



INTRODUCTION TO PROGRAMS AND RESEARCH ACTIVITIES

By

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Director**



WERI

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

May 2003



WERI



Water & Environmental Research Institute of the Western Pacific at the University of Guam

The Water & Environmental Research Institute of the Western Pacific or WERI is one of 55 similar water research institutes set up by U.S. Congressional legislation at each Land Grant University in the United States and in several territories. The institute is now in its 27th year of operation.

WERI's mission is to seek solutions through research, teaching, and outreach programs, to issues and problems associated with the location, production, distribution, and management of freshwater resources. WERI provides technical expertise, and conducts vigorous research and both undergraduate and graduate teaching programs aimed at improving economic conditions and the quality of life for citizens of Guam and regional island nations. WERI also runs a state of the technology water analytical laboratory and geographical information systems facility.

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) money under Section 104-B of the National Institute of Water Research (NIWR) 104-B Program. WERI has responsibility for 104-B money on Guam, in the Commonwealth of the Northern Mariana Islands (CNMI), and in the Federated States of Micronesia (FSM). In FY2003 WERI

faculty will be involved as Principal Investigators on twenty research and training projects with a combined budget of about \$882,500: \$253,000 from ten 104-B projects, \$71,500 from two other federal agencies, \$160,000 from Federal sources awarded through Local Agencies, and \$398,000 from local grants from the Guam legislature.

Currently WERI has a fulltime director who is also a UOG faculty member, five regular research faculty, two adjunct research faculty, a water analysis laboratory manager and technician, two office staff, as well as six graduate research students who are completing their MS degree in the Environmental Sciences program. During the year 2002, WERI faculty and staff taught 9 graduate courses and four undergraduate courses in the Environmental Science MS program and the undergraduate Pre-Engineering curriculums respectively. At the same time WERI faculty were first or second authors on 18 refereed journal articles or conference proceedings, five technical reports, and 14 professional presentations. Currently WERI faculty members serve as committee members on, or chairs of about 14 MS research theses in the Environmental Sciences and Biology graduate programs.

See us on the web at:

www.uog.edu/weri



ACTIVE PROJECTS



Water & Environmental Research Institute of the Western Pacific at the University of Guam

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

Groundwater Infiltration and Recharge in the Northern Guam Lens Aquifer as a Function of Spatial and Temporal Distribution of Rainfall

Speciation Studies of Arsenic in Guam Waters

FSM:

Improving Weno Water Distribution System Using Geographic Information System and Hydraulic Modeling Techniques

Development of an Annual Rainfall Distribution Map for the Island of Pohnpei, Federated State of Micronesia

CNMI:

Exploring the Operational Effectiveness of Saipan's Existing Slow Sand Filter and Developing Recommendations to Improve the Operation of the Filter Plant

Rainwater And Dry Litter Waste Management: An Alternative Water Conservation System In Swine Operations

Inventory and Evaluation of Karst Features Relating to Past and Present Groundwater Flow on Rota, Commonwealth of the Northern Mariana Islands (CNMI), in Terms of the Carbonate Island Karst Model

USGS CNMI: (continued)

Persistent Pollutants in Biotic Components of Tanapag Lagoon, Saipan, with Emphasis on Areas Impacted by Streams, Storm Water Runoff and Sewer Outfalls

NASA

Ground Based Radar Rainfall Estimation Project: Guam TRMM Validation

**NATIONAL WEATHER SERVICE
Pacific ENSO Applications Center**

GUAM WATERSHED PROJECTS GUAM EPA

Development of Strategies for the Reduction of Nitrate Contributions from Septic Tanks to the Streams and Coastal Waters of Guam

Contaminant and Restoration Assessment of Agana Swamp and Adjacent Waters

GUAM BUREAU OF PLANNING

Contaminant and Restoration Assessment of Agana Swamp and Adjacent Waters

DIRECT LOCAL FUNDING

Guam Hydrologic Survey

Water Resources Monitoring Program



Groundwater Infiltration and Recharge in the Northern Guam Lens Aquifer as a Function of Spatial and Temporal Distribution of Rainfall



Funded by:

US Geological Survey, Water Institute Program

P.I.

Dr. Mark Lander

Funding: \$15,139

In ongoing work, we have identified at least three time periods for wellhead response to rainfall. One of these is an almost instantaneous response to widespread heavy rains such as that which occur during monsoon squalls or tropical cyclones. The increase of the wellhead from such events returns exponentially to near the background state within a period of approximately 8 to 10 days. A slow rise and fall of the background state is closely tied to instantaneous variations in sea level and to monthly rainfall totals in the current month's rainfall, with significant contribution from rainfall in the two preceding months. Long-term surpluses and deficits of rainfall (largely a result of recurring episodes of El Niño) appear in the wellheads at a lag of approximately 18 months. Die trace studies also show transport of water from the die injection site to the monitoring sites to occur over a wide range of time periods from nearly instantaneous to almost 2 years. From the proposed study, we expect to gain further corroboration of the time lags at

which water moves through, and is stored in the Northern Guam Lens Aquifer. A graduate student will acquire and analyze independent data from more recent years (1997-2001), and also acquire and analyze wellhead data from years prior to those already used for study. Statistics and graphs from this project will provide a means of inferring the proportion of water from a given storm that is actually captured in long-term storage by the lens and is thus available for extraction by pumping. From the proposed project we expect to produce a set of statistical models that will predict, to a known degree of accuracy, the proportion of rainfall that is retained in short and long-term storage. Hydrologists will then be able to make wellhead predictions based on known rainfall variations and known storage parameters. The nearly two-year lag in the response of the wellheads to long-term surpluses and deficits of rainfall may allow for long-term prediction of wellheads. These could be especially accurate if rainfall variations due to EL Niño could be accurately anticipated (as they were in 1998 and again in 2002)..



