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

Fena Lake, Guam's only man-made water reservoir, was constructed in 1951 to provide drinking water for the U.S. Navy base on island. WERI scientists are currently exploring strategies to mitigate soil erosion processes affecting Guam's surface water resources during major storm events.

A rainwater catchment and storage system on Fais Island, Yap State, Federated States of Micronesia. Helping island communities to conserve and manage their freshwater resources is all part of the WERI mission (photo courtesy of Dr. John Jenson, WERI)

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 similar 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 32nd 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 geographic 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) funds 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-2006 WERI faculty were involved as Principal Investigators on twenty research and training projects with a combined budget of about $808,000: $235,000 from eight 104-B projects, $81,000 from three other Federal agencies, $125,000 from Federal sources awarded through local agencies, and $378,000 from local grants and direct funding from the Guam legislature.

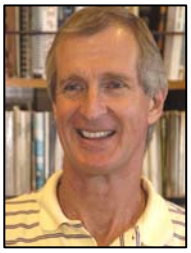
Currently WERI has a fulltime director who is also a UOG faculty member, five regular research faculty, one adjunct research faculty, a water analysis laboratory manager and technician, two office staff, as well as five graduate research students who are completing their MS degree in the Environmental Sciences Program. During the year 2005, WERI faculty and staff taught seven courses in the Environmental Science Masters Degree Program and three undergraduate courses in the undergraduate Pre-Engineering Program respectively. At the same time WERI faculty were first or second authors on 14 refereed journal articles or conference proceedings, nine technical reports and 11 professional presentations and workshops. WERI faculty currently serve as members or chairs of 23 research thesis committees of students in the Environmental Sciences and Biology graduate programs.

See us on the web at:

www.uog.edu/weri

WERI FACULTY, STAFF & STUDENTS

DIRECTOR



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Prof. Hydrogeology

Dr. Shahram Khosrowpanah
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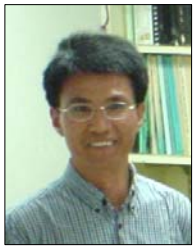

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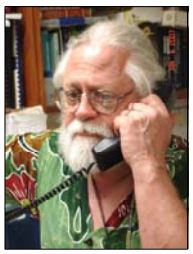

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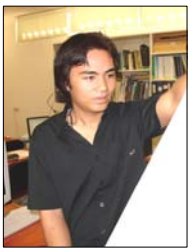

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ACTIVE PROJECTS

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

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

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 Senpehn 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

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

Ongoing research projects include:

a) Updating the Geologic Map of Guam

b) Determining Background Fluorescence in Guam's Groundwater

c) Development of a Unified Model for Contaminant Transport within the Saturated Zone of the Northern Guam Lens Aquifer, Phase I: Energy & Water Balance Data Collection

2. WATER RESOURCES MONITORING PROGRAM

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

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
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 is 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 will be able to better 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
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 complete, the next step involves an accuracy assessment to compare the classification to ground truth or other data. Recent IKONOS and QuickBird imagery will be used as reference data to assess Landsat imagery extracted land cover accuracy. Aerial orthophotos of 1975 are also available and can be used as reference data. GPS and a GPS compatible digital camera will be 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 can be conducted. The objectives of this project are 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

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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, 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. The source and extent of the mercury contamination in the Micro Beach area is currently unknown and is the primary focus of this proposal. Past military activities are strongly suspected to be linked with the contamination and will be assessed by analyzing sediments from storm drains and drainage basins in the Garapan area where the majority of military personal were stationed towards the end of WWII. Surface sediments from within the lagoon will also be examined to delineate the area of mercury enrichment. The full impact on the biotic resource of the area will be assessed using squirrel fish, *Myripristis violacea*, and snapper, *Lethrinus harak* as bioindicators. Both species of fish show a high propensity for mercury and are favored by local fisherman. Samples will be collected for analysis on a monthly basis to determine if there are critical times during the year when fish consumption from this area should be more restrictive.

The study has relevance from an ecological and 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 will also provide the basis for determining whether remediation strategies are necessary.

