Guam Hydrologic Survey (GHS)

And

Comprehensive Water Monitoring Program (CWMP)

FY 2005-2006

Status Report

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

January 2006

PROGRAM SUMMARIES

Guam Hydrologic Survey (GHS)

The GHS program provides annual funding to WERI to accumulate, synthesize, evaluate, archive, and disseminate water resources data collected on Guam by federal and local government agencies (including WERI) and private firms. The Guam Hydrologic Survey is a permanent part of WERI's program as stated in PL 24-247.

GHS also funds a diversity of water resource educational programs in various formats, including teacher workshop courses at UOG, workshops for Gov-Guam agency professionals, lectures, seminars field trips, and workshops for the general public, and the publication and distribution of educational posters, maps, and fact sheets.

GHS also provides funding to support the operation of a state of the art computer analysis and Geographic Information System (GIS) laboratory. Almost every water research project that is carried out by WERI involves a GIS analysis and mapping component. The GIS laboratory provides the required hardware and expertise in GIS analysis and serves as a data archive for GIS generated databases. WERI also works closely with various Government of Guam and Federal Agencies in sharing GIS data that becomes available.

ARCMAP GIS SOFTWARE

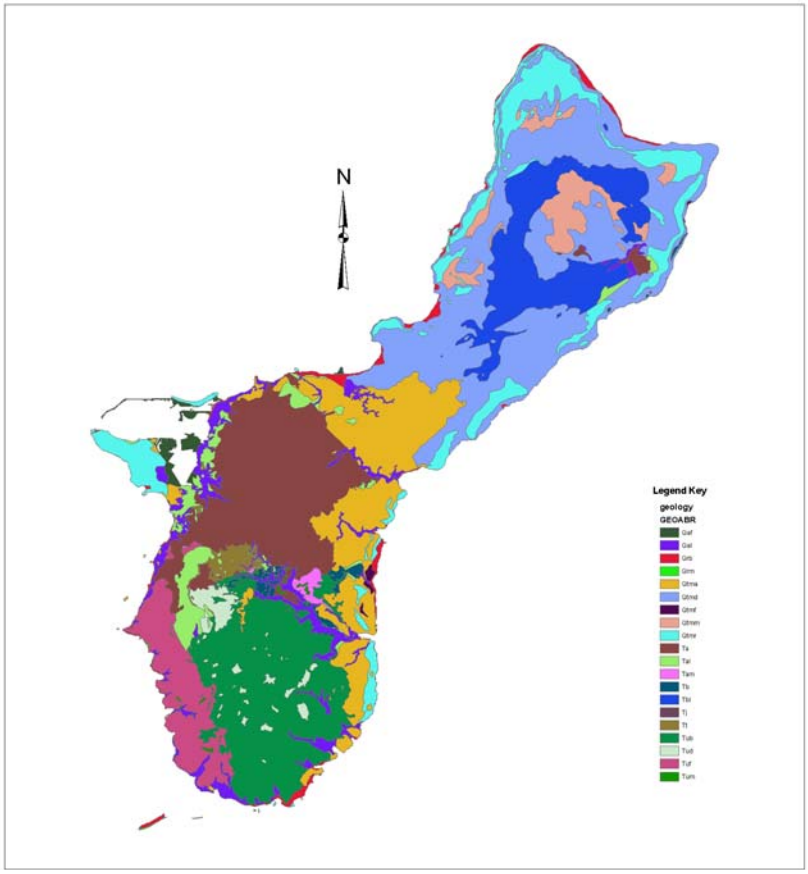
GRADUATE STUDENTS IN GIS LAB

GHS provides limited stipends, tuition, and fees for research graduate students working on their MS degree in Environmental Science, several UOG undergraduate field and lab assistants, and partial summer salaries to WERI faculty advising those students. GHS funds the salary of a fulltime research associate charged with operating WERI's complex and sophisticated computer analysis and Geographical Information System.

Several new projects were initiated during the 2005-2006 period. These projects included: Updating the Geologic Map of Guam, Determining Background Fluorescent Materials in Guam's Groundwater, Development of a Unified Model for Contaminant Transport Within the Phreatic Zone of the Northern Guam Lens Aquifer (NGLA), Heavy Metal Assessment of Sediments and Biota in the Lonfit River Upstream and Downstream of Ordot Dump, and a continuation of a previous project to develop a 3-dimensional groundwater model of the Northern Guam Lens using the US Geological Survey (USGS) SUTRA Model.