Speciation Studies of Arsenic in Guam Waters



Funded by:
US Geological Survey, Water Institute Program
P.I.

Dr. Maika Vuki
Funding: \$25,816

Arsenic contamination in water has received significant attention over the last few years due to its carcinogenic properties. There has been reported incidences of arsenic contamination in drinking waters in the US and also internationally. USA EPA has recently revised the Maximum Contamination Level for As to 10ppb. The total arsenic concentrations in natural waters represent several forms of arsenic compounds in the environment. Speciation of the organic and inorganic forms of arsenic is often as important as total quantification because of the varying degrees of toxicity and removal mechanisms. Data available show that very few studies have been undertaken on the levels of arsenic in Guam waters, while no studies on arsenic speciation have been carried out. Part of the reason is the very low levels that have been reported for ground waters. However, a study conducted in 2001 along the springs at Tumon Bay reveal unusually high levels of arsenic. One likely source of arsenic in these spring waters would be from anthropogenic input, however, no follow up studies has been undertaken to confirm this finding. Tumon Bay is the major tourist attraction in Guam and it is where all the major hotels are located.

Previous studies have shown high levels of nutrients and fecal coliform due to the high level of discharge from the hotel industries along the bay catchment area. The objectives of this study would be:

- i. To investigate the levels of Arsenic in Tumon Bay and the connecting freshwater wells on Guam.
- ii. To conduct speciation studies of arsenic to ascertain the levels of the different forms of As both
- iii. To correlate the levels of arsenic to the likely sources.

Water samples will be collected from the Tumon Bay area and ground water wells. Sampling sites will taken from some previously used sites together with new sites that will be identified in this study. Total arsenic levels will be measured using atomic absorption spectroscopy under vapor generation technique. Organic arsenic levels will be determined by solid phase extraction followed by HPLC analysis. The different oxidation states, As (III) and As (V) will be determined using stripping voltammetry. Data from these three different methods will provide a clear indication on levels and the possible sources of As. This study will provide useful information on the level of As pollution along the Tumon Bay. The data will assist the relevant authorities in monitoring and designing management guidelines to address any potential threat to the environment.



Improving Weno Water Distribution System Using Geographic Information System and Hydraulic Modeling Techniques



**Funded by:
US Geological Survey, Water Institute Program
P.I.'s**

Dr. Shahram Khosrowpanah

Dr. Leroy F. Heitz

Funding: \$23,583

Water hours, lack of information about the water distribution system, and lack of effective management are common problems for the water utilities throughout the Federated States of Micronesia. This is especially true for Chuuk State. After the drought of 1997-98, the Chuuk State Public Utility Corporation (CPUC) added several wells to the system, but still cannot provide adequate water to customers. Presently, CPUC does not have information on the water distribution system, components. This is making it difficult for water managers to run the system effectively. The first objective of this project is to develop a Geographic Information System (GIS) based inventory of system resources. This GIS system will describe the water sources available, the well systems in place, transmission lines, and major lines in the distribution system. This system will consist of maps showing the location of the various components of the water transmission system and ancillary equipment, and a complete database of all equipment and spare parts resources available. The second objective is to develop a computerized hydraulic model of the CPUC water distribution system. This model will be developed using information gathered during the development of the GIS management

system. The third component of this project will be training the CPUC personnel on the use of the GIS based resource management system and implementing various management scenarios of the water system using the computer model of the system. The methodology that will be used includes:

- 1) Gathering complete physical and hydraulic description of the Weno water distribution system. This will include global positioning system (GPS) mapping and use of as-built drawings of piping, storage tanks and wells.
- 2) Development of GIS based utility management system by using the information from above.
- 3) Development of a hydraulic network model of the CPUC water transmission system

Training of CPUC personnel on the use of these models. .



Development of Annual Rainfall Distribution Map for Island of Pohnpei State, Federated State of Micronesia



Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. Shahram Khosrowpanah
Dr. Mark Lander
Funding: \$31,889

Existing annual rainfall maps for most of the islands of Micronesia are incomplete, inaccurate, and/or non-existent for many areas. This has created problems in many areas such as;

- 1) Difficulty in estimating the rainfall erosivity factors that are being used for erosion protection and identification of land slide areas,
- 2) Difficulty in developing infrastructure for storage and distribution of surface water,
- 3) Difficulty for disaster managers to better understand the processes that lead to slope failure and local stream flooding and,
- 4) Difficulty in planning and design of hydro electrical power plants for future power production.

The objective of this project is to acquire, compile, and analyze rainfall data from a transect of manual and electronic recording rain gages to produce accurate annual rainfall maps for Pohnpei. Also to be determined are any differences in short-term rainfall distribution as a function of wind direction and precipitation event type. The network of manual and electronic rain gages in the highlands of Pohnpei will also help to determine whether fog drip is an important contributor to water quantity in the higher elevations of the island. To accomplish the objective of this project a site will be selected in the central high island of Pohnpei.