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, 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 proposes to better refine 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 are 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, Mark A. Lander

Funding: $36,064

The Senpehn 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 Senpehn 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 Senpehn 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 Senpehn watershed is relatively pristine and unimpacted by the activities of man.

The Senpehn watershed contains of five kousapws (village units), each with a Soumas (village chief). The kousapws that make up the Senpehn 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 is 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 are to: 1) install stream flow, sediment, and rain gages for selected sites within the Senpehn 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.

The result of this project will be the development of baseline information and identification of relationships between the dynamic components of the Senpehn watershed environment. The baseline information obtained will provide 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 will reveal the impact of these various activities 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 all watersheds in Pohnpei.

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,
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 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 aid FSM island leaders and water resource managers in establishing sustainable and practical groundwater extraction practices.

This project will engage a multi-disciplinary team composed of a hydrogeologist, an anthropologist, a GIS specialist, and a graduate research assistant. The process of fulfilling the objectives has partially been accomplished. Intense literature study has been performed, and will continue to be performed, and the first stages of constructing a groundwater model have already been accomplished. The current proposal will enable the completion of the project.

The construction of the models requires 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 2-13 2006, and another trip to the same atoll is planned for January 2007. A trip to Pingelap Atoll, Pohnpei State, FSM, is envisioned for the summer of 2007. Both of these atolls have readily available field data that will be vital in the model calibration process, to be undertaken shortly.

Groundwater modeling development will continue as the models are calibrated and simulations are run to calculate the effects of various extraction and recharge scenarios on the freshwater lens. Accompanying the state-of-the-art numerical computer model will be a simpler, analytical model using rainfall, soil, and evaporation data in GIS format, which will be calibrated by the more complex numerical model This simple analytical model will be a useful tool for predicting the volume and thickness of the freshwater lens for a given atoll island. Finally, all information, results, and tools will be relayed to the leaders and water resource managers of the islands.

Water System Operation and Maintenance Training for Yap State, FSM

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah
Leroy F. Heitz

Funding: $18,194

The Yap State Utility Corporation (YUC) operation and maintenance division has undergone relatively large changes in personnel over the last few years and many of the technicians presently working on the system are relatively untrained. Presently YUC is experiencing their most serious operation and maintenance problems with the mechanical and electrical controls for their pumps in the water supply and wastewater collection systems and for the maintenance and repair of altitude and pressure regulating valves in the distribution system. The YUC 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. The utilities in the other states in the FSM are experiences similar operation and maintenance problems.

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 carried out in Yap state but the training will be made available to utility employees from the other three states in the FSM.

The proposed training will consist of the following topics:

PUMP REPAIR AND MAINTENANCE

1. Site inspection of water supply facilities
2. Pump station equipment design, operation and maintenance
3. Hands on training at the YUC 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 YUC maintenance shop covering preventative and overhaul maintenance of valves
4. Discussion of future needs and required actions for long term preventative maintenance program for automatic valves in utility systems

PROJECTS
COMPLETED MARCH 2007

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

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM

GUAM:

Response of Well Heads of the Northern Guam Lens Aquifer to Rainfall and Sea Level Fluctuations at Daily Resolution

Watershed Land Cover Change Detection in Guam

CNMI:

Polychlorinated Biphenyls (PCBs) and Organochlorine Insecticides in Biotic Components of Tanapag Lagoon, Saipan

Development of Optimum Operational Management Strategies for the Saipan Water Distribution System

FSM:

Hydrological Modeling of Atoll islands in the Federated States of Micronesia

Management of the Nanpil River Watershed, Pohnpei Island, the Federated States of Micronesia

Integrating Environmental Education into Pohnpei's Primary School Curriculum

OTHER FUNDED PROJECTS

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center

NATIONAL SCIENCE FOUNDATION

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

GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

Development of a Geographic Information System (GIS) Based Erosion Potential Model for Southern Guam

GUAM DEPARTMENT OF AGRICULTURE

Heavy Metals and Abiotic Components of a Guam Reef Flat Impacted by Leachate from a Municipal Dump

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY:

a) Impact of Ordot Dump on Heavy Metal Status of Sediments and Biota in the Lonfit River by Ordot Dump

