clerks@guamlegislature.org

From: Speaker's Office <speaker@guamlegislature.org>
Sent: Friday, July 31, 2020 4:10 PM
To: Clerks Office
Cc: Rennae Meno
Subject: Fwd: FY21 Budget Request for Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey (Due 1 Aug) (corrected copy)
Attachments: GHS CWMP Letter_7.31.2020-jjgp.pdf; P.L. 24-161.pdf; P.L. 24-247.pdf; USGS WERI JFA CWMP FY21.pdf; FY21 GHS Budget Request-2020-07-27.pdf; FINAL Annual Summary of Activities 18-19.pdf; Email-FY2021 Budget Request for Guam Comprehensive Water Monitering Program.pdf

07-31-20	12:15 PM	07-31-20	FY21 Budget Request for Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey.*	Water and Environmental Research Institute of the Western Pacific-University of Guam	35GL-20-2107

Sinseru yan Minagåhet,

Office of the Speaker • Tina Rose Muña Barnes
Committee on Public Accountability, Human Resources & the Guam Buildup

35th Guam Legislature
I Mina'trentai Singko na Liheslaturan Guåhan

Guam Congress Building | 163 Chalan Santo Papa | Hagatna, GU 96910
T: (671) 477-2520/1
speaker@guamlegislature.org

This e-mail message is intended only for the use of the individual or entity named above and may contain confidential and privileged information. If you are not the intended recipient, any disclosure, copying, distribution or use of the information contained in this transmission is strictly PROHIBITED. If you have received this transmission in error, please immediately notify us by replying to speaker@guamlegislature.org and delete the message immediately. Thank you very much.

Gumai pribilehu yan konfedensia este siha na mensåhi. Solo espesiåtmente para hågu ma entensioña pat ma aturisa para unrisibi. Sen prubidu kumu ti un ma aturisa para manribisa, na'setbe, pat mandespåtcha. Yanggen lachi rinisibu-mu nu este na mensåhi , put fabot ago' guatu gi I numa'huyong gi as speaker@guamlegislature.org yan despues destrosa todu siha I kopian mensåhi. Si Yu'os ma'åse'.

---------- Forwarded message ---------
From: **Dr. John Jenson** <jjenson@triton.uog.edu>
Date: Fri, Jul 31, 2020 at 12:18 PM
Subject: FY21 Budget Request for Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey (Due 1

Aug) (corrected copy)
To: speaker@guamlegislature.org <speaker@guamlegislature.org>
Cc: Krise, Thomas <tkrise@triton.uog.edu>, Randall V. Wiegand <wiegandr@triton.uog.edu>, Rachel F. Cubacub <rachelfc@triton.uog.edu>, Hoffmann, John P <jphoffma@usgs.gov>, RACHAEL TAITANO LEONGUERRERO <rachaeltlg@triton.uog.edu>, Gema Payumo <capatigp@triton.uog.edu>, Agustin, Anthony <agustina@triton.uog.edu>, Nathan Habana <nchabana@triton.uog.edu>

27 July 2020

The Honorable Tina Rose Muña Barnes, Speaker

I Mina'trentai Singko Na Liheslaturan Guåhan

163 Chalan Santo Papa Juan Pablo Dos

Hagåtña, 96910, Guam

Subject: FY2021 Budget Requests: Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey Program

Dear Speaker Barnes:

1. In compliance with Guam Public Laws 24-161[1] and 24-247[2] (Attachment 1), WERI is pleased to submit this year's budget requests for the Guam Comprehensive Water Monitoring Program (Attachment 2) and the Guam Hydrologic Survey Program (Attachment 3).

2. In 1998, Public Law 24-161 established the Guam Comprehensive Water Monitoring Program (CWMP) to provide for Guam's continued participation in the National Groundwater and Streamflow Information Program (https://www.usgs.gov/water-resources/groundwater-and-streamflow-information), under which the US Geological Survey (USGS) offers matching federal funds (currently about 40% federal to 60% local) to the states and territories to collect data on the quantity, quality, and trends in their groundwater and surface water resources. For the data-collection program on Guam, WERI collaborates with the USGS Pacific Island Water Science Center in Honolulu, which sends teams of hydrogeologists and technicians every 90 days to service and download data from rain gauges, groundwater observation wells, and stream gauges installed across the northern aquifer and in the utilized southern watersheds. These data are processed by USGS and added to their national database.

3. A few months after Public Law 24-161 created the CWMP, Public Law 24-247 created the Guam Hydrologic Survey (GHS) Program to "establish a permanent program for not only collecting, but also for consolidating and storing all of the water resource data on Guam, and making all of it readily retrievable for use by the people of Guam." The intent

was to ensure that not only the data collected by the CWMP, but historical information and data collected by other activities—such as drilling, logging, and pump testing of new wells—are captured and kept available in a permanent, locally maintained, and readily accessible archive to support sustainable management of Guam's water resources. Along with CWMP data, WERI has thus collected and archived five decades of historical hydrologic data that are permanently maintained in its GHS databases (https://guamhydrologicsurvey.uog.edu). These databases are continually updated, and provide WERI researchers information needed to track the amount of freshwater in the aquifer, the salinity of the water, and how the volume and salinity of our freshwater supply is responding to pumping, droughts, storms, and cyclical climatic changes in rainfall and recharge. The databases also support WERI's ongoing aquifer modeling program, which is also done in collaboration with the USGS, to determine sustainable limits and best management practices for drinking water production on Guam.

4. Public Law 24-247 further specifies that the intent of the legislation is to "ensure that ongoing analyses of local water resource concerns are conducted by local scientists so that the Island's water resource policy-makers, managers, regulators, and educators, businesses, and citizens have timely information and readily accessible advice for sound decisions regarding use, conservation and development of Guam's water resources." The statute thus also specifically mandates that WERI not only maintain a consolidated database of all hydrologic data pertaining to Guam, but that it coordinate with other agencies to keep the database up to date, conduct analyses of the status and trends of Guam's water resources and provide regular reports on them, provide educational materials on Guam's water resources, and conduct research into water resource problems of current concern. Attachment 4 is the current annual report of WERI's operations and products that meet these mandates. Additional information is available at the Guam Hydrologic Survey Website.

5. Public Law 24-247 directs WERI to work with the USGS to prepare an annual work plan and budget for the CWMP and to submit the annual budget request for Guam's share of the program *I Liheslaturan Guåhan* by August 1st of each year. The attached Joint Funding Agreement (JFA) between WERI and USGS (Attachment 2) will continue the CWMP from October 1, 2020 to September 30, 2021. The total cost of the CWMP for this year is $256,980, of which $94,187 will be contributed by USGS and $162,793 is to be contributed by WERI. WERI is therefore requesting $162,793 to support the CWMP.

6. Public Law 24-247 also directs WERI to "prepare and submit the annual budget request for the Guam Hydrological Survey to *I Liheslaturan Guåhan* by August 1st of each year." Attachment 3 contains a detailed breakdown of our FY2021 budget request for $$398,947 to support WERI's GHS mission for ongoing water resource data management, analysis and reporting, research, education, and outreach, as described above. WERI will soon be delivering this year's State of the Aquifer Report and will be contacting your office to schedule this year's presentations on the current operations and results of our GHS data collection, analysis, research, and education activities. We at WERI are available at your convenience to answer any questions regarding these requests or to provide additional information to support effective stewardship of Guam's freshwater resources.

Most respectfully yours,

John W. Jenson, Ph.D.

Director, Water & Environmental Research Institute of the Western Pacific

Chief Hydrogeologist & Professor of Environmental Geology

University of Guam

Mangilao, GU 96923

Ph. (671) 735-2689

GMT + 10

Attachments

1. Public Laws 24-161 & 24-247

2. FY2021 WERI-USGS JFA for CWMP, 29 June 2020

3. FY2021 Budget Request for GHS

4. Annual WERI/GHS Report, February 2020

[1] *An act to add a new Article 3 to Chapter 14, Title 12 of the Guam Code Annotated, relative to establishing a Drought Measurement and Comprehensive Water Conservation Plan*, 4/09/98.

[1] *An act to establish the Guam Hydrologic Survey as a permanent program to be administered by the Water and Energy Research Institute of the Western Pacific, University of Guam*, 8/14/98.

Water and Environmental Research Institute of the Western Pacific

UNIVERSITY OF GUAM

303 University Drive UOG Station, Mangilao Guam 96923

[1] *An act to add a new Article 3 to Chapter 14, Title 12 of the Guam Code Annotated, relative to establishing a Drought Measurement and Comprehensive Water Conservation Plan*, 4/09/98.

[2] *An act to establish the Guam Hydrologic Survey as a permanent program to be administered by the Water and Energy Research Institute of the Western Pacific, University of Guam*, 8/14/98.

Speaker's Office <speaker@guamlegislature.org>

FY21 Budget Request for Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey (Due 1 Aug) (corrected copy)

1 message

Dr. John Jenson <jjenson@triton.uog.edu> Fri, Jul 31, 2020 at 12:18 PM
To: "speaker@guamlegislature.org" <speaker@guamlegislature.org>
Cc: "Krise, Thomas" <tkrise@triton.uog.edu>, "Randall V. Wiegand" <wiegandr@triton.uog.edu>, "Rachel F. Cubacub" <rachelfc@triton.uog.edu>, "Hoffmann, John P" <jphoffma@usgs.gov>, RACHAEL TAITANO LEONGUERRERO <rachaeltlg@triton.uog.edu>, Gema Payumo <capatigp@triton.uog.edu>, "Agustin, Anthony" <agustina@triton.uog.edu>, Nathan Habana <nchabana@triton.uog.edu>

27 July 2020

35GL-20-2107
Speaker Tina Rose Muña Barnes

The Honorable Tina Rose Muña Barnes, Speaker

I Mina'trentai Singko Na Liheslaturan Guåhan

163 Chalan Santo Papa Juan Pablo Dos

Hagåtña, 96910, Guam

JUL 3 1 2020
Time 12:18 ( )AM (X)PM
Received By: matt

Subject: FY2021 Budget Requests: Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey Program

Dear Speaker Barnes:

1. In compliance with Guam Public Laws 24-161[1] and 24-247[2] (Attachment 1), WERI is pleased to submit this year's budget requests for the Guam Comprehensive Water Monitoring Program (Attachment 2) and the Guam Hydrologic Survey Program (Attachment 3).

2. In 1998, Public Law 24-161 established the Guam Comprehensive Water Monitoring Program (CWMP) to provide for Guam's continued participation in the National Groundwater and Streamflow Information Program (https://www.usgs.gov/water-resources/groundwater-and-streamflow-information), under which the US Geological Survey (USGS) offers matching federal funds (currently about 40% federal to 60% local) to the states and territories to collect data on the quantity, quality, and trends in their groundwater and surface water resources. For the data-collection program on Guam, WERI collaborates with the USGS Pacific Island Water Science Center in Honolulu, which sends teams of hydrogeologists and technicians every 90 days to service and download data from rain gauges, groundwater observation wells, and stream gauges installed across the northern aquifer and in the utilized southern watersheds. These data are processed by USGS and added to their national database.

3. A few months after Public Law 24-161 created the CWMP, Public Law 24-247 created the Guam Hydrologic Survey (GHS) Program to "establish a permanent program for not only collecting, but also for consolidating and storing all of the water resource data on Guam, and making all of it readily retrievable for use by the people of Guam." The intent was to ensure that not only the data collected by the CWMP, but historical information and data collected by other activities—such as drilling, logging, and pump testing of new wells—are captured and kept available in a permanent, locally maintained, and readily accessible archive to support sustainable management of Guam's water resources. Along with CWMP data, WERI has thus collected and archived five decades of historical hydrologic data that are permanently maintained in its GHS databases (https://guamhydrologicsurvey.uog.edu). These databases are continually updated, and provide WERI researchers information needed to track the amount of freshwater in the aquifer, the salinity of the water, and how the volume and salinity of our freshwater supply is responding to pumping, droughts, storms, and cyclical climatic changes in rainfall and recharge. The databases also support WERI's ongoing aquifer modeling program, which is also done in collaboration with the USGS, to determine sustainable limits and best management practices for drinking water production on Guam.

