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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WERI scientists, Drs. Shahram Khosrowpanah (left) and Mark Lander (right) meet with the President of the Republic of the Marshall Islands, Mr. Tomeing Litokwa (center), in Majuro, October 7, 2009, to discuss the impact of El Niño on the water resources of islands throughout the region.

WERI is currently sponsoring research to determine the usage, state and infrastructure of freshwater resources on low islands of Pohnpei State in the Federated States of Micronesia. Information of this nature is urgently needed due to the high rate of development, human modification and population increase in the Micronesian low islands.

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 35th 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-2009 WERI faculty were involved as Principal Investigators and/or advisors on 16 research and training projects with a combined budget of about $963,000. Of this, $229,000 came from seven 104-B projects, $100,000 from federal agencies, $256,000 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 and one emeritus research faculty, a water analysis laboratory manager and technician, two office staff, as well as four graduate research students who are completing their MS degree in the Environmental Sciences program. During FY-2009, WERI faculty and staff taught 11 graduate courses and six 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 14 refereed journal articles and conference proceedings, four technical reports, and 25 professional presentations and workshops. WERI faculty also served as members or chairs of 19 research thesis committees of students in the Environmental Science and Biology graduate programs.

For more information on WERI's research and academic programs please see us on the web at:

www.weriguam.org

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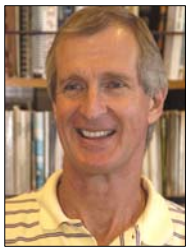
WERI FACULTY, STAFF & STUDENTS

DIRECTOR



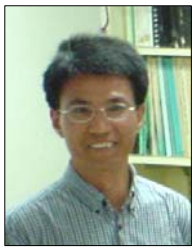
Dr. Gary Denton
Prof. Environmental Toxicology

Dr. John Jenson
Prof. Hydrogeology

Dr. Shahram Khosrowpanah
Prof. Engineering

Dr. Mark Lander
A/Prof. Meteorology

Dr. Charles Luo
Prof. Engineering



Dr. Yuming Wen
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Gwendolyn Manglona
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Norma Blas
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Graduate Res. Assistant

Theresa Datuin
Graduate Res. Assistant

Marie Kottermair
Graduate Res. Assistant

Blaz Miklavic
Graduate Res. Assistant

Kennedy Tolenoa
U/Graduate Res. Assistant

ACTIVE PROJECTS

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

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

The Influence of Sediment Load and Riparian Vegetation on the Diversity and Habitat use of Native Streamfish and Invertebrates of Guam.

Presenting 'Guam Water Kids': Public School Outreach and Teacher Relations Program Reconstructing the Ancient Rainfall-Drought History of Guam

Reconstructing the Pre-Historic Rainfall-Drought History of Guam

Continuing Calibration and Application of LUOM in Southern Guam Watersheds

Applications of LiDAR Data for Inarajan Watershed Management

CNMI:

Development of a GIS Data Base for Saipan's Drinking Water Delivery System

CNMI Water Kids: An Educational Resource for Teaching Children about Fresh Water and How to Protect It (*An adaptation of Guam Water Kids*)

Impact of Urban Runoff, Wastewater Discharges and Past Solid Waste Disposal Practices on Contaminant Profiles in Fish from Saipan Lagoon

FSM:

Comprehensive Survey of the Current State, Infrastructure, and Usage of Freshwater Resources in the Mortlock Islands, Chuuk State, Federated States of Micronesia

Atoll Island Sustainability: Information Transfer and Training for the Federated States of Micronesia (FSM)

Water System Leak Detection Training for Kosrae State, Federated State of Micronesia

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 (Phase II)

GUAM EPA (USEPA)

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

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY

- **a) Spatio-temporal Analysis of Groundwater Quality in Guam (ongoing)**
- **b) Stratigraphic Sections of the Revised Geologic Map of Guam**

2. WATER RESOURCES MONITORING PROGRAM

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

The Influence of Sediment Load and Riparian Vegetation on the Diversity and Habitat Use of Native Streamfish and Invertebrates on Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Frank Camacho

Funding: $15,735

Fresh water is one of Guam's premier natural resources and is vital to life on our island. Beyond drinking, washing and the daily activities of life, we must have a reliable and amply source of clean water to support our industries including tourism, to preserve community health, to control fires, and for recreation. A stable supply of fresh water improves property values and is essential to the island's economy. Guam residents must have access to information about the value of our freshwater supply if they are to take responsibility for curtailing pollution originating in households and businesses, conserving water through consumer-side system maintenance and water saving practices, and participating in community action and decision-making.

This education program will create an awareness of public policies and an interest in adopting personal practices that support the protection of clean and abundant fresh water on Guam. The working title, "Protect Guam's Fresh Water," is intended to target adult residents of Guam especially home owners, business owners, and farmers who handle hazardous chemicals or toxic waste. The program consists of a (1) Public Service Campaign, (2) an Online Clearinghouse, and (3) Partner Recruitment of businesses and agencies. The Public Service Campaign includes the components needed to promote awareness and methods to "Protect Guam's Fresh Water." Local mass media will be alerted to the campaign and oriented to the purpose and availability of campaign materials, and will be able to conveniently download print ads, radio spots, and a television spot in appropriate formats for use by their respective publications and broadcast needs. Information about avoiding pollution, practicing conservation and participating in community action will be emphasized. Simple methods and tips that take into consideration local lifestyles and conditions will be included. The Online Clearinghouse will give easy, 24/7 public access to information in the following three areas: 1) Information tips and FAQs on how one can make a difference in Protecting Guam's Fresh Water with simple practices at home and work; 2) Ideas for speaking to key officials, media outlets, and online forums will be included in a directory; 3) A registry will offer community action groups an opportunity to recruit participants. The Partnership Recruitment will target the mass media, businesses, agencies, civic groups and community leaders providing opportunities to help spread information by reprinting and sending statement stuffers, posting tips on bulletin boards, and adopting 'fresh water friendly' practices.

