INTRODUCTION TO RESEARCH ACTIVITIES & TEACHING PROGRAMS

by

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

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

Guam's only civilian landfill in the village of Ordot continues to present challenging environmental and human health problems, some of which WERI scientists are investigating. One recently completed WERI study determined the impact of heavy metal contaminants in leachate streams discharged from the landfill on fisheries resources within the Pago River watershed and Pago Bay.

Mapping and modeling soil erosion in Guam's 'badlands' are vital aspects of watershed management that WERI scientists are actively involved with.

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

The Water & Environmental Research Institute of the Western Pacific, or WERI, is one of 54 water research institutes established by U.S. Congressional legislation at each Land Grant University in the United States and in several territories. The institute is now in its 33nd 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 various 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 monies on Guam, in the Commonwealth of the Northern Mariana Islands (CNMI), and in the Federated States of Micronesia (FSM).

In FY-2007 WERI faculty were involved as Principal Investigators on twenty research and training projects with a combined budget of about $808,000: $253,000 from seven 104-B projects, $50,000 from federal agencies, $103,000 from Federal sources awarded through Local Agencies, and $378,000 from local grants and direct funding from the Guam legislature.

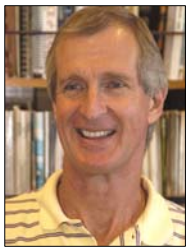
Currently WERI has a fulltime director who is also a UOG faculty member, five regular research faculty, one adjunct research faculty, a water analysis laboratory manager and technician, two office staff, as well as seven graduate research students who are completing their MS degree in the Environmental Sciences program. During the year 2007, WERI faculty and staff taught 11 graduate courses and two 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 11 refereed journal articles or conference proceedings, seven technical reports, and 16 professional presentations and workshops. WERI faculty currently serve as members or chairs of 16 research thesis committees of students in the Environmental Science and Biology graduate programs..

See us on the web at:

www.uog.edu/weri

WERI FACULTY, STAFF & STUDENTS

DIRECTOR



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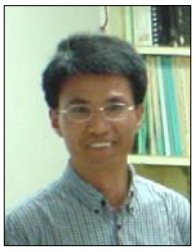

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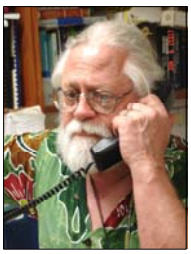

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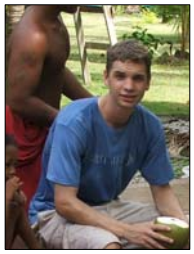

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ACTIVE PROJECTS

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

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

Guam Water Kids: An Educational Campaign for Children to Learn about Guam's Water and How to Protect It.

A Field-Based Simulation for Groundwater Education on Guam

Using Remote Sensing to Determine Changes in Soil Erosion and Sediment Loads from Guam Badlands

CNMI:

Water System Operation and Maintenance Training for Yap State, FSM

Development of Sub-Region Water Production for the Saipan Water Distribution System Model and Exploration of Scenarios for Optimal Operation

Spatial and Temporal Nitrate Variations in Groundwater from Southern Saipan

Heavy Metals in Biotic Components from Saipan Lagoon with Emphasis on Nearshore Areas Impacted by Stormwater and Wastewater Discharges

FSM:

Comprehensive Survey of the Current State, Infrastructure, and Usage of Freshwater Resources on Low Islands of Pohnpei State

Watershed Management for Pohnpei Island in the Federated States of Micronesia

Groundwater Resources Management Training in FSM

OTHER FUNDED PROJECTS

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center

GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

Development of a Digital Watershed Atlas for Guam Phase

GUAM EPA (USEPA)

GWUDI Study: Precision Mapping of Isohyets in Target Storms over the Northern Guam Lens Aquifer

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY

- **a) Spatio-temporal Analysis of Groundwater Quality in Guam**
- **b) Spatially Distributed Precipitation and Water Table Response of the NGLA**
- **c) Modeling Groundwater Recharge**

2. WATER RESOURCES MONITORING PROGRAM

- **a) Continued Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam (ongoing)**

Water Kids: An Educational Campaign for Children to Learn about Guam's Water and How to Protect It.

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Ann Card and John Jocson

Funding: $16,060

The environmental educational materials about water resource issues in earth science textbooks and online at the websites of government agencies now available to Guam children and educators are focused on conditions existing on the U.S. mainland. These materials and accompanying illustrations and images do not fully address basic features of Guam's fresh water resources and the island's critical need to protect and conserve them. The island's unique needs must be taken into consideration if an understanding of the importance of Guam's fresh water as a key resource in our lives and a sense of stewardship are to be developed.

The project proposed here will create materials that will support teachers of children from 9 to 12 years of age about Guam's fresh water resources and will serve children interested in individual study. The materials will feature Guam-based issues and images including photos of Guam children engaged in discovery activities, Guam place names, English-Chamorro vocabulary, and typical island flora, fauna and geological features. Interactive Flash™ animation will be used to illustrate basic concepts such as how an aquifer functions using the unique specifics of Guam's aquifer.

The following components will be developed: a (1) "GUAM WATER KIDS" WEBSITE with corresponding downloadable lesson plans for teachers and group leaders; (2) a CD ROM PRESENTATION in PowerPoint ™ with animation that can be used as (a) a scripted or extemporaneous slideshow, (b) a stand-alone Presentation with pre-recorded narrator and music, and (c) a continuous "unmanned" Presentation in an exhibit booth, and (3) EXHIBIT banner and POSTERS promoting Guam water conservation awareness and the web address and (4) COLLATERAL promotional items (a) a direct mailing of postcards to announce the website, (b) a recycled sports bottle to remind children of the website and water issues, and (c) "business" cards with water conservation tips and the web address.