Updating the Geologic Map of Guam

Accurate knowledge of the origins, history, characteristics, and field relationships of the rock units and surface deposits of any given locale provides the essential basis for earth scientists to provide reliable and accurate scientific advice to developers, planners, engineers, resource managers, policy makers, and regulators, as well as other scientists in related disciplines. Geologic maps, in particular, support successful prospecting for mineral and groundwater resources; evaluation of geologic hazards; informed planning for the development and management of watersheds and agricultural land; the construction of airports, roads, aqueducts, and pipelines; and the development of safe and livable urban centers. Guam is fortunate that the US Geological Survey conducted a comprehensive study of the island's geology in the 1950s and 1960s, which revealed the fundamental geological origins of Guam and produced a map that has been a valuable resource for the economic development of the island. Subsequent work by geologists with the benefit of the past 40 years of accumulated knowledge of regional geology, as well as new technology for dating rocks and conducting spatial analysis, however, has revealed some errors in the original map, shed new light on questions that were left unresolved, and resulted in some revision of the interpretations of the original study. Moreover, the emergence of new and better techniques for dating certain types of rocks, including cave deposits, has made it possible to obtain information on ages of rock units and related features that were not available to earlier workers. Unfortunately, in spite of the accumulation of information and availability of new and better methods for field and laboratory analysis, the geologic map of Guam, which is now over 40 years old, has yet to be updated. This project will consolidate the information from subsequent studies and focus new field and laboratory work on areas where important questions have emerged or remain unresolved. The result will be an updated geologic map of Guam incorporating all of the revisions of past 40 years as well as some



GEOLOGIC MAP OF GUAM

new data on selected questions. These will include more accurate and precise dates of the volcanic rocks, corrections to the limestone stratigraphy, and new information on post-emergence history of the limestone units, including ages of cave deposits, and post-emergence climate history of Guam

Determining Background Fluorescent Materials in Guam's Groundwater

Dye trace studies are an effective and meaningful way to characterize groundwater transport within an aquifer. Such studies on Guam have revealed a highly-permeable, triple-porosity system in the Northern Guam Lens Aquifer. Results of a 2002 study conducted by David Moran and funded by the Guam Hydrological Survey (GHS) and the Guam Environmental Protection Agency (EPA) indicate that injected dyes carried by slow, diffuse flow through the bedrock matrix may discharge continuously over several months. These long term dye residuals have important implications when considering how to interpret the results of past and future dye trace studies.

DATA GATHERING FOR
BACKGROUND FLORESCENCE STUDY

True background fluorescence arises from overlapping spectra of other fluorescent materials, but contamination by the actual tracer material poses the most common threat. The tracer may be derived from off-site sources or it may mimic the spectra of another fluorescent material present. This project will carry out a comprehensive study of the nature of background fluorescent materials in the waters discharging along the western coast of Guam, from Agana Bay north to Double Reef. This will serve to provide a baseline for past and future dye trace surveys. Additionally, the analysis of common dyes used in dye tracing, as well as other fluorescent materials – such as optical brighteners, antifreeze and marine biota – will be performed in the lab to determine their physical and spectral properties, such as, but not limited to: photochemical decay rates; rates of adsorption/absorption to limestone substrates; detection limits in waters of varying salinity and the effectiveness of various sample preparation solvents (elutents) in each of those conditions.

Unified Model for Contaminant Transport Within the Saturated Zone of the NGLA: Phase I – Energy and Water Balance Data Collection

Guam's primary source of drinking water is the North Guam Lens Aquifer (NGLA). The NGLA is a karst aquifer and is therefore especially susceptible to contamination from the ground surface. Little is known, however, about the rates and processes by which infiltrating surface waters descend and interact with the lens. It is not known, for

example, how much or the rain that arrives during high-intensity rainfall events such as thunderstorms and tropical storms is actually taken into the lens rather than running off of the lens and discharging immediately to the coast. Because it is impossible to monitor and measure coastal discharge accurately, especially during and after heavy storms, there has so far been no quantitative data gathered on the volumes, and residence time of water that arrives at the water table after rainstorms. It has long been recognized however, that there are definitive differences in temperature between rainwater, groundwater, and seawater on Guam, as in similar tropical areas. This project will collect temperature data on rainwater and Guam's freshwater lens to establish appropriate boundary conditions for a numerical saturated zone transport model that will then used to evaluate the heat and mass budgets for the water going into, through, and out of the lens. The model will thus be used to calculate the quantities and rates at which recharge waters go into storage, transport, and discharge in response to rainfall events of different intensities under both wet- and dry-season conditions. The model thus calibrated, will eventually provide a tool for obtaining accurate estimates of rates and quantities of water-soluble contaminants, such as nitrate, that might be carried to the lens by recharge waters under these different kinds of conditions.