The program objectives are to 1) provide the public with easy access to information about protecting Guam's freshwater resources; 2) promote personal responsibility for controlling pollution at home and work especially from household-type chemicals, landscaping and farming activities and septic tanks; 3) promote personal responsibility to repair consumer-side water leaks and instituting water saving practices; 4) provide access to information about participating in decision-making and community discussions and 5) serve as an ongoing reminder of the value and importance of the island's natural resource of fresh water.

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Presenting Guam Water Kids': Public School Outreach and Teacher Relations Program

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Ann Card

Funding: $7,685

The environmental educational materials for students age 9-12 about fresh water resource issues on Guam have recently been developed. The "Guam Water Kids" materials emphasize the importance of Guam's fresh water as a key resource, explain hydrological concepts, and introduce a sense of stewardship for conserving and protecting Guam's fresh water. These materials include a pre-recorded presentation, teacher's lesson plans and suggested activities, a Chamorro language glossary, and a companion website. The educational materials are correlated to learning standards recognized by the Guam Department of Education and have been approved for use in Guam public schools by the superintendent's office and announced in the GDOE newsletter. The materials were developed, in part, to support outreach efforts by WERI. There is a need to familiarize teachers with the materials and demonstrate the value of incorporating them into curriculum. Working directly with these educators will also increase awareness of WERI as a resource for water related issues and will open opportunities for WERI to engage educators in the future. As materials are employed and as teachers become engaged in water resource issues, an evaluation is needed to assess the effectiveness of the "Guam Water Kids" materials and to explore additional needs teachers may report such as a willingness to participate in water related courses for educators which may be developed in the future.

Specifically, we intend to follow the public schools' chain of approval, schedule a presentation targeted to reaching the 5th graders at each of the 6 elementary schools and follow the presentations with an evaluation by educators involved in teaching subjects related to water resource issues. Procedures include:

1) Contact and present materials to the principals at each of the six elementary schools in the Guam public school system for approval at the school level. Upon principal's approval, contact appropriate head teacher and schedule presentation to all fifth grade sections to be conducted in the spring 2010 and fall 2010 semesters.
2) Conduct six team presentations of the "Guam Water Kids" program led by Ann Card and with WERI professionals serving as resource persons. Leave participating teachers with a packet of the educational materials including the CD presentation, printed copies of the two related Lesson Plans and Activities, and WERI contact information as appropriate.
3) Conduct a survey of participating educators to evaluate the "Guam Water Kids" presentation and related lesson plans. Include additional questions about needs teachers may have and specifically poll interest in participating in future teacher training courses in water resources, a critical need which has been identified by the advisory council. The survey will be conducted online with an "on paper" option in order to facilitate participation. Contact information will be preserved in order to facilitate future communication with educators.
4) Analyze and report survey results. Make any appropriate adjustments to existing "Guam Water Kids" materials indicated by educators' assessments.

Reconstructing the Pre-Historic Rainfall-Drought History of Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
John Jenson

Funding: $16,241

At its 2008 meeting, the Guam Water Resources Advisory Council identified as one of its research priorities "expanding and updating the rainfall database for Guam," to include long-term rainfall variability (Item 16, under *Water Quantity Issues*, *Guam's Critical Water Resources Research, Education And Training Needs*). This need was reiterated at the 2009 meeting. Although the instrumental climate record for Guam begins only at the end of World War II, current research is revealing that regional climates everywhere are characterized by decadal, centennial, and millennial scale oscillations. Even the oldest of historical instrumental records in the world—which date at best from the early Eighteenth Century—are too short to document long-term cycles. It is becoming increasingly important for economic planners and managers, however, to be able to anticipate or understand the likely duration and severity, if not the causes, of long-term or persistent shifts in weather and climate patterns. Of particular interest in the west Pacific Ocean region are the patterns of flooding/drought, prevailing winds, and the frequency and severity of major storms, which are already known to follow cycles of decadal and longer duration. To characterize long-term rainfall and temperature patterns prior to the historical record, however, requires estimating them from proxies, i.e., indirect evidence recorded in natural features such as ocean or lake sediment layers, pollen and tree-ring records, or cave deposits.

One the most productive sources of long-term pre-historic climate data is stalagmites, i.e., layered calcite deposits precipitated from cave dripwater. With current laboratory techniques, stalagmites can reveal datable changes in certain chemical parameters that can be resolved at intervals ranging from seasons to millennia and spanning histories ranging from decades to hundreds of millennia. Changes in the amount and/or sources of rainfall and sometimes above-ground temperature can be inferred from the chemical parameters and changes in rate of growth, especially if the relationship is known between the chemistry of the modern calcite layers and the dripwater from which they precipitate. Fortunately, WERI researchers working have identified and mapped a number of accessible caves on Guam that contain promising stalagmite records from which the pre-historical climate record of Guam might thus be reconstructed.

This project will continue and extend the very promising work begun during the past year to collect regular monthly samples of dripwaters from caves in which speleothems have been collected, and which are currently undergoing analysis at the Jackson School of Geosciences at the University of Texas at Austin, in a separately funded project. The proposed project would continue the detailed investigation of the chemical environment from which the climate data are to be derived. Instrumentation of one of the caves in northern Guam has produced very promising data so far. Moreover, since the current year has brought a fairly strong El Nino, we now have an opportunity to capture a representative El Nino signal. Finally, the project will be an important element in a larger collaborative project for which we have applied for National Science Foundation funding, and that will include similar work on caves in Borneo, The Philippines, The Solomon Islands, and Vanuatu to determine the climate history of the entire western Pacific region.