The objectives of the project are to provide:

1. An online resource for teachers and other youth leaders that will enable them to share the importance of Guam's water resources and the need for protecting them.

2. A website for youth to independently explore Guam's water resources while developing a sense of stewardship.

3. A convenient Presentation that WERI professionals can use to fulfill speaking invitations at schools, career days, and other gatherings of youth groups, and to enhance exhibit opportunities with a narrated CD Rom Presentation and a portable exhibit banner with the purpose of sharing the importance of Guam's fresh water resources with children age 9-12.

4. An ongoing reminder of the importance of Guam's water resources and publicize the Guam Water Kids website address to children, teachers, village mayors and youth organizations.

A Field-Based Simulation for Groundwater Education on Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Paul R. Wallace and John W. Jenson

Funding: $18,873

Studies reveal that middle school and high school students hold inappropriate conceptions of the importance of groundwater in their daily lives as well as inaccurate mental models of the scale and structure of groundwater. Moreover, it has been shown that middle school and high school science teachers receive inadequate formal education concerning groundwater, and possess inaccurate mental models of groundwater. Given the poor scores of local students on national standardized tests for science concepts, it is likely that very few students or teachers on Guam hold appropriate concepts regarding the structure and importance of groundwater, one of the most vital natural resources of the island.

This project will result in increased awareness of the importance of groundwater and a more accurate spatial understanding of fundamental groundwater concepts for teachers and students on Guam. A group of twelve middle school and high school science teachers from the Guam Public School System (GPSS) will receive training in the development of field-based simulations for engaging students in fundamental issues related to the structure, scale, and the role of groundwater in the hydrologic cycle on the island. Field-based educational simulations supported by handheld technologies, also known as augmented reality simulations, are an emerging type of learning tool that integrate game-design principles and scenarios; and incorporate rich media content, such as images, audio, and video. Users employ location-aware mobile devices to receive information and explore the environment in a field-based setting.

As a result of the teacher training, a field-based simulation on groundwater concepts will be developed and implemented with students from GPSS and participants from youth organizations, with approximately 40 youth expected to take part in the simulation during the first year. Data collected will be used to assess the effectiveness of both the teacher training and the simulation. Results and analysis will be fully documented in a final report, an article submitted for publication in a refereed journal, and a conference paper.

Project objectives are to:

1. Train GPSS middle school and high school science teachers in the development of a field-based simulation related to the importance, structure, and scale of groundwater systems on the island of Guam;
2. Assess the effectiveness of the teacher training among GPSS middle school and high school science teachers on their perceived importance of knowing about groundwater, and conceptions regarding groundwater scale and structure;
3. Develop a field-based simulation, based on fundamental groundwater concepts, that can be used for GPSS field trips, youth group excursions, and outreach programs on Guam;
4. Implement the water resource field-based simulation with youth participants on Guam;
5. Assess the effectiveness of the field-based simulation on perceived importance of knowing about groundwater, among Guam's youth;
   Provide an online resource for schools and organizations to access teaching materials, field-based simulation examples, and results of this study.

Using Remote Sensing to Determine Changes in Soil Erosion and Sediment Loads from Guam Badlands

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah and Yuming Wen

Funding: $21,161

In southern Guam, dramatic erosion processes are visibly evident in large, bare plots of earth that occur throughout watersheds in the southern half of the island. These areas of land along the steeply sloping topography are called “badlands” and are continually eroding soil leaving patches of exposed earth. Previous studies have indicated that badlands can contribute an average of 157 tons/acre/year of soil erosion in a watershed, which is 30 times more than any other type of land coverage. The major problems with badlands are that they have tendency to move and expand within a watershed. To implement effective erosion control practices on badlands requires: 1) knowledge of the location and the extent of current badland areas, 2) identification of where the badlands have expanded in size over time, and 3) details on the underlying soil type and slope angle where the badland expansion has occurred. Traditional field inventories and surveys may accurately delineate the boundaries of each badland area, but it difficult to monitor changes in the badland areas over time by this method alone. Remote sensing applications provide a useful means of overcoming this disadvantage.

Currently, there are satellite images as well as aerial photos of Guam which were recorded on different years. By using remote sensing applications, changes in the total area of badlands can be identified, and mapped over time. The specific remote sensing software application that will be used in this study is called ERDAS Imagine®, created by Leica Geosystems. Satellite images of Guam are analyzed by the remote sensing software to detect changes in the area of badlands over time. The slope angle, soil type, and estimated soil erosion for each badlands will be determined by the GIS soil erosion base model that has been developed by WERI researchers. The model combines the Universal Soil Loss Equation (USLE), the Geographic Information Systems (GIS), and the Digital Elevation Model (DEM) for predicting potential soil erosion. The model is capable of identifying the areas of high erosion potential, evaluating the effectiveness of various soil erosion reduction practices, and estimating the sediment yield for an entire watershed. The objectives of this project are to: 1) identify, map, and monitor the changes in badland areas over time, 2) use the GIS erosion base model to identify the underlying soil types and slope angle of the terrain where badland expansion is occurring, and 3) provide recommendation on appropriate soil erosion control practices and re-vegetation methods for the areas where badland expansion is occurring..