The following activities will be implemented:

1. Manual rain gages that include four-foot tall, 6-inch PVC pipes will be designed and a unit assembled within the confines of the already existing WERI dense rain gage network.
2. The manual rain gages designed for Pohnpei, and the tipping bucket gages intended for use at Pohnpei, will be evaluated by comparison to known accurate rain readings obtained at the WERI site.
3. The WERI project investigators will travel to Pohnpei to locate and assemble the rain gage transect.
4. The WERI project investigators will travel to Pohnpei at least once every three months to perform maintenance on the rain gages and to collect data.
5. After the third data collection (~ 9 months into the data collection effort), the WERI project investigators will begin to assess the differences among rain collection along the transect.
6. A map (such as Figure 1) of the annual rainfall at Pohnpei will be produced.
7. The contribution of fog drip to the water budget of the highlands will be assessed.



Exploring the Operational Effectiveness of Saipan's Existing Slow Sand Filter and Developing Recommendations to improve Operation of the Filter Plant



Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. Shahram Khosrowpanah
Dr. Leroy Heitz
Funding: \$26,200

The Saipan slow sand filter facility was originally constructed in 1984 and it was rehabilitated in 1992. The system includes:

- a) A 20 million gallon storage reservoir catching direct rainwater runoff from Saipan International Airport (Isley Field),
- b) A pumping station next to the rainwater catchment reservoir that delivers water to the filters through an 8 inch PVC pipe,
- c) Two parallel slow sand filters that are constructed of concrete and each measures 100 feet by 35 feet,
- d) A nearby reservoir that stores finished water from the filter.

According to the Commonwealth Utility Commission (CUC), the Saipan slow sand filters have not been able to deliver the design flow, which is 350 gpm since 1993. A recent flow measurement indicates that the filters are delivering 50 to 60 gpm, which is 17 % of the design flow of 350 gpm. In addition, the Department of Environmental Quality (DEQ) does not have a record of data that shows how effective the filters are at removing bacteria and turbidity. The objective

of this project is to monitor the quality and the quantity of the water that is being produced by the Saipan Slow Sand Filters, and then to make recommendations on how to improve the system operation in order to increase the finished outflow from the plant. To complete the project the following phases will be undertaken:

- 1) Filter preparation that includes draining the filters, repairing and installing new automatic control switches for the pumps, inflow and out flow valves, replacing the existing piezometers, and scraping the top layer of the filters,
- 2) Monitoring and testing that includes daily measurement of the turbidity, inflow and outflow rate, head loss, and weekly monitoring of the inflow and outflow bacteria level, dissolved oxygen, ph level, and monthly monitoring of iron and manganese levels,
- 3) Evaluation of the information from above to determine the effectiveness of the filters in removing bacteria, reducing turbidity, and to determine filters run times between required scraping,

- 4) Report on how to improve the operation of the system.



Rainwater And Dry Litter Waste Management: An Alternative Water Conservation System In Swine Operations



Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. A.C. Sabaldica
L.J. Duponcheel
Funding: \$14,767

Raising swine is a traditional and cultural activity for the majority of Commonwealth of the Northern Mariana Island (CNMI) farmers and most of the livestock produced is for personal family consumption. Island farmers are less likely to engage in the swine business, because of:

1. Low productivity of swine raised on limited quality feeds and limited supplies of water,
2. Animal health problems associated with a lack of available resources, and
3. A lack of technical support.

Nutrition plays an important role in swine production. Water is of supreme importance in pork production. An inadequate supply of water will result in poor swine performance. Symptoms associated with water intake below the pig's daily requirement include reduced feed intake, poor daily gain, poor feed conversion, an increase in scour problems, loss of milk production, lower weaning weights and overall lower digestibility of feed.

The CNMI continues to suffer from water supply deficiencies especially in many agricultural homesteads where water supply is limited or non-existent due to the inflated cost of piping and a high utility cost of commercial water. Fortunately, the Northern Marianas has a high average annual rainfall of 42.5 inches (IPM Trap Monitoring, NMC-CREES, 2001) which would imply that rain catching systems are a potential catalyst in dealing with the water supply issues. In addition, there is a limited understanding of the potential impact of animal waste seepage into the water aquifer since the carbonate island Karst features that control the input, transport, and discharge of fresh water from these islands is still being investigated.

Given the conditions noted above, the need for water conservation management becomes evident. "Rainwater and Dry Litter Waste Management: An Alternative Water Conservation System In Swine Operations" aims to develop self-sufficiency in water supply, or at least to alleviate water shortage impacts, and simultaneously reduce the risks of aquifer contamination inherent in animal husbandry.

The first phase of the study hopes to:

1. Produce usable baseline data of water management/ conservation for swine operations using rain water catchment systems (RWCS). It aims to adopt the RoofRain spreadsheet program developed by Dr. Leroy Heitz at WERI, to design storage tank sizes, gutter configuration, and roofing sizes in relation to animal size and numbers for the entire swine operation.
2. Incorporate carbon materials such as wood chips and coconut husks as beddings for dry litter waste management system as a way to conserve water and reduced the seepage of waste components into the groundwater aquifer.

The final phase of the project aims to develop:

1. Publications in the form of brochures on application of RWCS as a water conservation strategy for CNMI with implementation of the WERI RoofRain spreadsheet for farmers who wish to duplicate the system,
2. Undertake targeted public education on water resources and
3. Conduct workshops and training.