2. WATER RESOURCES MONITORING PROGRAM

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

Response of Well Heads of the Northern Guam Lens Aquifer to Rainfall and Sea Level Fluctuations at Daily Resolution

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Mark Lander

Funding: $19,958

This project makes an in-depth study of the response of the wellheads of the Northern Guam Lens Aquifer (NGLA) to rainfall and sea-level fluctuations at daily resolution. A characterization of the observed responses has immediate applicability to ongoing modeling efforts of WERI and USGS researchers of NGLA wellheads with SUTRA. One of the weaknesses of the SUTRA simulations is computation of water movement through an unsaturated zone more than 100 m thick. It is hoped that the analysis of the observed response of the wellheads to short-term variations of rainfall and sea level will help to calibrate the model, and determine the rate and time-lags at which the rainfall moves through the thick unsaturated zone of the NGLA. A goal of both the observational studies and the modeling studies was to elucidate the geological and hydraulic properties of the NGLA to better manage the resource.

The project included an intensive study of newly acquired daily values of wellhead, rainfall, and sea level. Data was obtained for other wells that were not available in previous research efforts. Recent acquisition of rainfall, sea level, and wellhead data at daily resolution, plus the acquisition of data for considerably more wells than used in previous studies, have allowed for a more in-depth analysis of the well hydrograph responses to variations in the rainfall and sea level. A major effort was required to properly inspect and organize all data for ready analysis and inter-comparison. The known timing of extreme short-term variations of rainfall and sea level helped to validate each time series.

The immediate objective of the project was to obtain a set of statistical model predictions of the daily value of the head at each selected well using the values of the daily rainfall and daily sea level. The parameters of the statistical model that optimize these predictions give insight into the hydraulic and geological properties of the NGLA.

Of particular interest are the well responses to pulses of heavy rainfall, and the nearly step-function drops of sea level that occur after the close passage of typhoons. There are several historical pulse occurrences of substantial rainfall and several rapid changes of sea level in response to typhoons and also to El Niño. The responses of the wells to these extreme events are benchmark tests of any numerical model simulation of the NGLA. The information gained from the statistical models will enable researchers to develop appropriate boundary conditions for the numerical simulations of the aquifer, and to calibrate the model to reproduce the observed behavior. This study provides baseline information for identifying the physical properties of the aquifer and their implications for numerical simulation of the NGLA and for Guam's water management plan. The project addresses the following issues identified by the Guam Advisory Council:

- Develop water budgets for Guam's surface and groundwater watersheds.
- Develop a three dimensional groundwater flow model for the Yigo-Tumon trough aquifer for use in water quantity studies
- Continue studies to determine the response of the Northern Guam Lens to various rainfall events
- Re-evaluation of the North Guam Aquifer sustainable development estimates will also be evaluated.

Watershed Land Cover Change Detection in Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Yuming Wen, Shahram Khosrowpanah, Leroy Heitz

Funding: $35,822

Land cover change (LCC) has been a subject of concern for the past century, particularly the past few decades around the world. Although many of the changes have been recorded qualitatively through the use of comparative photography and historical reports, little quantitative information has been available at the watershed scale. It is currently possible to detect land cover change and determine trends in ecological and hydrological condition at the watershed scale using advanced geo-spatial technologies. Satellite remote sensing, spatial statistics, geographic information systems (GIS), and global positioning system (GPS) can be used to identify LCC of 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 watershed condition related to disturbance from human and natural stresses.

Landsat observations have evolved from an experimental system in the 1970s to a feasible system to ensure our ability to explore, characterize, monitor, manage, and understand changes in the Earth's surface. Land cover has been derived from a multi-date satellite imagery database which incorporates Landsat Multi-Spectral Scanner (MSS) imagery from the early 1970s to early 1990s, Landsat Thematic Mapper (TM) imagery from early 1980s to current, Landsat Enhanced Thematic Mapper Plus (ETM +) from early 1999 to current at local and/or regional scale. 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 like forest fires and development and also 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.

