in the US have some degree of flexibility in setting State fish advisories and do not always strictly adhere to USEPA guidelines. The Iowa Department of Public Health, for example, decrees that all fish containing <0.3 µg/g mercury are safe to consume with no meal restrictions. Consumption of up to one 8-oz meal per week of fish containing 0.3-1.0 µg/g of mercury is also considered safe while fish containing over 1.0 µg/g of mercury should not be eaten at all. If Saipan were to adopt a similar policy then all fish examined here would fall into the unrestricted consumption category.

Inter-site mercury comparisons for each fish type were to some extent hampered by size range discrepancies between captured specimens. This is clearly illustrated in the composite scatterplots shown in Fig. 3. Based on the available data for *Myripristis* spp., nearshore water adjacent to the Puerto Rico Dump contributed greater mercury loads to resident fish populations than did any of the other sites visited. The data for *A. lineatus* and *L. harak* are currently

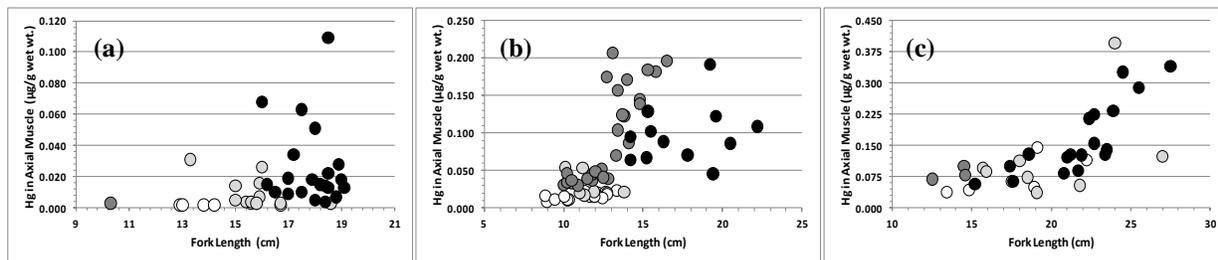
**Table 1: Mercury in Dominant Fish Groups Analyzed**

Location	N	Fork Length (cm)		Mercury Level (µg/g wet wt.)	
		Mean	Range	Mean	Range
<b><i>Acanthurus lineatus</i></b>					
Controls <sup>a</sup>	5	14.1	12.9 - 16.7	0.002	0.002 - 0.002
Port Area <sup>b</sup>	12	15.7	13.3 - 18.6	0.010	0.003 - 0.031
Dump	1	10.3	-	0.003	-
Micro Reef/Beach	21	17.9	16.0 - 19.1	0.026	0.004 - 0.109
<b><i>Myripristis</i> spp.</b>					
Controls <sup>a</sup>	18	11.1	8.8 - 13.3	0.018	0.009 - 0.024
Port Area <sup>b</sup>	7	12.0	10.1 - 13.8	0.028	0.014 - 0.054
Dump	28	12.8	10.0 - 16.5	0.094	0.030 - 0.207
Micro Reef/Beach	12	17.5	14.0 - 22.2	0.097	0.045 - 0.191
<b><i>Lethrinus harak</i></b>					
Controls <sup>a</sup>	5	17.7	13.4 - 22.2	0.079	0.039 - 0.146
Port Area <sup>b</sup>	9	19.7	15.7 - 27.0	0.116	0.037 - 0.396
Dump	3	13.9	12.5 - 14.6	0.083	0.069 - 0.100
Micro Reef/Beach	18	21.8	15.2 - 27.5	0.164	0.057 - 0.340

<sup>a</sup>From nearshore/offshore waters in northern reaches of Saipan Lagoon

<sup>b</sup>From Docks to Seaplane Reef

inconclusive because of insufficient numbers of suitably sized individuals to permit normalization of data to standardized fish lengths. Sampling therefore continues.



**Figure 3: Mercury levels in fish examined: (a) = *Acanthurus lineatus*, (b) = *Myripristis* spp., (c) = *Lethrinus harak*. ○ = Controls; ◐ = Port area; ◑ = Puerto Rico Dump; ● = Micro Beach and Micro Reef complex**

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# Augmented Saipan daily rainfall measurements to inform a study of well head and well salinity variations

## Basic Information

<b>Title:</b>	Augmented Saipan daily rainfall measurements to inform a study of well head and well salinity variations
<b>Project Number:</b>	2015GU287B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Category:</b>	Water Quality, Climatological Processes, Groundwater
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Mark Lander

## Publications

1. Guard, C.P., and Mark A. Lander, 2015: National Weather Service in Guam and the University of Guam Press Release: Typhoon Soudelor Wind Assessment for Saipan, CNMI. Press release to government agencies, local media, and the public of Guam and the CNMI. Meteorological assessment of the intensity and damage caused by the passage of Typhoon Soudelor over Saipan on the night of 02 August 2015.
2. Lander, Mark A., 2015, Damaging Typhoons and Major Drought: The Ongoing and Forecast Effects of the 2015 El Niño in the Tropical Pacific, The Second Conference on Water Resource Sustainability Issues on Tropical Islands December 1 - 3, 2015 | Hilton Hawaiian Village | Honolulu, Hawaii
3. Lander, Mark A., 2016: National Weather Service Forecast Office Guam and the University of Guam Water and Environmental Research Institute Typhoon Soudelor Wind Assessment for Saipan, American Meteorological Society 32nd Annual Conference on Hurricanes and Tropical Meteorology, Puerto Rico, April 2016. Online proceedings.

## PROJECT SYNOPSIS REPORT

**Project Title:** Augmented Saipan daily rainfall measurements to inform a study of well head and well salinity variations

### **Problem and Research Objectives**

There are now only two locations on Saipan where there is a direct measurement of daily rainfall: the Saipan International Airport and at the Emergency Management Office on Capitol Hill. These sparse rainfall records are the only data available to support studies of the contamination of Saipan groundwater by sea water. There are no rain gauges at several important well sites (e.g., Marpi). Many of Saipan's wells have a sea water concentration that severely degrades the taste and smell of the water supply, and may even pose a health risk. During 2014, personnel at the water laboratory of the Saipan Commonwealth Utilities Corporation (CUC) compared groundwater salinity levels to observed rainfall. This USGS-sponsored project yielded some findings that were as one might expect; for example, higher salinity in wells closer to the coast. Another key observation was counter-intuitive and remains unexplained: the salinity in some wells actually *increased* after heavy rainfall events! During the course of the 2014 CUC study, a test rain gauge was installed at the CUC water lab. This rain gauge often obtained higher rainfall values than observed at the official primary climate observation site at the airport and another secondary reporting site on Capitol Hill. It is possible that very large gradients of rainfall during isolated heavy storms might be partially responsible for the observed unusual salinity changes in the wells. The magnitude of the differences in the rainfall measured at the CUC water lab versus the other two rainfall sites is often large, and needs further validation with a dual rain gauge configuration.

The objectives of the respective phases of this project were:

- (1) Continued data acquisition regarding the spatial and temporal distributions of rainfall, well head and salinity;
- (2) Analyses of the spatial and time-series data on rainfall, groundwater levels, and chloride concentrations;
- (3) Verification of large rainfall gradients on Saipan as suggested during 2014 from the one rain gauge at the CUC lab versus the Airport and Capitol Hill sites; and,
- (4) Document that nature of groundwater salinity changes after heavy rainfall events.

### **Methodology**

During April 2015, the project PI installed two rain gauges at the CUC lab to validate the earlier finding during 2014 of higher rainfall at that location. The UOG PI worked with Saipan CUC laboratory personnel to rehabilitate two other key rain gauge sites, one at Marpi (north-central Saipan) and another at Kagman (southeastern Peninsula). The project PI also enlisted the help of CUC lab personnel to regularly visit the rain gauge sites for upkeep, and to assist the project PI in the task to obtain well water level and salinity readings at selected well sites (on a non-interference basis with operations).

When the project PI visited Saipan on the 8<sup>th</sup> of August 2015, it was found that a devastating typhoon had destroyed the project rain gauges and forced the CUC laboratory personnel into an emergency task of performing only basic water quality testing.

### **Principal Findings and Significance**

During 2015, several typhoons affected Saipan. On the night of 02 August 2015, a strong Category 4 typhoon (Soudelor) passed directly over Saipan with severe damage occurring island-wide. Power was out for over two months in some places. Water service was cut-off. The rain gauges at the CUC lab were destroyed in the typhoon. After the typhoon and for several months thereafter, the staff of the CUC laboratory was put on detail to perform only basic water testing, since the water infrastructure on Saipan was severely damaged by the typhoon. A week after the typhoon struck Saipan, I traveled to Saipan in order to conduct a meteorological assessment of the intensity and damage of Typhoon Soudelor. I participated in a project to determine that Soudelor was a Category 4 system when it passed over Saipan. While on this visit, I reassembled the destroyed USGS rain-gauge housing at the CUC lab and placed a new rain gauge in it. This new rain gauge was also destroyed in yet another tropical cyclone (TS Champi), which hit Saipan on October 15<sup>th</sup>. In the second case of rain-gauge destruction, very heavy rainfall was not able to escape the housing of the rain gauge, so that water damage occurred to the electronics. Since the data logger was sealed, I was able to obtain rainfall stored on the data logger up to the time that the water level rose to the electronics of the tipping bucket mechanism. I obtained a partial reading (through about 1 PM on the 15<sup>th</sup>) of the rainfall during Champi. It was an island-wide high value of nearly 14 inches in less than 24 hours! In yet another trip to Saipan in early 2016, I installed, for a third time, another rain gauge at the CUC laboratory, and worked with CUC lab personnel to replace the batteries and restart the gauges at the sites in Marpi and Kagman. These rain gauges are now in good working condition.

Saipan is now in its post-Peak El Niño drought, and we will try to utilize the rain gauge network to restart our 2015 project, and inform our new USGS project to study the 2016 El Niño drought.