Inventory and Evaluation of Karst Features Relating to Past and Present Groundwater Flow on Rota, Commonwealth of the Northern Mariana Islands (CNMI), in Terms of the Carbonate Island Karst Model



**Funded by:
US Geological Survey, Water Institute Program**

P.I.

Dr. John J. Jenson

Funding: \$35,933

The island of Rota in the Commonwealth of the Northern Mariana Islands relies on groundwater derived from the uplifted limestone aquifer that covers most of the island's surface. Although the island has a budding tourist industry and has seen important development in recent years, including a large golf resort, there has yet to be a systematic study of the karst geology to support the development of the island's groundwater resources. This project will provide a survey of the karst features that control input, transport, and discharge of fresh water from the aquifer. Groundwater developers and managers on Rota will benefit directly from improved specific knowledge of aquifer properties and groundwater transport and storage. Specific work proposed includes mapping and cataloging karst surface features, caves, and coastal discharge features. Such work provides the foundation for detailed hydrogeologic studies and engineering evaluations to support appropriate development of Rota's island karst aquifer.

In addition to obtaining specific data on Rota's aquifer, the proposed project will contribute to ongoing efforts to develop a more accurate and complete conceptual model of carbonate island karst aquifers in general. It is well understood that standard hydrologic models for diffuse flow through particulate media are inadequate for karst aquifers. Even models that have been developed for temperate continental karst aquifers,

however, cannot accommodate the unique geologic complexity and hydrologic properties of carbonate aquifers comprised of the young limestone units in tropical islands and coastal plains. Karst research begun on the relatively uncomplicated aquifers of Atlantic-Caribbean islands has recently been extended to Guam (Taborosi, 2000; Mylroie et al., 2001), Saipan, and Tinian (Stafford et al., in press). The proposed project will extend such work to Rota as well. Rota is unique in that most of the island's potable water comes from permanently flowing karst springs that appear to be fed by water shunted down the flank of its volcanic core through conduits along the contact with the limestone bedrock. Reconnaissance work in the summer of 2002 suggests that the caves from which the spring water emerges may have formed along an ancient shoreline at a previous relative sea level. These attributes make the island's aquifer ideal for testing certain hypotheses regarding the structure and properties of island karst aquifers. A more solid understanding of them will also, of course, provide a reliable basis for successful aquifer protection and development on Rota.

The proposed work will support an M.S. thesis in environmental science at the University of Guam. Results will be presented in professional journals, international conferences, and website publications, and will be made accessible to local water resource professionals and educators through technical reports, local conferences, outreach publications, and personal interaction between WERI researchers and professional water resource managers in the CNMI.



Persistent Pollutants in Biotic Components of Tanapag Lagoon, Saipan, with Emphasis on Areas Impacted by Streams, Storm Water Runoff and Sewer Outfalls



**Funded by:
US Geological Survey, Water Institute Program
P.I.'s**

**Dr. Gary R. Denton
Harold R. Wood Brian Bearden
John Starmer Peter Houk
Funding: \$33,167**

Tanapag Lagoon borders the western shore of central Saipan. It harbors a rich diversity of marine life and supports a variety of commercial and recreational activities. Over the last quarter century, Tanapag Lagoon has become heavily impacted by the activities of man. Primary sources of anthropogenic disturbance in these waters include a power station and commercial port (Saipan Harbor), two small boat marinas, a sewer outfall, several garment factories, auto and boat repair shops, wood shops, government vehicle maintenance yards, a commercial laundry, and an acetylene gas producer. There are also a number of old military dumps and disposal sites in the area as well as a municipal dump that has served as the island's only solid waste disposal site for the last 50 years. Several streams and storm drains empty into the lagoon during the rainy season and provide a mode of transport into the ocean for any land-based contaminants. Overflows from sewer lines are also commonplace at this time of the year and the whole area is inundated by storm water runoff during periods of prolonged wet weather. The effects of these perturbations on the indigenous biota within the lagoon are largely unknown. Likewise, fundamental data describing the abundance and distribution of persistent and potentially toxic pollutants within the system is also lacking. Mindful of these shortcomings, a contaminant assessment of surface sediments within Tanapag Lagoon was recently completed. The project described herein proposes to determine contaminants of potential concern (heavy metals, pesticides and PCBs) within biotic components of this lagoon and is seen as a logical extension of the work already completed.

The study will essentially be divided into two discrete phases. Phase I will focus on dominant organisms inhabiting the shallow near shore waters of the lagoon with emphasis given to those groups that have high bioindicator potential and are either sessile or are restricted in their movement. Sampling will be conducted largely on an opportunistic basis depending upon species abundance and availability at each site of interest and will be biased towards potential land-based contaminant sources. The area north of San Roque village, in the northern section of the lagoon, is relatively far removed from potential contaminant sources and will serve as a reference (control) site. It is anticipated that samples will be collected from 8-10 locations along the coastline between the reference site and Muchot Point at the southern end of the lagoon. Phase II of this investigation will explore contaminant levels in biotic resources from the lagoon that are popularly consumed by local people. Particular emphasis will be given to food fish commonly taken by conventional fishing methods.

The objectives of the study are to establish a reliable database with which future findings may be compared and evaluated; identify 'hotspots' and delineate areas of contaminant enrichment within the study area, and assess the degree of contamination in Tanapag Lagoon by reference to levels reported for clean and polluted environments in tropical regions from elsewhere in the world, including Guam. Potential health risks (if any) associated with the long-term consumption of edible resources surveyed will also be evaluated.