Spatial and temporal modeling of changes in wetlands and badlands in Southern Guam watersheds was identified as one of the highest priority research needs for Guam on the Guam Advisory Council meetings of November 15, 2004 and October 4, 2005. Four (4) temporal Landsat images from 1970s, 1980s, 1990s and 2005 (with about ten year's interval) were obtained to measure changes of watershed land cover over three decades in Guam. The 1978 topographic map of Guam and recent IKONOS imagery were used as auxiliary information sources to improve land cover classification accuracy. Ten (10) meter digital elevation model (DEM) data were used to delineate the watersheds in Guam. The study area focused on 14 watersheds in Southern Guam. The main objectives of this project were to:

- Search and obtain Landsat imagery for different dates
- Preprocess the images such as georeference, projection and georectification
- Conduct classification to extract land cover information from the satellite images
- Compare the spatial and temporal land cover information to detect changes
- Provide change detection maps

Polychlorinated Biphenyls (PCBs) in Biotic Components of Tanapag Lagoon, Saipan

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Gary R. Denton, Harold Wood,
Michael Trianni

Funding: $50,615

Tanapag Lagoon borders the western shore of central Saipan. It harbors a rich diversity of marine life and supports a variety of commercial and recreational activities. Over the last quarter century, Tanapag Lagoon has become heavily impacted by the activities of man. Primary sources of anthropogenic disturbance in these waters include a power station and commercial port, two small boat marinas, a sewer outfall, several garment factories, auto and boat repair shops, wood shops, government vehicle maintenance yards, a commercial laundry, and an acetylene gas producer. There are also a number of old military dumps and disposal sites in the area as well as a 50-year-old municipal dump that served as the island's only solid waste disposal site until its closure a little over two years ago. Several streams and storm drains discharge into the lagoon during the rainy season and provide a mode of transport into the ocean for any land-based contaminants from these and other facilities. 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 surface sediments from the southern half of the lagoon and identified areas of enrichment around the port, the small boat marinas, and the dump. Subsequently, dominant ecological representatives (algae, seagrass, seacucumbers, bivalve mollusks and fish) were collected for chemical analysis from strategic locations within the lagoon in order to determine the impact of these perturbations on resident biota. All samples have since been analyzed for heavy metals and archived specimens await analysis for other contaminant groups of concern. This project has screened the archived collection for PCBs and organochlorine insecticides (e.g. DDT and related compounds). These ubiquitous contaminants are of interest because of their persistence, high bioaccumulation capacity and endocrine disruptive influence. Virtually nothing is known of their distribution and abundance in biota from Tanapag Lagoon despite PCB 'hotspots' being previously identified inland. The study therefore adds significantly to the existing contaminant database required for future trend monitoring purposes in the lagoon. Moreover, it provides valuable information on levels of a potentially harmful group of organic chemicals in key indicator organisms and identifies potential health risks associated with the unrestricted consumption of edible species. Overall, the program provides the necessary foundations for the future 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.

All analyses was conducted on freeze-dried samples to compensate for water losses incurred during storage of the achieved collection. Previously determined wet to dry weight ratios were reported with the data along with extractible lipid weights (%)

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Development of Optimum Operational Management Strategies for the Saipan Water Distribution System

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah
Leroy F. Heitz, Mariano Iglecias

Funding: $23,694

The Government of the Commonwealth Northern Marianas Islands (CNMI) has invested a large amount of funds to improve Saipan's water distribution system 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 Utility Corporation (CUC) water system. This goal will be unattainable until the CUC has a 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.

The Saipan water distribution system has been divided into 12 sub-regions. Each region is expected to operate somewhat independently. However, due to inadequate inflow to the system, system leakage, and lack of knowledge of system behavior, the system is unable to provide 24-hour water services to all customers. WERI researchers have developed computerized models of each of the 12 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 includes a Skeleton of the existing 12-region water system models that are joined together at the boundary points. The next step, addressed by this study, was to examine various system operational schemes in order to find an optimum way to transfer source water to the customer.

The project, now completed, provides a better understanding of the adequacy of the existing well, pump and storage facilities to cope with fluctuations in daily demands and provide sufficient flows to maintain 24 hour water to all areas of the system. It also highlights the most efficient means of moving water from water supply rich regions to those that have supply shortages.