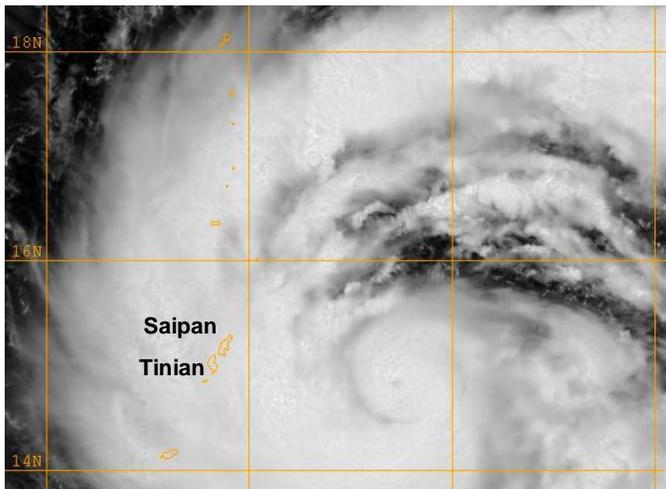
### **Notes on Typhoon Soudelor**

Typhoon Soudelor made a direct hit on the island of Saipan in the Commonwealth of the Northern Mariana Islands on August 2 at an intensity stronger than predicted, and while intensifying as it approached and passed over the island. The typhoon was a very small system, with a 5-mile diameter eye, and with typhoon force winds extended no more than 10 miles from the center and tropical storm force wind extending no more than 20 miles from the center.

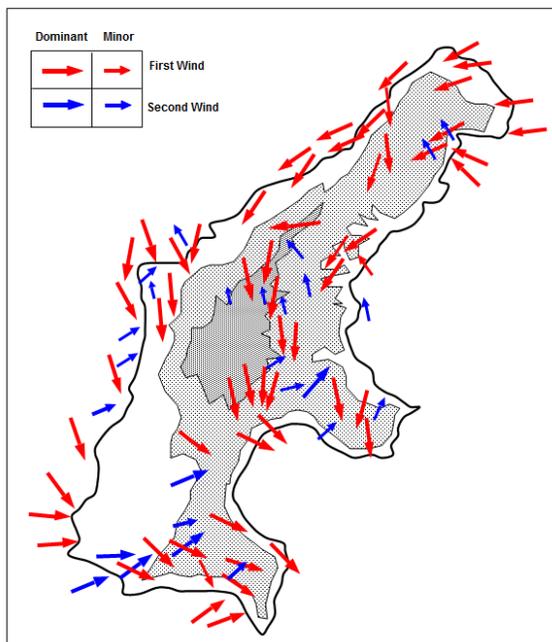
The level of damage, the perceived storm high intensity, and the lack of determinant maximum wind measurements (the official airport anemometer failed prior to peak wind) led the National Weather Service Pacific Region Headquarters at Pearl Harbor Hawaii to approve a scientific wind assessment on Saipan. A team of two scientists, Mr. Chip Guard, Warning Coordination Meteorologist at the Guam NWS forecast office, and Dr. Mark Lander, Meteorologist at the Water and Environmental Research Institute (WERI)

of the University of Guam (UOG) set out to Saipan on August 10<sup>th</sup> to conduct a scientific assessment of Soudelor's characteristics as it passed across the island. Both experts hold a strong background in conducting post-typhoon assessments in the western North Pacific. These assessments are sometimes conducted when there is some question as to the actual intensity of a destructive typhoon.

On August 18, Mr. Guard and Dr. Lander issued a press release to local media with a determination of the "over-water" intensity of Typhoon Soudelor as it passed across Saipan, and an estimate of the maximum winds likely experienced on the island. Based on the assessment of all available meteorological information, the best estimate of the maximum "over-water" wind in Typhoon Soudelor as it passed over Saipan was 115 knots with gusts to 140 knots or 132 miles per hour with gusts to 162 miles per hour. This wind speed is at the threshold of a Category 4 typhoon on the Saffir-Simpson Tropical Cyclone Scale. There was no evidence of tornadoes on the island, and all heavier damage could be related to topography or wind passing around obstacles such as large concrete buildings.



Typhoon Soudelor bears down on Saipan in this visible satellite image on the morning of 02 August 2015.



The treefall pattern caused by Typhoon Soudelor on Saipan.

# Impacts of Land Cover Change on Groundwater Quality in Saipan

## Basic Information

<b>Title:</b>	Impacts of Land Cover Change on Groundwater Quality in Saipan
<b>Project Number:</b>	2015GU288B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Water Quality
<b>Focus Category:</b>	Water Quality, Groundwater, Methods
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Yuming Wen, Brian Bearden, Derek Chambers

## Publication

1. Wen, Y. and D. Chambers. Change Detection of Land Cover Change in Saipan, 37th Annual Research Conference, University of Guam, March 8, 2016, p3.

# PROJECT SYNOPSIS REPORT

**Project Title:** Impacts of Land Cover Change on Groundwater Quality in Saipan

## **Problem and Research Objectives**

Saipan is the largest and southernmost island in the Mariana Islands. The ground water supplies about 48,000 people of Saipan and thousands of tourists annually. Saipan is mainly composed of limestone, and the high-permeability of limestone poses a high risk for contamination. Because of run-off and anthropogenic activities, and unreliable drinking water delivery systems and management (EPA Pacific Southwest/Region 9, 2006), the potential for contamination is high.

The CNMI/University of Guam Water and Environmental Research Institute (WERI) Research Advisory Council Meeting of October 9, 2014 identified the impact of historical and recent land use activities on ground and surface water quality and production as one of critical priority research needs for Saipan. Based on the critical water priority need, groundwater quality is a main concern in Saipan. This research project focused on impacts of land cover change and human induced activities on ground water quality in Saipan.

The main research objectives included 1) Geocoding the groundwater quality data of 2010 and 2011 to GIS formats so that the data could be utilized; 2) Comparing land cover information collected in the field with the results from the recently completed project focusing on land cover change detection in Saipan (Wen and Chambers, 2014); 3) determining impacts of land cover and land cover change, and human induced activities on groundwater quality.

## **Methodology**

Geospatial technologies such as GIS, remote sensing, spatial analysis, global positioning system (GPS) and geospatial statistics were applied to complete the project. Water quality data from the Division of Environmental Quality (DEQ) of the Commonwealth of the Northern Mariana Islands (CNMI) and the Commonwealth Utilities Corporation (CUC) of CNMI, well locations, land cover information of 1978 and 2009, and watershed information were used. There are 165 wells, of which only 45 wells were sampled for nitrate concentration. These 45 wells are clustered in two locations. 15 sampled wells are located in Kagman Watershed, and 30 wells are located close to Saipan International Airport (Figure 1). The original nitrate data collected from selected wells were stored in MS Excel spreadsheet, and they were linked to a shapefile used to store well locations so that nitrate information could be processed and stored in a GIS format for further processing and analysis. The relationships between well locations and land cover information, nitrate trend and land cover information were evaluated.

## **Principal Findings and Significance**

The project concentrated on processing of groundwater quality data of 2010 and 2011, land cover and land cover change, and satellite images, and evaluation of impacts of land cover and land cover change, and human activities on groundwater quality. The project mainly focused on 15 wells in Kagman Watershed and 30 wells near the Saipan International Airport. The method used in this research can be applied to evaluate the relationship between land cover and nitrate level/trend. It can also be applied to assess the relationship between land cover change and nitrate level/trend.

Figure 2 represents the nitrate levels in Well IF-7 in different sampling dates. The graphic indicates that the nitrate levels tended to increase over the sampling dates, and the values were almost close to the maximum contaminant level (MCL) of 10 mg/L (EPA, 2009). Table 1 demonstrates that land cover near Well IF-7 changed from grass to urban from 1978 to 2009. Figure 3 shows the visual overview of percentage land cover in buffered well zones for sampled wells near Saipan International Airport. Since the land cover for Well IF-7 was grass (vegetated cover) in 1978, and currently was urban area, the high level of nitrate from Well IF-7 might be caused by human activities.

The GIS-based analytical method can be applied to determine whether land cover and land cover change will affect nitrate levels and other contaminant levels in Saipan and other islands in the western Pacific, and beyond.