RECENTLY COMPLETED PROJECTS

Water & Environmental Research Institute of the Western Pacific at the University of Guam



US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

Impact of Ordot Dump on Water Quality of Lonfit River Basin in Central Guam

Groundwater Infiltration and Recharge in the Northern Guam Lens Aquifer during the record-breaking 1997-1998 ENSO event

FSM:

Slow Sand Filter Conceptual Design Package for The Federated States of Micronesia

Water Quality Analysis and Water System Operation and Maintenance Training for Chuuk State, Federated States of Micronesia

An Alternative Model for Enhancing Access to Safe Drinking Water in Less-Wealthy Areas: A Low Cost, Equity-Oriented & Participatory Source Water Protection Plan for Chuuk, Federated States of Micronesia

CNMI:

Regional Dissemination of a Locally-developed Integrated Island Ecology & Resource Management Textbook, Website, & Teacher's Manual/Activity Guide

Inventory of Karst Features Relating to Past and Present Groundwater Flow on Tinian, CNMI, in Terms of the Carbonate Island Karst Model

A Rainfall Climatology For Saipan: Distribution, Return Periods, And Inter-Annual Variations



Impact of Ordot Dump on Water Quality of Lonfit River Basin in Central Guam

Funded by:

US Geological Survey, Water Institute Program

P.I.'s

Dr. Gary Denton and Dr. Mohamed Golabi

Funding: \$43,620



Guam's only municipal solid waste disposal site is centrally located in the village of Ordot and has been in use for over fifty years. Lacking in the conventional technology built in to modern day sanitary landfills, the site is essentially an open dump covering ~20 acres of the upper Lonfit River valley. The dump was operated by the US Navy at the end of WWII and transferred to the Government of Guam shortly thereafter. Although slated for closure more than 20 years ago, it still receives around 200 tons of solid waste per day from the civilian community. Early records of the types of materials disposed of at the Ordot Dump are nonexistent but are suspected to include the same array of toxic chemicals found at other military dumpsites on island. Today, there is some control over the bulk disposal of industrial chemicals, waste oil, and metallic waste at Ordot Dump. However, household waste is rarely screened and is known to contain a variety of hazardous substances, both biological and chemical. Leachate streams occur in several places around the perimeter of the dump and course their way down gradient into the Lonfit River and out into Pago Bay. Their chemical composition is largely unknown and their impact on the local environment in terms of ecology, agriculture, and human health remains to be investigated.

As a first step in this direction, we propose to characterize the primary biological and chemical contaminants in leachate water emanating from the Ordot Dump and trace their respective movements down the watershed out into the ocean. We will focus primarily on a time-series analysis of aqueous samples with secondary emphasis on soil and biota where appropriate. Lysimeters will be used to extract interstitial

waters from soil inundated by the leachate streams down gradient from the dump, and downstream in the Lonfit-Pago River system. Differential mobilization rates of primary contaminants will be evaluated by comparing their surface and subsurface distributions and abundances. Finally, their potential impact on the receiving waters will be assessed from an ecological and public health standpoint

The intended study will take two years to complete and will be divided into two phases of approximately equal duration. Funds are sought here to support the initiation of Phase I, which will focus on nutrients, heavy metals and disease causing microorganisms. Our laboratories are adequately equipped to analyze water samples for all three contaminant groups (the latter using fecal indicator bacteria, *Enterococci* and *E. coli*). We propose to send a one-time leachate sample to an off-island laboratory (Montgomery Watson Harza, Pasadena, CA) to screen for priority pollutants listed under the Clean Water Act and identify organic chemicals of potential concern. Once these have been identified we will develop the necessary analytical techniques to monitor their abundance and distribution in the watershed during Phase II of the study to be submitted for consideration next year.



Groundwater Infiltration and Recharge in the Northern Guam Lens Aquifer during the record- breaking 1997-1998 ENSO event



**Funded by:
US Geological Survey, Water Institute Program
P.I. Dr. Mark Lander
Funding: \$14,905**

This study will investigate well hydrographs and rainfall statistics for the major ENSO episode of 1997-1998 to explore the effects on Guam's northern aquifer system. The immediate objective is an analysis of well responses to a year that featured an abundance of rainfall (1997) followed immediately by the driest year ever recorded on Guam (1998). This will provide baseline information for identifying deviations from the average distribution that have measurable impacts on the aquifer, and implications for a water management plan.

Results from this project will provide insight into how Guam's northern lens aquifer is affected by an extreme of inter-annual variation of rainfall. The major 1997-98 ENSO event was the largest year-to-year variation of rainfall ever recorded on Guam: from the approximately 130 inches of rainfall experienced during 1997 (including nearly 40 inches of monsoonal rains in August, and 20 inches of rain in 24 hours in Typhoon Paka in December), to the less than 60 inches of rain experienced during the drought year of 1998. This extreme event should provide insight into our understanding of rainfall-recharge relationships that will enable more accurate and precise estimates of recharge, and therefore sustainable yield, to be made for designated well fields and sectors of production in the aquifer. Such understanding will provide a basis

for determining appropriate environmental and land use regulations and storm water management practices over the aquifer.

The work will be done by the UOG PI (Mark A. Lander) and UOG student help in collaboration with UOG faculty member John Jenson. The results of this study should nicely compliment collaborative research to be undertaken by John Jenson and Steve Gingrich of the USGS Honolulu Field Office who will attempt to model the behavior of the northern Guam lens aquifer.