Calibration and Application of LOUM in Southern Guam Watersheds

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Charles Luo and Shahram Khosrowpanah

Funding: $25,971

The Large-scale, Unified and Optimization Model, LUOM (Luo, 2007) is a fully physically based, 2-dimensionally distributed watershed model simulating the hydrologic cycle on a watershed scale. The model discretizes the watershed into rectangular grid cells and makes use of DEM (Digital Elevation Model) data, vegetation data and climate input data, mainly precipitation, temperature and wind speed, to generate one-dimensional output – discharge hydrographs and two-dimensional hydrologic quantities such as evapotranspiration, infiltration, soil moisture, groundwater table and surface water depth. Simulating impacts of land use (vegetation) transformation and global climate changes are within the model's capability.

During the preceding project, Calibration and Application of LUOM (Luo, 2007) in Southern Guam Watersheds With and Without Flow Data, DEM, vegetation, soil, rainfall and streamflow data have been collected, hydrologic watershed boundaries and stream networks have been delineated, and LUOM has been calibrated in the Ugum watershed and 4 other watersheds with both rainfall and flow data, and 7 other watersheds without flow data. Combining all available climate stations in southern Guam provided 54 years of rainfall data from which time series of flow data were generated by the calibrated model for all 12 watersheds.

The objective of the project described herein, is to continue the calibration and application of LUOM in the rest southern Guam watersheds that were not covered in the previous project. Using the data collected in the preceding project, LUOM will be calibrated in Talofofo, Ylig, Pago and other watersheds with available streamflow data. The calibrated model will be used to provide any missing data for these watersheds as well as for other southern Guam watersheds without streamflow data.

The benefits of this project will be enormous not only to Guam but also to other islands in Western Pacific. Researchers will be able to implement various watershed management practices within the watershed. For example, by having flow data, researchers studying the impact of various watershed management practices, can develop a correlation between stream flow, rainfall, and turbidity at various sections of a watershed. The model will also assist the Guam Waterworks Authority (GWA) with future explorations for potential sources of potable surface water in southern Guam. Finally, by providing flow data for the 16 ungaged streams on island, potential sites for small dam construction may be identified.

Applications of LiDAR Data for Inarajan Watershed Management

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Yuming Wen and Shahram Khosrowpanah

Funding: $25,171

Guam, an unincorporated U.S. territory in the western Pacific, is the largest (about 541.3 km^2) and southernmost island in the Mariana Islands. The population of Guam has gradually increased since WWII and currently stands at around 180,000. Because of military buildup activities, an estimated 40,400 active military personnel and dependents are expected by 2014. With more population to stream to Guam in the next few years and beyond, more solid wastes will be generated.

On February 11, 2004, the Government of Guam (Guam Department of Public Works and Guam Environmental Protection Agency) entered into a Consent Decree (Civil Case No. 02-00022) with the United States of America (U.S. Environmental Protection Agency with the U.S. Department of Justice) in U.S. District Court, Territory of Guam. The Consent Decree is a settlement agreement to resolve issues related to the unauthorized discharge of pollutants from the Ordot Dump to the Lonfit River. The historical and continuing discharge of pollutants to the Lonfit River is a violation of the Clean Water Act (CWA). The Consent Decree aims to resolve civil penalties and to establish a schedule for construction of a Municipal Solid Waste Landfill Facility (MSWLF) and closure of the Ordot Dump.

As part of the Consent Decree, Guam is required to site and must design, construct, and operate a landfill that is fully compliant with Guam Solid Waste Disposal Rules and Regulations. As part of the agreement, the landfill must be in operation on September 23, 2007, or earlier. Within the constraints of the Consent Decree and in accordance with the 2000 Integrated Solid Waste Management Plan (ISWMP), the Government engaged in a site screening and site selection process. Based on the selection process, an area in Layon, Dandan, Inarajan, was selected for the future landfill site.

This research proposal focuses on applications of LiDAR data collected in early 2007 for Inarajan Watershed management. Raw LiDAR data will be used to obtain watershed characteristics for Inarajan Watershed. In this project, GIS and related technologies such as remote sensing and global positioning system (GPS) will be used to collect, digitize, organize, model and analyze data on watershed characteristics. GPS can be used for data ground-truthing, remote sensing can be used to collect data for hard-to-reach areas and to update GIS database, while GIS, enhanced by remote sensing and GPS capabilities, will be the core tool for this project. The overall objective of the project aims to obtain watershed characteristics from LiDAR data for the Inarajan Watershed.

The main objectives of this project are listed as follows:

1. Preprocess the raw LiDAR data collected in early 2007;
2. Find and remove noises from the LiDAR data if they exist;

Obtain watershed characteristics for the Inarajan Watershed.

Development of a GIS Data Base for Saipan's Drinking Water Delivery System

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah, Yuming Wen & Mariano Inglecias

Funding: $30,490

The environmental educational materials about water resource issues in earth science textbooks and online at the websites of government agencies now available to Commonwealth of the Northern Mariana Islands (CNMI) school 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 related to water resources and the critical need to protect and conserve as related to Saipan, Rota and Tinian.

Recently, environmental educational materials for students age 9-12 about fresh water resource issues on Guam were developed. The "Guam Water Kids" materials emphasize the importance of Guam's fresh water as a key resource, explain hydrological concepts, and introduce a sense of stewardship for conserving and protecting fresh water. These materials include a pre-recorded presentation, teacher's lesson plans with suggested activities, a Chamorro language glossary and a companion website.

Specifically, in order to foster a better understanding of the importance of fresh water as a key resource and a sense of stewardship, we intend to adapt the existing materials in "Guam Water Kids" to create "CNMI Water Kids" featuring water resource information and issues pertaining to Saipan, Rota and Tinian. Some materials such as the animated illustration of the water cycle, the photos defining fresh water featuring a tropical setting, and conservation at home, may be retained. The Chamorro language glossary will require only minor revisions. Illustrations featuring maps with the location of ground and surface water for each of the three islands and some place-specific photos will need to be developed. In addition to revising illustrations, the written text and script will need to be adapted and recorded.