The project was split into two phases. The first phase finalized the skeleton of each Saipan's sub-water system. We worked closely with CUC Engineering staff to ensure all included components, e.g., pipes, tanks, wells and reservoirs were correctly modeled and matched field data. The second phase will determined the optimum system operation. This phase was accomplished in close consultation with CUC staff engineers. First the model was operated in steady state mode and the response of the system during critical times was examined to determine if the system could meet the required demands and, if not, what changes in either operation or physical make up of the system were required to solve the problems. Next, the model was operated in extended time simulation mode to examine storage tank operations. The response of the storage tanks during critical times was examined to determine if all of the tanks were operating in an optimal manner and, if not, what changes in either operation or physical make up of the system were necessary to improve tank operations.

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,
Don Rubenstein

Funding: $42,873

Water shortages pose a grave concern to the inhabitants of atoll islands. The small size, unique geology, and high solar isolation on atoll islands combine to subject entire 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, exhaust water storage tanks and reduce island water supply to extremely limited alternatives. Tropical storms or typhoons can also destroy or severely damage rain catchment facilities.

At such times groundwater is the only alternative to importation. On most islands, groundwater is not utilized or the use of it is not systematic, however. 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 disproportionately thick transition zones between freshwater and saltwater, render traditional coastal aquifer models inappropriate. Moreover, sophisticated numerical models, such as are built for research purposes, are expensive and impractical for public or private sector planners and resources managers. The development of simple and elegant models to support groundwater resource assessment and management is needed by FSM resource managers to aid them in establishing sustainable and prudent groundwater extraction, protection and land use practices. The goal of this project was to produce a model consisting of two components, a steady-state GIS-based analytical model using hydrological and geological data assembled this past year during the first phase of this project, and a three-dimensional, dynamic computer model to simulate freshwater lens responses to changing levels of recharge, extraction, and tidal and sea-level fluctuations. The dynamic model will be used to calibrate the simpler analytical model, enhancing its accuracy. Based on the more sophisticated model, appropriate correction factors will be integrated into the analytical model to develop a user-friendly and reliable, Excel Spreadsheet-based tool for water resource managers. The model will also incorporate supply and demand related to the availability and production of rainwater catchment and agricultural water uses.

The model, aside from its practical importance will contribute to a greater understanding of the hydrogeology and water use on atoll islands. The models will provide FSM water resources managers with a better understanding of the conditions and processes that control the capacities and demands on atoll aquifers. They will also aid island leaders in developing practical and comprehensive water resources plans. Outside of the models, the report generated from this work will review general water-use practices to ensure that the proposed management plans are both culturally and economically feasible.

Management of the Nanpil River Watershed, Pohnpei Island, The Federated States of Micronesia

Funded by:
US Geological Survey, Water Institute Program

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

Funding: $38,837

The Nanpil Watershed is situated in the Sokehs and Nett Municipalities on the Northern side of Pohnpei Island. It is unique in many aspects. This area of approximately 3 square miles provides inflow to the Nanpil River -- a major source of drinking water to island residence. In recent years large areas of native forests and ecologically sensitive areas have been cleared for housing and road development projects and unmanaged agricultural activities (e.g., sakau/kava plots). These new development activities are now negatively impacting the biodiversity of much of the area, the headwaters and freshwater resources as well as the mangrove forests and coral reefs of Pohnpei Island. To implement any watershed management/protection plan requires having a better understanding of the physical and environmental components of the watershed. This includes how much rain the watershed receives, how much flow runs through the streams, what is the sediment load in the streams during the year, and how all these dynamic components are related to man's activities within the watershed. The lack of baseline information about the components of watersheds is a critical issue throughout the Federated States of Micronesia. When the political status of the Federated States of Micronesia with the United States changed from Trusteeship into Free Association in 1986, all the stream flow gages that were built and monitored by the US Geological Survey were deactivated and have remained effectively abandoned. Since 1986 there has been no information on how much flow runs through the streams and how much sediment is being carried to the reefs.