This proposal directly supports three of the Guam Advisory Council's stated needs in Water Quality and Water Quantity:

- Conduct evapotranspiration and rainfall studies for northern Guam.
- Determine how global warming/climate change might affect sustainable yield.
- Identify environmental cues that could be structured into an early warning system for climate changes and associated impacts on Guam's water resources.



Slow Sand Filter Conceptual Design Package for The Federated States of Micronesia

Funded by:

US Geological Survey, Water Institute Program

P.I.'s

Dr. Shahram Khosrowpanah and Dr. Leroy Heitz

Funding: \$16,918



Cholera outbreaks have occurred repeatedly throughout the islands of the Federated States of Micronesia (FSM). Outbreaks occurred in Chuuk in 1983 and in Pohnpei State in April 2000. The Pohnpei outbreak resulted in 20 deaths, and over 3,000 people were infected with the disease. The rapid spread of this disease was attributed to lack of proper water and food sanitation especially in villages that are being served by small community water supply systems. There are over 14 municipal water supply systems around Pohnpei that provide untreated and non-potable water to the rural communities. These small systems provide water to more than 50% of Pohnpei's population. The other islands, Yap, Chuuk, and Kosrae, have very similar situations.

Since 1999 the principal investigators of this proposed project have been exploring the use of slow sand filtration technology as a means of improving the water provided by small community systems throughout the FSM. Results indicate that it is feasible to use local materials for filter media. These studies have also determined optimum filter loading rates for the local filter media. What is needed now is to pull together the results of the pilot studies and to develop design plans, cost estimates, and operational manuals. The objective of this project is to assemble the findings of earlier Kosrae slow sand filter pilot studies and to develop detailed conceptual construction drawings,

operation recommendations, and construction costs for full scale slow sand filtration plants. The resulting recommendations and drawings will be planned around and sized appropriately for use by the many small community water supply system throughout the FSM.

A site visitation will be made to all community water supply systems in Pohnpei, Kosrae, and Chuuk State. Information such as how much flow is being delivered to the systems, daily water demands, and the turbidity levels of the inflows will be measured. From this information, complete drawings of the facilities for three different sizes of slow sand filters will be developed. The three sizes will reflect that required for the smallest, largest, and medium sized community water supply systems. These drawings will show inflow and outflow pipes to the plant, the under drain systems beneath the filter media, and the required flow controls. To estimate the cost of the plants, graphs will be developed that show the cost of the slow sand filter plants as a function of the area of the filters. In addition, recommendation will be made on plant operations such as scraping, and back filling the filters.



Water Quality Analysis and Water System Operation and Maintenance Training for Chuuk State Federated States of Micronesia



Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. Leroy F. Heitz and Dr. Shaharam Khosrowpanah
Funding: \$21,723

The Chuuk State Public Utility Corporation (CPUC) is in the process of upgrading the Weno Public Water supply and wastewater collection Systems. The chance for having a twenty-four hour water supply might be achieved after completion of this upgrade, but the quality of water being produced is still questionable. In order to ensure that the system produce potable water, the Chuuk EPA and CPUC have requested training in water testing to better enable them to monitor the quality of this water. The CPUC operation and maintenance division has also undergone relatively large changes in personnel over the last few years and many of the technicians presently working on the system are relatively untrained. Presently CPUC is experiencing their most serious operation and maintenance problems with the mechanical and electrical controls for their pumps in the water supply and wastewater collection systems. CPUC has requested that we carry out a hands-on training program in pump repair and maintenance for their operation and maintenance people in both the water supply and wastewater areas.

The training will consist of the following topics:

WATER QUALITY TRAINING

1. Microbiological quality of system
2. Chemical and Physical Parameters affecting water quality
3. Identification of representative sampling points
4. Chlorination and other necessary treatments
5. Assessment of future training needs for operators and laboratory
6. Review of existing water quality standards for possible amendments.

PUMP REPAIR AND MAINTENANCE

1. Site inspection of water supply facilities
2. Pump station equipment design, operation and maintenance
3. Hands on training at the CPUC maintenance shop covering preventative and overhaul maintenance of existing pumps and controls
4. Discussion of future needs and required actions for long term preventative maintenance program



An Alternative Model for Enhancing Access to Safe Drinking Water in Less-Wealthy Areas: A Low Cost, Equity-Oriented & Participatory Source Water Protection Plan for Chuuk, Federated States of Micronesia



**Funded by:
US Geological Survey, Water Institute Program
P.I. Dr. John Byrne, Ph.D.
Funding \$19,870**

Micronesia has a high incidence of water-borne disease, including an alarming out-break of Cholera in the study area of Chuuk in the 1980s. At least 3/4 of the population lacks access to "safe" water, and related diseases are the 3rd largest cause of death. Threats to water quality from non-point pollution are widespread in the islands, and common "at the pipe" western models involving importing expensive technology and consultants are often not a sustainable option. This is especially true given the low GDP, Compact exit strategy, importance of traditional style of local governance, and physically fragmented nature of the country -- all of which discourage costly centralized solutions. No GIS capacity exists to enhance source water protection via planning and coordination, environmental analysis, or environmental education methods:

A multi-method approach will incorporate geographic techniques. Land use maps and vulnerability indices will be developed for the main islands by basin based on use and threats to source water.

