INTRODUCTION TO PROGRAMS AND RESEARCH ACTIVITIES

By

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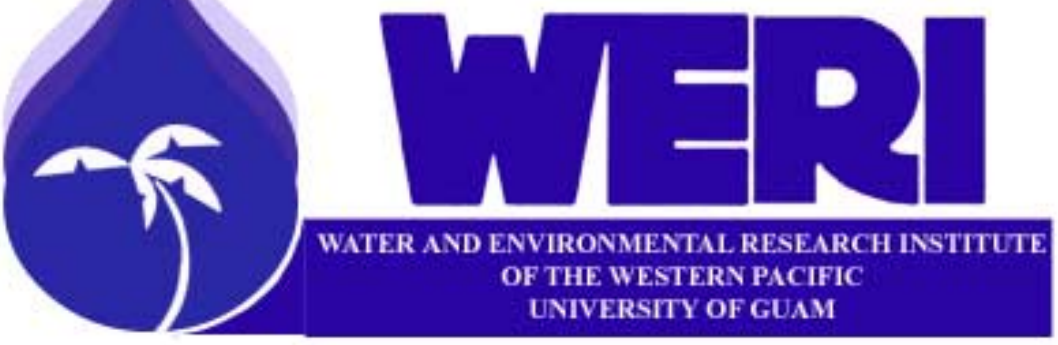
Director



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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 28th 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 was involved as Principal Investigators on twenty seven research and training projects with a combined budget of about $852,000: $256,000 from eleven 104-B projects, $95,000 from three other federal agencies, $85,000 from Federal sources awarded through Local Agencies, and $416,000 from local grants and direct funding 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 2003, WERI faculty and staff taught eight 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 13 refereed journal articles or conference proceedings, five technical reports, and 9 professional presentations. Currently WERI faculty members serve as committee members on, or chairs of about 20 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:

Speciation studies of arsenic in Guam Waters Phase II

Presence and Survival of Fecal Indicator Bacteria in Soil from the Banks of Major Rivers and Streams on Guam

FSM:

Groundwater Development and Utilization for Emergency Drinking Water Supply on Fais, Yap State, FSM

Refining the Rainfall Erosivity Factors and Developing Rainfall Distribution Maps for the Island of Pohnpei

CNMI:

Persistent Contaminant Assessment of Food Fish from Tanapag Lagoon, Saipan

Hydrology of the Sabana Watershed and Water Cave, Rota, CNM

OTHER FUNDED PROJECTS

NASA

Ground Based Radar Rainfall Estimation Project: Guam TRMM Validation

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center

NATIONAL SCIENCE FOUNDATION

Modeling of Fine-Grained Till Deposits by the Laurentide Ice Sheet

GUAM WATERSHED PROJECTS GUAM EPA

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

GUAM BUREAU OF PLANNING

Contaminant and Restoration Assessment of Agana Swamp and Adjacent Waters

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

DIRECT LOCAL FUNDING

Guam Hydrologic Survey

Water Resources Monitoring Program

Speciation Studies of Arsenic in Guam Waters: Phase II

Funded by:
US Geological Survey, Water Institute Program
P.I.
Dr. Maika Vuki
Funding: $31,199

Arsenic is a ubiquitous element and is present in minerals, sediment and water. Arsenic contamination in water has received significant attention over the last few years due to its carcinogenic properties. There had been reported incidences of arsenic contamination in drinking waters in the US and also internationally. US EPA has recently revised the Maximum Contamination Level for As to 10ppb.

Guam's main water source is from a limestone aquifer that lies in the northern half of the island. An estimated 80% of the total water source is derived from the aquifer and the remaining comes from surface water sources located in the southern part of the island. There are more than 100 wells that serve the population and most of these are located on the northern part of the island. Some of these wells are connected through conduits that flow out through springs along Tumon Bay. Initial studies in 2001 conducted by Guam EPA along the Tumon Bay springs show unusually high levels of arsenic from these springs. This was followed up with speciation studies of arsenic along the same springs. Results from the speciation study show low levels of arsenic. The big differences in the two sets of data and the differences in methodology used renders these data inconclusive. Further investigation is required verify these data. The aim of this project is to verify the differences from the two studies and to also extend the investigation into sediments and biological materials to establish the possible sinks and the mobilization conditions for arsenic species.