Water System Operation and Maintenance Training for Saipan, Commonwealth of the Northern Mariana Islands

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Shahram Khosrowpanah

Funding: $14,787

Due to budgetary constraints, the Saipan Commonwealth Utility Commission (CUC) operation and maintenance division has undergone relatively large changes in personnel over the last few years. Many of the technicians have left the agency and new personnel, currently working on the system, are relatively untrained. Presently, CUC is experiencing a serious operation and maintenance problems with the various components of water and waste water systems. This includes mechanical and electrical controls for pumps in the water supply and wastewater collection systems and the maintenance and repair of altitude and pressure regulating valves in the distribution system. The CUC has requested that we carry out a hands-on training program in pump and automatic regulating valve repair and maintenance for their operation and maintenance people in both the water supply and wastewater areas.

We are proposing to provide and one weeklong comprehensive training program in operation and maintenance of pumps and valves for utility personnel. The training will be made avalailble to utility employees of the Commonwealth of the Northern Mariana Islands (CNMI) and will be carried out in Saipan.

The proposed training will consist of the following topics:

PUMP REPAIR AND MAINTENANCE

1. Site inspection of water and wastewater facilities
2. Pump station equipment design, operation and maintenance
3. Hands on training at the CUC 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

VALVE REPAIR AND MAINTENANCE

1. Site inspection of existing altitude and pressure regulating valves (PRV)
2. Theory of operation of Altitude and PRVs
3. Hands on training at the CUC maintenance shop covering preventative and overhaul maintenance of valves

Discussion of future needs and required actions for long term preventative maintenance program for automatic valves in utility systems

Development of Sub-Region Water Production for the Saipan Water Distribution System Model and Exploration of Scenarios for Optimal Operation

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah and Leroy F. Heitz

Funding: $25,816

The Saipan water distribution system has been divided into 10 sub-regions. Each region is expected to operate somewhat independently. However, due to inadequate inflow to some of the sub-regions, system leakage, and lack of knowledge of the system behavior as a whole, the system is unable to provide 24-hour water services. A stated goal of the Commonwealth of the Northern Marianas Islands (CNMI) government is to provide 24-hour water to all residents served by the Commonwealth Utility Corporation (CUC) water system. The CNMI Governor created a task force whose primary purpose is to find funding and oversee the CUC accomplishments toward the 24-hours water service goal. To assist in reaching their goals, the CUC commissioned the University of Guam, Water and Environmental Research Institute of the Western Pacific (WERI), to develop a hydraulic model of the Saipan water system and to train CUC water division staff in the use of that model.

WERI researchers have developed computerized models of each of the ten sub-regions of the CUC water system using the Haestad WaterCad water system modeling program. They also, developed a source, transmission and storage model of the Saipan water system. This included a skeleton of the existing 10-region water system models that are joined together at the boundary points. For the model to provide optimal results, it is essential to have a good knowledge of the residential and commercial demands being placed on the distribution system. This estimation has been completed by WERI and the water usage values have been imported into the model. The next vital pieces of information required include estimates of how much water is being put into the system from each source and the most effective way of transferring this source water between the regions.

This project proposes to refine estimates of both the quantities and spatial distribution of water production from wells and springs in each sub-region and to explore the most effective means of transferring the water sources between the regions. The specific objectives of this project are:

1. To determine the amount of water production in each sub-region.

2. To locate all production sites using Geographical Information System (GIS) techniques.

3. To explore various operational scenarios for effectively transferring water throughout the regions.

The resulting improvements to the water production estimates and the transfer efficiency studies will provide the CUC water division with the capability to better identify the rates of unaccounted water throughout the system and to determine what changes in operation and system improvements are required in order to meet the goals of improved water quality and 24-hour water delivery to all of the CUC customers.

Spatial and Temporal Nitrate Variations in Groundwater from Southern Saipan

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Derek Chambers and Heidi Yelin

Funding: $29,900

Ingestion of water containing high nitrate or nitrite concentrations can be fatal to infants. Nitrate and nitrite are rarely a problem for people older than six months. However, long term exposure to nitrate and nitrite can lead to diuresis, starchy deposits, and hemorrhaging of the spleen. In fact, nitrate and nitrite are such a significant health threat that public water systems are required to monitor delivered waters for these constituents at regular intervals, no less than once a year, with increasing sampling frequencies required if concentrations fluctuate significantly over time. The maximum contaminant level (MCL) for nitrate and nitrite is 10 mg/l and 1 mg/l respectively.

The major source of drinking water for the island of Saipan is groundwater pumped from the karst (fractured limestone) aquifer by the local water utility, Commonwealth Utilities Corporation (CUC). The groundwater is susceptible to nitrate contamination from the numerous on-site septic systems that exist in many villages on Saipan, and possibly from the use of nitrate based fertilizers on agricultural plots. CUC monitors for nitrate and nitrite at 45 sites throughout the distribution system. In June of 2006, one water sample from the CUC southern water distribution system exceeded the nitrate MCL. While this was the first exceedence since monitoring began in 2001, one additional violation was noted in December 2006 and eight in June 2007 with levels as high as 14 mg/l. CUC was required to notify their customers of nitrate contamination and the risks from consuming the contaminated water.