Integrated management tools for mitigating non-point pollution include:

1. Land use mapping and planning in 3-D (including change detection);
2. Conservation (including BMPs) proven successful elsewhere such as Pohnpei
3. Discharge mitigation of point and non-point sources (i.e. buffers)
4. Site design or village-scale planning and placement to mitigate pollution
5. Erosion and sediment control (including storm water management)
6. Whole basin (watershed) stewardship and outreach programs
7. Public policy analysis (including regulations and basin modeling to consider how to meet multiple stakeholder needs while simultaneously protecting source water).

Principle objectives for this project are to build capacity for source water protection, environmental analysis and planning, and public participation in water resource management vis-à-vis working through diverse partnerships with Chuuk's communities. Water quality will improve in the streams used as sources of drinking water. By protecting source water public health will be guarded, technical capacity enhanced, and informed participation in stakeholder management of natural resources



Regional Dissemination of a Locally-developed Integrated Island Ecology & Resource Management Textbook, Website, & Teacher's Manual/Activity Guide



**Funded by:
US Geological Survey, Water Institute Program
P.I. Mr. John Furey
Funding: \$29,700**

Throughout the Pacific island region, human populations suffer from the combination of distressed social and financial economies, growing populations, and limited and fragile island resources. A locally-applicable program of integrated environmental education is critical to address these issues and the need has been widely expressed throughout the region in recent years.

This project proposes to directly address this need. "Experts" in field of environmental science and in the field of education are often recruited from non-island areas and lack needed foundational information of island ecology and island resource management regimes to adequately address island needs. Regionally-applied two year professional contract programs--originally meant to automatically lapse and therefore provide professional opportunities to islanders who complete their collegiate studies and professional training--effectively cause an exporting of expertise, leaving little environmental and educational knowledge behind. Oftentimes, any reports that are left behind are written in such scientific "ese" as to be uninterruptible by many local program directors.

The Northern Mariana Islands made a concerted effort to address this problem since 1996 and developed a highly readable, regionally-appropriate, 800 page Island Ecology & Resource Management: Commonwealth of the Northern Mariana Islands textbook. The book was designed to be applicable throughout the region and permission to "cut & paste" from it is part of the book's purposes.

This proposal seeks to, in part, address the above-identified problems through a concerted effort to regionally disseminate this comprehensive island ecology/resource management textbook/curriculum throughout the Western Pacific to encourage fellow island education and resource management entities to model it to address their own needs and to save years of start up and drafting and editing time.

The Goals of this project are to:

1. Revise and print the Activity Guide/Teachers Manual for the Island Ecology & Resource Management: Commonwealth of the Northern Mariana Islands textbook.
2. Establish a website for the project.
3. Travel to ten islands to share the work and encourage regional adoption, revision, and transformation of the information into language and frameworks applicable to each island's needs.



Inventory of Karst Features Relating to Past and Present Groundwater Flow on Tinian, CNMI, in Terms of the Carbonate Island Karst Model



**Funded by:
US Geological Survey, Water Institute Program
P.I. Dr. John Jenson
Funding: \$27,190**

The island of Tinian in the Commonwealth of the Northern Mariana Islands relies on groundwater for its potable water. Groundwater is derived from the uplifted limestone aquifer that forms nearly the entire surface of the island. In spite of the fact that the island has seen important development in recent years, to include the installation of a large tourist resort, there has yet to be a systematic study of the karst geology of the aquifer. This project proposes to survey the karst features that control the input, transport, and discharge of fresh water from the island. Groundwater developers and managers on Tinian will benefit directly from improved specific knowledge of aquifer properties and more reliable explanations of the behavior of the aquifer. Specific work to be done includes mapping and cataloging karst surface features, caves, and coastal discharge features, in preparation for eventually undertaking a long-term comprehensive hydrogeologic study of Tinian's island karst aquifer. In addition to obtaining such specific data to support sustainable use of Tinian's aquifer, the proposed project will broaden ongoing efforts to develop a more accurate and complete conceptual model of carbonate island karst aquifers in general. Standard hydrologic models for watershed management and well-field design are well known to be inadequate for the karst of temperate

continental aquifers. Karst aquifers in island and coastal settings are still more complicated, and even such models as have been developed for temperate continental karst aquifers do not accommodate the unique geologic complexity and hydrologic properties of island and coastal karst aquifers. Planning, design, and management of systems for groundwater development of groundwater on carbonate aquifers requires a better understanding of their unique properties. Work begun on the relatively uncomplicated aquifers of Atlantic-Caribbean islands has recently been completed on Guam and extended to Saipan, and with this project, will be extended to Tinian as well. Tinian is unique in that it is a composite island with relatively compact shape and simple topography. This makes it ideal for testing certain hypotheses regarding the evolution of island karst aquifers. The work will support an M.S. thesis as well as undergraduate research. Results will be presented in professional journals, international conferences, and website publications, and made accessible to local water resource professionals and educators through technical reports, local conferences, and outreach publications..



A Rainfall Climatology For Saipan: Distribution, Return Periods, And Inter-Annual Variations



Funded by:

US Geological Survey, Water Institute Program

P.I. Dr. Mark A. Lander

Funding: \$17,181

Improved information on rainfall depth-intensity-duration-frequency and their areal distribution is needed for use in designing storm water control systems. Previous estimations (based on rainfall records of limited duration) of Saipan's mean monthly and mean annual rainfall, and the distribution of rainfall throughout the island will be re-examined. Prior calculations of return periods of heavy rainfall events on Saipan can be shown to be erroneous and are in need of a complete overhaul.