4. Public Law 24-247 further specifies that the intent of the legislation is to "ensure that ongoing analyses of local water resource concerns are conducted by local scientists so that the Island's water resource policy-makers, managers, regulators, and educators, businesses, and citizens have timely information and readily accessible advice for sound decisions regarding use, conservation and development of Guam's water resources." The statute thus also specifically mandates that WERI not only maintain a consolidated database of all hydrologic data pertaining to Guam, but that it coordinate with other agencies to keep the database up to date, conduct analyses of the status and trends of Guam's water resources and provide regular reports on them, provide educational materials on Guam's water resources, and conduct research into water resource problems of current concern. Attachment 4 is the current annual report of WERI's operations and products that meet these mandates. Additional information is available at the Guam Hydrologic Survey Website.

5. Public Law 24-247 directs WERI to work with the USGS to prepare an annual work plan and budget for the CWMP and to submit the annual budget request for Guam's share of the program *I Liheslaturan Guåhan* by August 1st of each year. The attached Joint Funding Agreement (JFA) between WERI and USGS (Attachment 2) will continue the CWMP from October 1, 2020 to September 30, 2021. The total cost of the CWMP for this

year is $256,980, of which $94,187 will be contributed by USGS and $162,793 is to be contributed by WERI. WERI is therefore requesting $162,793 to support the CWMP.

6. Public Law 24-247 also directs WERI to "prepare and submit the annual budget request for the Guam Hydrological Survey to *I Liheslaturan Guåhan* by August 1st of each year." Attachment 3 contains a detailed breakdown of our FY2021 budget request for $$398,947 to support WERI's GHS mission for ongoing water resource data management, analysis and reporting, research, education, and outreach, as described above. WERI will soon be delivering this year's State of the Aquifer Report and will be contacting your office to schedule this year's presentations on the current operations and results of our GHS data collection, analysis, research, and education activities. We at WERI are available at your convenience to answer any questions regarding these requests or to provide additional information to support effective stewardship of Guam's freshwater resources.

Most respectfully yours,

John W. Jenson, Ph.D.

Director, Water & Environmental Research Institute of the Western Pacific

Chief Hydrogeologist & Professor of Environmental Geology

University of Guam

Mangilao, GU 96923

Ph. (671) 735-2689

GMT + 10

Attachments

1. Public Laws 24-161 & 24-247
2. FY2021 WERI-USGS JFA for CWMP, 29 June 2020
3. FY2021 Budget Request for GHS
4. Annual WERI/GHS Report, February 2020

[1] *An act to add a new Article 3 to Chapter 14, Title 12 of the Guam Code Annotated, relative to establishing a Drought Measurement and Comprehensive Water Conservation Plan*, 4/09/98.

[1] *An act to establish the Guam Hydrologic Survey as a permanent program to be administered by the Water and Energy Research Institute of the Western Pacific, University of Guam*, 8/14/98.



Water and Environmental Research Institute of the Western Pacific

UNIVERSITY OF GUAM

303 University Drive UOG Station, Mangilao Guam 96923

---

[1] *An act to add a new Article 3 to Chapter 14, Title 12 of the Guam Code Annotated, relative to establishing a Drought Measurement and Comprehensive Water Conservation Plan*, 4/09/98.

[2] *An act to establish the Guam Hydrologic Survey as a permanent program to be administered by the Water and Energy Research Institute of the Western Pacific, University of Guam*, 8/14/98.

---

6 attachments

GHS CWMP Letter_7.31.2020-jjgp.pdf
169K

P.L. 24-161.pdf
1785K

P.L. 24-247.pdf
1082K

USGS WERI JFA CWMP FY21.pdf
612K

FY21 GHS Budget Request-2020-07-27.pdf
175K

FINAL Annual Summary of Activities 18-19.pdf
9201K

Annual Summary of Activities

including

Guam Hydrologic Survey

activities

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

February 2020

Doc. No. 35GL-20-2107.*

Annual Summary of Activities

including Guam Hydrologic Survey activities

Edited by
Kaylyn K. Bautista

February 2020

Period of report: 1 Oct 2018 - 30 Sept 2019

Dr. John W. Jenson, Director

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

Doc. No. 35GL-20-2107.*

TABLE OF CONTENTS

Director's Message 1

Mission 2

Vision 2

Core Values 2

2020-2025 Research Agenda 3

Guam Hydrologic Survey Program 4

Comprehensive Water Monitoring Program 6

Completed Projects 8
- PFOS Trend Monitoring in a Guam Drinking Water Production Well: Seasonal Influences 8
- Yigo-Tumon Basin Well Capacity 8
- Salinity Patterns and Trends in the NGLA 9
- GWA Production-Well Rehabilitation Assessment: Well Exploration and Development 10
- Impact of Stormwater from a Natural Wetland in Saipan on Receiving Waters and Fisheries Resources 10
- Effects of Seawater on Nitrification in a Biofilm Treatment Process 11
- Determination of Rainfall Erosivity Factors to Selected Islands in CNMI 12
- Aerial Survey and Field Instrumentation of Landslide Threat to Tropical Watershed in Southern Guam 12
- Response of the Freshwater Lens to Variations in Recharge, Northern Guam Lens Aquifer 13

Ongoing Research 14
- Mapping Submarine Groundwater Discharge with Thermal Infrared and Unmanned Aerial Vehicle 14
- Hydrogeological Control on Submarine Groundwater Flow in Ayuyu Cave 14
- GIS Based Imagery Database of Groundwater Recharge Areas and Key Reaches of Streams on Guam 15
- N-Baseline Data and Abatement Methods for the Northern Guam Lens Aquifer 16
- Three-Dimensional Finite-Element Groundwater Model of the Yigo-Tumon Basin, NGLA 16
- Potential PFAS Contamination Sites Near the GWA Production Well A-25 16
- PFOS Trend Monitoring in Saipan Production Wells 17
- Improvements to Sewage Treatment on Yap: Hydroponics and Composting of Waste Sludge 18
- Hydrological Features and Analysis in the Finegayan Area 18
- Water Use Data and Research in Guam 19
- Northern Guam Lens Aquifer Monitoring System Expansion Rehabilitation Program 19

Education and Outreach 20
- Digital Atlas of Yap - A Geospatial Map and Data Server for Resource Management 20
- Professional Workshop Series on Guam Groundwater Resources 20
- Comprehensive Guam and CNMI WERI-Web-Based Comprehensive Rainfall Data Utility 21
- Sand Filtration Training in Yap 22
- Advisory Council Meetings 22
- Virtual Tour and Professional Field Trip of the Northern Guam Lens Aquifer 23
- Guam Water Kids 23

University of Guam Programs Supported by WERI 24
- Environmental Science Graduate Program
- School of Engineering

The Joseph D. Rouse Scholarship for Professional Excellence and Integrity 26

Doc. No. 35GL-20-2107.*

In Memoriam



Dr. Joseph D. Rouse

Professor, Water Resources Engineering

2011 - 2019

Dr. Joseph Rouse is admired by all who knew him for his integrity, confidence, humor, originality, and graciousness. His contributions were fundamental to the success of WERI and the University of Guam in serving the people of our island and the region. He was a first-rate classroom instructor and student advisor. He had genuine affection for his students, and was dedicated to their success. He was twice elected as Chair of the Environmental Science Program, played a pivotal role in launching the School of Engineering, and served on numerous University committees. He was a first-rate scientist and professional engineer. He had extraordinary talent for innovative work on practical problems. His work on small island waste management and treatment in Yap and Pohnpei epitomize the WERI mission of finding practical solutions for island water resource management problems. Dr. Rouse's soft-spoken, gentle demeanor, and subtle sense of humor will be remembered by all who worked with him. May he rest in peace.

DIRECTOR'S MESSAGE

The Water & Environmental Research Institute of the Western Pacific (WERI) is one of 54 water research institutes established by U.S. Congressional legislation at each Land Grant University in the U.S. and in several territories. The Institute is now in its 45th 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. The Institute provides its regional stakeholders with technical expertise in water resources related fields spanning the entire natural water cycle and spectrum of human water use, including tropical climatology, surface water hydrology, rainfall catchment systems, groundwater modeling and management, and various aspects of water quality. 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 Marianas islands (CNMI), and in the Federated States of Micronesia (FSM). The faculty and staff of WERI seek to improve economic conditions and quality of life for the citizens of Guam and its regional island partners.

In FY-2019 WERI faculty were involved as principal investigators and/or advisors on 24 research and training projects with a combined budget of approximately $2,406,901. Of this, $277,005 was awarded through the Water Resources Research, Institute Program administered by USGS under 104 B, while $309,009 was received as a special appropriation from the Guam Legislature. The remainder came from other Federal and Private Sources awarded directly to the Institute, or indirectly through local Government Agencies.

Currently, WERI has seven full-time research faculty, one of whom serves as Director on a rotational basis; one emeritus research faculty member; a water analysis laboratory manager, technician, and chemist; two office staff, as well as several graduate and undergraduate research assistants. WERI provides teaching and student advisement for the undergraduate Pre-Engineering and graduate Environmental Science Programs, and also provides community services to the university and public. WERI runs a state-of-the-art water quality laboratory that supports research and provides public service for water testing.

WERI faculty members have published refereed journal articles, technical reports, and conference proceedings. They have also given numerous professional presentations and training workshops. Following its 5-year evaluation, WERI was congratulated by the evaluation panel for continuing to promote an outstanding program appropriately focused in a programmatically separate way on the water problems of Guam, the CNMI and the FSM.

In August 2019, we were saddened by the loss of our colleague Dr. Joseph Rouse. In his memory, WERI established a scholarship to promote the values of professional competence and integrity in professional science and integrity Dr. Rouse epitomized. See page 26.

For more information on WERI's research and academic programs please visit us on the web at:
http://www.weri.uog.edu or contact:

Dr. John W. Jenson, PhD
Director, WERI
jjenson@triton.uog.edu
303 University Dr.,
Mangilao, Guam 96913
Tel: 1-671-735-2685
Fax: 1-671-734-8890



Doc. No. 35GL-20-2107.*

MISSION

Trustworthy and timely research, instruction, and advice to support scientifically informed development and effective management of the freshwater resources of Guam, CNMI, and FSM.

WERI's mission flows from its federal and local mandates to conduct applied research and provide education, training, and scientific advice on the development and management of the fresh-water resources of Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and the Federated States of Micronesia (FSM). Research, teaching, and outreach focus on exploration, production, distribution, and management of local freshwater resources, but also extend to related basic scientific topics of region, national, and international scope. WERI trains new environmental scientists and fosters integrity in research and application of environmental science. WERI thus provides high quality graduate instruction and student research support. Under its Guam Hydrologic Survey (GHS) mandate, WERI maintains a hydrologic database for Guam and provides regular support to policy-makers and managers of Guam's water resources. WERI maintains essential laboratories, including a Water Quality Analysis Laboratory to support hydrologic and environmental research and meet public and commercial needs for water quality analyses on Guam and in the western Pacific region.

CORE VALUES

1. Reliable and honest science
2. Consultative decision-making and across-the board teamwork
3. Superb instruction and conscientious mentoring
4. Earnest service to the community and university
5. Sincere partnerships with public and professional agencies

VISION

WERI's vision is to remain the acknowledged local and regional source of choice for scientific and technical advice on water resource exploration, development, and management; and a nationally-ranked and internationally recognized center of excellence for research in its strategic specialties. To fulfill this vision, WERI will maintain broad expertise in the essential subdisciplines of scientific and engineering hydrology and leverage its expertise with strategic partnerships and collaborations.

Breadth of Expertise

WERI seeks to maintain a portfolio of core expertise that spans the natural water cycle from meteorology through surface and groundwater hydrology, and essential water-use activities including exploration, development, and management; water quality protection and remediation; wastewater treatment and disposal; and related basic supporting fields, such as geospatial analysis, climatology, environmental chemistry, and microbiology.

Partnerships and Collaborations

WERI leverages its expertise on local geology and hydrology with national resources through active partnerships with the *USGS Pacific Islands Water Science Center* in Honolulu, Hawaii, with which it jointly administers the *USGS Groundwater and Streamflow Information Program* for Guam through the locally-funded *Guam Comprehensive Water Monitoring Program*, the *Guam Hydrologic Survey Program*, and - starting soon - the *One-Guam Aquifer Monitoring Program* in partnership with the Department of Defense's *Joint Region Marianas*. Local collaborative partners include the Guam Waterworks Authority and Guam Environmental Protection Agency, and Naval Facilities Engineering Command Marianas. WERI also has active external collaborations with researchers at other universities.