The concentration of nitrates in the groundwater of the southern end of Saipan appears to fluctuate rapidly. Three sites with nitrate concentrations a little over 14 mg/l in June 2007, had concentrations between 6 and 8 mg/l two weeks later. Notably, during the timeframe when nitrate levels were high there was little rain, and several days of heavy rain in the following two weeks resulted in lower nitrate concentrations. Accordingly, this project aims to further investigate the potential relationship between rainfall and nitrate concentration in the groundwater of the southern end of Saipan. To this end, weekly samples will be collected from approximately 20 wells in southern Saipan, over a one year period, and analyzed for nitrate at the CNMI Division of Environmental Quality (DEQ) lab, following EPA-approved methods. Additional analysis (pH, conductivity, temperature, dissolved oxygen or turbidity) may be conducted in the field at each sampling site as deemed necessary. Electronic rainfall gauges will be installed at four sites in the watershed of the southern Saipan well field and the data downloaded monthly.

The objectives of the study are to conduct regression analyses to determine the dependence of nitrate levels upon rainfall, and if so, to quantify the negative relationship (e.g. rates and concentrations). The result of this project will provide regulatory guidance to CUC on how frequently the monitoring for nitrate concentration should be conducted for southern Saipan's aquifers.

Heavy Metals in Biotic Components from Saipan Lagoon with Emphasis on Nearshore Areas Impacted by Stormwater and Wastewater Discharges

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
John A. Starmer,
Gary R.W. Denton and H. Rick Wood

Funding: $34,534

Saipan is the second most densely populated island in Micronesia and experiences many of the environmental pollution problems seen in the larger industrialized nations of the world. Solid and hazardous waste disposal, illegal dumping, urban runoff, unregulated waste discharges from various commercial premises, and the disposal of primary treated sewage effluent directly into the ocean, rank among the most critical environmental problems seen on the island today. A large lagoon that borders the western side of the island serves as a sink for many of the more recalcitrant pollutants mobilized into the ocean from land-based sources during major storm events. Locally referred to as Saipan Lagoon, this body of water is geographically divided into three separate lagoonal entities all of which are impacted to some degree by the activities of man. The largest and most northerly of these is Tanapag Lagoon which extends along some of the most industrialized coastline on island. An ongoing pollution monitoring and assessment program for Tanapag Lagoon was established by WERI in 1997 and we now have a reasonable understanding of the abundance and distribution of the contaminants of primary concern in these waters (i.e., heavy metals and PCBs). Comparable data for the two lagoonal entities further south is, however, lacking. The smaller and most southerly of these two water bodies is Chalan Kanoa Lagoon which borders mostly rural and residential areas and receives relatively little in the way of stormwater runoff. It does, however, receive effluent from a sewage treatment plant and is, therefore, of special interest from an environmental monitoring standpoint. Immediately to the north of Chalan Kanoa Lagoon is Garapan Lagoon, a relatively long narrow stretch of water that borders both residential and commercial premises between the villages of Susupe and Garapan. Relatively high levels of mercury were recently discovered in fish taken from the northern end of this lagoon and were attributed, at least in part, to storm drain contributions from two land-based sources identified in the Garapan area. Sediment deposition patterns around these storm drains suggest that fisheries further south may also be impacted. Heavy metal contributions into Garapan Lagoon from the many other storm drains that discharge along much of its length are currently unknown.

Extending the baseline survey for Tanapag Lagoon into the southern half of Saipan Lagoon therefore seems a logical extension of WERI's ongoing pollution monitoring and assessment program for Saipan's coastal waters. To this end, the project described herein proposes to determine heavy metals in dominant ecological representatives inhabiting the shallow, nearshore waters of Garapan Lagoon and Chalan Kanoa Lagoon with emphasis given to those groups with proven bioindicator capability and/or food potential for local residents (e.g., algae, seagrass and bivalve mollusks). 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 the southern half of Saipan 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.

Comprehensive Survey of the Current State, Infrastructure, and Usage of Freshwater Resources on Low Islands of Pohnpei State

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Danko Taborosi and John W. Jenson

Funding: $17,845

Freshwater resources on coral atolls and other low islands in the Federated States of Micronesia (FSM) are under threat of overuse due to changing lifestyles and increasing population pressures, damage by pollution and unsustainable development, and obliteration by global climate change. The extent of specific problems are different on various islands, but cannot be evaluated at present due to the lack of basic field data. Despite the rapid socioeconomic and environmental changes being experienced by the low islands in the FSM, there has been no comprehensive study to examine the current condition, infrastructure and utilization of their freshwater resources. The lack of such information represents a huge obstacle to government planners, resource managers, engineers, educators, environmental scientists, and others dedicated to the sustainable use of freshwater resources in Micronesia. Funding permitting, we therefore propose to carry out a comprehensive study of all low island atolls in Phonpei State (Ahnd, Pakin, Pingelap, Mwoakilloa, Oroluk, Sapwuahfik, Nukuoro, and Kapingamarangi) and document the condition of their freshwater resources and related infrastructure, as well as examine the local people's relationship with those resources. Such information needs to be made available not only to improve our understanding of the water situation in the low islands, but also to avoid or better respond to fresh water emergencies, agricultural difficulties, food shortages, health problems and other environmental crises that may arise due to lack of knowledge, awareness or preparation. Specifically, we intend to use a combined hydrogeologic/engineering/sociologic fieldwork approach to document hydrologically relevant natural aspects and infrastructure, as well as people's usage patterns and perceptions of freshwater resources on each of Pohnpei's eight low islands. Essentially, the project will comprise of eight separate research trips (one per island), each of which will include hydrogeologic component comprising of field observations and mapping, engineering component comprising of infrastructure examinations and measurements, and "people-oriented" component comprising of standardized surveys and freeform interviews of local residents. The immediate objectives of the project are to:

- Compile a comprehensive reference source of low islands of Pohnpei State (e.g., descriptions of each island's natural and human environment, highlights of significant natural, man-made, and cultural features).
- Examine and describe the state of freshwater resources and their usage patterns on each island, as well as other relevant lifestyle practices (e.g., waste disposal, burial practices, animal husbandry, etc.)
- Inventory, assess and map the hydrologically significant infrastructure on each island (e.g., rainwater catchment systems, storage tanks, shallow wells, etc.)
- Record island residents' attitudes and other relevant cultural norms, perceptions, and opinions related to freshwater resources.
- Identify and report any critical problems related to freshwater resources.