Components for CNMI will include (1) a CD PowerPoint ™ presentation with pre-recorded narrator and music with animation that can be used as (a) a scripted or extemporaneous slideshow, (b) a stand-alone presentation with pre-recorded narrator and music, or (c) a continuous "unmanned" presentation such as at an exhibit booth, (2) two Lesson Plans for teachers with activities, related vocabulary, and Chamorro glossary, and (3) "CNMI Water Kids" website featuring self-study slide shows, activities, and downloadable copies of the educational resource materials including the teacher lesson plans.

The project will accomplish the following objectives.

1. Provide an online resource for teachers and other youth leaders that will enable them to share the importance of water resources and the need for protecting them using materials that students in the CNMI can easily relate to.
2. Provide a website to support educators with downloadable materials and for youth to independently explore CNMI water resources while developing a sense of stewardship.
3. Provide a convenient, self-contained classroom presentation that shares the basic concepts of the hydrological cycle and water resource issues with support materials for teachers on CD.

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CNMI Water Kids: An Educational Resource for Teaching Children about Fresh Water and How to Protect It (*an adaption of Guam Water Kids*)

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Ann Card

Funding: $7,980

In March of 2009, the Commonwealth Utilities Corporation (CUC) entered into a stipulated order (STO) for preliminary relief under an agreement with the Government of the United States. The order provided for a long list of compliance items that CUC must complete in order to satisfy the stipulated order. One major item that CUC must prepare is a Master Plan for their water supply and waste water systems. A part of the Master Plan is the "Development of a Geographic Information System (GIS) of the CUC drinking water and wastewater systems to facilitate better management of the CUC's system". As mentioned in the STO, the GIS shall locate, map, and develop GIS layers for all of the following: treatment facilities, wells, water lines, storage tanks, collection systems, pump stations, and CUC's and DEQ's water quality monitoring stations.

A healthy water system that can perform all of its essential functions requires a good record of system inventory, location, connectivity, and maintenance. This information should be easily available to the water managers and field operators. At the present time, the water and wastewater inventory and maintenance data are being entered manually and stored in file folders. This has created excess paperwork and makes it very difficult to track the frequency of maintenance, which makes it hard to provide timely information to the field operator groups, and creates a lack of close communication between system managers and field operators. Additionally there is no link between the physical description of the water system that has been previously created by WERI and the maintenance and system inventory. What is needed as mentioned in the stipulated order is a GIS data base that contains all the system descriptions and system maintenance schedules and that can be made readily available to system managers and field operators. The proposed project will satisfy this need and will be divided into four discrete phases. The primary emphasis will be on the drinking water system. Later we will focus on the wastewater system and the data from water meters that are being installed.

The benefit of this project will be to provide and improved and more efficient management and operation of the Saipan water system by development of a GIS database. The specific objectives of this project will be to: a) install GIS software on a newly purchased computer and provide three days training on the use of GIS and data entry to one or two personnel from CUC; b) export the information from Saipan's Haestad model into GIS layers, c) using GPS, locate components of the CUC water distribution system not included in the Haestad model; d) create data layers for each component of the water system; e) integrate the maintenance schedule and system inventory into GIS layers, and f) make the data base available to the system managers and system operators.
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Impact of Urban Runoff, Wastewater Discharges and Past Solid Waste Disposal Practices on Contaminant Profiles in Fish from Saipan Lagoon

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Michael Trianni and Gary R.W. Denton

Funding: $29,164

Saipan is the largest and most densely populated island of the Commonwealth of the Northern Mariana Islands (CNMI) 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 in wastewater discharges and 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. The smallest and most southerly entity is Chalan Kanoa Lagoon, which borders mostly rural and residential areas. While this body of water receives relatively little in the way of stormwater runoff, it does receive effluent from a sewage treatment plant and was used as a solid waste disposal site until the mid 1970s. Immediately to the north of Chalan Kanoa Lagoon is Garapan Lagoon, a relatively long narrow stretch of water that boarders both residential and commercial premises between the villages of Susupe and Garapan. At least 20 storm water drains discharge into this centrally located lagoonal entity.

An ongoing pollution monitoring and assessment program for Saipan Lagoon was initiated by WERI in 1997. We now have a reasonable understanding of the distribution and abundance of the contaminants of primary concern (heavy metals and PCBs) in biotic and abiotic components of Tanapag Lagoon. Comparable studies from the two lagoonal entities further south have only recently been initiated. Relatively high levels of mercury have subsequently been discovered in fish and several species of intertidal bivalves from the northern end of Garapan Lagoon. The contamination source was traced back to a storm drain that receives drainage from a disused incinerator site at the local hospital about 1 km inland. Intertidal bivalves from the southern end of Chalan Kanoa Lagoon were also found to contain relatively high levels of lead. The source of this contamination remains to be identified. Studies are currently underway to determine distribution profiles of heavy metals in sediments within both of these lagoonal entities. Considering the importance of subsistence and recreational fishing in these waters, the proposal described herein seeks funding to extend the monitoring program to fish inhabiting these waters. Squirrel fish, *Myripristis* spp, and snapper, *Lethrinus* spp. will be the primary bioindicators of interest. Both types of fish have limited foraging ranges and are favored by local fisherman. Samples will be analyzed for total mercury, lead and PCBs.

The study will add significantly to the existing contaminant database and should command the interest of those involved with environmental protection, water quality and resource management. It will also identify potential health risks (if any) associated with the unrestricted consumption of fish from these waters. Overall, the program will provide the necessary foundations for future monitoring, assessment and regulation of pollution problems in the area. Such information is vital for the overall protection and sustainable development of aquatic resources in Saipan's coastal waters.