The objectives are:

1. To investigate the levels of Arsenic in Tumon Bay, the connecting freshwater wells on Guam and other potential sites during the wet and dry seasons.
2. To conduct speciation studies of arsenic to ascertain the levels of the different forms of As both organic and inorganic.
3. To conduct speciation study on the sediments and biota samples.
4. To conduct an inter-laboratory validation exercise.
5. To correlate the levels of arsenic to the likely sources and sinks.
6. To relate these levels to the parameters; pH, alkalinity, salinity, dissolved oxygen.

The hydride generation method coupled with Atomic Absorption Spectroscopy that was successfully developed from the first part of this study has shown adequate differentiation between the inorganic arsenic(III) and arsenic(V) species. Part of this continuing project will be to develop and set up the method for differentiating the organic forms of arsenic. For this the Gas Chromatograph and HPLC method will be used. Water samples will be collected from the Tumon Bay area, ground water wells, and other potential contamination sites for comparison. Sediments and biological samples will also be collected from the study sites. This study will establish the levels and the forms of arsenic in the environment and will show whether there is any threat of arsenic contamination in Guam waters. It will also explain the differences from the two studies. The data will assist the relevant authorities in Guam on monitoring and designing management guidelines to address any potential threat to the environment. It will also provide necessary training and skills for speciation studies and analytical instrumentation experience for graduate and under graduate students at the University of Guam.

Presence and Survival of Fecal Indicator Bacteria in Soil from the Banks of Major Rivers and Streams on Guam

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

Funding: $38,822

The use of fecal bacteria to monitor the hygienic quality of recreational waters has some serious limitations in many tropical and subtropical regions of the world. This is because favorable ambient temperatures encourage extended survival times of these organisms in the environment and dramatically increases the risk of false positives occurring. On Guam, E. coli and enterococci are used to monitor rivers and coastal waters around the island respectively. Both organisms have been observed to survive indefinitely in sediments and soils in Hawaii, Puerto Rico, southern Florida, and northern Australia. Their growth in various environmental media has also been reported in several instances. While the survival, growth and proliferation of E. coli and enterococci is suspected to occur in sediments and soils on Guam, the limited available data is inconclusive because it fails to differentiate between possible contributions from fecal and non-fecal sources. The fact remains, however, that exceedances of the recreational water quality standards are far more frequent during wet weather than they are during dry spells. This strongly suggests that local riverbank soil is a major reservoir for enterococci, and that these bacteria are mobilized into the coastal belt by erosive processes during prolonged periods of heavy rain.

The objectives of the study described herein are to demonstrate whether or not E. coli and enterococci are capable of surviving in Guam riverbank soils over extended periods of time, and to elucidate the importance of various soil related factors that might influence the data. To this end, we propose to screen riverbank soils for E. coli and enterococci from all major rivers and streams on island. Sampling sites will coincide with those adopted by Guam EPA for recreational water quality monitoring purposes. Subsequent investigations, at selected sites, will explore any horizontal and vertical variations in abundance of both organism in relation to soil type, organic matter content, nutrient levels, and moisture content. We will also attempt to determine their survivability in the total absence of sustainable sources of fecal bacteria such as storm water runoff and animal excrement.

Fecal bacteria will be removed from all soil samples by sonic probe and cultured using Colilert® and Enterolert® commercial growth media for E. coli and enterococci respectively. Bacterial enumerations will be accomplished using the Quanti-TrayTM MPN method following incubation at 41oC for 18 h ± 2 h for both organisms. All soils tested during the study will be characterized according to type, and analyzed for organic carbon, nitrate, orthophosphate, total nitrogen, total phosphorus and moisture content. Survival tests will be conducted using closed-jar microcosms.

The analytical work will be carried out at the Water and Environmental Research Institute (WERI), Water Quality Laboratory, at the University of Guam, where adequate support facilities, infrastructure and equipment necessary for the study are present. The analytical procedures will adopt USEPA approved methods in all instances. Quality control and quality assurance procedures will be rigidly adhered to.

The data obtained should command the attention of water quality managers, environmental regulators and public health officials in tropical and sub-tropical regions throughout the world.