Information outlined above is urgently needed due to the high rate of development, human modification and population increase in the Micronesian low islands. We plan to make it available as an on-line series of information-packed technical reports, supporting databases, photographic collection, and GIS coverages, so that it is readily accessible to the FSM and US government bodies, regulatory agencies, utility corporations, non-government organizations, research and academic institutions, and the private sector entities involved in the utilization, monitoring, management, and protection of the freshwater resources of Pohnpei State.

Watershed Management for Pohnpei Island in the Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah,
Leroy F. Heitz and Mark A. Lander

Funding: $35,273

In 1987, the Pohnpei State legislature passed the Pohnpei Watershed Forest Reserve and Mangrove Protection Act in which close to 5,000 hectares (12,500 acres) of upland forest were set aside as a protected Watershed Forest Reserve. The purpose of this act was to halt the degradation of the interior forests from road construction and population encroachment as well as to protect the watershed and water supply for the island's population. However, when surveyors attempted to mark the boundary of this reserve, suspicious and angry villagers with machetes and guns turned them back. With this single act, the story of watershed management on Pohnpei began and continues to unfold today.

According to the Conservation Society of Pohnpei (CSP), recent land clearing for agriculture, road construction and housing developments have been paralleled by a degradation of water quality in some of Pohnpei's major rivers and streams. Such negative changes emphasize an urgent need for developing and implementing sound watershed management strategies. A fundamental prerequisite for the development of any watershed management/protection plan is a complete understanding of the physical and environmental components of the watershed and their interrelationships with one another.

The overall objective of this project is to study the impact of man's activities on the quality of the water in the watershed and make recommendations to reduce the impact of these activities. The specific objectives are to continue to 1) monitor stream flow, turbidity, and rain gages for previously selected sites within the Senipehn and Nanpil Watersheds; 2) develop a correlation between stream flow, turbidity and rainfall; 3) make a comparison with the findings of these two watershed with Enipein Watershed that have been monitored during previous studies, and 4) develop recommendation on watershed management.

The result of this project will be the development of baseline information and correlations among the dynamic components of the Senipehn watershed environment. The baseline information will be used for comparison between Senipehn watershed, where there is less human activity, and other watersheds such as Enipein and Nanpil where there is a high human impact in the watershed. The results will reveal the impact of the various activities such as land clearing, land sliding/slope failures, and population growth on the quality of the watershed. This information will help various parties such as Conservation Society of Pohnpei (CSP), Land Management, the Pohnpei EPA, and local mayors to implement plans for protecting the watersheds in Pohnpei.

Groundwater Resources Management Training in the Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
John W. Jenson

Funding: $32,204

Water shortages are a serious concern to the residents of atoll islands. Small size and isolation subject entire island populations to the stresses of drought and difficult, expensive, and sometimes untimely aid operations. Under normal conditions, water demand is met by rooftop rain catchment. Prolonged droughts, such as those associated with El Niño, however, exhaust water storage, leaving residents dependent on groundwater or imported water. Typhoons can destroy the rain catchments and coconut crops, leaving residents dependent on groundwater. However, wash-over of storm-driven surf can contaminate groundwater just when it is needed most.

The proposed project will meet the following needs of the Federated States of Micronesia, as specified during the WERI Advisory Council meetings from 2006 and 2007:

1. "Develop a water resources management scheme for low island atolls in Yap and elsewhere in FSM"

2. "Make training manuals used in various training activities available to all interested parties"

3. "Presentation of Atolls Groundwater Modeling to appropriate users through workshops in each of the states with atoll islands"

The purpose of the project is to disseminate the knowledge gained from the past year's efforts in understanding the behavior of the freshwater lens on atoll islands. This will occur through the preparation of spreadsheet model of atoll island aquifer response to recharge, the preparation of a user's manual for the spreadsheet model, the training of water resources managers on Yap, Chuuk, and Pohnpei on the manual, and the preparation and printing of an instruction pamphlet on groundwater resources and its distribution to schools located on atoll islands, and presentation of the model and user's at a scientific meeting with other professional scientists and educators working in similar areas.

The previous project has produced a simple algebraic model, based on numerical modeling results, which predicts the thickness of the freshwater lens in both steady-state and transient conditions. This model can easily be placed into a spreadsheet and made available to water resources managers in FSM. The model is also an excellent teaching tool, as it explains the relationship between the freshwater lens and the geological and climatic factors which govern its behavior and thickness. This model will aid FSM island leaders and water resource managers in establishing sustainable and practical groundwater extraction practices.