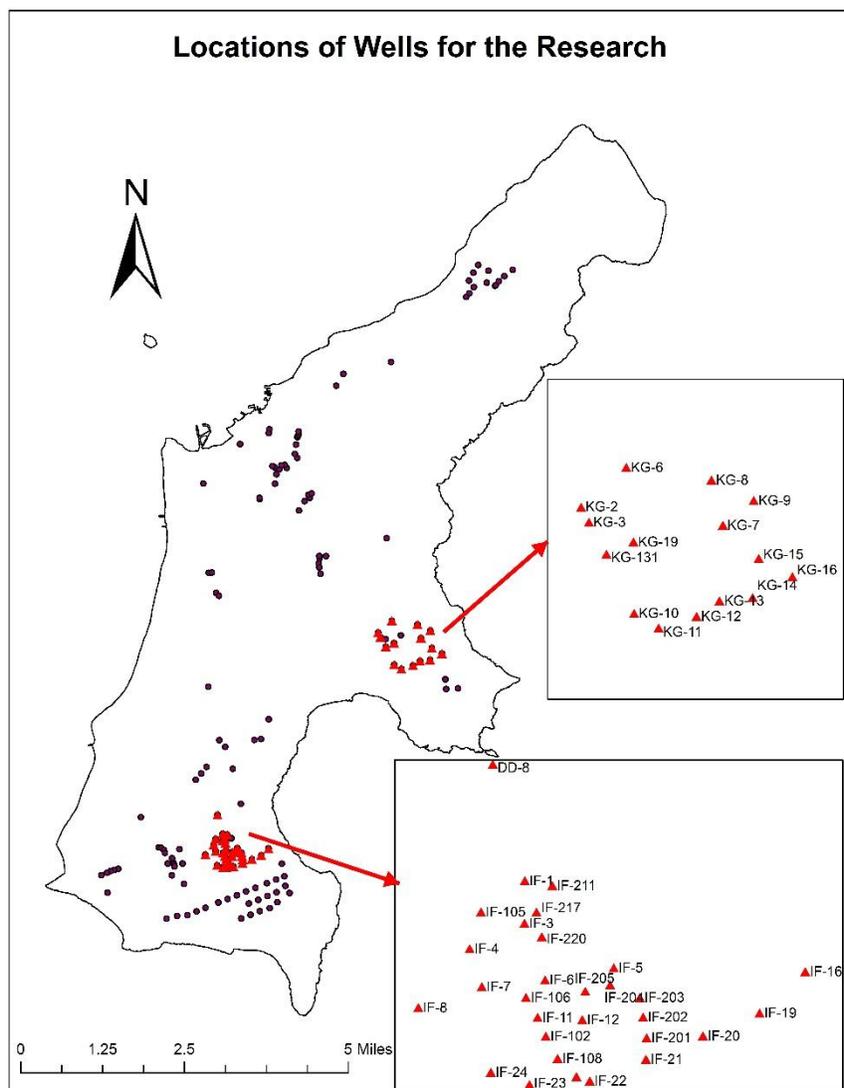


Figure 1. Locations of Sampled Wells for the Research

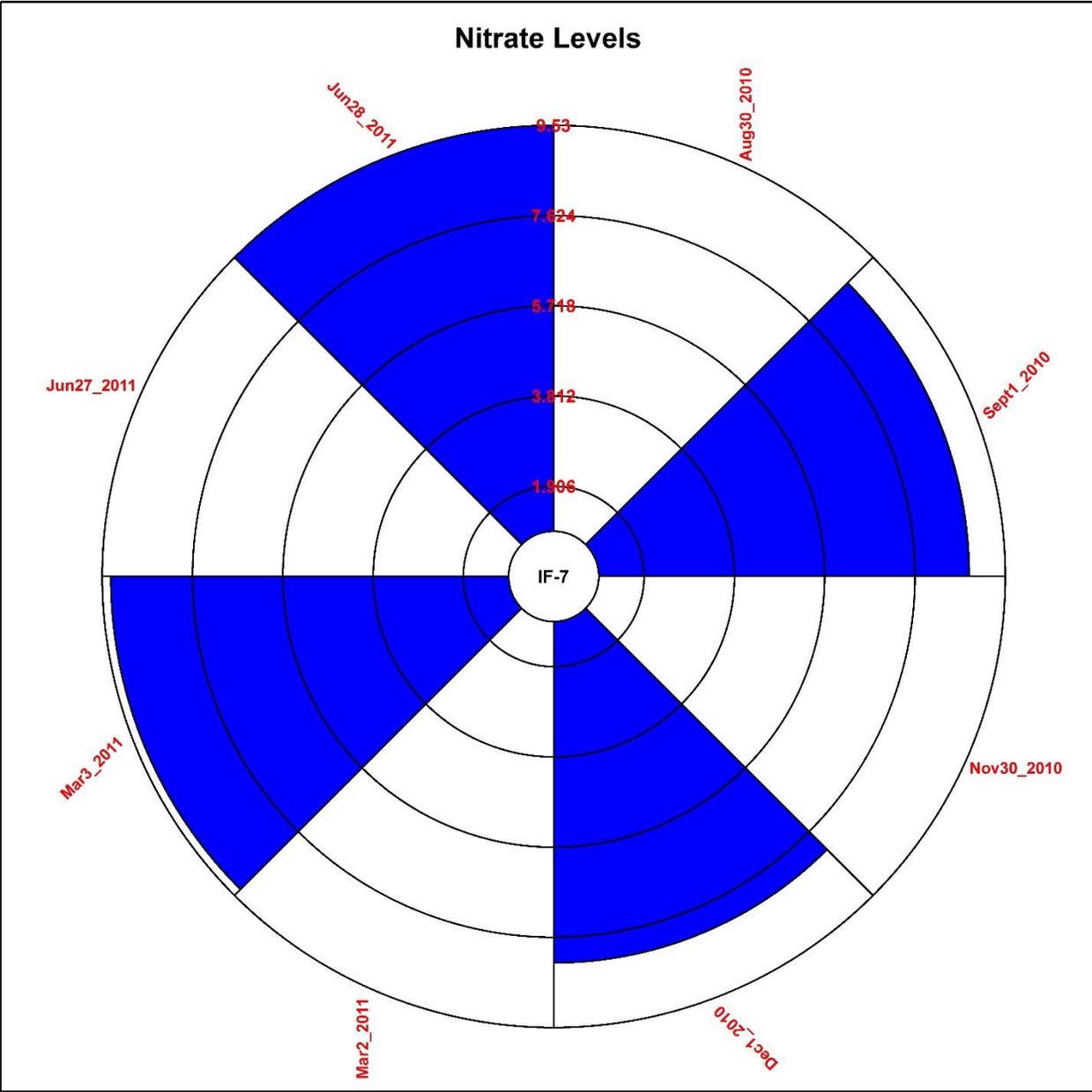


Figure 2. Nitrate Levels for Well IF-7

**Note:** Blue stands for real values from samples, and white for no samples or no data or non-detectable value (ND).

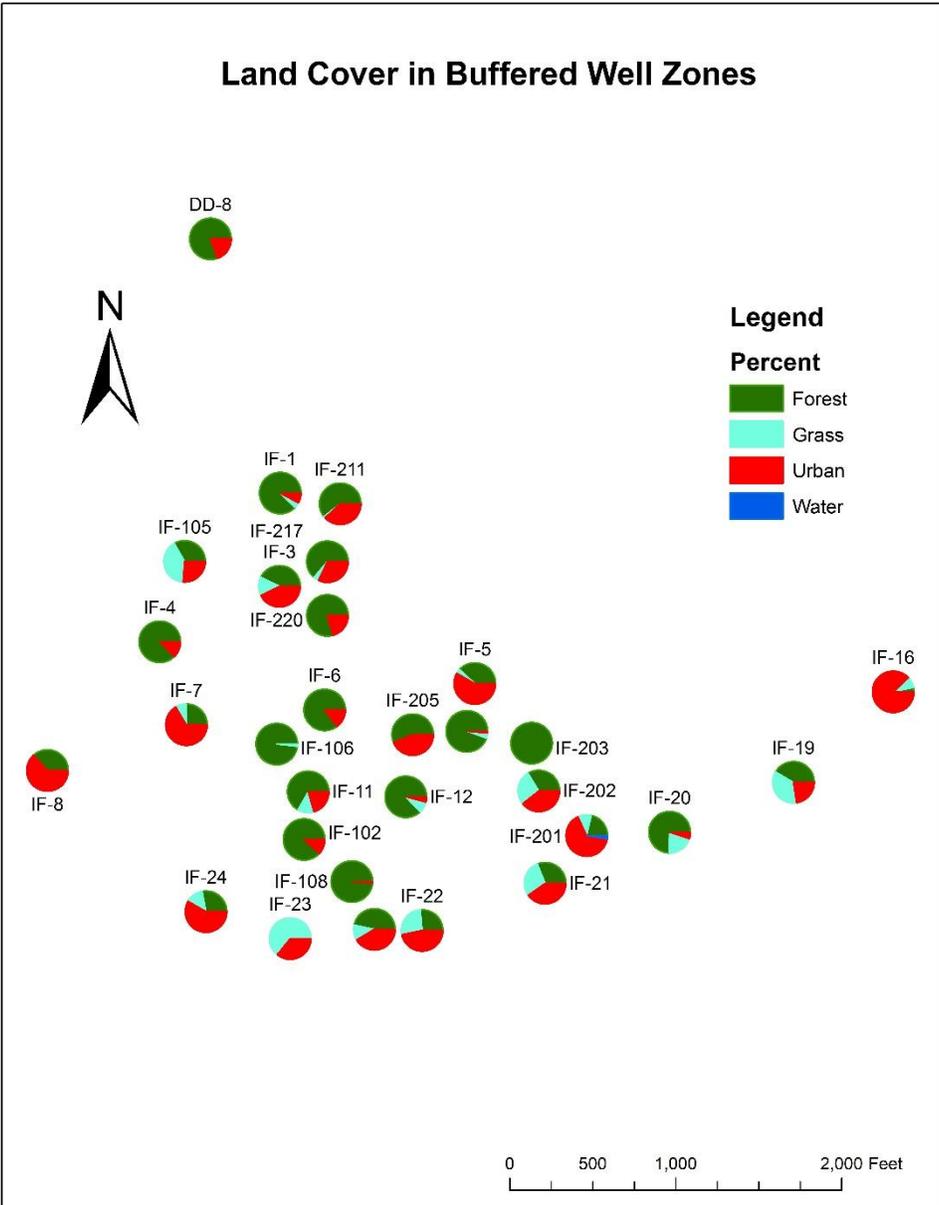


Figure 3. Percentage land cover in buffered well zones near Saipan Airport

<b>Well_ID</b>	<b>Forest</b>	<b>Grass</b>	<b>Urban</b>	<b>Water</b>	<b>LC1978</b>	<b>LC2009</b>
DD-8	80.3	0.0	19.7	0	2	1
IF-1	87.8	4.2	8.0	0	1	1
IF-101	46.6	12.0	41.4	0	2	2
IF-102	88.1	0.0	11.9	0	2	1
IF-105	33.2	40.6	26.2	0	2	1
IF-106	97.1	1.9	1.0	0	2	1
IF-108	98.7	0.0	1.3	0	2	1
IF-11	66.8	12.5	20.7	0	2	1
IF-12	87.1	8.7	4.2	0	1	1
IF-16	3.4	8.5	88.1	0	1	3
IF-19	41.6	35.8	22.6	0	1	2
IF-20	74.3	20.6	5.0	0	1	1
IF-201	21.4	10.5	65.5	0	2	1
IF-202	33.6	26.7	39.0	2.6	2	2
IF-203	100.0	0.0	0.0	0.7	2	1
IF-204	94.5	3.9	1.6	0	2	1
IF-205	56.4	0.0	43.6	0	1	3
IF-21	31.0	28.8	40.1	0	2	2
IF-211	60.5	1.3	38.2	0	1	1
IF-217	63.7	4.2	32.1	0	2	1
IF-22	26.3	26.9	46.7	0	2	3
IF-220	79.3	0.0	20.7	0	1	1
IF-23	0.0	64.2	35.8	0	1	2
IF-24	27.9	13.8	58.3	0	1	3
IF-3	42.9	14.4	42.8	0	2	3
IF-4	87.1	0.2	12.7	0	1	1
IF-5	38.2	3.5	58.3	0	2	3
IF-6	85.3	0.0	14.7	0	2	1
IF-7	25.3	8.2	66.5	0	2	3
IF-8	36.8	0.0	63.2	0	3	1
KG-10	49.2	34.4	16.4	0	2	1
KG-11	2.0	10.6	87.4	0	2	3
KG-12	0.2	61.3	38.5	0	1	2
KG-13	67.7	0.0	32.3	0	1	1
KG-131	14.0	12.4	73.6	0	2	3
KG-14	9.2	13.8	77.0	0	1	3
KG-15	64.3	4.5	31.2	0	2	1
KG-16	17.0	21.5	61.5	0	1	2
KG-19	24.7	17.3	58.0	0	2	3
KG-2	100.0	0.0	0.0	0	2	1
KG-3	97.0	3.0	0.0	0	2	1
KG-6	98.8	1.2	0.0	0	2	1
KG-7	0	6.9	93.1	0	2	3
KG-8	0	8.4	91.6	0	2	3
KG-9	0	66.2	33.8	0	2	2

Table 1. Percentage land cover in buffered well zones, and land cover of 1978 and 2009 relevant to corresponding wells. For land cover of 1978 and 2009 (the right two columns), 1 stands for Forest, 2 for Grass, 3 for Urban and 4 for Water.