The Water Quality Laboratory supports WERI water quality research projects and operates as a semi-commercial laboratory that offers water quality testing. Testing services are categorized into three sections: microbiological, chemical, and physical tests.

Doc. No. 35GL-20-2107.*

Guam

I. Aquifer research
- Baseline/core products: databases, map series
- Water availability: modeling, exploration, rehabilitation
- Water quality: salinity, sewage, chemical contaminants

II. Surface watershed research
- Baseline/core products: watershed imagery, maps
- Water availability: southern karst springs; stream flows
- Water quality

III. Water-use management: new USGS water-use database

IV. Training, education, outreach
- Website, State of the Aquifer Report, technical reports
- Workshops, Professional Aquifer Tour, Guam Water Kids

CNMI

I. Water availability
- Comprehensive Guam & CNMI rainfall

II. Water quality
- PFOS trends in Saipan

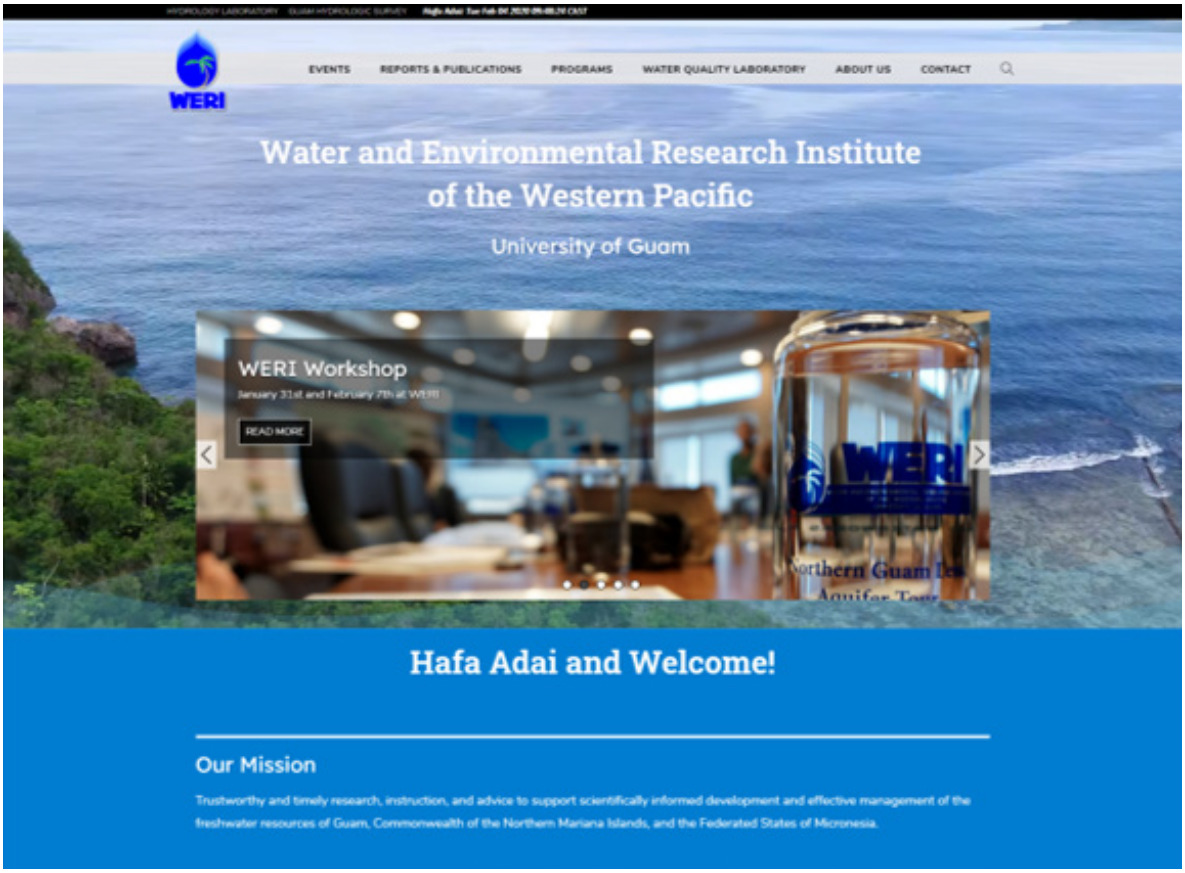
III. Stormwater management and planning

FSM

I. Yap
- Sand filtration training
- Wastewater treatment improvements

II. Kosrae
- Surface watershed research
- Baseline/core products: databases, maps
- Water availability: exploration

III. Education and outreach
- Yap Digital Atlas
- New education outreach for K-12
- Chuuk Digital Atlas
- Kosrae water resources training and outreach



Visit the WERI website for a new, user-friendly experience:
www.weri.uog.edu

Doc. No. 35GL-20-2107.*

GUAM HYDROLOGIC SURVEY PROGRAM

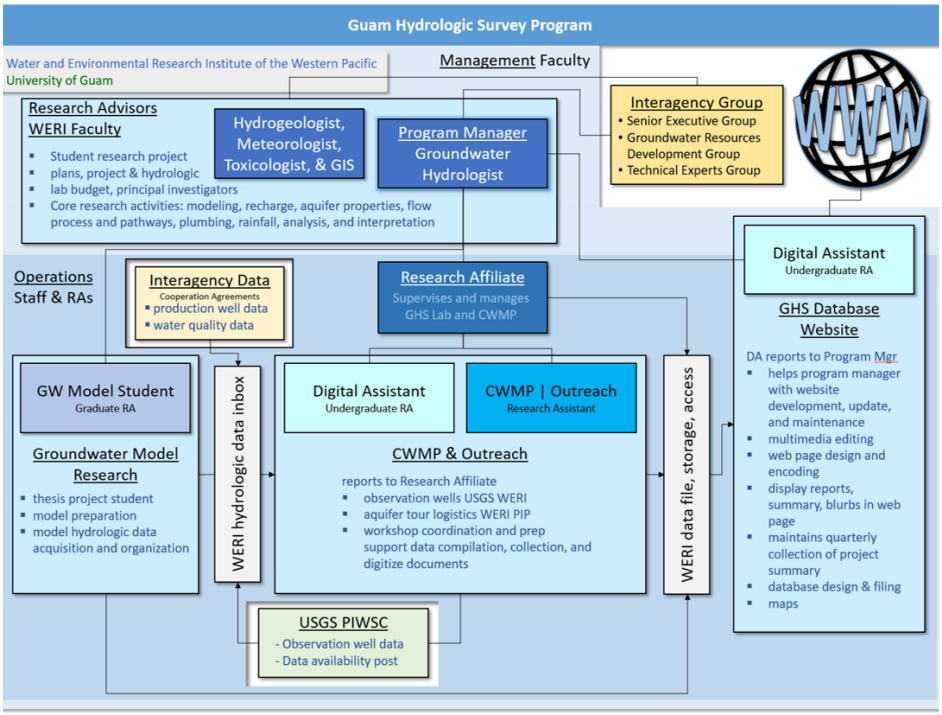
Dr. Nathan Habana, Operations Manager
Funded by Government of Guam

The Guam Hydrologic Survey (GHS) and the Comprehensive Water Monitoring Program (CWMP) were created in 1998 by the 24th Guam Legislature under Public Laws No. 24-247 and 24-161 respectively. WERI was charged with administering the annual legislative appropriations necessary to drive these two programs and facilitate, direct and implement their primary objectives. Both programs are now an integral component of the WERI water resources research, information dissemination, education and training mission.

The purpose of GHS is to consolidate Guam's hydrological data gathered over the years by local and federal government agencies and consultants, and to conduct research on water related issues of local importance. GHS also funds a variety of water resource educational programs in various formats, including guest lectures and seminars at UOG and in the community, informational and training workshops for teachers and professionals from other government agencies, field trips and talks for schoolchildren, and the publication and distribution of educational posters, maps, and fact sheets.

The CWMP was created to collect data on saltwater intrusion and water lens thickness in Guam's sole source aquifer in the northern part of the island and stream flow and other parameters associated with surface waters in the south. The program builds on studies previously undertaken by the US Geological Survey (USGS) that were abandoned in 1998 because of a discontinuance of matching funds from the Government of Guam. The CWMP annual appropriations from the Guam legislature have facilitated the collaborative reinstatement of these studies with USGS under their 50-50 Federal/State-Territory cost-sharing program for water resource monitoring.

The foresight of the Guam Legislature in creating these two very important



Guam Hydrologic Survey and Comprehensive Water Monitoring Program Management.

programs deserves special mention here. Through their efforts and continued support, we have consolidated and interpreted several vital water resources databases for Guam and revitalized the USGS water resources monitoring program. Our understanding of the complex physical, chemical and biological processes that influence Guam's water resources has broadened considerably and the increase in graduate student research opportunities provided by the programs has substantially added to the number of highly trained water resources professionals in the island's work force.

GHS and CWMP Program Management Organization

WERI organizes and integrates the GHS and CWMP programs to manage and execute the public law. The WERI personnel organizational chart of duties and responsibilities are shown below. WERI'S groundwater hydrologist is the program manager, supported by research advisors of hydrogeologist, meteorologist, toxicologist, and GIS expert. The research affiliate reports to the program manager, and is supported by a CWMP research assistant and digital assistant. Program manager has a digital assistant for the GHS website and a graduate research assistant for groundwater model research.

One-Guam Groundwater Resources Development Group and Technical Experts Group

WERI is also a member of the local water resource interagency organization called the Technical Experts Group (TEG) and the Groundwater Resource Development Group (GWRDG), created in the December 2016 MOU. The GHS and CWMP mandate requires interagency collaboration and cooperation, as written, "establish a direct working relationship with each organization collecting hydrologic data important to Guam, and maintain a permanent flow of new data from each organization to keep the data library up to date." Attending local government and federal agencies are Guam Waterworks Authority, Guam Environmental Protection Agency, Consolidated Commission on Utilities (CCU), US Navy (NAVFAC, Marianas), US Air Force (CES), and

Doc. No. 35GL-20-2107.*

USGS. Our interagency groups also include private consultants: Duenas Camacho and Associates, Allied Pacific Environmental Consultant (APEC), EA Engineering, Brown and Caldwell, and AECOM. Meetings are organized and held quarterly at Guam Waterworks Authority (Gloria B. Nelson Public Service Building), Fadian. Current discussion is the expansion of monitoring (observation) wells, see details in Ongoing Research section.

Program Activities for FY 2019

The GHS program management, WERI Director, and Research Affiliate has reorganized the program management to include undergraduate research assistant support. The undergraduate research assistant's slot to be filled will assist the program management, supporting web development as GHS mandate part of data repository, access, and distribution. The Research Affiliate will utilize an undergraduate research assistant to manage data and field assistance.

The Guam Hydrologic Survey office and computer hydro-laboratory at WERI had been remodeled to improve GHS functionality. Designated storage space and work table has been built to organize and prepare valuable field equipment. Workstations and workspace have been configured properly for research assistants in the environmental science program. A Guam geologic rock display section was built to improve collection and organization of the island's rock inventory. This area was also designed as a small geology laboratory.

GHS provides limited stipends for research by graduate students working on their MS degree in Environmental Science and partial summer salaries to WERI faculty advising those students. It also pays for undergraduate field and lab assistants working on water resources projects on Guam, and the salary of one full-time Research Affiliate is charged with operating and managing WERI's information database, the hydrology laboratory, and preparation and update of routine reports and presentations.

Research Projects

Research projects are grouped into four sections: database, maps, sustainable management, and outreach. The database organizes a borehole database, which is the basis of subsurface information, and a water resources library. It also includes the collection and organization of pertinent meteoric, hydrologic, and water quality data. The maps often summarize the data analysis, and are truly indispensable tools for water resource management. Sustainable management is a multi-faceted approach to quality sustainable water resource. The workshops provide training and outreach to our interagency partners.

Outreach

Guam Hydrologic Survey provides outreach programs. WERI teams up with Guam Waterworks Authority, Guam Water Kids, UOG Professional and International Programs, for the NGLA Executive Tour and Technical Workshops.





Executives from local and federal agencies, and visiting water resource researchers at the Professional Field Tour of the Northern Guam Lens Aquifer in March 2019.