PROJECTS COMPLETED MARCH 2008

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

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

Identifying the Optimum Land Coverage Practices for Reducing Soil Erosion in the Ugum River Watersheds Using a Newly Developed GIS Based Erosion Potential Model

Land Cover Accuracy Assessment for Southern Guam

CNMI:

Mercury Contamination in Garapan Lagoon, Saipan: An Evaluation of Potential Drainage Pathways and Impact on Fisheries Resources

Development of Realistic Residential and Commercial Water Demands for Use with the Saipan Water Distribution System Model

FSM:

Watershed Management for the Senepehn Watershed, Pohnpei Island, Federated States of Micronesia

Hydrological Modeling of Atoll Islands in the Federated States of Micronesia

Water System Operation and Maintenance Training for Yap State, FSM

OTHER FUNDED PROJECTS

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center

GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

Development of a Digital Watershed Atlas for Guam (ongoing)

Development of a GIS Based Erosion Potential Model for Estimating Sediment Delivery to Estuarine and Coral Reef Environments in Southern Guam

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY:

- **a) Updating the Geologic Map of Guam**
- **b) Determining Background Fluorescence in Guam's Groundwater**
- **c) Construction of Web Accessible Digital Annotated Continuous Aerial Map of Guam's Coast**

2. WATER RESOURCES MONITORING PROGRAM

- **a) Continued Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam (ongoing)**

Identifying the Optimum Land Coverage Practices for Reducing Soil Erosion in the Ugum River Watesheds Using a Newly Developed GIS Based Erosion Potential Model

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah,
Leroy F. Heitz and Yuming Wen

Funding: $18,147

Surface runoff and sediment losses from soil erosion are major contributors to reductions in surface water quality and subsequent degradation of the coral reefs in Southern Guam. A study of the Ugum watershed in this part of the island indicates that soil erosion from vegetated savanna grassland is around 70 tons ha^{-1} yr^{-1} but can be as high as 547 tons ha^{-1} yr^{-1} in unvegetated sloping sites known as "badlands". In contrast, agricultural lands in the Ugum watershed have an average soil erosion loss of 45 tons ha^{-1} yr^{-1}. Additional problems associated with soil erosion include loss of soil productivity at the eroded site, reduced water storage capacity in streams and lakes, and loss of wildlife habitat. The negative impact of sediment loading on the aquatic environment of Guam is well documented. Several researchers have clearly demonstrated that coral reef decline associated with sediment deposition is directly linked with a reduction in the quantity and quality of solar radiation. Corals growing in areas subjected to high sediment loads in stream runoff are especially vulnerable. Undesirable effects associated with the degradation of coral reefs include declining fish populations and a negative impact on tourism.

Effective land use planning and the implementation of proper erosion control measures requires: 1) a basic understanding of runoff and erosion rates at the plot, on hill slopes, and at small catchment scale and how these rates vary across the landscape, 2) a means of identifying areas that have the potential for high soil erosion, and 3) a means of implementing proper soil reduction practices that are both effective and economic.

For the past several years, various agencies such as the Natural Resources Conservation Service (NRCS) and the Guam Department of Agriculture have been implementing erosion control practices by carrying out extensive tree planting programs. However, it is important to investigate: 1) the impact of tree growing in reducing soil erosion, 2) the identification of other kinds of land coverage (e.g., Vetiver grass) that may be more effective in reducing soil erosion, and 3) the cost of applying these erosion reducing alternatives.

The objective of this project was to use a GIS based erosion model, recently developed by WERI researchers, to investigate the effectiveness of various vegetative cover schemes in reducing soil erosion, and attempt to determine the relative costs of applying these erosion prevention schemes.

The benefit of this project is that that NRCS and the Guam Department of Agriculture are now better equipped to choose between soil erosion prevention alternatives in the future.

Land Cover Accuracy Assessment for Southern Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Yuming Wen,
Shahram Khosrowpanah and Leroy F. Heitz

Funding: $32,707

Land cover change (LCC) is caused by human disturbances and/or natural events such as climate variation and flooding. The quantitative analysis of LCC has been of major concern to scientists and researchers around the world over the last few decades. Identifying land cover change in a watershed can help determine ecological and hydrological changes in the watershed over time. Satellite remote sensing, geographic information systems (GIS), geo-statistics, and global positioning system (GPS) can all be used to identify LCC in watersheds. These technologies provide the basis for developing landscape composition and pattern indicators as sensitive measures of environmental change and thus, may provide an effective and economical method for evaluating changes in watershed conditions related to disturbances from human and/or natural stresses.

Landsat observations have evolved from an experimental system in 1972 to a sophisticated means of monitoring changes in the Earth's surface using a multi-date satellite imagery databases. These include Landsat Multi-Spectral Scanner (MSS) imagery, Landsat Thematic Mapper (TM) imagery, and Landsat Enhanced Thematic Mapper Plus (ETM +). Recent surveys indicate that land cover/use changes have a direct and enormous effect on water quality and environmental change. Watershed water quality and ecosystem are threatened constantly by both human impacts, such as forest fires and development as well as natural phenomena like storms and droughts. In addition, the combined uses of GIS, remote sensing and GPS tools have been highlighted with respect to their advantages in watershed applications and management.

Spatial and temporal modeling of changes in wetlands and badlands in Southern Guam watersheds was one of the highest priority research needs recently identified for Guam. Previously, five (5) temporal Landsat images, including Landsat MSS image of November 14, 1973, and Landsat TM images of June 18, 1989, September 22, 1989, May 11, 1993, June 12, 1993, and March 15, 2001, were used to extract land cover information for watersheds in Southern Guam. The 1978 topographic map and 1975 digital raster graphics (DRG) for Guam were also utilized with the Landsat MSS image of 1973 to obtain land cover information. The classification process now completed, the next step of the investigation involved an accuracy assessment to compare the classification to ground truth or other data. Recent IKONOS and QuickBird imagery were used as reference data to assess Landsat imagery extracted land cover accuracy. Aerial orthophotos of 1975 were also available and were used as reference data. GPS and a GPS compatible digital camera was used to collect field data for ground truthing and land cover classification accuracy assessment. By this means, a land cover accuracy assessment for each watershed in Southern Guam was conducted. The objectives of this project were to:

1. Select reference pixels at random for classification accuracy assessment
2. Use a GPS unit to collect field data as reference for accurate assessment
3. Use a GPS compatible digital camera to take photos as reference for the GPS collected data for ground truthing
4. Conduct accuracy assessment, and achieve results.