## **Literature Cited**

EPA, 2009. National Primary Drinking Water Regulations, EPA 816-F-09-004, May 2009.

EPA Pacific Southwest/Region 9, 2006. *EPA Progress Report 2006*, San Francisco, California.

Wen, Y. and D. Chambers. (2014). Land cover change detection in Saipan, *Technical Report 149*, Water and Environmental Research Institute of the Western Pacific, University of Guam.

# Continuation and expansion of data collection for sewage treatment pilot study on Yap with addition of a composting pilot test for reuse of waste sludge

## Basic Information

<b>Title:</b>	Continuation and expansion of data collection for sewage treatment pilot study on Yap with addition of a composting pilot test for reuse of waste sludge
<b>Project Number:</b>	2015GU289B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Engineering
<b>Focus Category:</b>	Wastewater, Education, Treatment
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Joe Rouse

## Publication

1. Rouse, Joseph D.; 2015, Studies on Enhancement of Sewage Treatment and Composting of Sludge on Yap Island. Second Conference on Water Resources Sustainability Issues on Tropical Islands, Honolulu, Hawaii; December 1-3, 2015. (Conference Presentation with Abstract)

# PROJECT SYNOPSIS REPORT

**Project Title:** Continuation and expansion of data collection for sewage treatment pilot study on Yap with addition of a composting pilot test for reuse of waste sludge

## **Problem and Research Objectives**

The sole sewage treatment plant (STP) on Yap Island in the Federated States of Micronesia consists of an Imhoff-tank system with dual, parallel channels, which by design provides only a primary level of treatment with little more than removal of easily settle able solids. Upgrading to achieve a secondary level of treatment by constructing a biological process for removal of dissolved organic compounds would require a major capital investment and be met with higher O&M costs as well. However, the possibility exists of fitting a biofilm process to the existing structure, which would allow for retention of beneficial biomass resulting in enhanced treatment efficiency. The objectives of the proposed project are to evaluate the addition of an attached-growth process to the existing primary treatment system and to determine an effective procedure for composting the waste sludge. These objectives were met by fitting frames with attached biocarrier material to the flow channel of the existing Imhoff tank and quantifying removal of contaminants across the biocarrier zone over time; in addition, pilot-scale composting was employed to assess the potential of this environmentally friendly technology to cut pathogens from the municipal waste sludge.

## **Methodology**

The methods employed over the course of this project incorporated civil engineering fieldwork and water quality laboratory analyses. The work was carried out under the supervision of the Principal Investigator (PI) and the manager of the Water and Wastewater Division of Yap State Public Service Corporation (YSPSC). As an aggregate indicator of organic compounds in the sewage, chemical oxidation demand (COD) was quantified, which required a significant part of the first-year's budget. For the composting pilot test, a simple wooden frame structure was used. Guidance was followed from proven sources, but some adaptation was necessary to determine the best mix ratio of grass cuttings and dried sludge and turning/mixing frequency. The Yap EPA staff assisted with monitoring of pathogens, which required adapting their liquid-based method for use with solid sludge.

## **Principal Findings and Significance**

### Wastewater treatment

To explore the possibilities for achieving a higher degree of treatment in a cost-effective and sustainable manner, a pilot test was initiated using an attached-growth process for retention of beneficial biomass consisting of a mesh material fixed to PVC-pipe frames. After insertion of the complete complement of frames, wastewater was then directed to flow through the maze-like configuration in the pilot test (Figure 1).

Initial results during the six-month startup period from June through December 2014 indicated extreme variations in influent COD levels (data shown in 2014 Project Synopsis Report). With closer observation of weather conditions, it became evident that this was due to dilution by storm-water intrusion. Thus, subsequent efforts were made to avoid sampling immediately

following rain-fall events. At the end of this startup period, a visual check was made of one of the biocarrier frames confirming a healthy growth of biofilm (Figure 2).



**Figure 1.** Wastewater flow directed through the biocarrier frames.



**Figure 2.** Inspection of a biocarrier sheet showing biofilm growth.

Sampling across the STP over a 14-month period was conducted as shown in Table 1. For evaluation of the pilot test, treatment performance across the whole channel was considered with samples drawn at stations 1 and 5. Background, or control, data was obtained from testing with the wastewater flow directed through the channel without the biocarrier material. These results revealed a COD removal efficiency of only 1.5% (SD = 14%, n = 8), with a COD cut of approximately 6 mg /L.

With wastewater flow directed through the channel with the biofilm pilot, treatment performance was enhanced to 15% (SD = 17%, n = 10), with a COD cut of approximately 59 mg/L. This indicates an improvement contributable to inclusion of the biocarrier by a factor of 10, or an order of magnitude. Defining the surface area that accommodates biofilm growth to be the two sides of the biocarrier sheets included in the central 1/3 of the channel, the specific area amounts to approximately 1 square foot (SF) of surface/ cubic foot (CF) of tank volume. It was not demonstrated here that a linear increase in treatment efficiency would follow with an increase in surface area, though it would not be unreasonable to assume a further improvement to 30% or even 60% removal efficiency would be possible.

Table 1. Time course of COD levels across the treatment plant. Results are from channel without (control) or with biofilm material as indicated. Biofilm material had exposure to influent flow since June 2014.

Sample station →	1	2	3	4	5
Date (2015)	Flow directed to open channel (without biofilm)				
1/23/15	331	273			234
1/30	328	290			285
2/6	256	272			254
2/11	330	300			340
2/13	297	305			295
3/27	355	425			383
4/24	223	289			246
4/30	Flow directed to biofilm channel				

5/16 (with bio.)	464	476		301	311
5/19 (with bio.)	349	286		260	284
7/10 (with bio.)	389	280		282	311
7/24 (with bio.)	311	315		310	293
8/21 (with bio.)	267	363		280	290
9/25 (with bio.)	389	280		282	311
10/2 (with bio.)	424	384		339	394
10/9 (with bio.)	362	274		216	214
10/16 (with bio.)	294	268		219	326
Late October	Flow directed to open channel (without biofilm)				
11/6	309	355			341
Mid December	Flow directed to biofilm channel				
2/5/16 (with bio.)	334	243		232	259
2/28	End of project funding				

### Composting of excess sludge

Partially digested excess sludge is drawn from the under chambers of the Imhoff tanks approximately four times per year. This sludge is then held on a drying bed for one week prior to intended disposal in the solid-waste landfill. Prior to delivery to the landfill, though, this material is always taken away by local farmers for use as a soil amendment for production of food crops. Accordingly, composting pilot tests were conducted consisting of excess sludge and grass cuttings (straw), which are both in abundance at the STP.

For the first round of testing (of 6/24/2015, Table 2), two bins were loaded with three layers of sludge sandwiched within four layers of straw. Each bin was loaded with 75 lbs of sludge and 100 lbs of straw (wetted to an estimated 50% moisture content) for a total of 175 lbs per bin (or 350 lbs for the two bins combined). Temperature was monitored and was shown to climb steadily from 90°F to a peak of 120°F in a period of one week, after which it gradually dropped down over one week to a plateau of approximately 92°F, which was maintained for two more weeks prior to assuming what appeared to be an ambient temperature of approximately 85°F.

As shown in Table 2, the initial sludge used for the test was overloaded with both total coliform and *E. coli* (both > 2,400/g). Samples collected from the mid sections of both bins after 42 days indicated total coliform was still > 2,400/g; *E. coli*, though, had dropped greatly to a most probable number (MPN) of 21/g (Table 2, 8/6/15). The contents of both bins were then combined and the moisture content raised to approximately 50% and left to cure until the next site visit. Upon return (1/14/16), the contents looked and smelled like a rich garden soil and *E. coli* had dropped to zero (0), while total coliform persisted at > 2,400/g.

At that time, sampling was conducted to determine background levels of these indicators, by which it was shown that total coliform bacteria were at high levels (> 2,400/g) in nearby natural soil. This indicates that total coliform does not always serve dependably as an indicator of human contamination, considering that the same soil and nearby sand were found to be absent of *E. coli* (Table 2, 1/14/16).

Table 2. Time courses of composting tests. MPN of bacteria based on one gram of sludge or compost material suspended in 100 mL of sterile water with standard nutrients.

Date & description	Total Coliform MPN/g	E. coli MPN/g	Comments
6/24/15, raw sludge	> 2,400	> 2,400	After 7 days on drying bed
8/6/15, 42-day compost	> 2,400	21	From mid part of compost heap
1/14/16, cured compost *	> 2,400	zero	From mid part of compost heap
1/14/16, natural soil	> 2,400	zero	Ca. ½” below surface
1/14/16, near-by sand	7.5	zero	Ca. ½“ below surface (sun baked)
1/14/16, raw sludge	> 2,400	> 2,400	After 5 days on drying bed
2/25/16, 42-day compost	> 2,400	10	From mid part of compost heap

\* Compost heap remaining since 8/7/16. Odor and texture of cured compost appeared as ordinary garden soil – totally un-offensive.

The second round of testing (of 1/14/16), as before, started off with total coliform and E. coli both being > 2,400/g. For this round only one bin was used, which was loaded with 12 layers of material, each consisting of 30 lbs of air-dried sludge, 25 lbs of straw (wetted to 50% moisture), and one shovel of seed compost (ca. 5 lbs, from previous test). These components, manually mixed for each of the 12 layers, totaled 720 lbs of material. In addition, a layer of dry straw was included under and above the mix (25 lbs each). Furthermore, two pipes were inserted, which would allow for some ventilation

In this case, the higher sludge content and a larger volume of material was used in hopes that a greater activity would be achieved. In addition, due to the under- and over-lying straw “blankets,” following 42 days of composting the contents still appeared to be at a proper moisture level of approximately 50% (i.e., with a dark, wet appearance). Under these testing conditions, the E. coli count was further cut to an MPN of 10/g (Table 2, 2/25/16).

The results obtained here are not meant to give us a final design for a full-scale composting project at the STP; they do, though, show that the sludge is compostable and that such a project should be undertaken, and could be done at a very minimal cost. Even without the total cut required for food crop application, such a product could still be used for reparation of badlands, etc. One must recall, that currently even the raw sludge is being used for food crops, thus any improvement would be a big help.