Heavy Metal Assessment of Sediments and Biota in the Lonfit River Upstream and Downstream of Ordot Dump

Guam's only civilian waste disposal facility is located just outside the village of Ordot in the center of the island. Ordot Dump as it is locally known has been in continuous use for over 50 years and has been operating at over capacity for almost 20 years. The western borders of the dump encroach on wetlands that drain into the Lonfit River. This rather picturesque stream converges with the Sigua River further downstream to form the Pago River, which in turn drains into Pago Bay on the eastern side of the island. Local residents fish all three rivers for food and the adjacent lands support a variety of agricultural activities including subsistence farming.

ORDOT DUMP

Unlike modern sanitary landfills, Ordot Dump is unlined and does not have a leachate retention system in place. As a result, streams of brown, foul smelling leachate intermittently flow from the perimeter of the dump and find their way into the Lonfit River valley below. Chemical characterization of the

leachate streams has been attempted on a number of occasions since 1982. In each case, heavy metals have been identified as the contaminants of primary concern, both from an ecological and human health perspective. Specific elements flagged as exceeding toxicity thresholds include arsenic (As), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), silver (Ag) and zinc (Zn). These predominantly exist in particulate form and, as a consequence, tend to accumulate in bottom sediments in the leachate streams and their confluence point in the Lonfit River. It was previously anticipated that metal contaminated sediments are periodically swept downstream during the wet season. Recent analyses of Pago Bay sediments and biota, however, have failed to find any signs of significant metal enrichment. The question therefore begs as to whether metal contaminants entering the upper reaches of the Lonfit River remain in the watershed or are mobilized beyond Pago Bay into deeper waters during major storm events.

This study will determine seasonal changes of heavy metals in sediments and biotic representatives (water weeds, shrimp, snails and fish) of the Lonfit River, upstream and downstream of leachate stream entry points. Samples will also be collected for analysis from the upper reaches of the Pago River and further down in the estuary. A suit of samples from the Sigua River will serve as additional controls

Development of a three-dimensional groundwater model of the Northern Guam Lens using the US Geological Survey (USGS) SUTRA Model

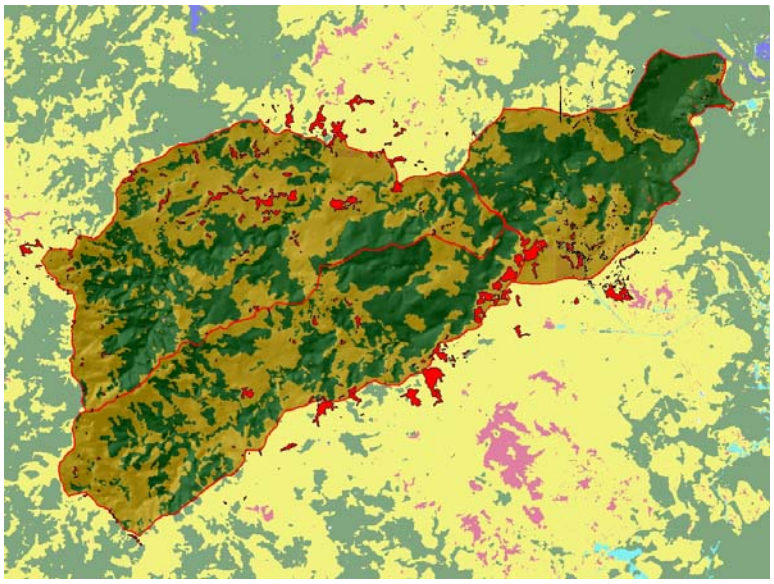
This research project reflects the continued concern for the health of Guam's Northern Guam Lens Aquifer (NGLA), which provides at least 40 million gallons per day of drinking water to the island. Within the NGLA, the Yigo-Tumon Sub-Basin is the principal water-producing sub-basin, accounting for about 40% of the total production and probably as much of the remaining fresh water reserve. It is also the most heavily developed area, containing over half of the island's population, and nearly all of its civilian commercial and industrial activities.

GRADUATE STUDENT WORKING WITH 3-D SUTRA MODEL

The study is a collaborative effort between WERI, Guam EPA and the US Geological Survey (USGS). Previous and ongoing Guam Monitoring Program data collection has collected a significant amount of data on water table response to recharge events and lens thickness. Abundant data are therefore available with which to parameterize and test the model. The scope of the study is limited to the Yigo-Tumon Sub-basin, the most prolific and most heavily developed sub-basin in the NGLA. The basic objective of this year's effort will be to prepare a model that accurately simulates the response of the aquifer to historical monthly recharge and sea-level forcing.