Doc. No. 35GL-20-2107.*

COMPREHENSIVE WATER MONITORING PROGRAM

Dr. John Jenson, WERI &
Dr. John Hoffman, USGS
Funded by USGS and Government of Guam

The United States Geological Survey (USGS) has monitored our island's water resources since 1951. Unfortunately, during the 1990s they were forced to downsize this program because matching support from the Government of Guam was discontinued. This resulted in the abandonment of all deep monitoring wells needed to monitor saltwater intrusion in the north, and most of the stream gages in the south by the mid-1990s. In 1995, the USGS closed its field office at Naval Station, but continued to run a limited monitoring program (out of its Saipan and Honolulu offices). In August, 1998 the Comprehensive Water Monitoring Program (CWMP) was made a permanent part of WERI's program when Governor Gutierrez signed PL 24-161. This resulted in the refurbishment of the deep monitoring wells and a renewed program of water resource monitoring on Guam. The intent of PL 24-161 was 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. The CWMP is a permanent investment in Guam's future.

A well-designed long-term CWMP can save communities millions of dollars, and even human lives, by providing critical information for water-supply, culvert and bridge design, delineating flood-hazard areas, and tracking effects of climate change. The USGS started a water-resource monitoring program in Guam in 1951 with installation of stream gages at Pago, Lonfit, and Tolaeyuus and a rain gage near Fena dam. At the same time, measurements of discharge from Almagosa Springs and water levels in Fena Reservoir started. Since 1951



Locations of USGS monitoring stations on Guam.

about 22 continuous streamflow, 8 rain, and 16 groundwater monitoring stations have been operated, providing reliable information on the water resources and hydrologic hazards of Guam.

Currently, USGS monitoring on Guam consists of 6 continuous-recording streamflow gages, 7 continuous-recording groundwater wells, 6 groundwater wells where the thickness of the freshwater lens is measured, and 8 continuous-recording rain gages. From a broad perspective, the program provides long-term information on the hydrologic cycle of Guam so that its water resources can be understood and sustainably managed. The bulk of the monitoring stations on Guam are funded as part of a Joint Funding Agreement between the USGS and WERI.

Stream Gages for Water Availability and Flood Planning in Southern Guam

Most freshwater used in southern Guam comes either from streamflow or wells that withdraw water from near the banks of streams. Data from USGS stream gages provide information needed by managers and engineers to properly manage the long-term sustainability of these water resources. Statistical analysis of long-term streamflow data are needed so the effects of abnormally wet or dry years can be understood and planned for. For example, USGS gages provide information that can be used to assess and manage the sustainability of surface water from the GWA Ugum Treatment Plant. Other gages, funded in cooperation with the U.S. Navy, are used to manage withdrawals from Fena Reservoir.



Flow in Pago Stream has been measured since 1951.

Doc. No. 35GL-20-2107.*

Long-term streamflow information is needed for flood planning. This information is used to delineate flood zones, estimate the magnitude of floods and frequency with which they could be expected to occur, and design bridges and culverts. For example, information from 11 stream gages and 3 other sites was used to assess the flood peak magnitude and recurrence interval following Typhoon Chata'an in 2002. FEMA uses information from USGS stream gages to determine the level of financial aid from FEMA after storms. Currently, the WERI-USGS CWMP funds the operation of 3 stream gages at key locations in southern Guam.

Well Monitoring of the Northern Guam Lens Aquifer

Monitoring wells operated as part of the USGS-WERI CWMP provide information to assess the health and sustainability of the Northern Guam Lens Aquifer. This aquifer is the most important source of freshwater on the island. Currently, the program includes 7 wells where water level is continuously measured and 6 wells where the thickness of the freshwater lens is measured biannually. Collectively, this information allows scientists at WERI, GEPA, GWA, and USGS to understand the flow of water through the aquifer and refine sustainability estimates of this resource. This information is used to understand how current levels of pumpage are affecting the aquifer and how future changes in climate and groundwater production may affect the sustainability of groundwater resources. Coupled with detailed geologic mapping and modern hydrologic tools such as groundwater flow models, information from this long-term program will be invaluable as additional water is needed to support increasing economic development on Guam.

Rainfall Data to Estimate Water Supply Recharge and Flood-Water Distribution

The USGS currently operates 8 rain gages on Guam, 6 of which are funded by the WERI-USGS CWMP. Rainfall data are fundamental to understanding the water supply and threats from flooding. Information from these gages is used to evaluate the extent of drought during El Nino events and the severity of flooding during typhoons. Information from rain gages is also essential in determining how much freshwater infiltrates past the ground surface to reach the water table. This water, known as recharge, is the source of freshwater in the Northern Guam Lens Aquifer and only by measuring rainfall can its abundance be accurately estimated.

What does it cost to operate a stream flow and other gages?

In fiscal year 2019, the cost to operate a continuous-record streamflow gage will be $23,085. This includes all operation and maintenance, site visits, field data collection, data analysis, and computation of the flow record. Gage operations are frequently reviewed and upgraded as improvements become available. Other gages, such as rainfall ($10,085) and groundwater ($7,305), require less funding. With over 100 years of experience, USGS procedures ensure that data are reliably collected, analyzed, and publicly available

How can one get USGS water resource information?

Most data from USGS gages are readily available on the internet. As part of CWMP between WERI and the USGS, historic data and other hydrologic information for Guam are consolidated and made publicly available at: http://hi.water.usgs.gov.



WERI field assistant measures water levels in an observation well in the Northern Guam Lens Aquifer.



Instrumenting observation well with conductivity-temperature-depth sensor (sonde) to profile and record water level and salinity changes.

USGS
science for a changing world

Doc. No. 35GL-20-2107.*

COMPLETED PROJECTS

PFOS Trend Monitoring in a Guam Drinking Water Production Well: Seasonal Influences

Dr. Gary Denton, Dr. John Jenson, Dr. Mark Lander & Carmen Sian Denton
Funded by USGS

Perfluorooctane sulfonate (PFOS) is a fully fluorinated anion that was once widely used in industry. It is very persistent and has substantial bioaccumulation and biomagnification properties, particularly in humans. PFOS is moderately water soluble (~600 mg/L) and has recently emerged as a drinking water contaminant of potential concern, having so far been detected in approximately 2% of public water systems across the Nation. In 2009, USEPA issued a provisional drinking water health advisory (HA) for PFOS of 200 ng/L. A final HA of 70 ng/L was promulgated in May 25, 2016 (Federal Register 2016).

The Guam Waterworks Authority (GWA) began monitoring PFOS in Guam's groundwater in March 2015, in response to USEPA's third Unregulated Contaminant Monitoring Rule, (UCMR3). Overall, five production wells were identified as PFOS contaminated and levels in two of them (A-23 and A-25) were consistently above the USEPA's 70 ng/L benchmark. The highest PFOS levels occurred in well A-25 and ranged from 220-410 ng/L in March and September of 2015 respectively. Both A-23 and A-25 are currently offline as a result of this contamination and may be retrofitted with GAC filters sometime in the future. Until then, all further monitoring of PFOS in both wells has ceased. WERI saw merit in continued monitoring and embarked upon a collaborative project with GWA to continue sampling well A-25 on a monthly basis as of June 2017. The study is currently ongoing and funded by awards made possible through the USGS 104-B Water Resources Research Institute Program and the Guam Hydrological Survey, with in-kind contributions from GWA.

Results acquired to date show a strong positive correlation between PFOS concentrations in well A-25 and monthly rainfall averaged over the three months prior to each sampling event. The delayed relationship between these two variables implies that the source(s) of PFOS contaminating A-25 may be located some considerable distance away from the well-head. Moreover, the fact that the highest PFOS value encountered at the peak of 2017's wet season (September 2017: 340 ng/L) was approximately 20% less than that recorded in September 2015, suggests that some degree of PFOS attenuation is indeed occurring within the watershed.

On the strength of the data gathered thus far, it would seem prudent to continue the PFOS trend monitoring of well A-25, at least through one more dry/wet season cycle. Thereafter, pending further refinement of the time delay between rainfall and the PFOS concentration encountered in the well, continued sampling could be scaled back to coincide with rainfall extremes occurring in prior months. The proposal submitted herein therefore seeks funding to continue the PFOS monitoring of A-25 on a monthly basis for an additional year in order to further understand the dynamics driving the system and ultimately implement science based, cost-effective management strategies to deal with the problem.



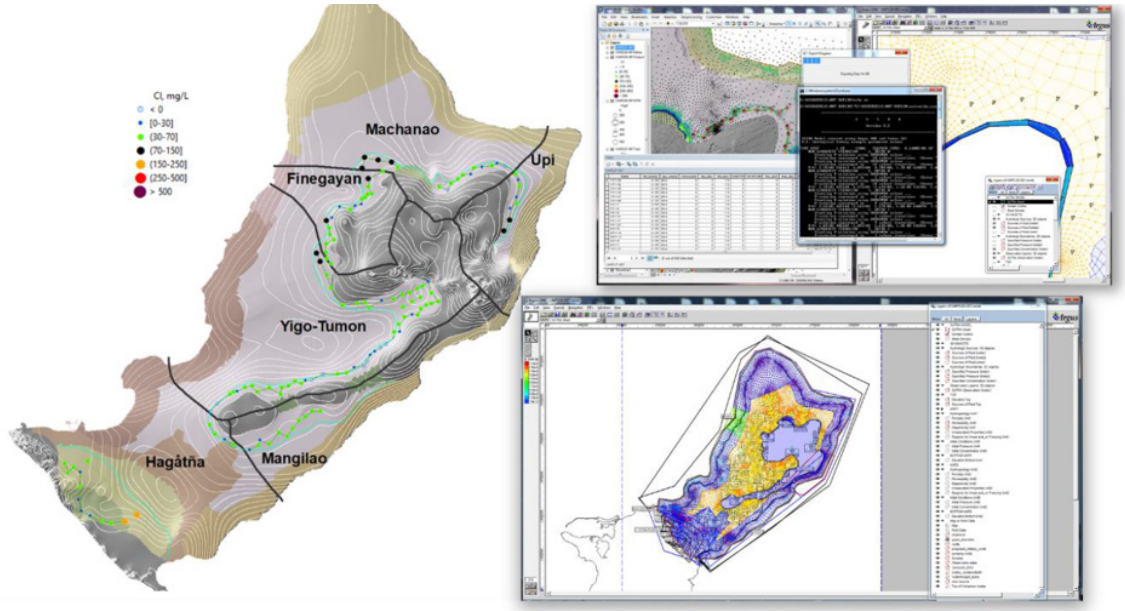
Well A-23 (bottom left) and A-25 (right of power line) are situated about 100 feet apart and located along Guam's Sinajana-Agana highway, Route 4.

Yigo-Tumon Basin Production Well Capacity Simulation

Daniel Superales, Dr. Nathan Habana, Dr. John Jenson & Stephen Gingerich
Funded by GHS
MS Environmental Science Thesis
Dec 2019

A numerical groundwater model of the Northern Guam Lens Aquifer was used to evaluate the potential capacity of the freshwater lens. 130 vertical wells were simulated within the parabasal zone, the portion of the freshwater lens that is supported by the volcanic basement rather than seawater, in successive average-pumping scenarios from 100 gpm to 500 gpm. Baseline simulation results produced about the same volume of freshwater as the observed system but with a lower overall production weighted average chloride concentration of 44 mg/L compared to 123 mg/L. Successive simulation

Doc. No. 35GL-20-2107.*



Simulation of groundwater production wells situated in the parabasal zone of the six basins of the Northern Guam Lens Aquifer. Few wells (orange dots in Hagatna Basin) exceed the US EPA MCL 250 mg/L for drinking water at a maximum pump rate of 500 gallons per minute (gpm). Majority (blue and green dots) remained below the US EPA standard.

results show that up to 89 million gallons per day can be extracted from the aquifer while maintaining the production weighted average chloride concentration at 250 mg/L, the safe drinking water guideline set by the Guam Environmental Protection Agency. These results show the advantage of focusing development of carbonate island karst aquifer on the parabasal zone.