Groundwater Development and Utilization for Emergency Drinking Water Supply on Fais, Yap State, FSM

Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. John W. Jenson
Dr. Donald H. Rubinstein
Funding: $53,220

This project will provide an assessment of the physical resources and socio-cultural factors that must be considered to develop a reliable source of potable groundwater to meet emergency needs of the residents of the small (2.6 km2), remote island of Fais, Yap State, Federated States of Micronesia. Fais's permanent population of about 320 people currently relies almost exclusively on rainwater catchments to meet its potable water needs. However, on average once a decade a major storm destroys or damages existing catchments, most recently in November 2003. Groundwater, however, has yet to be developed, even for emergency supply. To do so requires first making a general survey to locate prospective sites that could yield sufficient quantities of potable water under emergency conditions. Moreover, in light of the small size and subsistence economy of Fais and the prevailing traditional social organization and land tenure, technical recommendations for development and protection of groundwater must be compatible with the island's social traditions, cultural values, and indigenous authority. The central objective of this study will therefore be to map the key karst features that constrain the catchment, storage, and discharge of groundwater, and prepare preliminary maps of potential sources within the inferred catchment areas that can serve for planning and engineering purposes in the immediate future. The supporting but equally important objectives of the socio-cultural portion of the project include making an inventory of patterns of usage, storage, and sharing of water from existing rainwater catchments and other sources. Collection of demographic data, in addition, will provide a basis for evaluating foreseeable future water resource needs. The study will employ the classical methods of geological and anthropological fieldwork. The expected result will be a preliminary map of potential groundwater resources that could be developed for emergency needs, with recommendations for appropriate development and management approaches that will ensure that water from the developed sources will be available when needed. The principal investigators will draw, respectively from over 10 years of experience in studying the hydrogeology of similar raised carbonate island in the region and 35 years of personal association with residents of Fais. Finally, the project will support a graduate thesis in the Environmental Science program at the University of Guam. The graduate research assistant will be trained on a broad range of graduate academic topics, including hydrology, hydrogeology, cultural anthropology, environmental economics and management, and the use of databases and GIS.

Refining the Rainfall Erosivity Factor and Developing Rainfall Distribution Maps for the Island of Pohnpei

Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. Shahram Khosrowpanah
Dr. Mark Lander
Funding: $36,803

In Micronesia, where tropical cyclones and other manifestations of deep convection are common, very high short-term rain rates are experienced. We have chosen the island of Pohnpei to set up a network of manual and electronic rain gages to study the spatial and temporal distribution of rain. Located at low latitude in the western North Pacific (where deep convection in various organized patterns and stages of development is the dominant producer of rain), the island of Pohnpei is one of the wettest places on earth. Our recently installed rain gage network indicates that the high interior of the island may receive over 300 inches of rain annually. Stream and urban flooding as well as deadly slope failures are recurring problems on Pohnpei.

Human activity and other factors are changing the physical and biological character of Pohnpei's unique tropical rain forest. Insufficient spatial distribution of rain gages and lack of appropriate measurements of short-term extreme rain rates have resulted in rainfall statistics for most of the islands of Micronesia that 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 landslide 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 the planning and design of hydro electrical power plants.

The objective of this project is to acquire, compile, and analyze rainfall data from a transect of manual and electronic rain gages (some already installed and some others to be placed at crucial locations) to produce statistics of rain fall needed to address land and surface-water management problems, and to help identify the character and thresholds of rainfall that lead to dangerous flooding and slope failures. A key parameter we wish to determine are the R-factors that govern erosion on the island. The R factors are related to the peak 15-minute rain rates, and this data is only now beginning to be acquired. With our newly acquired rainfall dataset, we will be able to refine the maps of the distribution of the R factor on the Island. Also, a complete description of the hydrologic cycle on Pohnpei is not complete without some assessment of the magnitude of fog drip in the interior highlands that are often enshrouded in cloud. In order to get better information on the possible contribution of fog drip to the total annual precipitation in Pohnpei's rain forest, we will install a fog-drip collector at our mountain rain gage site.

Persistent Contaminant Assessment of Food Fish from Tanapag Lagoon, Saipan

Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Dr. Gary R. Denton, Harold R. Wood
Brian Bearden. Peter Houk, Michael Trianni
Funding: $38,099

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 50-year-old municipal dump that served as the island's only solid waste disposal site until its closure a little over a year ago.