Comprehensive Survey of the Current State, Infrastructure, and Usage of Freshwater Resources in the Mortlock Islands, Chuuk State, Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Danko Taborosi

Funding: $27,762

Atolls and other carbonate islands in the Federated States of Micronesia are extremely limited in area and resources yet support a disproportionately high number of residents. The so-called Outer Islands of Chuuk State alone, for example, are home to well over 10% of the entire Micronesian population. Due the islands' truly miniscule sizes, the resultant population densities are among the highest in the world. Their freshwater resources are threatened by overuse due to population growth and changing lifestyles, damage by pollution and unsustainable practices, and obliteration by global climate change. However, the extent of specific problems on individual islands cannot be evaluated at present due to the lack of baseline information. In response to that concern, we have begun two years ago a comprehensive effort to characterize freshwater resources, infrastructure, and practices on each of Pohnpei State's low islands and have already acquired a exhaustive body of vital data. That information is currently being processed for dissemination and publication, so that it can be provided to government planners, resource managers, engineers, educators, environmental scientists, and others involved in sustainable development in Micronesia. We now propose to continue the comprehensive study of the current state, infrastructure, and usage of freshwater resources on FSM's low islands by surveying the most densely populated atolls in Chuuk State: the Mortlock Islands. We intend to investigate the islands of Ta, Satowan, Moch, Kuttu, Lukunor, Oneop, and Ettal, 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 is urgently needed from the Mortlocks in order to clarify the water situation there and help us 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 the mentioned seven islands. Essentially, the project will comprise of 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: a) compile a comprehensive reference source for the Mortlock Islands; b) examine and describe the state of freshwater resources and their usage patterns on each island, as well as other relevant lifestyle practices; c) inventory, assess and map the hydrologically significant infrastructure on each island; d) record each island residents' attitudes and other relevant cultural norms, perceptions, behavior and opinions related to freshwater resources; e) Identify and report any critical problems related to freshwater resources.

Information outlined above is urgently needed for the Mortlock Islands. We wish to make it available as information-packed technical reports, supporting databases, and photo and GIS data collections, all readily accessible to government bodies, regulatory and utility agencies, NGOs, research and academic institutions, and the private sector entities involved in the utilization, monitoring, management, and protection of the freshwater resources of Chuuk State.

Atoll Island Sustainability: Information Transfer and Training for the Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
John W. Jenson

Funding: $18,433

This is an information transfer project specifically requested by FSM water managers at the 2009 WERI Advisory Council meeting, which will build on the instructional services provided last year. In summer 2009, the authors of the model trained FSM users on how to operate WERI's atoll island spreadsheet groundwater model to estimate the responses of atoll island aquifers in the Caroline Islands to expected types of seasonal and inter-annual changes in rainfall. This year the authors of the model will present it at a workshop that will be conducted as part of a national meeting of FSM water resource managers to address central concerns regarding the sustainability of live on atoll islands.

Users of the model will include local government water resource managers, environmental staff, and educators (Item III.1, Education and Professional Training, FSM Critical Water Resources Research, Education And Training Needs, September 16, 2008).

The objective of this year's training program is not only to train additional end-users of the model, but to demonstrate its application to questions of sustainability, such as the calculation of groundwater responses to sea level rise and changes in crop management practices. Such use may also include making forecasts of the effects of selected changes in rainfall on atoll islands affected by significant natural events, such ENSO-driven droughts, tropical storms, or wash-over events. A second objective is to cultivate an ongoing technical support relationship between the authors and end-users so that there will be a continuing dialogue to support continued successful use and application of the model to water resource management in the Federated States of Micronesia.

Water System Leak Detection Training for Kosrae State, Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Shahram Khosrowpanah

Funding: $19,070

Water system leakage is a serious problem for all utility agencies throughout the Western Pacific. It reduces the performance of the system and represents a big money loss to water utility agencies. The development of modern water distribution systems in the FSM started in 1970 with periodic upgrades sponsored through a series of US capital improvements projects. Despite this, the majority of systems operating today suffer from excess water leakages, some as high as 60% on some islands. Aside from the negative impact on revenues, such losses all too often result in water utility agencies being unable to provide their customer base with a reliable 24-hour water service. One relatively rapid and cost-effective means of overcoming this problem is to implement a simple leak detection program with appropriate equipment and training for water utilities personnel. At its 2009 meeting, the FSM Water Resources Advisory Council requested that WERI carry out a leak detection training program on all the major islands of the FSM (Yap, Chuuk, Pohnpei and Kosrae). This proposal seeks funding to implement such a training program on the island of Kosrae, which currently ranks among the most severely affected islands, insofar as no-revenue water losses from leaks are concerned. One representative from each of the other islands will be invited to participate in the program. We anticipate conducting similar training programs on other islands in future years.

The proposed training will be conducted over a period of one week and will provide participants with a workable knowledge of leak detection theory. It will also consider common cause of water leakages in distribution systems and provide participants with hands-on field experience on how to find leaks and fix them. The topics to be presented at this proposed training exercise are summarized below:

1) Leak detection theory and how to determine when a leaky survey is required.
2) Economic benefits of a leak detection survey.
3) How to incorporate a leak detection survey and/or permanent leak detection crew for your water facility.
4) How to become familiar with various sounds created by leaks and type of leaks encountered.
5) Types of leak detection surveys and proper record keeping.
6) Getting familiar with various leak detection equipment and techniques.
7) Field demonstration and actual leak detection scenarios and exercises. This will include field demonstration, general survey, general pinpointing, emergency pinpointing, estimating leakage, reporting, and vehicle setup

PROJECTS
COMPLETED MARCH 2010

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

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

Protect Guam's Fresh Water: Taking Personal Responsibility for Pollution, Conservation and Community Action.