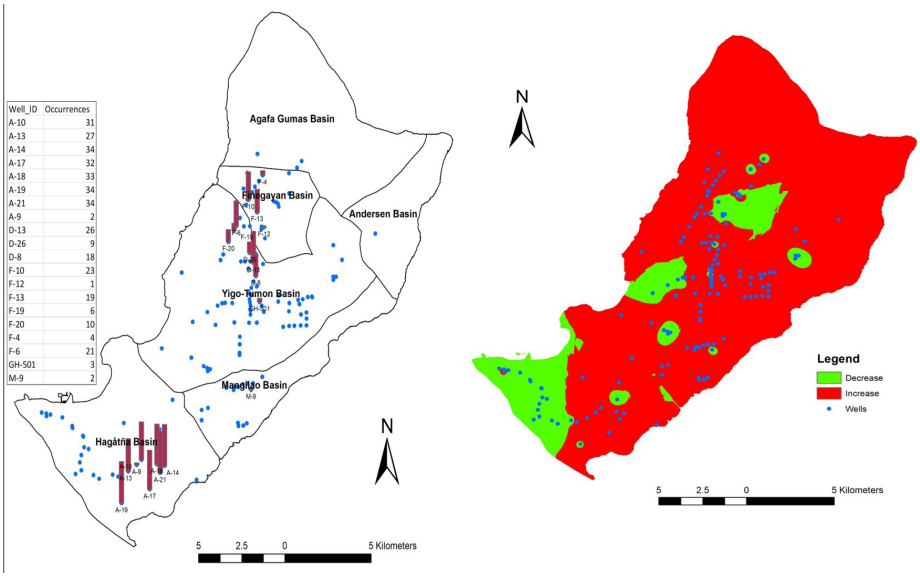
Visualization of Salinity Patterns and Trends in the NGLA

Dr. Yuming Wen, Dr. John Jenson,
Dr. Nathan Habana & Dr. Romina King
Funded by USGS

This project focused on processing, visualization and analysis of the patterns and trends of salinity from drinking wells in the Northern Guam Lens Aquifers (NGLA). Water quality data was available from Guam Waterworks Authority and GIS was utilized to process and analyze salinity data, and therefore locate wells with water quality problems with salinity. Since high level of salinity in drinking water poses risks to man's health, it is crucial to identify at-risk wells and archive them in a format that permits rapid visualization of spatial and temporal trends of salinity in the study area.

Based on the analysis of the salinity data, and visualization of the locations of the wells with salinity problems, conclusion can be made that most of well with salinity problems are located in Hagatna Basin and Yigo-Tumon Basin, and many located in Finegayan Basin though it is a small basin. Only Well M-9 located in Mangilao Basin was monitored with salinity problem. Changes of the trends of salinity can be achieved from time-series data.

Data analysis also determined that salinity levels increased between 2001 and 2009. This technique is especially useful for identifying and predicting subtle long-term trends (increases or decreases) in salinity levels within the aquifer when analyses of salinity data from different dates are provided. The analyses of salinity can provide local government agencies including Guam Waterworks Authority and Guam EPA which are interested in water contamination, particularly salinity.



(left) Problematic wells with salinity in the NGLA. Table shows well names and occurrences count of chloride. Blue dots are well locations, and maroon columns are cumulative occurrence count. (right) Salinity change in the NGLA between 2001-2009. Increasing trend of salinity was mapped as red shading. Decreasing trend was mapped as green.

Doc. No. 35GL-20-2107.*

COMPLETED PROJECTS

Guam Waterworks Authority (GWA) Production-Well Rehabilitation Assessment: Lessons Learned/Manual for Well Exploration and Development

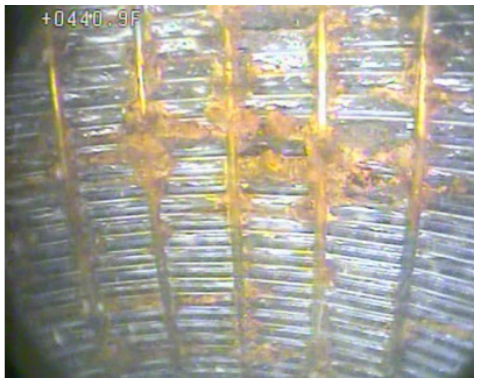
Dr. Yong Sang Kim, Dr. Nathan Habana, & Dr. John Jenson
Funded by USGS

Currently, Guam Waterworks Authority (GWA) produces 90% of the 45 MGD potable water from its main source, the Northern Guam Lens Aquifer (NGLA). GWA is currently managing 120 deep vertical production wells in this aquifer to meet the demand. However, many of these production wells are deteriorating from age with more than 40 years in operation, thus lifespan exceeded, maintenance is no longer economically viable, and production has become unsustainable. During the first project year (June 2018 – June 2019), main reasons why production wells had been shut down were analyzed based on the analysis of GWA production well data including 20 inactive wells. Classified main issues are: 1) aging, 2) contamination, and 3) water depletion. As of 2018, over 50% of production wells are over 40 years old. Main reasons why production wells had been shut down caused by an aging issue are classified as collapsed well casing, collapsed well screen and pump stuck in well casing. Four production wells have been taken offline due to exceeding maximum contaminant levels (MCL) of chlordane, tetrachloroethylene (PCE) and health advisory levels of perfluorooctanesulfonic acid (PFOS) regulated by US EPA.

- Chlordane : Well M-14, Yigo-Tumon, basal zone (since 1983)
- PCE : Well A-28, Hagatna, basal zone (since 2006)
- PFOS : Well A-23, A-25, Hagatna, para-basal zone (since 2017)

Two production wells have been shut down due to a water depletion issue. These two wells experienced pumped air during operation.





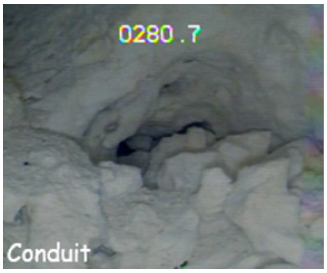
Over 50% of GWA production wells are over 40 years old. Main reasons why production wells have been shut down caused by an aging issue are classified as collapsed well casing, collapsed well screen and pump stuck in well casing.

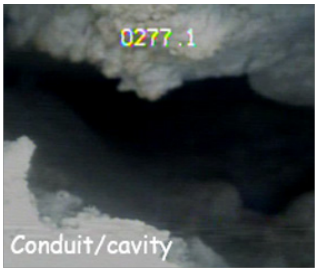


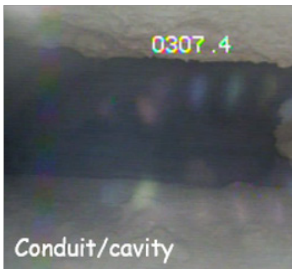




Screenshots from a borehole drilled next to D-22 (low water production).







Screenshots from well D-18 (good water production).

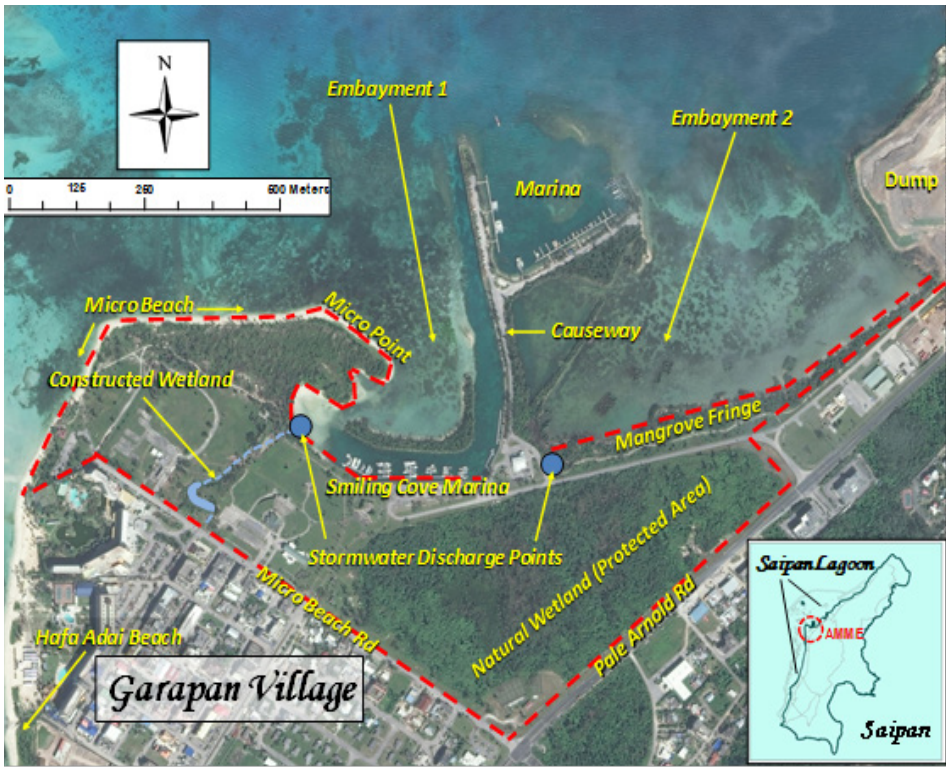
Impact of Stormwater from a Natural Wetland in American Memorial Park, Saipan, CNMI, on Receiving Waters and Resident Fisheries Resources

Dr. Gary Denton
Funded by USGS

The American Memorial Park (AMME) in Saipan was established in 1978 to commemorate US soldiers and civilians killed on island during WWII. The land was occupied by the US Navy immediately after WWII and used as a motor pool and maintenance facility. It also served as a disposal site for unexploded ordnance and residual wartime munitions, as well as a general dumping ground for toxic chemicals and other hazardous wastes. Mercury levels in surface soils within the park commonly exceed 100 ng/g and are largely attributed to fulminated mercury released from surplus ammunitions detonated and/or buried on the property. Two wetlands currently exist within the park. One is natural while the other was created in the 1990s as part of a flood mitigation program for Garapan village. Both wetlands discharge excess stormwater into separate nearshore embayment (opposite page). Mercury levels in a popular table fish (*Lethrinus harak*) from each embayment were therefore of interest.

Doc. No. 35GL-20-2107.*

Overall, sixty fish were examined with fork lengths that ranged from 9.5-29.3 cm. Total mercury levels in their axial muscle ranged from 0.009-0.493 µg/g wet weight and were clearly size-dependent (coefficient: 0.705). Normalization of the log-transformed data to a 20-cm fish length yielded an average value of 0.097 µg/g (95% CL: 0.080-0.117 µg/g). Scatterplots of the datasets revealed no obvious mercury differences in fish between embayments. Since mercury levels in fish from clean waters typically range from 0.001-0.100 µg/g, the restricted consumption of *L. harak* from both embayments is advised for captured specimens exceeding 20 cm fork lengths.



American Memorial Park (AMME) in Garapan Village. Dashed red line indicates MME boundary. Blue plots indicated stormwater discharge points.

Effects of Seawater on Nitrification in a Biofilm Treatment Process

Lyuqin Liu, Dr. Joseph Rouse, Dr. Yong Sang Kim, Dr. Yuming Wen & Dr. Bulan Wu

Funded by Guam Waterworks Authority
MS Environmental Science Thesis
Dec 2019

With growing populations in the coastal areas globally, the amount of freshwater resources has become an issue of increasing concern. In Guam, a multi-year drought could detrimentally impact the capacity of 90% of the freshwater resource coming from the Northern Guam Lens Aquifer. Using seawater for flushing toilets is a way to save freshwater in coastal areas. However, seawater can influence the efficiency of wastewater treatment if it directly flows into wastewater treatment plants.

The objective of this study was to evaluate the nitrification rate of wastewater under different salinity concentrations. To meet this objective, two conducting bench-scale, continuous-flow bioreactors using PVA-gel beads biocarrier were operated under the same conditions, such as temperature, pH, and dissolved oxygen, with the exception that seawater bioreactor influent was mixed with stepwise increasing sea salt. The performance of key nitrogen parameters (NH4+, NO3-, and NO2-) was monitored for the determination of nitrification rates and efficiencies.

In light brackish water (0% to 30% seawater), the salinity had no significant effect on the nitrification rate. In brackish water (30% to 80% seawater), the nitrification process was inhibited by the stepwise increasing salinity. In saline water (80% to 100% seawater), the transient decrease of nitrification was observed due to the inactivity of bacteria. After recovery time, the short-term effects of salt on nitrification in the biofilm treatment process were reversible, which could go back to original treatment efficiency.



Polyvinyl alcohol (PVA)-gel beads (left) have a porous microstructure that allows for microorganisms to enter and attach inside and outside the gel material, thus providing favorable retention and cultivation conditions. Salt biological reactor system (experimental) (right) indicated bacteria absorbed from suspended water.

Doc. No. 35GL-20-2107.*

COMPLETED PROJECTS

Determination of Rainfall Erosivity Factors to Selected Islands in CNMI.