Mercury Contamination in Garapan Lagoon, Saipan: An Evaluation of Potential Drainage Pathways and Impact on Fisheries Resources

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Brian G. Bearden, Michael S. Trianni,
Gary R.W. Denton and H. Rick Wood

Funding: $39,725

Garapan Lagoon is one of three lagoons that border the western shoreline of Saipan. All three lagoons harbor a rich diversity of marine life and support a variety of commercial and recreational activities. However, over the years, increased urban growth and commercial developments along the adjacent coastline have resulted in a loss of environmental quality in these waters. This is especially true in the southern half of Tanapag Lagoon where a commercial port (Saipan Harbor), power station, municipal dump, two small boat marinas, a sewer outfall, several garment factories, auto and boat repair shops and government vehicle maintenance yards have all taken their toll. Several streams and storm drains empty into the lagoons 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.

Until recently, the availability of information concerning the distribution and abundance of major contaminant groups in this area was extremely limited. The turning point came in 1998 when WERI scientists conducted a detailed assessment of heavy metals, PCBs and PAHs in sediments from the southern half of Tanapag Lagoon and identified areas of contaminant enrichment around the port, the small boat marinas and the dump. Subsequently, dominant ecological representatives, including a number of popular table fish, were collected for chemical analysis from these waters. Surprisingly, mercury levels in the majority of specimens taken from the Micro Beach area, at the northern end of Garapan lagoon, were significantly higher then those found elsewhere in the study area. Moreover, close to 60% of the total catch from this site (~50 fish) had levels sufficiently high enough to warrant restricted consumption. This compares with about 15% from an outer lagoon control site. An assessment of the source and extent of the mercury contamination in the Micro Beach area was the primary focus of this investigation. To this end, soil from storm drains and drainage basins in the Garapan area and surface sediments from within the lagoon were collected for analysis. Significant sources of mercury were identified in storm water drains servicing the hospital and a newspaper printing press in Garapan. The full impact on the mercury enrichment on biotic resource of the area are currently being assessed using squirrel fish, *Myripristis* spp., and snapper, *Lethrinus* spp. as bioindicators. Both species of fish show a high propensity for mercury and are favored by local fisherman. Samples were collected for analysis on a monthly basis from the Micro Beach area and from control sites further offshore to determine if critical times exist during the year when fish consumption from this area should be more restrictive.

Aside from its ecological significance, this study is of importance from a public health standpoint and should command the interest of those involved with environmental protection, water quality management and the sustainable development of fisheries resources in the area. It also provides the local enforcement agency with sufficient data to determining whether remediation strategies are necessary or not.

Development of Realistic Residential and Commercial Water Demands for Use with the Saipan Water Distribution System Model

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Leroy F. Heitz and Shahram Khosrowpanah

Funding: $29,439

The US Environmental Protection Agency (EPA) has recently stressed that the water treatment system in Saipan, CNMI is still in need of improvement. The EPA has acknowledged that the lack of safe drinking water is among the top environmental challenges currently facing the CNMI, particularly Saipan. In a previous assessment, the EPA found Saipan to be the only municipality of its size in the United States without 24-hour water delivery. The agency reported that the distribution water on island flows through the pipes only a few hours each day for almost half of the island's residents and is largely undrinkable due to its high chloride content.

One important step in establishing 24-hour water delivery and improving water quality in the system is for the Commonwealth Utility Corporation (CUC) is to have a better understanding of how their distributions system delivers water to customers and what improvements are needed to meet operational and water quality goals. To assist in reaching their goals, the CUC commissioned The University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) to develop a hydraulic model of the Saipan Water System and to train CUC water division staff in the use of that model.

In order to have a sound hydraulic model of the system it is necessary to have a good knowledge of the residential and commercial demands being placed on the distribution system. As mentioned by the US EPA above, much of the water system is not supplying water on a 24-hour basis and many of the customers have never been metered. At this point in time there is little knowledge on the usage rate values and how this usage is spatially distributed across the water system. Without this knowledge it is impossible to have a well calibrated hydraulic model of the water system.

This project refined estimates of both the quantities and spatial distribution of water demands of both residential and commercial customers of the Saipan CUC water system. The specific objectives of this project were to:

1. Determine the average use rate for residential customers in Saipan and to determine the actual use rate for high commercial consumers such as laundromats and bottle water manufacturers.

2. Use Geographical Information System (GIS) techniques locate all residential and commercial customer locations in Saipan and assign appropriate use rates to the water system model junction that is closest to each customer location.

3. Export the data developed in Step 2 into the Saipan Water System hydraulic Model.

The resulting improvements to the demand estimates used in the existing water system model will provide the CUC water division with the capability to better identify what changes in operation and system improvements are required in order to meet the goals of improved water quality and 24-hour water delivery to all CUC customers.