Calibration and Application of LUOM (Luo, 2007) in Southern Guam Watersheds With and Without Flow Data

Reconstructing the Ancient Rainfall-Drought History of Guam

Impacts of Land Cover Change on Groundwater Quality in Guam

CNMI:

Sustainable Well Yield Determinations Using Conductivity Probes on Active wells (granted 1-year no cost extension)

Influence of Stormwater and Wastewater Discharges on the Distribution and Abundance of Heavy Metals in Sediments from Saipan Lagoon

Development of Optimal Operation of Saipan's Water Distribution System Using a Newly Developed Hydraulic Model

FSM:

Atoll Water Budget Modeling, Information Transfer and Training for the Federated States of Micronesia

Prediction of Flow Duration Curves for Use in Hydropower Analysis at Ungaged Sites in Pohnpei, FSM

OTHER FUNDED PROJECTS

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center (ongoing)

GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

Development of a Digital Watershed Atlas for Guam Phase (Phase II)

GUAM EPA (USEPA)

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

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY

- **a) Spatio-temporal Analysis of Groundwater Quality in Guam**
- **b) Stratigraphic Sections of the Revised Geologic Map of Guam**
- **b) Reconstructing the Climate History of Guam**

2. WATER RESOURCES MONITORING PROGRAM

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

Protect Guam's Fresh Water: Taking Personal Responsibility for Pollution, Conservation and Community Action.

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Ann Card and John Jocson

Funding: $20,000

Fresh water is one of Guam's premier natural resources and is vital to life on our island. Beyond drinking, washing and the daily activities of life, we must have a reliable and amply source of clean water to support our industries including tourism, to preserve community health, to control fires, and for recreation. A stable supply of fresh water improves property values and is essential to the island's economy. Guam residents must have access to information about the value of our freshwater supply if they are to take responsibility for curtailing pollution originating in households and businesses, conserving water through consumer-side system maintenance and water saving practices, and participating in community action and decision-making.

This education program will create an awareness of public policies and an interest in adopting personal practices that support the protection of clean and abundant fresh water on Guam. The working title, "Protect Guam's Fresh Water," is intended to target adult residents of Guam especially home owners, business owners, and farmers who handle hazardous chemicals or toxic waste. The program consists of a (1) Public Service Campaign, (2) an Online Clearinghouse, and (3) Partner Recruitment of businesses and agencies. The Public Service Campaign includes the components needed to promote awareness and methods to "Protect Guam's Fresh Water." Local mass media will be alerted to the campaign and oriented to the purpose and availability of campaign materials, and will be able to conveniently download print ads, radio spots, and a television spot in appropriate formats for use by their respective publications and broadcast needs. Information about avoiding pollution, practicing conservation and participating in community action will be emphasized. Simple methods and tips that take into consideration local lifestyles and conditions will be included. The Online Clearinghouse will give easy, 24/7 public access to information in the following three areas: 1) Information tips and FAQs on how one can make a difference in Protecting Guam's Fresh Water with simple practices at home and work; 2) Ideas for speaking to key officials, media outlets, and online forums will be included in a directory; 3) A registry will offer community action groups an opportunity to recruit participants. The Partnership Recruitment will target the mass media, businesses, agencies, civic groups and community leaders providing opportunities to help spread information by reprinting and sending statement stuffers, posting tips on bulletin boards, and adopting 'fresh water friendly' practices.

The program objectives are to 1) provide the public with easy access to information about protecting Guam's freshwater resources; 2) promote personal responsibility for controlling pollution at home and work especially from household-type chemicals, landscaping and farming activities and septic tanks; 3) promote personal responsibility to repair consumer-side water leaks and instituting water saving practices; 4) provide access to information about participating in decision-making and community discussions and 5) serve as an ongoing reminder of the value and importance of the island's natural resource of fresh water..

Calibration and Application of LUOM (Luo 2007) in Southern Guam Watersheds with and without Flow Data

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Charles Luo and Shahram Khosrowpanah

Funding: $26,687

The Large-scale, Unified and Optimization Model, LUOM (Luo, 2007) is a fully physically based, 2-dimensionally distributed watershed model simulating the hydrologic cycle on a watershed scale. The model discretizes the watershed into rectangular grid cells and makes use of spatial distributed GIS (Geographic Information Systems) data such as DEM (Digital Elevation Model), vegetation, soil and aquifer data. The model comprises of a series of sub-models for climate data distribution, evapotranspiration, infiltration, groundwater, surface flow, etc. The surface flow sub-model solves the two-dimensional Saint Venant equations. Making use of climate input data, mainly precipitation, temperature and wind speed, the model is able to generate not only one-dimensional output – discharge hydrographs, but also two-dimensional hydrologic quantities such as evapotranspiration, infiltration, soil moisture, groundwater table and surface water depth. Simulating impacts of land use (vegetation) transformation and global climate changes are within the model's capability.

In southern Guam, there are some watersheds with both rainfall and flow gages. But some other watersheds have only rainfall gages but no flow gages. In these watersheds without a flow gage, it is obviously difficult to carry out watershed management studies which require flow data. Even in some those watersheds with a flow gage, the flow gage is not always located at the watershed outlet but a distance upstream of the outlet.

The objective of this research is to calibrate the LUOM (Luo, 2007) in a watershed with both rainfall and flow gages such as Ugum Watershed. Then to apply the calibrated model to those watersheds without a stream flow gage or the whole watershed that the flow gage is not located at the outlet. The application of the calibrated model will generate hydrographs for the whole watershed.

The benefits of this project will be enormous not only to Guam but also to other island in Western Pacific. Researchers will be able to implement various watershed management practices within the watershed. For example, by having flow data, researchers could develop a correlation between stream flow, rainfall, and turbidity at various section of a watershed for studying the impact of various watershed management practices. The model will benefit to Agencies such as Guam Water Authority (GWA) for exploring potential sources of drinking water in Southern Guam. As mentioned earlier, there are 16 streams that are not gauged; by having flow data, potential sites for developing drinking water supply such as construction of small dam will be identified.

Reconstructing the Ancient Rainfall Drought History of Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
John Jenson

Funding: $33,636

Current research on climate dynamics around the world is revealing, regional climates everywhere are typically characterized by decadal, centennial, and even millennial scale oscillations. Unfortunately, the long-term historical rainfall record for Guam begins only at the end of World War II and even the oldest of historical records—which date at best from the early Eighteenth Century—are too short to document such long-term cycles. It is becoming increasingly important for economic planners and managers, however, to be able to anticipate or understand the likely duration and severity, if not the causes, of long-term or persistent shifts in weather and climate patterns. Of particular interest in the west Pacific Ocean region are the patterns of flooding/drought, prevailing winds, and the frequency and severity of major storms, which are already known to follow cycles of decadal and longer duration. To characterize long-term rainfall and temperature patterns prior to the historical record, however, requires making estimates of them from proxies, i.e., indirect evidence recorded in natural features such as ocean or lake sediment layers, pollen and tree-ring records, or cave deposits, to name only a few.