Dr. Mark Lander
Funded by USGS

Last year we began a study of soil erosion and sedimentation in the islands of the CNMI. Specifically, we set out to develop Universal Soil Loss Equation (USLE) average annual rainfall factors (R factor) values for the islands of the CNMI in what hereafter will be called Phase 1 of the R factor study. On several trips to Saipan during 2017, we gathered available rainfall and storm data for Saipan, Tinian and Rota. Computation of the R factor requires detailed information about storms. A key parameter is the intensity (I) of the rainfall, usually at 15-minute intervals. There are many cases in which 15-minute rainfall data is not available, and methods for using hourly data exist. Rainfall intensities at time intervals greater than one hour are not recommended unless there is a very clear relationship between these and the 15-minute or hourly rainfall. On Saipan, there was only one source of hourly data: the Fisher-Porter rain gauge on Capitol Hill. The record is relative short, and does not contain data for typhoon passages.

For Phase 2 of this project, we proposed a thorough review and treatment of the rainfall data for computations of the R factor and other hydrological applications (e.g., return-period calculations) in the CNMI. The Saipan Fisher-Porter data needs to be carefully scrutinized and edited. For example, not all the hourly data in the raw data is truly hourly, but sometimes at a longer interval, but tallied in one hour. The other deficiency is the lack of typhoon captures. For this, we planned to use high-resolution rainfall captured in typhoons on Guam. Rain rates during typhoons are a factor of two higher than possible from any other storm type. Thus, to get her R factor correct, there must be a proper accounting for typhoon rainfall.

At the completion of Phase 2, a representative hourly rainfall time series was constructed to be used for the assessment of Saipan's R factor. It included the impact of typhoons. A comprehensive CNMI rainfall data base was developed to include all station meta-data, identification of possible data pitfalls and a strategy to properly account for typhoon rainfall. Major benefits of this project was the ability of various agencies dealing with soil erosion to identify areas of potentially high erosion. The rainfall data base was also informative for other hydrological applications such as the determination of rainfall return periods, and estimation of aquifer recharge.



Soil erosion and sedimentation are major sources of non-point pollution into streams, rivers, lakes, and onto reef systems. Understanding contributing factors requires organized baseline datasets and relevant models which can be calibrated and validated.

Aerial Survey and Field Instrumentation for Investigation of Landslide Threat to Tropical Watershed in Southern Guam

Dr. Ujwalkumar Patil, Dr. Shahram Khosrowpanah, Dr. Mark Lander & Dr. John Jenson
Funded by GHS

Tropical cyclones, common to the western Pacific islands including Guam, bring large amounts of rainfall within short durations, thereby triggering shallow slope failures and landslides. Accurate modeling of the slope failures resulting from heavy rainfall in mountainous basins requires spatial-temporal information of temperature and rainfall (meteorological and environmental factors); physical properties, degree of saturation, suction and shear strength parameters (geotechnical and hydrological properties) of soil. Conventional methods of slope stability analyses (saturated and dry soil) do not include the unsaturated soil properties and hence cannot accurately predict the rainfall-induced shallow slope failures. However, accurate seepage and slope stability analyses would require inclusion of unsaturated soil properties. This research project performed geotechnical investigations of shallow slope failures which included field instrumentation and lab testing in search of various factors that



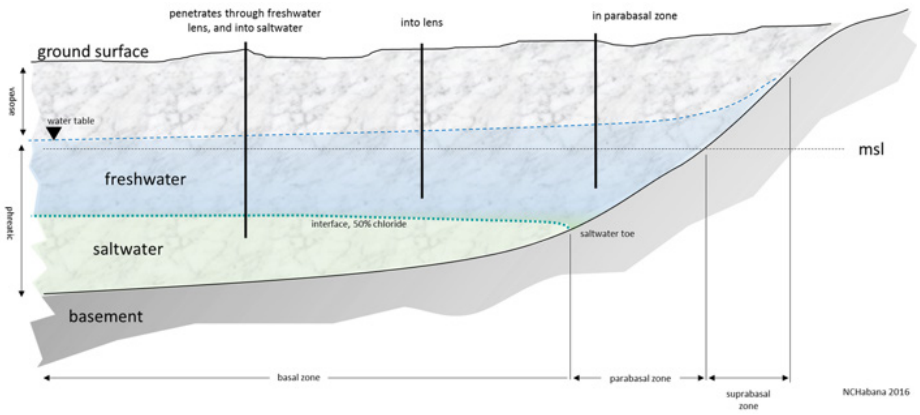


(left) Aerial photograph (from UAV) of rainfall-induced shallow slope failures in Inarajan, southern Guam. (above) Soil sampled for geotechnical, hydrologic, and shear strength properties.

Doc. No. 35GL-20-2107.*

triggered the shallow slope failures in southern Guam. Aerial photographs of slope failures in hard to reach mountainous terrain were obtained via UAV (Phantom 4 Pro).

Two sites are chosen for these studies. First area of study includes slopes in Inarajan watershed along route 4 and is to the North of Tinago river. Second study area Fena watershed. Rainfall induced shallow slope failures are prominent in the Inarajan watershed of southern Guam. Once the soft low-density topsoil layer supporting the grass/vegetation is lost from slope failure, it is very common that the land turns into badland. Badlands do not support new vegetation and hence the scars remain forever. Field validation and laboratory soil testing will aid in creating shallow slope failure and landslide predictions in a finite element model.



Well positions in the saturated (phreatic) zone of the Northern Guam Lens Aquifer. Deep observation wells intercept the saltwater zone, allowing sensors to collect measurements of chloride concentrations, and thus delineating the changes in thicknesses of the freshwater and saltwater layers.

Dynamic Response of the Freshwater Lens to Natural Variations in Recharge, Northern Guam Lens Aquifer, Yigo-Tumon Basin

Bekah Dougher, Dr. Nathan Habana, Dr. John Jenson, Dr. Mark Lander & Dr. Kevin Ho

Funded by GHS

MS Environmental Science Thesis

May 2019

The limestone aquifer of northern Guam supplies more than 90% of the island's drinking water. The quantity of groundwater available for extraction can be measured in terms of the freshwater lens thickness. Lens thickness can be measured directly from well salinity profiles and inferred indirectly from water levels. The amount of recharge that replenishes the aquifer depends primarily on seasonal and inter-annual changes in rainfall as well as on evapotranspiration, rainfall intensity, and infiltration pathways.

Time series data were evaluated in order to determine lens response to recharge and drought. Lag time responses to variations in recharge were determined and can be used as an indicator of lens responsiveness. This project characterizes the response of the lens to natural climate variations, and documents lens and transition zone dynamics driven by both abundant recharge and extensive drought. It will provide an observational baseline against which the accuracy of past, present, and future modeling studies can be evaluated and by which future modeling studies can be reliably parameterized.



Several WERI faculty and graduate research assistants have been trained as a collaborative field team to complete drilling, borehole lithological logging, sample collection, and casing the boreholes. Pictured above is the WERI team drilling piezometer boreholes in the immediate vicinity of Santa Rita Springs catchment (concrete reservoir with corrugated tin roof).

Doc. No. 35GL-20-2107.*

ONGOING RESEARCH

Identifying, Analyzing and Mapping Submarine Groundwater Discharge (SGD) with a Thermal Infrared (TIR) Sensor and Unmanned Aerial Vehicle (UAV)

Eliana Walker, Dr. John Jenson & Dr. Romina King
Funded by NASA EPSCoR
MS Environmental Science Thesis

An autonomous aerial vehicle improved with a visual-thermal infrared gimble camera will be used to locate and quantify the plumes of freshwater discharging from the Northern Guam Lens Aquifer (NGLA), a sole-source karst limestone aquifer that comprises the northern half of the island and supplies over 90% of the island's drinking water. The Guam-based research team has already found and mapped numerous seeps and springs with discharges that can be evaluated to test the technology and the university's graduate environmental science program provides the human intellectual infrastructure of faculty and students who can conduct year-round fieldwork as well as laboratory analyses of GIS/remotely-sensed products and integrate the proposed work with previous and ongoing hydrological and spatial analytical studies. Quantifying the aquifer's discharge provides a means of back-calculating its recharge, which comprises the limit to sustainable development for the island's groundwater – the overriding question for water resource managers in any jurisdiction.

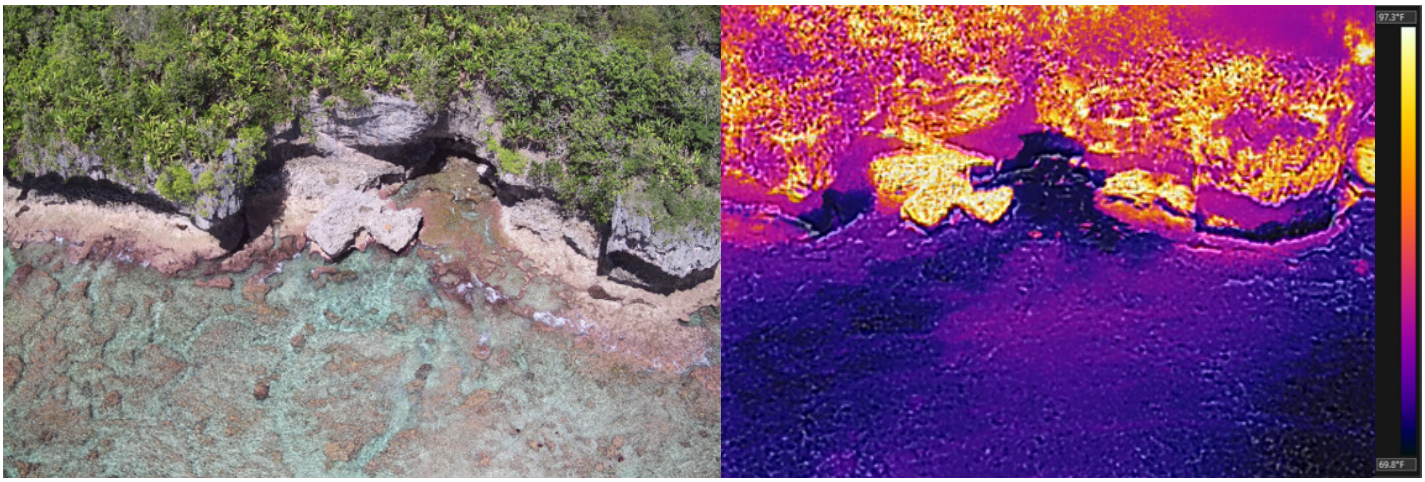
Besides proving the application of this new technology, this project will also build regional technical capacity for water resource management using UAVs and remote sensors and help local natural resource managers in Pacific islands build more detailed and useful geospatial datasets of geographic conditions affecting water resources. Specifically, it will make the application of the technology (through separately-funded related projects) available to the Federated States of Micronesia (FSM), which still have little useful geospatial data by which to manage their water resources. It will also expand the nascent Geography Program at UOG and put in place a local system to monitor geospatial data and manage natural resources using regular UAS flights and data collection. Finally, beyond these terrestrial applications, the NGLA provides a terrestrial analogue to help NASA in their studies of karst landscapes and processes on other planets.

Preliminary images (below) were acquired in the first week of summer field work, when tide was the lowest-low (-1 ft) and weather was optimal for operating the UAV.

Hydrogeological Control on Submarine Groundwater Flow in Ayuyu Cave

Maria Jhonnie Villareal, Dr. John Jenson & Dr. Romina King
Funded by NASA EPSCoR
MS Environmental Science Thesis

Characterizing karst features is integral to understanding groundwater movement in karst aquifers, which in turn assists scientists and water resource managers toward effective aquifer management. A USGS modeling study (Gingerich, 2013) of withdrawal and drought in the Northern Guam Lens Aquifer (NGLA) concluded a point that an estimated 163 million gallons per day (Mgal/day) discharges continuously along the northern coastline. 30.8 Mgal/day (20%) of that discharges along a single basin's coast (Finegayan Basin) on the northwest side of the island. Previous coastline projects observed a channel of freshwater discharge at a single cave, Ayuyu Cave, which measured 2.3 Mgal/day, 18% of the estimated 13 Mgal/day, the second largest area of freshwater discharge. This cave is hypothesized to be located at the edge of the Pugua Fault, an important geologic feature with potential to channel groundwater in Finegayan. Previous field work was conducted in a cenote on the fault surface.