Watershed Management for the Senpehn Watershed, Pohnpei Island, Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah,
Leroy F. Heitz and Mark A. Lander

Funding: $36,064

The Senepehn watershed basin is located in the southeastern section of Pohnpei and is the largest watershed on island (8.6 square miles). The combined annual discharge of the two rivers in the basin exceeds 94,450 acre-feet/year (A-FT/year). The interior of the Senepehn Watershed basin is heavily forested. The vegetation consists of several forest types including upland, palm, and swamp forests and, at the highest elevation, dwarf of cloud forest. Much of the lower slopes and coastal areas of the Senepehn are characterized by agro forest and secondary vegetation with a few small areas of grass and fern savanna. Lowland areas consist of swamp forest and taro patches. Mangrove forests of moderate width extend along the coast. The Senepehn watershed is relatively pristine and unimpacted by the activities of man.

The Senepehn watershed contains of five kousapws (village units), each with a Soumas (village chief). The kousapws that make up the Senepehn include Diadi, Elieliwi, Nan Kepin Sapwehrek, Nan Kepra, and Pohnauleng. The total population of the five kousapws in 1978 was 592. Currently, it exceeds 14,000. The watershed is typical of many of Pohnpei's rural areas. The majority of the population practice a largely subsistence lifestyle, with a strong dependence on the forest and lagoon to provide their daily needs. Only a small percentage of the population is employed for wage income (9%).

According to the Conservation Society of Pohnpei (CSP), the water quality of some Pohnpei streams has been seriously degraded in recent years as a result of land clearing for agriculture, road construction and housing development. To implement any watershed management/protection plan requires a complete understanding of the physical and environmental components of the watershed.

The overall objective of this project was to study the impact of man's activities on the quality of the watershed and make recommendations to reduce the impact of these activities. The specific objectives were to: 1) install stream flow, sediment, and rain gages for selected sites within the Senepehn watershed; 2) monitor the stream gages and develop a streamflow vs. stage rating curve at each site; 3) develop a correlation between stream flow, sediment load and rainfall; and 4) make a comparison with the findings of other previously examined watersheds on the island, e.g., the Enipein and Nanpil watersheds.

This project provides the necessary baseline information and identifies of relationships between the dynamic components of the Senepehn watershed environment. The baseline information obtained provides a useful comparative measure for the Enipein watershed, which currently supports a relatively high degree of anthropogenic and associated activity, e.g., land clearing, land sliding/slope failures, and population growth. The results can now be used to assess the impact of these various activities on the quality of the watershed. Such information is vital for those actively involved with watershed management and protection on the island (e.g., the Conservation Society of Pohnpei (CSP), Land Management, the Pohnpei EPA, and local mayors).

Hydrological Modeling of Atoll Islands in the Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
John W. Jenson,
Yuming Wen and Donald H. Rubenstein

Funding: $53,519

Water shortages pose a serious concern to the inhabitants of atoll islands. Small size and isolation translate into entire island populations being subjected to the stresses of drought and difficult, expensive, and sometimes untimely aid operations. Under normal conditions, water demand is met by rooftop rain catchment. Prolonged droughts, such as those associated with El Niño, however, exhaust water storage, leaving residents dependent on groundwater or imported water. This completion of this project meets the need of developing "an accurate and practical saltwater intrusion and groundwater evaluation model(s) for low islands in the FSM", as recommended by the WERI Advisory Council, which met on Pohnpei, October 23, 2006.

The best emergency source of water is groundwater, but on most islands groundwater is not utilized or the use of it is not systematic. Atoll aquifers have thin freshwater lenses immediately underlain by saltwater. High permeability and near sea-level elevation make the aquifer susceptible to saltwater intrusion and even depletion of the freshwater lens during times of limited or no recharge. The unique characteristics of atoll island aquifers, such as the thick transition zones between freshwater and saltwater, render traditional coastal aquifer models inappropriate. The development of computer groundwater modeling tools to analyze the atoll island aquifer system, and training on how to use these tools, will now aid FSM island leaders and water resource managers in establishing sustainable and practical groundwater extraction practices.

This project engaged a multi-disciplinary team composed of a hydrogeologist, an anthropologist, a GIS specialist, and a graduate research assistant. It now completes a series of investigations directed towards the successful modeling of atoll island water resources.

The construction of the models required values from published data and additional data gathered during field tests on several atoll islands. Ulithi Atoll, Yap State, FSM, was visited by the investigators August 2006, and for January 2007. A trip to Pingelap Atoll, Pohnpei State, FSM, was conducted in June 2007. Field data vital to the model calibration that was undertaken during the current work was readily available from both these atolls.

Groundwater modeling development was continued as the models were calibrated and simulations were run to calculate the effects of various extraction and recharge scenarios on the freshwater lens. Accompanying the state-of-the-art numerical computer model was a simpler, analytical model that used rainfall, soil, and evaporation data in GIS format, that was calibrated by the more complex numerical model This simple analytical model is a useful tool for predicting the volume and thickness of the freshwater lens for a given atoll island. All information, results, and tools arising from this study will now be relayed to the leaders and water resource managers of the islands.

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 arena. 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.

Graduate students in a WERI hydrology class calculate stream flow of a local river

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 and engineering, and management. Further information may be obtained from the Program Chair, **Dr. Mohammad Golabi**, ‘phone: (671) 735-2134, **e-mail: mgolabi@uguam.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.

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.

Students in WERI computer/GIS lab

WHERE TO 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 Dr. Shahram Khosrowpanah (khosrow@uguam.uog.edu) at the Water and Environmental Research Institute of the Western Pacific, UOG Station, Mangilao, Guam 96923 (telephone number (671) 735-2685).

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