This proposal seeks to develop a climatology of Saipan's rainfall to include:

- An estimation of the distribution of rainfall at mean monthly to mean annual time periods.
- Calculations of return periods of heavy rainfall events
- An examination of interannual variations in mean annual rainfall.

Previous estimations of Saipan's mean monthly and mean annual rainfall, and the distribution of rainfall throughout the island will be re-examined. Prior calculations of return periods of heavy rainfall events on Saipan can be shown to be erroneous and are in need of a complete overhaul.

Interannual variations of Saipan's rainfall are closely linked to the El Niño/Southern Oscillation (ENSO) phenomenon. The CNMI and Guam are in an ENSO core region that features very dry conditions in the year following El Niño and an increase in the level of threat from typhoons during an El Niño year.

The long-term variations of rainfall on Saipan are very similar to those on Guam. As on Guam, the mean annual rainfall on

Saipan varies substantially (15%) at different locations on the island. The recurrence interval of heavy rain events, however, can not be considered to have a similar distribution as the annual mean since the causes of extreme daily rainfall events are typhoons, monsoon squall lines, and other so-called meso-scale weather systems that produce rain amounts that are independent of the island topography.

The proposed project directly supports three of the CNMI's stated needs in Water Quality and Water Quantity, and Education and Professional Training:

- Improved information on rainfall depth-intensity-duration-frequency and their areal distribution for use in designing storm water control systems
- Develop regional (Guam/CNMI) manual of best management practices for control of storm-water runoff.
- Task force organization to address special water resource issues.



Environmental Science Graduate Program University of Guam



The Environmental Science Program is designed to provide students with an appreciation of the interdisciplinary nature of environmental problems that exist in the world today and prepare them for professional employment, teaching or advanced studies in diverse areas of environmental science or related disciplines. The program also serves working professionals in local schools, government agencies and the private sector who are seeking career advancement and/or professional enrichment, e.g., educators, regulators, administrators and planners.

The interdisciplinary focus of the program is intended to train students to identify and understand environmental problems and exercise sound judgment in effecting their remediation. This is accomplished through a careful blend of core courses and electives in an integrated teaching-research approach. Students are required to conduct a research project and document their study in thesis form. They are encouraged to present their findings in a variety of forums (e.g., society meetings, conferences, workshops, seminars, peer-reviewed journals, technical reports, newsletters and the local newspaper). Students also have the opportunity to serve out an internship with a local environmental or engineering firm, or an appropriate Government of Guam or Federal Government Agency. This permits them to gain professional problem solving skills in the

environmental market place. Students who graduate from the MS program can, therefore, reasonably expect to enter professional employment in a variety of areas in the public and private sectors where an understanding of the complex interdisciplinary scientific, social, and political dimensions posed by environmental problems is increasingly necessary.

The Environmental Science Program strives to promote educational and service projects within island communities of the Western Pacific, and attract a broadly based group of scholars committed to seeking answers to the many environmental questions that are arising in developing island nations of the tropical Pacific Basin. Areas of faculty expertise center around three broad areas of concentration namely, biology-ecology, geosciences-engineering, and management. Further information may be obtained from the Program Chair, Dr. Gary R.W. Denton, telephone: (671) 735-2690, e-mail: gdenton@uog.edu.



Pre Engineering Program University of Guam



Engineers are society's problem solvers. They take the theoretical ideas of the scientist and bring them into reality in today's world for the benefit of mankind. Engineers are involved with projects that vary from the design and construction of transportation systems to the planning of the space stations of the future. Nearly all aspects of our lives are touched by the projects worked on by people in the various engineering fields.

WHAT IS PRE-ENGINEERING AT THE UNIVERSITY OF GUAM?

The University of Guam offers a program in Engineering Science that parallels the engineering programs offered during the first two years at major colleges and universities.

The first two years of engineering study places emphasis on learning the tools and theories and providing the background for all engineering fields. Rigorous studies in mathematics and the physical sciences are required of all students. Students are also required to take courses in the social sciences and humanities to round out their educational experience.

WHAT IF I AM NOT SURE IF I REALLY WANT TO BE AN ENGINEER?

Each fall semester the University of Guam offers a course titled "INTRODUCTION TO ENGINEERING". This course is designed to acquaint students to the engineering profession. Discussions are held on all of the various engineering fields. Educational and

professional registration requirements are also introduced. Various guest speakers relate their experiences in the real world of engineering. Finally, students get a taste of the problem-solving techniques used by engineering students and practicing engineers.

WHAT IF I HAVE A WEAK BACKGROUND IN MATHEMATICS AND THE PHYSICAL SCIENCES?

Engineering requires a strong aptitude for both math and science. For students with these kinds of aptitudes but with weaknesses in prior training, there are remedial classes available to help bring the student up to a competitive level. These students will require more than the normal two years to complete the Pre-Engineering Program.

WHERE CAN I GET MORE INFORMATION?

For more information on the Pre-Engineering Program, contact the University of Guam Counseling Center, the Dean of the College of Arts and Sciences, or contact **Dr. Shahram Khosrowpanah** (khosrow@uog.edu) or **Dr. Leroy Heitz** (lheitz@uog.edu) at the Water and Environmental Research Institute of the Western Pacific, UOG Station, Mangilao, Guam 96923 (telephone number (671) 735-2685).