## Information Transfer Program Introduction

WERI's research activities focus predominantly on local water resources problems and issues identified largely through discussions with regional stakeholders at our annual advisory council meetings. Disseminating the results of these investigations to appropriate governmental agencies, environmental managers, policy makers and other local decision makers in the water resources business, has the highest priority and is accomplished in various ways. Institutional technical reports remain a strong vehicle for transmitting such information to our target audiences, many of whom are remotely situated and do not have access to the scientific literature, or require a greater degree of detail than is normally permissible in a standard journal publication. Our recently improved website <http://www.weriguam.org/> is gaining increased popularity among professional circles, both at home and abroad. It features most recent technical reports that can be download informational links to WERI faculty, staff and Institutional facilities, our current research, and education and training activities. In addition, WERI revealed a unique digital data repository for Guam Natural Resources Atlas of Guam [www.hydroguam.net](http://www.hydroguam.net). This includes accurate baseline information for sustainable development that is available to anyone involved in resources management studies. We are in process to develop a similar one for the FSM. WERI faculty have also become increasingly more interactive with audiences overseas in recent years by sharing their research findings at professional meetings, conferences and workshops at the national and international level. Our annual Advisory Council meetings in Guam, the CNMI and the FSM are highly effective information transfer mechanisms, bringing together people who typically have little to no contact with one another during the rest of the year. These meetings serve as a valuable forum of information exchange and discussion on common issues, problems and needs in the water resources arena. We remain strong in our commitment to teaching and training the up-and-coming water resources professionals of tomorrow, in addition to conducting workshops, training, courses and seminars for those currently employed in this area. Educating the students and teachers on the importance of protecting and preserving our fresh water resources remains one of the institute's high priority areas. WERI faculty also continue to be major and effective participants in water related issues and policy making on Guam by serving as committee members and chairs on numerous governmental boards and by giving testimony at legislative oversight hearings, and private meeting with the Governor.

# Workshop Series on Guam Groundwater Resources

## Basic Information

<b>Title:</b>	Workshop Series on Guam Groundwater Resources
<b>Project Number:</b>	2015GU283B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Category:</b>	Education, Groundwater, Hydrology
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	John Jenson, Nathan C Habana

## Publication

1. Jenson, J.W., Danko, Taborosi, 2015, Professional Field Trip of the Northern Guam Lens Aquifer, WERI, 33pp. <http://www.weriguam.org/>

# PROJECT SYNOPSIS REPORT

**Project Title:** Workshop Series on Guam Groundwater Resources

## **Problem and Research Objectives**

The military buildup and ongoing economic growth anticipated on Guam over the next decade has raised concerns regarding sustainable management of Guam's groundwater resources. To support informed management decisions island policy-makers, agency heads, water resource professionals, and educators must be equipped with an accurate and up-to-date understanding of the essential characteristics of the island's aquifer and the factors that must be considered to frame and implement sustainable management practices. Professional people, however, have extremely limited time to engage in instructional opportunities. This project delivered a series of workshops, each of which completed in a single-day, to local water resource professionals and educators. The workshops included (1) a field trip of the aquifer, and instruction in (2) the Northern Guam Lens Aquifer Database, (3) the basement map of northern Guam, and (4) aquifer recharge and salinity trends, patterns, and processes in the aquifer. Instruction was supported by a Moodle website containing the instructional materials plus additional references and links to other relevant and useful resources, and forums for maintaining continuing educational interaction and information-sharing.

## **Methodology**

Each offering consists of a single full day of instruction. Materials for the course were extracted and modified from existing materials developed for previous courses. In addition, a new permanent web-page is being set up and equipped with a discussion board where former students and other users can engage in discussions or ask questions, etc. New features for the webpage will include additional maps and cross-sections that can be accessed and used by course participants and other users. Each set of users had access to resources designed to support their various needs: technical professionals, university and community college instructors, and secondary school educators. The instruction carried professional development credit through the University of Guam's Office of Professional and International Programs (PIP).

## **Principal Findings and Significance**

The aquifer field trip was conducted on April 14, 2015 in conjunction with the annual meeting of the Guam Section of American Water Works Association meeting and annual Pacific Island Sustainability Conference conducted by the University of Guam's Center for Island Sustainability. Participants included professional staff from the Guam Waterworks Authority, the Office of the Governor of Guam, and graduate students from the University of Guam. Participants visited four locations, where they observed in the field the rock units and geologic features that comprise the aquifer. Workshops for the aquifer database, basement map, recharge and salinity were conducted on June 10, 2015. A total of thirty (30) people from various Government of Guam's agencies, private sector engineers, faculty, teachers, and private citizens attended the workshop.

# REVIEW OF HYDRAULIC ANALYSIS METHODS AND ADVANCED MODELING TECHNIQUES USING THE EPANET WATER DISTRIBUTION SYSTEM MODEL

## Basic Information

<b>Title:</b>	REVIEW OF HYDRAULIC ANALYSIS METHODS AND ADVANCED MODELING TECHNIQUES USING THE EPANET WATER DISTRIBUTION SYSTEM MODEL
<b>Project Number:</b>	2015GU286B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Engineering
<b>Focus Category:</b>	Education, Water Supply, Models
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Leroy F. Heitz, Brian Bearden, Shahram Khosrowpanah

## Publications

There are no publications.

## **PROJECT SYNOPSIS REPORT**

**Project Title:** Review of Hydraulic Analysis Methods and Advanced Modeling Techniques Using the EPANET Water Distribution System Model

### **Problem and Research Objectives**

Water hours and low delivery pressure have long been a part of the daily lives of the people in the islands of the Western Pacific. In Saipan, Commonwealth of the Northern Mariana Islands (CNMI), large investments have been made in system improvements, but delivery problems still exist. A stated goal of the CNMI government is to provide 24-hour water to all residents served by the Commonwealth Utilities Corporation (CUC) water system.

Hydraulic modeling of water systems has proven to be a valuable tool used by water system engineers to maintain and improve the delivery systems for which they are responsible. Previously, WERI Engineers carried out training programs in the application of water system modeling to the Saipan water system. New personnel at CUC have not had the benefit of the original training and some of those originally taking the courses have not had the opportunity to apply these models and maintain the skills required to use the models effectively.

The objective of this training project was to conduct a training course in the use of water system modeling so that all the employees could be “Brought Up To Speed” in the use of water system modeling to improve the CUC system.

### **Methodology**

A syllabus for the hydraulic modeling training course is shown on the following pages. The first three sections of the training consisted of lectures and students performing calculation of typical hydraulics problems confronting water system engineers. The modeling phase of the training involved hands on training for developing and applying a sophisticated water system model to real world data. The non-proprietary water system modeling program EPANET developed by the US Environmental Protection Agency was used as the primary teaching tool for this phase of the training. This program is easy to apply yet very powerful in its analysis capabilities. The EPANET program can exchange file formats with the existing model that has been developed for the CUC system. Student example exercises used were taken from the actual CUC water distribution system. Lectures also included exchanging data with GIS applications.

Each student provided his own PC based laptop computer for the training. We loaded the EPANET program on each of the students’ computers along with the required user manuals and sample data. Portions of the existing CUC water system model were downloaded in EPANET format for use by students in the class. The free GIS program “QGIS” was provided to students for use in the GIS data exchange exercises.

Major topics covered in the modeling portion of the training included:

1. Pipe flow and network hydraulics
2. Water distribution system modeling and model assembly
3. Valves and controls
4. Assigning use patterns and using backdrops
5. Using ARCGIS and QGIS with EPANET
6. Developing models from Student examples

This phase of the training developed employees with expertise in the application of the EPANET modeling tools. This expertise will allow CUC engineers to better operate and maintain the CUC system and to explore various options for various expansions and improvements to the system.

**Course Syllabus – Water System Hydraulics & Modeling**

<b>Section</b>	<b>Topic</b>	<b>Instructor</b>	<b>Hours</b>
I.	Review of Hydraulics Fundamental	Dr. Khosrowpanah and DEQ Staff	12
II.	Anatomy of a Water Distribution System	Dr. Khosrowpanah and DEQ Staff	4
III.	Pump Performance Modeling	Dr. Khosrowpanah and DEQ Staff	4
IV.	Pipe Flow and Network Hydraulics	Dr. Heitz	5
V.	Water Distribution System Modeling and Model Assembly	Dr. Heitz	4
VI.	Valves and Controls	Dr. Heitz	4
VII.	Assigning Use Patterns and Using Backgrounds	Dr. Heitz	4
VIII.	Using Arc GIS and QGIS with EPANET and Student Examples	Dr. Heitz	4
	<b>Course Total Hours</b>		<b>41</b>

**Principal Findings and Significance**

This training course provided CUC Engineering Staff with expertise in the use of water system modeling so that this powerful engineering tool could be used to better operate and maintain the CUC system and to explore various options for various expansions and improvements to the system. A total of seven (7) engineers from CUC engineering section attended the training and successfully completed the training course and received a certificate of completion as shown below.



Saipan, CUC’s Engineers Completed the Training Course, January 2016

## Water System Leak detection Training for Yap State Public Services Corporation (YSPSC)

### Basic Information

<b>Title:</b>	Water System Leak detection Training for Yap State Public Services Corporation (YSPSC)
<b>Project Number:</b>	2015GU290B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Engineering
<b>Focus Category:</b>	Education, Water Supply, Management and Planning
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Charles Falmeyog, Shahram Khosrowpanah

### Publications

There are no publications.

# PROJECT SYNOPSIS REPORT

**Project Title:** Water System Leak detection Training for Yap State Public Services Corporation (YSPSC)

## **Problem and Research Objectives**

Water system leakage is a common problem for every utility agency. It reduces the performance of the system and causes financial losses for utilities. A healthy water system can have up to 20% leakage. This is depending up on the age of the system components such as pipes, valves, meters, and the system operation. This problem is more serious in the Western Pacific. The development of modern water distribution systems for most of the islands in this area started in 1970. Since then the systems have been upgraded through a series of US sponsored capital improvements projects. However, system leakage for some of these islands is as high as 60%. Utility agencies are suffering from lost revenues and are not able to provide 24- hour water service to their customers. Leak detection is one of the most cost effective and efficient ways to reduce non-revenue water. In fact, a leak detection program should be the highest priority with each utility agency. It is cost effective, and has the immediate results of increasing the system performance. In response to these unique circumstances, a special training program has been designed for FSM. The training concentrated on water system leak detection for Yap State Public Services Corporation (YSPSC). The specific objective of this training was to increase the technical understanding of: 1) system leakage theory, 2) application of leak detection, 3) how to manage the leakage, and 4) use state of the art leak detection equipment. This specific training was requested by the Yap State as part of the WERI advisory council meeting held in October 2014.