(left) Visual imagery from UAV of freshwater discharge site Ayuyu Cave. (right) Thermal infrared (TIR) of cave site during dry season low tide on May 8, 2019. Temperature ranged 97.3 to 68.7 degrees F. Freshwater discharge plume is dark blue shading from center of photo flowing toward the bottom left corner.

Doc. No. 35GL-20-2107.*

Observations of the cave interior noted two sections of the cave - an enlarged chamber filled with tidal debris (trash, shell and coral fragments, and cave rubble), inner passages of detached cave formations from the walls and ceiling, and a brecciated zone with varying-sized conglomerate limestone bedrock pieces. The most significant progress was an unexplored passageway that lead to the discovery of a cave pool. Water samples indicate the pool is in the brackish zone of the lens (386 mg/L chloride). Water level loggers currently are logging temperature and pressure in the cave pool and in the chamber the pool is located. These project aims to conduct an updated cave survey and produce a digital map of these new cave areas into 2D and 3D. Additional surveys need to be conducted on the fault surface at the cenote to characterize the position of Ayuyu Cave to the Pugua Fault. Project goals are to 1) further understand the geologic processes by which coastal karst aquifers transmit and discharge groundwater (particularly the Pugua Fault in the Finegayan Basin) and 2) improve existing models of groundwater storage and flow for coastal and island karst aquifers.



Varying sizes of limestone clasts of the brecciated zone, near a newly discovered brackish cave pool in Ayuyu Cave.Other cave features not shown are detached cave formations in a cave passage above the cave pool. The cave will be mapped, tied to LiDAR imagery, and the Pugua Fault will be studied in its hydrogeologic contribution to the Finegayan Basin and coastal freshwater discharge.

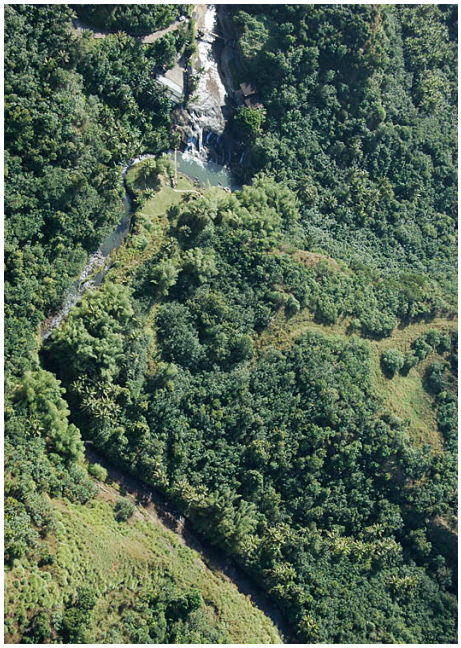
Development of a GIS Based Imagery Database of Groundwater Recharge Areas and Key Reaches of Streams on Guam

Dr. Nathan Habana & Dr. Leroy Heitz
Funded by USGS

Proper management of a region's water resources requires water managers and water resources researchers to have accurate baseline information on the geomorphological and ecological health of surface water streams in a region. It is also vital to have a detailed baseline knowledge of potential pollution sources in groundwater recharge areas. Along with this baseline information there is also a need for periodic sampling of water quality indicators to identify changes in the environmental health of streams and groundwater recharge areas. Studies such as surface and ground water supply studies, depend on this kind of long term variable information to develop the best management practices for a region's water resources. In the past, the only means of visual monitoring of stream and groundwater recharge areas health was either with direct on-ground monitoring or the use of high altitude satellite imagery or LIDAR (Light Imaging, Detection, and Ranging) data. This imagery and data was typically accurate to about 0.5-meter resolution. Because of the expense of data gathering, these resources were not available at intervals that could be used for the continued monitoring of the environmental health of Guam's streams and recharge areas.

Recent advances in commercially available sUAS (Small Unmanned Aerial Systems) technology have made lower cost, highly accurate, sub- meter resolution aerial imagery available. Commercial sUAS drones fly at elevations less than 400 ft., capable of gathering high resolution data used for the development of georeferenced imagery on these low elevation flights. The photographs can be used as detailed high resolution individual photos of streams or groundwater recharge areas or can be composited into highly accurate georeferenced photos of various areas of study. Photogrammetric procedures allow foliage cover removal from the data to develop high resolution composite ground surface digital elevation models of areas of interest.

Phase two will involve extensive testing of the WERI base station-GPS rover system to be certain that rover coordinates gathered using differential corrections from the base station match the coordinates of base maps used in WERI's GIS system. First, we will compare differentially corrected coordinates using the new base station with known locations on our GIS maps and surveyed locations on Guam. Once acceptable accuracy is established, we will fly Ground Control Point (GCP) missions at several locations around Guam. The Drone2Map software will apply the GCPs in order to develop accurately georeferenced photomosaic and digital elevation maps. These will be overlaid on our existing GIS base maps to be sure the desired accuracy is achieved.



Aerial image of Talofofo Falls and river, which discharges on the eastern side of Guam, at Talofofo Bay.

Doc. No. 35GL-20-2107.*

ONGOING RESEARCH

Phase-II of N-Baseline Data and Abatement Methods for the Northern Guam Lens Aquifer

Dr. Nathan Habana, Dr. Joseph Rouse, Dr. John Jenson & Jezreelyn Bulaklak
Funded by USGS and GHS

This project responds to the critical needs expressed at the Advisory Council Meeting to conduct research on spatial and temporal trends in levels of contaminants in Guam's groundwater, as well as the need for continuous baseline studies on levels of nitrogenous compounds, etc. with respect to time and location. In addition, it addresses the need for evaluation of innovative wastewater treatment units as alternatives to conventional septic tanks for individual homes, commercial buildings, or hotels.

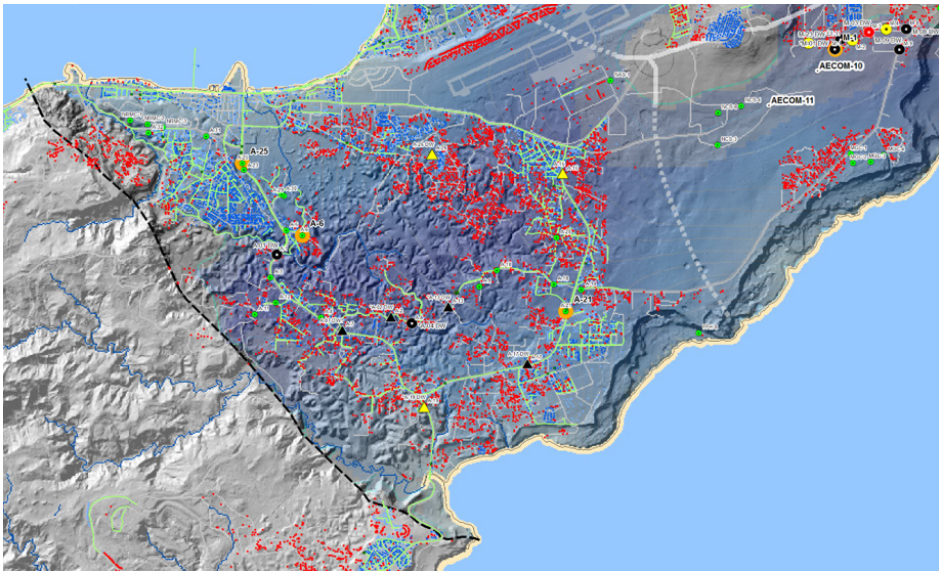
Civil and environmental engineering fieldwork will be incorporated in collecting effluent samples from package treatment plants in Northern Guam, which will be transported to the laboratory (at WERI, UOG) for water quality analyses. Computer analyses will be conducted to apply statistical analyses to the data, and trends and patterns may be overlaid onto the Northern Guam Lens Aquifer Map, a first in the series.

Three-Dimensional Finite-Element Groundwater Model of the Yigo-Tumon Basin, NGLA

Thomas Aguilo & Dr. Nathan Habana
Funded by GHS
MS Environmental Science Thesis

The Yigo-Tumon Basin is the largest, most developed, and most exploited of six basins fo the Northern Guam Lens Aquifer (NGLA). Previous models of the NGLA have been essential toward understanding and managing the aquifer. This project aims to create an updated model with modern software to further understanding of the NGLA. This model will be built using Aquaveo's Groundwater Modeling System (GMS) software and the FEMWATER mathematical model to incorporate data from production and observation wells with published values for regional hydraulic conductivity, recharge, and tidal attenuation. Aquaveo's GMS is at the forefront of groundwater modeling and allows users to build highly detailed models using common GIS objects - points, arcs, and polygons - and allowing models to be updated regularly as more information becomes available.

GMS is compatible with most groundwater numerical codes, including but not limited to MODFLOW-UGS, SEAWATER, and FEMWATER. The FEMWATER model will be used to simulate density-dependent flow and chloride transport and will be used to examine saltwater-freshwater dynamics and salinity intrusion. This model will be highly beneficial as a guide for future research endeavors and for improved water resource management and policy-making amid major island growth and expansion expected within the next 10 years. Furthermore, the Yigo-Tumon Basin is an appropriate pilot for the development of a model of the entire NGLA using this software.



NGLA water wells (light green circles with central black dot) and wastewater locations (red and blue clusters) at the proximity of the Pago-Adelup fault (black dashed line), which physiologically divides Guam to the northern limestone plateau and southern volcanic rise.

Potential PFAS contamination sites near the GWA production well A-25.

Mallary Duenas, Dr. Yong Sang Kim & Dr. Gary Denton
Funded by NIEHS and USGS
MS Environmental Science Thesis

Perfluoroalkyl substances (PFAS) have recently received attention as emerging contaminants in drinking water. Recent UCMR3 results reveal three Guam Waterworks Authority production wells to be contaminated with perfluorooctanesulfonic acid (PFOS). One of these wells (NAS-1) is located inside of the former Naval Air Station at Tiyan, in the village of Barrigada. PFOS concentrations found in this well to date range from 67-110 ng/L. The two other wells (A-23 and A-25) are located in Hagatña, one of the oldest villages on Guam. PFOS concentrations determined in both of these wells to date are consistently above 70 ng/L with maximum levels occasionally exceeding 400 ng/L in well A-25. Both wells are currently off-line. Ongoing PFOS source studies have so far identified four potential contamination sites based on historical records and favorable hydrogeological properties of the surrounding area.

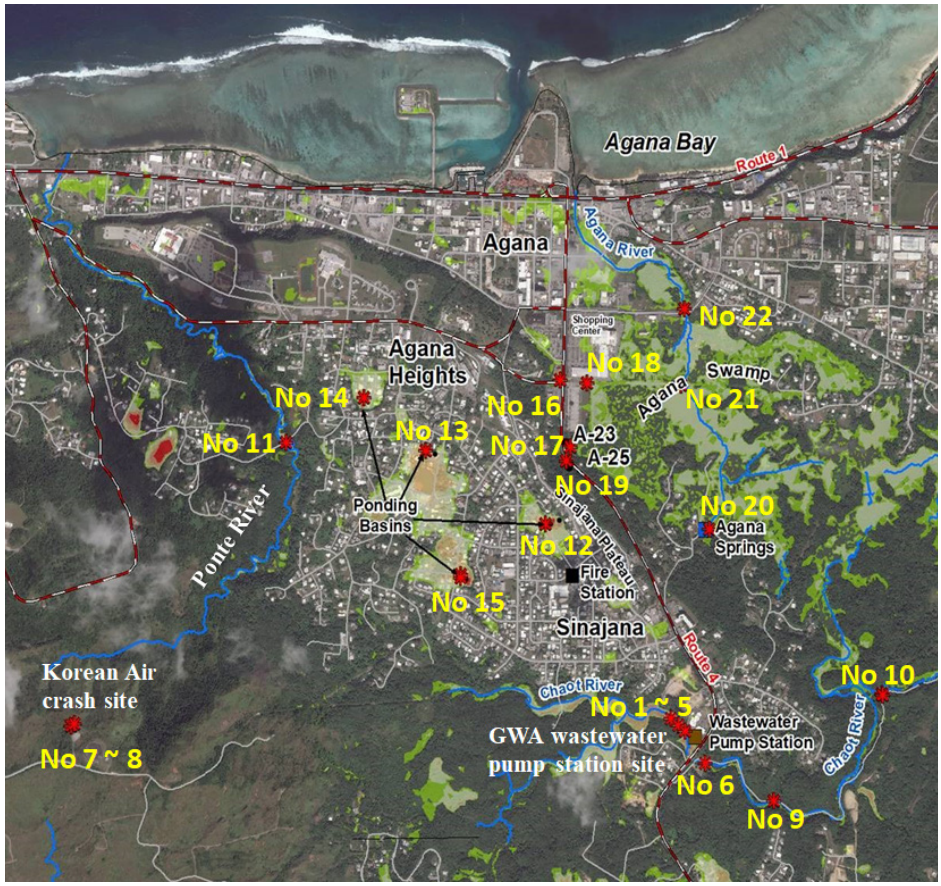
Doc. No. 35GL-20-2107.*

These sites include: 1) a defective wastewater pump station that leaked millions of gallons of wastewater into the Chaot River over a 25-year period, 2) Agana swamp which drains the Chaot River and where chronic illegal dumping has occurred since WWII, 3) neighboring ponding basins that direct stormwater into the underlying aquifer, and 4) a nearby air flight crash site.