One the most productive sources of long-term pre-historic climate data is speleothems, i.e., calcite mineral deposits that are precipitated from cave dripwater. With current laboratory techniques, stalagmites (which develop distinct and datable layers, like tree rings, as they accumulate on the floors of caves) can reveal datable changes in certain chemical parameters that can be resolved at intervals ranging from seasons to millennia and spanning histories ranging from decades to hundreds of millennia. Changes in the amount and/or sources of rainfall and sometimes above-ground temperature can be inferred from the chemical parameters and changes in rate of growth, especially if the relationship is known between the chemistry of the modern calcite layers and the dripwater from which they precipitate. Fortunately, WERI researchers working over the past decade have identified and mapped a number of accessible caves on Guam that contain promising stalagmite records from which the pre-historical climate record of Guam might thus be reconstructed

This project will capitalize on previous work by WERI researchers to collect monthly samples of dripwaters from caves in which speleothems have been collected, and which are currently undergoing analysis at the Jackson School of Geosciences at the University of Texas at Austin, in a separately funded project. More important, the proposed project would support a detailed investigation of the geologic and speleogenetic history of the caves from which the climate data are to be derived. This will provide researchers with an understanding of the sequence of deposition and its relation to the changes in the cave environment over time, which in turn will provide additional data and insights with which to make more confident inferences regarding the actual climate and environmental conditions of the island over time. Finally, the project will be an important element in a larger collaborative project that includes similar work on caves in Borneo, The Philippines, The Solomon Islands, and Vanuatu to determine the climate history of the entire western Pacific region.

Impacts of Land Cover Change on Groundwater Quality in Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Yuming Wen

Funding: $16,177

Guam has one of the finest limestone aquifers in the world. Located in the northern half of the island, this vital underground resource supplies island residents with about 80% of their drinking water needs. The population of Guam has gradually increased since WWII and currently stands at ~180,000. The majority of island inhabitants live in the northern half of the island where significant economic growth and urban development has occurred over the last two decades. The US military has also occupied large tracts of land in this region for the past 60 years. The risks of groundwater contamination are, therefore, very real considering the population density in northern Guam and the rapid recharge rates to the underlying aquifer. Since April 1996, Guam Waterworks Authority (GWA) has monitored the island's drinking water resources annually for all contaminants listed under the US Safe Drinking Water Act. Over 100 wells and two surface water sources are analyzed on a quarterly basis, and approximately 10,000 water samples have been tested to date. Data obtained to date are used only to determine which wells are out of compliance with no further statistical analysis to determine spatial or temporal trends. The proposed project described herein will incorporate all the data collections into GIS map coverages for each contaminant that has so far been detected. By so doing, the impacts of land cover change on groundwater quality in Guam can be evaluated; time-dependant changes in the distribution profiles of commonly occurring contaminants, e.g. fecal coliforms, chlordane, tetrachloroethylene (PCE) and trichloroethylene (TCE) can the be easily visualized, and areas of maximum concentration identified and delineated for the implementation of appropriate remediation strategies as necessary.

The water quality data are available on file from GWA. Land cover changes will be determined using Landsat images of 1993, historical aerial photos, and one scene of Landsat TM or ETM + image at the end of 2006, or early 2007 if available. However, QuickBird image of 2006 may be harnessed as an alternative data if necessary. These satellite images will be applied to extract land cover information. How land cover change affects groundwater quality will be the main concern for this research project.

The main objectives of this project are listed as follows:

3. Preprocessing of Landsat images for derivation of land cover information;
4. Classification of land cover information from available images and/or aerial photos;
5. Evaluation of the relationship between land cover change and groundwater quality
6. Temporal and spatial changes in the distribution and abundance of frequently occurring chemical and biological contaminants

The project outcome will be of tremendous benefit GWA and the Guam Environmental protection Agency whose collective responsibility is to maintain the chemical and biological integrity of the island's water resources and provide a reliable and continuous supply of safe drinking water for the people of Guam.

Sustainable Well Yield Determinations Using Conductivity Probes on Active Wells

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Derek Chambers

Funding: $17,950

The major source of drinking water for the island of Saipan is groundwater pumped from the karst (fractured limestone) aquifers by the local water utility, the Commonwealth Utilities Corporation (CUC). The most productive (most heavily pumped) well fields on Saipan are located over the basal lens aquifers, where the fresh water lens floats on salt water. Poor well construction (penetration through the fresh water lens), poor pump placement (too far below dynamic water levels), and over pumping have resulted in salt water intrusion at individual wells and well fields. The volume-weighted chloride ion concentration from the total amount of water pumped from wells on Saipan is about 1,100 mg/l, well above the USEPA recommended limit of 250 mg/l. In fact, the chloride ion concentration at individual wells can on occasions exceed 3,000 mg/l.

In order to improve the quality of the water pumped from the basal lens aquifers on Saipan, a reliable method needs to be developed to determine the sustainable yield for individual wells, while minimizing the chloride ion concentration. This project proposes to use conductivity probes in active production wells to measure electrical conductance (EC) of groundwater in three wells, to determine the highest sustainable yield while trying to keep the chloride ion concentration below 250 mg/l. The probes will also be used to determine the drawdown at each well, so that the pump intake can be placed at the highest possible elevation. This project also addresses the critical State water quality issue regarding a baseline for season and usage related changes in salinity in drinking water production wells.