## **Methodology**

The training was conducted on August 2015, and it was consisted of a one week long workshop that provided an understanding the leak detection theory and how to find leaks and fix them. As can be seen from the schedule below (Table 1), the training provided a mix of classroom, laboratory and field site instruction and hands-on activities. The YSPC provided the required classroom and shop space to carry out the training.

The instructor who led the training was Mr. Jeff Benjamin, field services/training from Utility Services Associates. This company is based in Washington and they specialize in leak detection.

Upon completion of the workshop the attendees had a much better understanding of key operation and maintenance activities required to sustain functioning water distribution and wastewater collection systems with special emphasis on pump repairs and operation.

## **Table 1. Training activities**

### **A. Classroom Training covering the following topics (Approximately 1.5 day):**

1. Introduction to a leak detection program / theory.
2. Explanation of how leak sounds originate. Discussion of leak sound transmission through different types and sized of pipe
3. Explanation of “Acoustic Leak Survey” & each type of survey including permanent monitoring. Introduction to survey tools/ equipment and the benefits of each.
4. Leak sounds exercise – (class did very well with this test)
5. Discussions and recommendations of paperwork / reporting practices that may be utilized in the field. Distributed field forms to attendees for consideration
6. Hands on experience to cover the operation of the LD-12 leak detection
7. Started discussion on correlation theory and explained how a correlator locates water leaks
8. Discussed three rules of correlation, best contacting practices, and correlation formula that enables the correlator to measure time delay

### **B. Field Training covering the following topics (Approximately 3.5 days):**

1. Demonstration of equipment
2. Hands on training and field practice on pinpointing leaks, estimating leakage, reporting, and review

### **C. Equipment:**

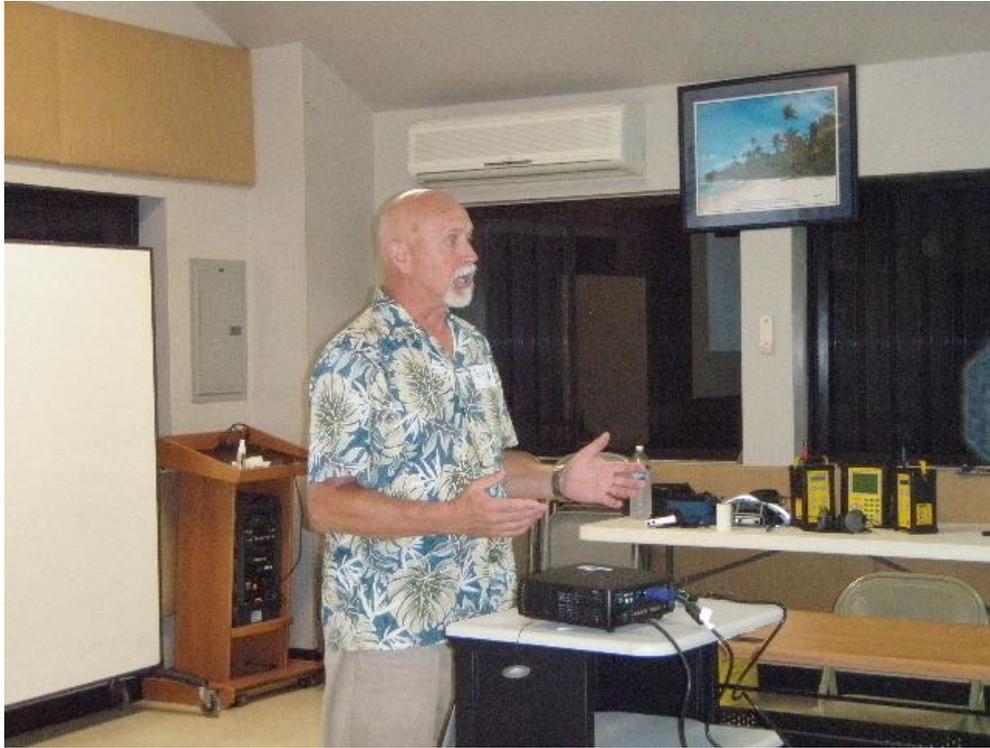
The following equipment was used during the training:

1. Subsurface Leak Detection LC2500 leak noise correlator
2. Fluid Conservation System S-30 leak noise surveyor
3. Subsurface Leak Detection LD-15 leak noise detector
4. Subsurface Leak Detection LD-12 leak noise detector
5. Subsurface Instruments PL-2000 pipeline locator
6. Subsurface Instruments ML1 Ferrous locator
7. Probe rods
8. Audio and visual media presentations

## **Principal Findings and Significance**

A total of fourteen (14) people working at the Yap State Public Services Corporation (YSPSC) completed the training. The training covered leak detection theory, and how to determine when a leaky survey is required, economic benefits of a leak detection survey, how to incorporate a leak detection survey, how to become familiar with various sounds created by leaks and type of leaks encountered, types of leak detection surveys and proper record keeping, get familiar with various leak detection equipment and techniques, and field demonstration and actual leak detection scenarios and exercises. Class , field activities, and those that completed the training are shown in Figure 1, 2,3, and 4.

The net result of this training is increased knowledge of YSPSC personnel on water conservation and leak detection technology. The benefits will be a reduction of non-revenue water and better management of one of Yap Island’s most valuable resources, its water. As always our goal will be to help provide the local government with on-island capabilities to maintain water supplies that that can provide safe drinking water for the entire island on a 24-hour basis.



**Figure 1. Class room lecture presentation**



**Figure 2. Students learning in class**



**Figure 3. Student at field**



**Figure 4. Students Completed the Training**

# Sustainable Conjunctive use of Groundwater and Rain Catchment Water under Variable Climatic Scenarios for Atoll Island Communities of Yap State: Ifalik, Eauripik, Satawal, Ulithi

## Basic Information

<b>Title:</b>	Sustainable Conjunctive use of Groundwater and Rain Catchment Water under Variable Climatic Scenarios for Atoll Island Communities of Yap State: Ifalik, Eauripik, Satawal, Ulithi
<b>Project Number:</b>	2015GU291B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Category:</b>	Groundwater, Hydrology, Models
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	John Jenson

## Publications

1. Wallace, C.D., R.T. Bailey, and J.W. Jenson, 2015, Atoll Island Freshwater Resources: Modeling, Analysis, and Optimization, Water & Environmental Research Institute of the Western Pacific, Technical Report #155: 147 p.
2. Wallace, C.D. and R.T. Bailey, 2015, Estimation of future freshwater lens volume of Micronesian atoll islands, Conference of the American Water Resources Association, Tyson's Corner, Virginia. (Program and Abstract)
3. Wallace, C.D. and R.T. Bailey, 2015, Estimation of future freshwater supply of Micronesian atoll islands using simulated climate data. In J. Ramirez, abstract in: Proceedings of the XXXV American Geophysical Union Hydrology Days, Fort Collins, CO. (Program and Abstract)
4. Wallace, C.D. and Bailey, R.T. and M. Arabi, 2015, Rainwater catchment system design using simulated future climate data. *J. Hydrology* 529, 1798-1809.
5. Biekmann, A.M. and R.T. Bailey (2016), Water resources on outer-lying islands in Micronesia. In J. Ramirez, abstract in: Proceedings of the XXXVI American Geophysical Union Hydrology Days, Fort Collins, CO.
6. Biekmann, A.M., 2016, Water Resources on Outer-Lying Islands in Micronesia. Thesis. Colorado State University, Fort Collins, CO.

## **PROJECT SYNOPSIS REPORT**

**Project Title:** Sustainable Conjunctive use of Groundwater and Rain Catchment Water under Variable Climatic Scenarios for Atoll Island Communities of Yap State: Ifalik, Eauripik, Satawal, Ulithi

### **Problem and Research Objectives**

This year's atoll modeling study focused on modeling conjunctive use of rain catchment and groundwater to support management of drinking water resources on outlying low islands of Yap State: Ifalik, Eauripik, Satawal, Ulithi. Water shortages are a persistent concern for residents of atoll islands. Under normal rainfall conditions, water demand is able to be met by rooftop rain catchment, but prolonged droughts, such as those associated with ENSO events in the western Pacific region, can exhaust water storage, leaving residents dependent on groundwater or imported water from distant islands. The conjunctive availability of these water sources varies in time according to climatic stresses such as decadal patterns in rainfall variability, drought, and sea-level rise, and hence these must be taken into account in the analysis.

### **Methodology**

WERI researchers have developed an accurate, readily portable groundwater management spreadsheet tool that is based on results from numerical modeling simulations. Beginning in April and May 2008, and continuing into August 2009, October 2010, and October 2011, the developers of the model presented demonstrations of the groundwater management tool to a limited number of available water resource managers and government officials, and during 2011-2012 the model was calibrated against observations in the FSM and used to predict the estimated freshwater lens thickness during average rainfall and intense drought conditions for each atoll island within the FSM (Bailey and Jenson, 2011; Bailey et al., 2012). During the previous year, a new spreadsheet tool was created that incorporates results of the groundwater modeling tool with daily rain catchment estimates using generic rain catchment storage dimensions and daily rainfall data. For the daily rain catchment storage estimates, a simple mass balance approach is used. The tool can be used to assess groundwater and rain catchment volumes during average rainfall or drought conditions, and can also be used to design a community's rain catchment system that will maintain adequate freshwater volumes during drought conditions. The tool was presented to the FSM Advisory Council and other water and environment personnel in October 2014, and training was conducted. In addition to using results from the groundwater management tool, three-dimensional models of the freshwater lens for the four islands were created using the USGS groundwater modeling code SEAWAT (Langevin et al., 2008). The models were run under historical and future-predicted rainfall conditions to determine the vulnerability of groundwater to drought and long-term rainfall patterns. For rooftop rainwater catchments, the daily water balance model was used to prepare "Design Curves" which can be used to size guttered rooftop areas and/or storage tank volumes to meet a certain level of reliability during drought conditions.