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 and a bio-indicator survey of the near shore waters is currently underway. The project described herein proposes to determine contaminants of potential concern (heavy metals, pesticides and PCBs) in important food fishes from within the lagoon and is seen as a logical extension of these studies.

The study will focus on those species commonly taken by local fishermen for food and recreational purposes. Emphasis will be given to fish that are relatively restricted in their movement and spend much if not all of their time in the lagoon. Sampling will be conducted in sea grass beds and patch reef areas throughout the lagoon encompassing both near shore and offshore habitats. Specimens will be collected by cast-net, beach-seine, spear gun, and hook and line. The assistance of local personnel and government agencies in procuring samples will be obtained as necessary.

The analytical work will be carried out at the Water and Environmental Research Institute (WERI), Water Quality Laboratory, at the University of Guam, where adequate support facilities, infrastructure, essential chemicals and items of equipment necessary for the study are present.

The primary objectives of the study are to evaluate contaminant levels in popular table fish from within the lagoon and identify potential health risks (if any) associated with their long-term ingestion. By including territorial species the results will also help identify and delineate areas of contaminant enrichment, and add significantly to the contaminant database required for future trend monitoring purposes.

Hydrology of the Sabana Watershed and Water Cave, Rota, CNMI

Funded by:
US Geological Survey, Water Institute Program
P.I.
Dr. John J. Jenson
Funding: $37,475

Rota, about 40 miles (64 km) north of Guam, supports a population of about 2500. The island obtains nearly all of its potable water from a karst spring estimated to produce from 0.5 to 1.5 mgd (0.02 to 0.06 m3/sec). Although the spring has historically produced more than enough during wet years, it can slow to very low flow during dry years, nearly ceasing entirely during the 1998 El Nino event. Reliable management of the water production over the long term requires a better understanding of the hydrology of the Water Cave and the catchment that feeds it. In a previous study of Rota led by the author of this proposal, several sink points in the Mount Sabana area have been documented are suspected to feed the spring. The Sabana area is undergoing active use, including the cultivation of crops in the watershed that feeds the sink points, and hence ultimately the spring. For the island to effectively manage this preeminent water source, it is crucial that engineers and planners have a better understanding of the properties of the Sabana Watershed and the hydrologic connection between the watershed and spring.

The proposed study would produce a set of maps of the Sabana Watershed boundaries, geologic contacts, vegetation, and land use. The maps would also include field relationships of the important hydro geological features, particularly the locations of the sink points and the inferred and observed flow paths to them. This work would be concurrent with parallel work by the US Geological Survey Field Office in the CNMI in collaboration with the Army Corps of Engineers (Capital Improvement Program) to reinstall a rain gauge in the Sabana Watershed, along with new stage gauging instruments in the spring, both of which were destroyed by a typhoon in July of 2002. The proposed project would use rainfall and spring hydrograph data obtained by the USGS Field Office from Spring of 2001 through July of 2002, along with new data. These data would be used to prepare a water budget for the watershed-spring system and to elucidate the relationship between rainfall, watershed characteristics, storm water runoff and ponding at the sink points, transport time to the spring, and stage response of the spring. They will also provide a basis for predicting the response of the spring to rainfall and to develop a hypothesis for pathways and flow rates in the aquifer. For resource managers and planners on Rota, the results of the proposed work will provide a basis for assessing the risk to water quality posed by human activities in the Sabana Watershed, along with appropriate strategies for aquifer protection and remediation.

RECENTLY COMPLETED 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

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

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 well head 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 well head 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 well heads 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 well head 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 well head predictions based on known rainfall variations and known storage parameters. The nearly two-year lag in the response of the well heads to long-term surpluses and deficits of rainfall may allow for long-term prediction of well heads. 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 nearly all of the major hotels are located. Previous studies have shown high levels of nutrients and fecal coliforms 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
4) 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 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,
5) 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 42.5inches (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 hydro geologic 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, which 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

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US Geological Survey, Water Institute Program
P.I.'s
Dr. Gary R. Denton
Harold R. Wood Brian Bearden
John Starmer Peter Houk
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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 1 will focus on dominant organisms inhabiting the shallow near shore waters of the lagoon with emphasis given to those groups that have high bio-indicator 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.

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. Ross Miller**, telephone: (671) 735-2141, **e-mail: rmiller@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 Natural and Applied 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)***.