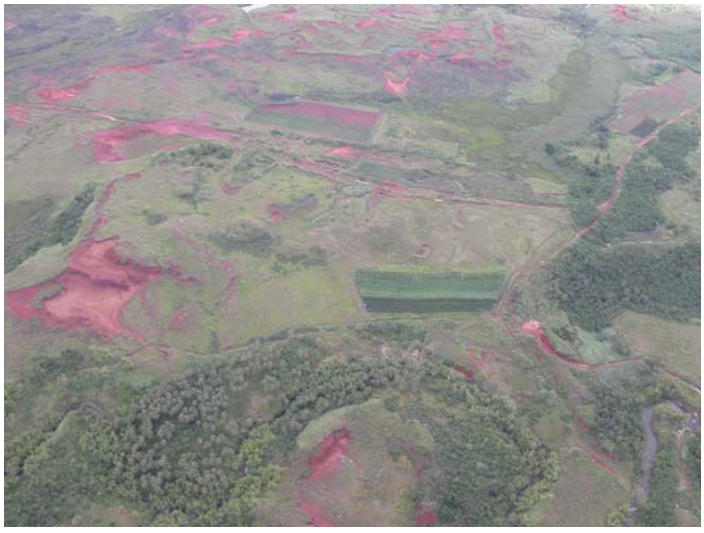
This project will produce an improved understanding of how contaminants from surface sources move through the aquifer and how the aquifer responds to recharge and pumping. Such knowledge will support more effective standards and regulations for land use and septic tank and sewer line installation and management. It will also provide information about aquifer response to recharge and pumping.

Ugum River Watershed Study



UGUM WATERSHED MAP SHOWING WATERSHED BOUNDARIES, BAD LAND EROSION AND VEGETAL COVER

WERI investigators have recently undertaken a watershed study of the Ugum River Basin. This river is particularly important to Guam since it is the major freshwater source for south Guam's drinking water supply. The study used streamflow and sediment data gathered under the Guam Monitoring Program and GIS data gathered under the Guam Hydrologic Survey to identify sources of non-point-source pollution in the Ugum basin. A companion study just getting underway will be developing strategies for modeling sediment production in the basin using GIS modeling techniques.



BADLAND EROSION IN UGUM RIVER WATERSHED

Comprehensive Water Monitoring Program (CWMP)

For many years, the United States Geological Survey (USGS) monitored our island's water resources from their field office at Naval Station. Unfortunately, several years ago, they were forced to downsize this program owing to a discontinuance of matching support from the Government of Guam. Stoppage of the USGS program accelerated deterioration and finally caused abandonment of all deep monitoring wells needed to monitor saltwater intrusion in the north, and all stream-gaging stations in the south. Then in 1995, the USGS closed its office on Guam, but did continue to run a limited monitoring program (out of its Saipan office), consisting of recording rainfall data from three stations and water table levels from eight shallow wells.

In 1999, the CWMP (PL 24-161) was initiated, first to restore, and then to expand, as needed, the discontinued monitoring program in order to help Guam manage and safeguard all of its freshwater resources, now and in the future. Under PL 24-161, WERI/UOG and the USGS entered into a memorandum of understanding to administer and fund this program on a 50/50 cost-sharing basis. Total first-year costs (GovGuam + USGS) were estimated to be $640,000, a number reflecting repair and replacement of deteriorated facilities in addition to limited data collection activities. In August, 1998 the CWMP was made a permanent part of WERI's program when Governor Gutierrez singed PL 24-247. The CWMP is a permanent investment in Guam's future.

LA SA FUA STREAM GAGE SITE

In 2002 Typhoons Chataan and Pongsona produced record high streamflows in Guam. Unfortunately these record high flows caused severe damage to the entire stream-gaging network that was in operation at the time. Before Typhoon Chataan, there were 12 recording stream gages and 2 crest-stage gages in operation, for a total

of 14 sites. During 2003 and 2004 all of the damaged sites were repaired and re-instrumented. During 2004 and 2005 two new sediment-monitoring stations were added to the surface water measurement sites. The 2005-2006 CWMP project funding was used to continue to gather the valuable data obtained from all of the stream gage sites.

There are 9 monitoring wells on Guam including the Agana tide gage. These gages are used to monitor well levels and to evaluate the freshwater saltwater interface. This year real time measurement and recording of changes in conductivity (an indirect measurement of water salinity) and water level was measured at four well sites. This data will be used in the model development and calibration for the SUTRA model that is being funded through a Guam Hydrologic Survey project. Also included is the monitoring at 5 stream gage sites two of which include sediment monitoring and three rain gage sites. All of the data that is being gathered is essential to the successful management of the surface and groundwater resources of Guam.

USGS MONITORING LOCATIONS

The data collected from this project cam be downloaded directly from the USGS Pacific Islands Water Science Center Web Site at http://hi.water.usgs.gov/ or through the WERI website at http://weriguam.org/home/index.htm.