### **Principal Findings and Significance**

This project built on the previous year's results by using the new groundwater-rain catchment storage calculator to assess daily freshwater water supply for Ifalik, Eauripik, Satawal, Ulithi. Three-dimensional modeling of the freshwater lens using the USGS code SEAWAT (Langevin

et al., 2008) was also used to assess lens thickness and lens volume. These assessments were performed under various climatic scenarios, such as rainfall variability, drought, and sea-level-rise to provide a broad range of application. Results were presented, along with training on the model, to the FSM water and environmental officials at the FSM Advisory Council in October 2015, and educational pamphlets were prepared for distribution to FSM atoll island schools. The numerical modeling simulations indicated that three of the islands (Ifalik, Satawal, Ulithi) can have sufficient groundwater resources under future climate scenarios if extensive groundwater pumping is not used and if groundwater contamination can be prevented. For rainfall storage, the created Design Curves can be used by island communities as an engineering tool to design or modify rainwater catchment systems.

community-based engagement for Watershed Forest Reserve to conserve and protect our fresh waters ecosystems in Pohnpei

# Enhance the network of community-based engagement for Watershed Forest Reserve to conserve and protect our fresh waters ecosystems in Pohnpei, Federated States Micronesia-FSM

## Basic Information

<b>Title:</b>	Enhance the network of community-based engagement for Watershed Forest Reserve to conserve and protect our fresh waters ecosystems in Pohnpei, Federated States Micronesia-FSM
<b>Project Number:</b>	2015GU292B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Water Quality
<b>Focus Category:</b>	Water Quality, Management and Planning, Models
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Joseph Eugene, Francisca Sohl Obispo

## Publications

There are no publications.

## PROJECT SYNOPSIS REPORT

**Project Title:** Enhance the network of community-based engagement for Watershed Forest Reserve to conserve and protect our fresh waters ecosystems in Pohnpei, Federated States Micronesia-FSM

### **Problem and Research Objectives**

The Conservation Society of Pohnpei (CSP) continues its 16<sup>th</sup> year of preserving Pohnpei's natural heritage and looks forward to strengthen a comprehensive effort as issues associated with effective conservation of island ecosystems become increasingly crucial for growth and sustainability in the state of Pohnpei. In 2002, the establishment of the Federated States of Micronesia's (FSM) National Biodiversity Strategic Action Plan (NBSAP) set the stage for biodiversity conservation in the country. CSP identified the need to empower communities to protect Pohnpei's biodiversity in which networks of community-based protected areas were established with long-term goals of self-sustenance and increased collaboration towards biodiversity conservation and management in Pohnpei. Poor land management practices in the uplands continue to be detrimental for ecosystems downstream. A watershed steering committee has continued to pursue ways to improve management of Pohnpei's forest reserves. CSP aims to improve community access to information and resources to carry out implementation of Pohnpei State's conservation policy and including fresh water regulations.

The objective of this project was *to improve the network of community-based engagement for Pohnpei's Watershed Forest Reserve to conserve and protect our fresh waters ecosystems while improving conservation policy by merging modern science and traditional resource management.*

### **Methodology**

To accomplish the project goal several activities were taken:

1. Conducting a series of water workshop and share fresh water regulations in the communities by developing and implementing their Conservation Action Plans. During the month of June 2015, CSP has conducted several water workshops with community in Madolenihmw and Sokehs (Figure1), they have shared the fresh water regulations and develop a conservation action plan for Lehiak community in Madolenihmw.
2. Improving the community-based watershed management programs. The Conservation Society of Pohnpei and the Pohnpei State Division of Forestry in collaboration with the Pohnpei Forest Rangers have conducted and completed 2015 forest monitoring. They have conducted their first monitoring on April 2015, second forest monitoring on June 2015, third quarter on November 2015.
3. Creating an interactive program to motivate local compliance to improve/maintain water quality: CSP has helped the communities identified source of pollution that affecting the water qualities. Main sources of pollution including: pigpens, trashes and outhouses.

## **Principal Findings and Significant**

As the result of the community workshops the Madolenihmw community identified several threats including less water or not enough water, pigs freely roaming around in their community, unmanaged agriculture farming practices and uncompleted roads. Pigs freely roam around and they cannot use the small streams or ground water. Unpaved road causes more runoff or sediment into the ocean and killing the corals and marine lives.

In Sokehs, most people were depending on the water that was distributed from Pohnpei Utilities Corporation, which people pay to use it. This water system they only use for cooking and showering, drinking water supply is either from the ground or purchasing from the water companies. Sokehs community has identified that trash; unmanaged farming activities; outhouses, and pigpens affect their land and their source of water from the ground. Trash, Sokehs municipal Government has help pick up trash and dispose it at the Pohnpei waste management. Pohnpei EPA has recommended people or communities to follow regulations regarding building outhouses and pigpens. Other recommended way to reduce pig waste is dry litter system but it still not yet practice in Sokehs.

The forest monitoring program that was completed on November 2015 shows that there were no clearings found in the Watershed Forest Reserve WFR of **Madolenihmw and U Municipalities**. CSP and Forest rangers are still continuing with the forest monitoring to keep collecting data and making sure that people are not clearing the forest.

CSP developed interactive program to improve and maintain water quality. CSP has work with several communities identifying their needs and ways they can work together to improve their water quality. Lehiak community in Madolenihmw municipality since their pigs are freely roaming around, the community has identified to do fencing around their ground waters to keep the pigs away. They have identified that they need to do a community clean up to maintain their waters, and not to build outhouses above or close to their ground waters. They also identified that they would need water tank to collect rain water. The community would seek other supports from other partners to help on water tank and other project that will help improve and safe their waters from contaminated.

The final valuable lesson that was learned was "community initiatives would never be effective without government legislations and government projects would not be successful without community participation". This new initiative will unite our successes and communicate lessons learned throughout Micronesia.



Figure 1. Pohnpei Island, FSM

## Second Conference on Water Resource Sustainability Issues on Tropical Islands

### Basic Information

<b>Title:</b>	Second Conference on Water Resource Sustainability Issues on Tropical Islands
<b>Project Number:</b>	2015GU293B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Not Applicable
<b>Focus Category:</b>	Education, Water Supply, Management and Planning
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Shahram Khosrowpanah

### Publication

1. Khosrowpanah, Sh., Mark Lander, 2015, Watershed Management: Ugum, Pit-Asan, and Geus Watershed, Second Conference on Water Resources Sustainability Issues on Tropical Islands. Abstracts. Honolulu, Hawaii, December 1-3.

# PROJECT SYNOPSIS REPORT

**Project Title:** Second Conference on Water Resources Sustainability Issues on Tropical Islands

## **Problem and Research Objectives**

Islands Region of the National Institutes for Water Resources are faced with a unique set of environmental and cultural issues pertinent to the management of water resources. Due to geographic isolation, limited physical resources, unique ecosystems, and susceptibility to natural disaster, tropical islands face immediate challenges in meeting the demand for safe and adequate drinking water supplies. The great distances that separate most island states from larger centers of academia and government mean that there is less frequent exchange between researchers on the islands and their colleagues in the major population centers. Enhanced communication and collaboration between island researchers can provide a vital, synergistic link which will strengthen all the researchers programs.

In response to these needs, the Island Institutes (Guam, Hawaii, Puerto Rico, U.S. Virgin Islands) will convene a conference in Honolulu, Hawaii during December 2015. The conference was a follow-up to a conference held by the institutes in November 2011 (Water Resource Sustainability Issues on Tropical Islands Conference, November 14-19, 2011, Honolulu, Hawaii) to provide a platform for discussion between water resources researchers and others on existing water resources issues facing tropical islands and those issues that are likely to develop in the future particularly due to the anticipated changes in climate.

## **Methodology**

The University of Guam, Water and Environmental Research Institute of the Western Pacific (WERI) with other water resources research institutes in the Island Region of the United States (Hawaii, Puerto Rico, and the US Virgin Islands), which are part of the Geological Survey's National Institutes for Water Resources Program sponsored "The Second Water Resources Sustainability Issues on Tropical Islands" that was held in Honolulu, Hawaii, December 1-3, 2015. The conference was a follow-up to a conference held by the institutes in November 2011 to provide a platform for discussion between water resources researchers and others on existing issues facing tropical islands and others on existing water resources issues facing tropical islands and those issues that are likely to develop in the future, particularly due to the anticipated change in climate.

## **Principal Findings and Significance**

A total of one hundred fifteen (115) attended the conference with 61 presenters from Guam, Hawaii, Puerto Rico, US Virgin Islands, US Main land, Australia, and Canada and twenty seven (27) poster presentations. Our invited lunch speaker, Senator Tom Ada, did an overview of some of the water resource challenges and solutions that we have experienced in Guam, both operational and legislative, and our outlook for the future (Figure 1). It was well received. The University was represented by Dr. Anita Enriquez, Dr. Lee Yudin and Dr. Khosrowpanah, who attended the conference (Figures 2, 3). The conference was successful, well received and it will enhance communication and collaboration between island researchers that could provide a vital, synergistic link which would strengthen all the researchers' programs.



Figure 1. Senator Tom Ada, Presenting the Distribution of Chamorro Land Trust Properties and Implication in the Northern Guam, December 2015



Figure 2. Drs. Yudin, Denton, Khosrowpanah, Enriquez, Senator Ada, Rouse, Jenson, Heitz, and Lander, December 2015

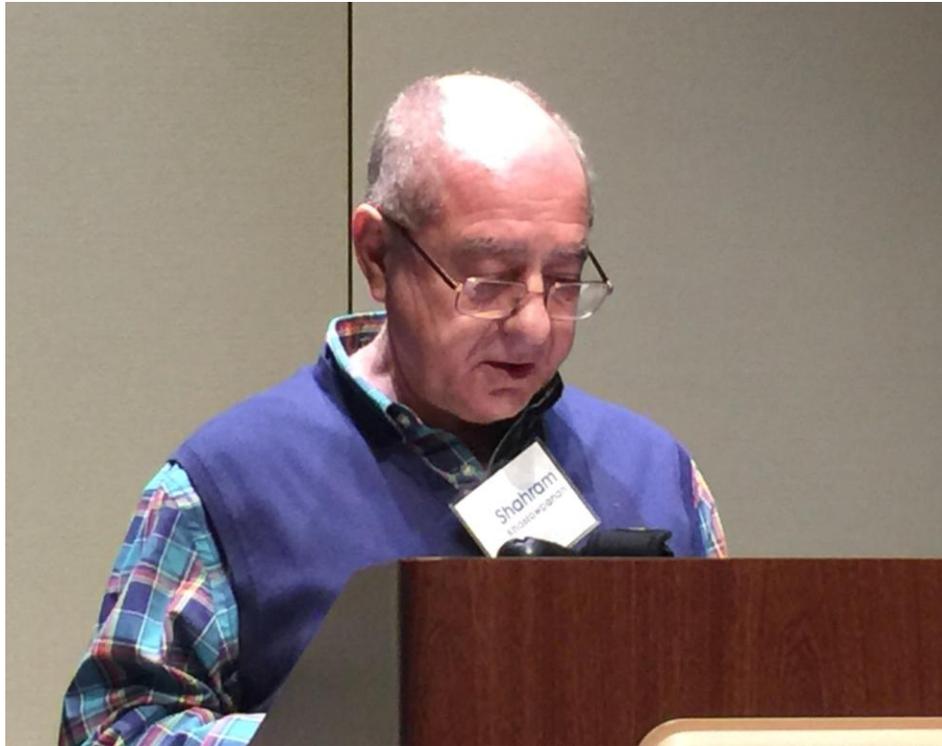


Figure 3. Dr. Khosrowpanah Presenting the Institute Activities, December, 2015

# Information Transfer

## Basic Information

<b>Title:</b>	Information Transfer
<b>Project Number:</b>	2015GU294B
<b>Start Date:</b>	3/1/2015
<b>End Date:</b>	2/29/2016
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	NA
<b>Research Category:</b>	Not Applicable
<b>Focus Category:</b>	Education, Management and Planning, None
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Shahram Khosrowpanah

## Publications

There are no publications.