Three active production wells in one well field will be studied simultaneously in the following manner: A 1-1/4 inch diameter sounding tube will be installed such that it penetrates the well cap and extends to 5 feet above the bottom of the hole. The sounding tube will be screened from 5 feet above the static water level to the bottom end of the sounding tube. A conductivity, temperature, depth (CTD) probe will be lowered into the sounding tube to measure and record the conductivity profile of the well during static conditions and compared with the profile measured later during pumping conditions. Recording conductivity values in two adjacent wells will help determine how pumping rates in one well affects nearby production wells.

The ultimate goal of the study are to develop a method to optimize the pump rate and pump depth setting for individual wells to minimize chloride ion concentration in the groundwater delivered to customers on Saipan..

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Influence of Stormwater and Wastewater Discharges on the Distribution and Abundance of Heavy Metals in Sediments from Saipan Lagoon

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
John A. Starmer and Gary R.W. Denton

Funding: $27,414

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 on 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). In 2008 the study was extended into the two lagoonal entities further south. 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 discharges from two land-based sources identified in the Garapan area. Heavy metal contributions into Garapan Lagoon from the many other storm drains that discharge along much of its length are currently being evaluated in sediments and nearshore biota. The impact of these discharges on ecosystems further off shore remains to be evaluated.

This project will address this deficiency by conducting an evaluation of heavy metals in surface sediments within Garapan Lagoon and Chalan Kanoa Lagoon along strategically positioned transect lines extending from the coast to the outer reef margin. Such a program is fundamental to understanding the dynamics of pollutant transport processes operating within these two lagoonal entities and is an essential first step towards protecting and preserving the vital fisheries resources therein. The overall objectives of the proposed study are to establish a reliable database for surface sediments within the southern half of Saipan Lagoon with which future findings may be compared and evaluated; delineate impacted offshore areas within the study area for later biological monitoring and assessment purposes, and determine the current degree of contamination by reference to levels reported for clean and polluted environments in tropical regions from elsewhere in the world, including Guam..

Development of Optimal Operation of Saipan's Water Distribution System Using a Newly Developed Hydraulic Model

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah and Mariano R. Iglecias

Funding: $26,950

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

Over the years the CUC water distribution system has grown and new wells have been added to the system. This physical expansion has been well documented, but improvements in the hydraulic characteristics and delivery capabilities of the entire system have never been fully examined. Recently, Stipulated Orders have been filed in the US District Court for the Northern Mariana Islands to compel the utility company to adhere to federal regulations governing water, sewer, and power. As part of this act, CUC should develop a hydraulic model of the water distribution system that will be used for system improvement, system operation, and future system expansion.

Researchers at university of Guam Water and Environmental Research Institute of the Western Pacific (WERI) have developed computerized models of each of the fifteen sub-regions of the CUC water system using the Haestad WaterCAD water system modeling program. Later on, they developed a source, transmission and storage model of the Saipan water system. This includes a skeleton of the existing 15-region water system models that are joined together at the boundary points. Using a Geographic Information System (GIS) capability and Saipan's 2003 census data, the WERI researchers determined the number of users at each system junction node for residential and commercial customers. During the past several months WERI researchers collected the flow production from the renovated wells during dry and wet seasons. To comply with the stipulated order there is a need to update the hydraulic model and input the inflow/outflow to the system and determine the optimum system operation.

This project proposes to update the Saipan water distribution model and to explore the most effective means of transferring the water sources between the regions. The specific objectives of this project will be to:

1. Update the skeleton model of the CUC water distribution that reflects all the new subdivisions that have been added to the whole system.
2. Determine the amount of water production in each sub-region.
3. Using Geographical Information System (GIS) techniques, locate all production sites.
4. 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: a) identify the rates of unaccounted water throughout the system, b) 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 and, c) comply with stipulated order #1..

Atoll Water Budget Modeling, Information Transfer and Training for the Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
John W. Jenson

Funding: $15,382

Water shortages are a persistent concern for residents of atoll islands. Normally, water demand is met by rooftop rain catchment, but prolonged droughts, such as those associated with ENSO events in the western Pacific region, can exhaust water storage, leaving residents dependent on groundwater or imported water. In response to the recommendation by the FSM Advisory Council meeting of October 23, 2006 in Pohnpei, WERI researchers have developed an accurate and practical saltwater intrusion and groundwater evaluation model for atoll islands in the FSM. During April and May 2008, the developers of the model presented an initial demonstration to a limited number of available water resource managers and government officials. At this year's Advisory Council meeting on September 16, 2008 in Yap, council members specifically requested that systematic training be conducted on the model for designated users in each of the states with atoll islands. Users of the model will include local government water resource managers, environmental staff, and educators (Item III.1, Education and Professional Training, FSM Critical Water Resources Research, Education And Training Needs, September 16, 2008).

This is an information transfer project in which end-users will be trained by WERI instructors on how to operate the model and apply it to estimate the responses of atoll island aquifers in the Caroline Islands to expected types of seasonal and inter-annual changes in rainfall. It is proposed that the authors of the model will travel, in accordance with the Advisory Council's request, to Yap, Chuuk, and Pohnpei to meet with and train designated users of the model and modeling results.

The objective is train the end-users of the model and its results sufficiently that they can independently use the model and interpret the results. Such use may include making forecasts of the effects of selected changes in rainfall on atoll islands affected by significant natural events, such ENSO-driven droughts, tropical storms, or wash-over events. A second objective is to establish an ongoing technical support relationship between the authors and end-users so that there will be a continuing dialogue to support continued successful use and application of the model to water resource management in the Federated States of Micronesia.

Prediction of Flow Duration Curves for Use in Hydropower Analysis at Ungaged Sites in Pohnpei, FSM

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah and Leroy F. Heitz

Funding: $31,746

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.

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. John Jenson**, ‘phone: (671) 735-2689, **e-mail: jjenson@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).

RECENT PUBLICATIONS BY WERI FACULTY AND ASSOCIATE INVESTIGATORS

(2000-2009)

WERI TECHNICAL REPORTS

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