The objectives of this project were to: 1) install stream flow, sediment, and rain gages for selected sites within the Nanpil Watershed; 2) monitor the gages and develop a rating curve for the selected site; 3) develop a correlation between stream flow, sediment load and rainfall; and 4) develop a database of flow and sediment data for future use. The project, now completed has generated baseline information and correlations among the dynamic components of the Nanpil watershed environment. The baseline information generated by this work can be used for future comparison between Nanpil watershed and an ongoing similar study of the Enipein Watershed. The findings will help elucidate the impact of various activities such as land clearing, land slide/slope failures, and population growth on the quality of the watershed. This information will help various parties such as the Conservation Society of Pohnpei (CSP), Land Management, the Pohnpei Environmental Protection Agency (EPA), and local mayors to implement plans for protecting the watersheds in Pohnpei. Pohnpei's Public Utilities Commission (PUC) will be able to operate the water treatment plant more efficiently by knowing the level of the stream's turbidity and the available water in the stream. The information obtained with this work is also of benefit to Pohnpei's Weather Service with regards to the provision of timely flash flood warnings for the Nanpil River.

Integrating Environmental Education into Pohnpei's Primary School Curriculum

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:

Carla Schuk, Ben Namakin
Leinson Neth, Nick Donre

Funding: $12,764

While environmental education has been designated as a component of Pohnpei's curriculum, it has never been made an instructional priority in the classroom. Because of this, Pohnpei's citizens have only minimal knowledge about their environment and the impacts of their actions on it. Pohnpei is faced with a number of environmental issues from the upland forest down to the coral reef. Deforestation and sedimentation effects on Pohnpei's drinking water are significant. Coastal water pollution, dredging, and over-fishing are other problems that Pohnpei is currently facing. CSP sees the need to provide local teachers with tools that will integrate environmental education into the current curriculum in order to educate kids about the issues we have and possible solutions to help mitigate these issues. CSP is dedicated to filling that gap and providing a sustainable system of environmental education in Pohnpei's primary schools.

CSP has developed an Environmental Resource and Activity Book (ERAB) for grades 1 through 8. The ERAB contains a resource guide for teachers, as well as activities that integrate information about Pohnpei's environment into curriculum subject areas. ERAB activities incorporate language arts, math, reading comprehension, visual arts, and science to enable teachers to cover environmental subject matter without creating increased curriculum requirements. About 30 percent of the activities deal with water and waste management. Through discussions with teachers and the Department of Education, it has been deemed impractical to try to teach environmental education as a new subject area. With this in mind, CSP designed the ERAB with environmental lessons and activities that will compliment various subject areas in the existing school curriculum. The objectives of the ERAB project are:

1. To provide resources to teachers that will complement their curricula with messages of environmental awareness without creating new burdens and work demands.
2. To develop in the youth an awareness and understanding of the environment and ecology of Pohnpei, fostering a sense of stewardship towards environmental protection.
3. To collect local teachers' input for the ERAB and to produce a final draft for printing.
4. To train teachers in the use of the ERAB within the classroom in order to integrate environmental education into their current curricula.

In the spring of 2006, CSP formed a task force of education professionals from the Department of Education and local teaching staff, to edit and produce a final draft of the ERAB. Participating teachers introduced some of the activities into their classrooms at a level that matched the abilities of the students. This process was followed by a series of teacher trainings in the summer of 2006 to introduce the ERAB to teachers and provide them with the opportunity to practice using the activities. The teachers participated in role-playing and practiced using the activities and lessons. The three training sessions were divided by grade levels: (1) for teachers of grades 1-3; (2) for teachers of grades 4-6; and (3) for teachers of grades 7-8.

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.

Downloading rain gage data for soil erosion studies in Guam 'Badlands'

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. Ross Miller**, telephone: (671) 735-2141, **e-mail: rmiller@uog.edu).**

Pre Engineering Program
University of Guam

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

WHAT IS PRE-ENGINEERING AT THE UNIVERSITY OF GUAM?

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

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

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@uog.edu) or Dr. Leroy Heitz (lheitz@uog.edu) at the Water and Environmental Research Institute of the Western Pacific, UOG Station, Mangilao, Guam 96923 (telephone number (671) 735-2685).

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