## PROJECT SYNOPSIS REPORT

### Project Title: Information Transfer

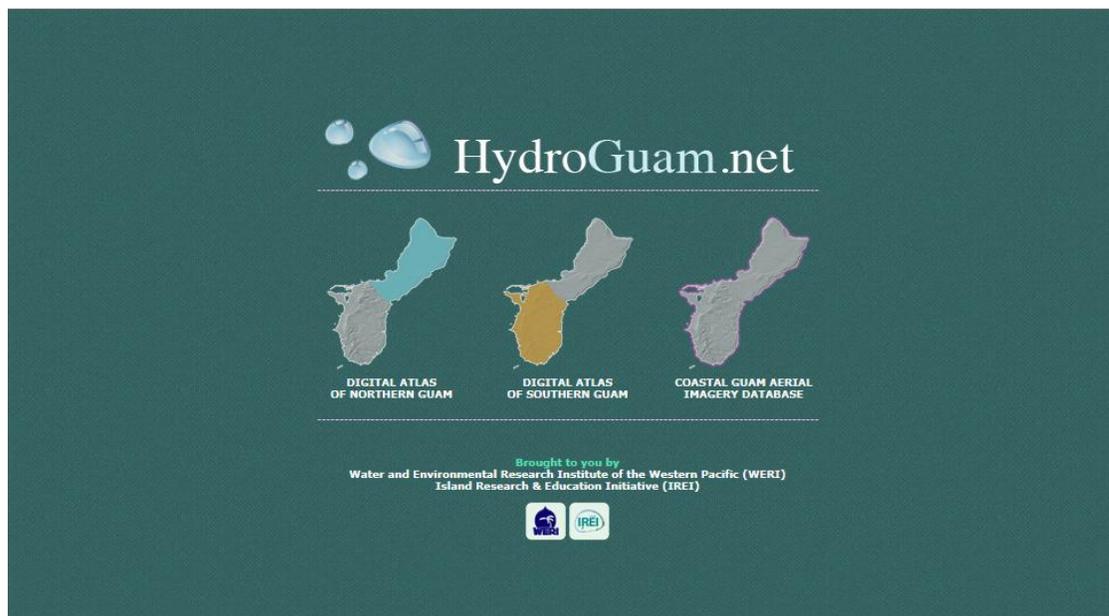
WERI's mission involves a large information transfer-dissemination component. Key elements include written forms such as brochures and pamphlets, a web site, technical reports, journal articles, newspaper columns, and book chapters. The audience for the results of USGS sponsored research is widely varied geographically and by education level. It is important that WERI make this information available in a very widely distributed form.

### *The Institute Websites*

The WERI website is the Institute's primary Information Transfer/Dissemination mechanism. The home page, shown below, is located at <http://www.weriguam.org/>. It features informational links to WERI faculty, staff and Institutional facilities, our current research, education and training activities, primary sponsors and most recent publications. The user friendly format is intended to increase visibility of the Institute's research programs and associated projects particularly for our stakeholders in remote locations where state-of-the-art internet services and computer technology are often lacking.

WERI Web-site <http://www.weriguam.org/>

In 2005, WERI revealed a unique digital data repository entitled “Natural Resources Atlas of Southern Guam”. That resource was inspired by the need for up-to-date baseline information required for sustainable development and other decision making. The atlas proved to be a highly effective data dissemination hub, as well as a much-used awareness and educational tool. At its core lay a wide range of Geographical Information System (GIS) data for southern Guam, providing valuable support for resource management and research, including hydrologic modeling, pollution prevention, soil conservation, and coastal zone management. Within a relatively short time, the “Natural Resources Atlas of Southern Guam” became so successful that in 2012 it inspired a “sister” project, which was to develop a comparable resource for Northern Guam. That work was completed in late 2013. In 2014, the southern Guam was updated to reflect the new additional information. The tool became very popular in Guam thanks to its simple and user-friendly data dissemination approach: all geospatial data are stored and formatted in such a way that the full content is freely accessible on the Internet via [www.hydroguam.net](http://www.hydroguam.net) address. The web interface also offers a range of additional textual, graphical, statistical, and geographic information to any interested user.



WERI Web-site - [www.hydroguam.net](http://www.hydroguam.net)

### ***Technical Completion Report***

Technical completion reports have always served as the cornerstone of WERI’s information effort. This project funded the design, layout and printing of five (5) major technical completion reports resulting from USGS funded research projects. Fifty (50) hard copies of each report were printed. All WERI technical completion reports are available in downloadable PDF format on the WERI web-site at <http://www.weriguam.org/reports/list>.

### ***Participation in Technical Conference***

Because of Guam’s remote location, and the escalating costs of air travel, it is difficult and costly for researchers to present their findings at technical conferences and symposiums in other parts of the Globe. A portion of the current Information Transfer Project was earmarked for off-Island

travel expenses for PI's and graduate students presenting refereed professional papers summarizing all or a portion of current or past USGS 104-B projects.

# USGS Summer Intern Program

None.

<b>Student Support</b>					
<b>Category</b>	<b>Section 104 Base Grant</b>	<b>Section 104 NCGP Award</b>	<b>NIWR-USGS Internship</b>	<b>Supplemental Awards</b>	<b>Total</b>
<b>Undergraduate</b>	1	0	0	0	1
<b>Masters</b>	6	0	0	0	6
<b>Ph.D.</b>	0	0	0	0	0
<b>Post-Doc.</b>	0	0	0	0	0
<b>Total</b>	7	0	0	0	7

## Notable Awards and Achievements

As the result of the Institute activities (Research, training, and information dissemination) that has been supported by the US Geological, Section104B, and others, WERI achieved several notable achievements during the FY2015 that are listed below.

On December 2015, WERI, along with the other water resources research institutes in the Island Region of the United States (Hawaii, Puerto Rico, and the US Virgin Islands), sponsored The Second Water Resources Sustainability Issues on Tropical Islands that was held in Honolulu, Hawaii, December 1-3, 2015. The conference was very successful attracting presenters as well as attended from the islands region, US Main land, Australia, and Canada. The Guam community was presented by Senator Tom Ada (33rd Guam Legislature), and University was represented by Dr. Anita Enriquez (UOG-Vice President), as well as Director and faculty at WERI.

On May 2014, the University of Guam undertook a thoroughgoing assessment of its programs, for a major re-prioritization and realignment of resources between programs, ranging from elimination of the weakest to heavy reallocation and investment in the strongest programs with the greatest potential (G2G Plan). From among the 60 academic and research program units that were evaluated in terms of demand, research quality, financial stability, and information dissemination, WERI was one of nine selected among 60 academic and research program units as the university's flagship programs. This recognition, gave the institute heavy additional investment and expansion over the next several years that will increase our research, training, and informational activities in a high priority area for the region. Examples are: 1) The acquisition of a faculty position for the institute was the first of G2G recognition: a faculty in Groundwater Hydrology was hired in Fall 2015, 2) The acquisition of a (Chemist II) for the Institute Water Quality Lab: The search committee has been established on Feb. 2016.

The Institute has been recognized as a leading source for research, training, and information on local and regional water resource problems by the university, all Government of Guam water related agencies and Guam communities. As a result, the institute receives \$338,320 annually from the Guam legislature under a special appropriation for the Guam Hydrological Survey and Comprehensive Monitoring program that is a 50% cost sharing with the USGS-Hawaii used for monitoring the wells, rain gages, and streams in Guam.

The Institute is trusted by the Office of the Governor and the Guam Legislature to provide expert advice on factors affecting Guam's water resources; including: climate, climate change, water quality, water system management and engineering, and field surveys and evaluations. Venues include private meetings with the governor and senators, and testimony at legislative hearings.

## Publications from Prior Years

1. 2011GU200B ("Environmental Impact of FUDS and Brownfields Sites in Watersheds on the Eastern Side of Saipan. Phase 1: Contaminant Analysis of Soil and Sediments") - Articles in Refereed Scientific Journals - Denton, Gary R.W., Carmen A. Emborski, April A.B. Hachero, Ray S Masga, and John A. Starmer, 2016. Impact of WWII Dumpsites on Saipan: Heavy Metal Status of Soils and Sediments. Environmental Pollution and Research, DOI 10.1007/s11356-016-6603-7
2. 2013GU250B ("Development of Environmentally Sustainable methods for Treatment of Domestic Wastewater and Handling of Sewage Sludge on Yap Island") - Articles in Refereed Scientific Journals - Rouse, Joseph D.; 2015, Development of Environmentally Sustainable Methods for Treatment of Domestic Wastewater and Handling of Sewage Sludge on Yap Island. Sustainability, Vol. 7, 12452-12464.
3. 2014GU277B ("Pilot study to improve wastewater treatment system in Yap, FSM") - Other Publications - Rouse, Joseph D.; 2015, Wastewater Treatment Practices in the FSM with a Focus on Pilot Testing on Yap. First Annual Conference, American Water Works Association, Hawaii Section, Western Pacific Sub-section. Tumon, Guam; April 13-14, 2015.