The objective of this study is to conduct a preliminary assessment of PFAS contamination sites in Hagatna and Ordot-Chalan Pago regions.



Polyethylene tubes were deployed to collect water samples in rivers and ponding basins found with PFAS contamination. The passive samplers accumulate organic compounds by diffusion in both aqueous and atmospheric conditions.



22 water and soil sample sites were previously visited to investigate PFOS and PFAS source contamination.

PFOS Trend Monitoring in Saipan Production Wells

Dr. Yong Sang Kim, Dr. Nathan Habana & Heidi Yelin
Funded by USGS

The third unregulated contaminant monitoring rule (UCMR3) test result revealed that drinking water contamination by PFAS in Saipan is more prevalent than in the US. The Commonwealth Utilities Corporation (CUC), a public and utility agency in Saipan, had collected water samples from 24 drinking water entry points. As the result of PFAS analysis, PFOS was detected in 5 wells and reservoirs. In particular, the production well IF-208, located within the Saipan International Airport (SIA) has been contaminated with the PFOS in the range of 4900 - 7000 ng/L, a value that is one hundred times higher than the US EPA's lifetime health advisory concentration (70 ng/L). The Airport Rescue Firefighting Facility (ARFF) at the SIA is suspected as a major PFOS contamination area and a main source for groundwater contamination.

In June 2016, the CUC stopped using well IF-208 due to its high concentration of PFOS. the CUC has also bi-annually monitored PFOS in wells adjacent to well IF-208, and found varied concentrations: wells that had high PFOS in 2016 now have lower concentrations while wells with less than 40 ng/L PFOS have above 70 ng/L. There are several reasonable reasons: 1) PFOS has also affected other wells and reservoirs, but had not been detected from two sampling attempts under UCMR3 due to effects of rainfall and tide, which influence volume and flow of groundwater, and/or 2) groundwater pumping from wells changes in groundwater flower and PFOS concentration.

To understand the PFOS migration pattern in this area, 1) the PFOs contaminated site, ARFF, must be investigated, 2) regular PFOS monitoring from wells and reservoirs adjacent to the well IF-208 should be conducted, and 3) seasonal variation of PFOS concentration and its relationship between rainfall events should be analyzed. This research will help to identify PFOS migration pattern in groundwater and establish a proper remediation plan.

Doc. No. 35GL-20-2107.*

ONGOING RESEARCH

Improvements to Sewage Treatment on Yap: Hydroponics and Composting of Waste Sludge

Dr. Joseph Rouse, Dr. Hyun-Jong Hahm, Dr. Chris Yeo & Ken Rekdahl
Funded by USGS

In Yap, FSM, pilot testing was conducted at the municipal sewage treatment plant to assess the implementation of low-cost upgrades to enhance treatment. Incorporation of a bio-carrier medium was demonstrated to be helpful, but this is of limited value due to the relatively small amount of biofilm attached. Composting of the excess sludge, though, has progressed from pilot testing to a full-scale facility. Preliminary results have demonstrated that a Class-A compost suitable for public use is achievable, but more training is required to assure ongoing success. Progress on this project has been reported at four conferences, three of which were international, in addition to various Advisory Council Meetings in the western Pacific.

To further enhance sewage treatment, a hydroponics process is being considered. A local lily plant (*Eichornia crassipers*) has been shown to be compatible with the raw sewage and has already propagated in the treatment zone of the STP. Results of preliminary testing in the wet and dry seasons (below) indicate that the conditions are favorable for the lily plant, which is known to be sensitive to high salt concentrations. For comparison with this field data, the conductivity of seawater is 50,000 µS/cm and that of potable tap water would normally be less than 500 µS/cm.

It is interesting to note that the conductivity levels are much lower in the wet season because the saltwater content in the sewage is diluted by intrusion of rainwater into the collection lines. In the next phase of this project, further testing to quantify removals of organic and nitrogenous contaminants will be required to assess the use of the lily plants in conjunction with the existing biofilm process. In addition, sludge and compost materials will be tested for metals (e.g.: Cd, Hg, Pb, etc.) to address public safety concerns.

Further testing will be required to determine the benefit for removal or organic contaminants. Parallel to this, ongoing improvements to composting will be pursued by providing guidance for proper methods of hands-on technical operation and of effective managerial practices. Further venues for communicating the project's overall benefits to the people and natural environment of Yap will also be developed.



Propagation of local lily plant (*Eichornia crassipers*) at a sewage treatment plant in Yap, FSM.

Hydrological Features and Analysis in the Finegayan Area

Dr. Yuming Wen, Dr. John Jenson & Dr. Nathan Habana
Funded by USGS

Guam Waterworks Authority (GWA), the custodian of Guam's public water supply, is responsible for ensuring it meets all appropriate standards as mandated under the Safe Drinking Water Act and Clean Water Act. To this end, GWA regularly evaluates the physical, chemical and biological integrity of the island's drinking water in accordance with US EPA requirements. While the agency has amassed a considerable amount of monitoring data over the years, only values that approach or exceed the water quality standards are paid attention. The rest, which account for well over 99% of all monitoring data collected so far, falls well below critical thresholds of concern and is of little immediate interest or attention. As a consequence, these data are simply stored on file for reference purposes only when in fact they could and should be used to identify subtle changes in contaminant abundances and distributions within the aquifer or changes for a long term basis.

Since around 5000 marines will be relocated to Guam, particularly the Finegayan Area in the next few years, it's very important to evaluate whether relocation fo the marines and their dependents and related activities will affect the quantity and quality of the water resources, especially groundwater resources. Based on this concern, the project will focus on inventory of hydrological features and hydrological analysis in the Finegayan Area. The hydrological features in the Finegayan Area will be collected, processed and organized into a geospatial database so that the data can be utilized for further analyses and applications in the future. Hydrological features will be evaluation on whether they will have imposed impacts on water quantity and quality of groundwater resources in the Finegayan Area.

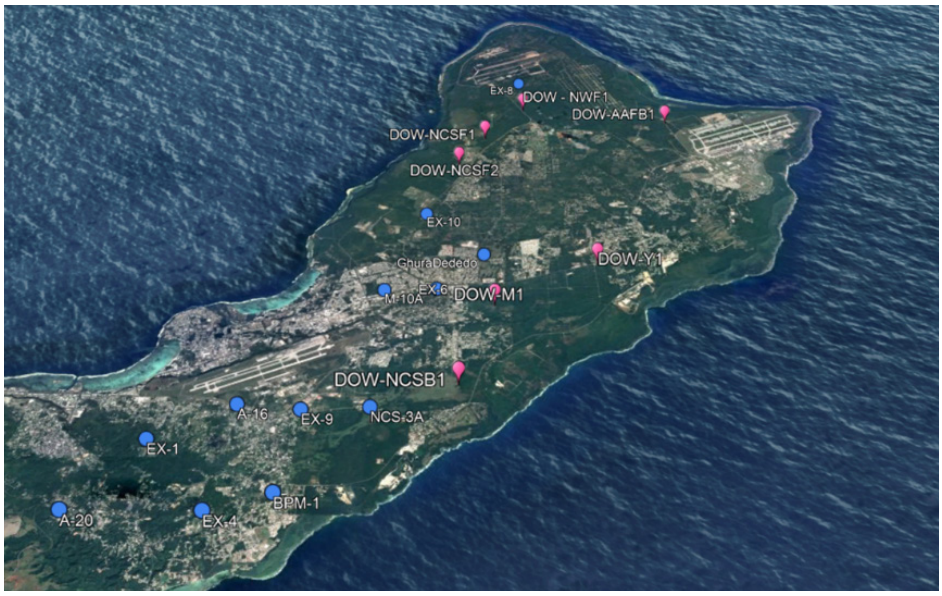
Doc. No. 35GL-20-2107.*

Water Use Data and Research in Guam

Dr. Yong Sang Kim
Funded by USGS

Ninety percent of Guam's 40 MGD of municipal water is produced from about 120 wells in its Northern Guam Lens Aquifer (NGLA)–the limestone bedrock aquifer beneath the uplifted plateau that covers the northern half of the island's 214 sq. mile surface and contains all its urban centers, including the tourist districts. Current production is estimated to be 14 to 17% of recharge but is constrained by increasing risks of drawing saltwater into the freshwater lens if new wells are set too close or too deep, pumped too hard, or placed in new locations that are vulnerable to saltwater contamination. Understanding the hydrogeological factors that determine where wells can best be placed; how they should be designed, built, and managed; and how water can be economically distributed from sources to customers is essential for effective water resources development. Stormwater and wastewater management also present increasing challenges for aquifer and coastal zone protection as urbanization continues and population grows.

On the volcanic upland of southern Guam, the US Navy's Facilities Engineering Command (NAVFAC) can produce up to 9 MGD of treated water from a surface reservoir. NAVFAC sells up to 3 MGD to the Guam Waterworks Authority to service the adjacent villages, except when the surplus is eliminated by drought. The reservoir is vulnerable to sedimentation from landslides in the watershed triggered by typhoons. Sediments and sewage releases carried by surface streams can threaten the health of reefs along the southern coast. Understanding how land use and other factors affect the quality and quantity of surface water resources in the south is thus also an essential component of water resources research, information transfer, and education programs on Guam. This project will analyze current water use data for Guam and compare it with baseline standard of USGS Water Use and Data Research (WUDR) and formulate a workable management plan whereby water use data can be readily comparable with other water use data from the United States.



Locations of observation wells scheduled to be rehabilitated (blue) and deep observation wells to be drilled (pink).

Northern Guam Lens Aquifer Monitoring System Expansion Rehabilitation Program

Dr. John Jenson, Dr. Nathan Habana & Kaylyn Bautista
Funded by Guam Waterworks Authority

The NGLA Monitoring System Expansion Rehabilitation Project (MSERP) launched on October 2017. This scope of work is divided into two tasks. Task 1 consists of (1) developing well-construction specifications for seven new deep-monitor wells and rehabilitating 12 existing monitor wells; and (2) defining sustainment requirements for the OEA-funded NGLA Monitoring System Expansion Project and associated expansion of the Guam Comprehensive Water Monitoring Program. Task 2 consists of geophysical logging of the seven new deep-monitor wells to evaluate aquifer properties, especially the characteristics of the water-bearing zones penetrated by the wells.

New deep-monitor well construction specifications and technical support: The USGS and WERI work with GWA's the Program Management Office (PMO) to refine well-construction specifications for seven new deep-monitor wells. WERI provides technical support, including on-site support, before, during, and after construction of the new deep-monitor wells. The PMO will be responsible for ensuring that the driller constructs the wells as designed in the specifications and that the required timelines are met. Existing-well rehabilitation specifications and technical support: The USGS and WERI will work with GWA's PMO to refine well-rehabilitation specifications for 12 existing monitor wells. WERI will provide technical support, including on-site support, before, during, and after rehabilitation of the existing monitor wells. The PMO will be responsible for ensuring that the driller rehabilitates the wells as designed in the specifications and that the required timelines are met. The USGS will remove and reinstall water-level recording equipment before and after rehabilitation of existing monitor wells.

Doc. No. 35GL-20-2107.*

Digital Atlas of Yap – A Geospatial Map and Data Server for Resource Management

Dr. John Jenson & Dr. Danko Taborosi
Funded by USGS

The island of Yap is the westernmost high island in the Federated States of Micronesia (FSM) and the capital of Yap State, one of FSM's four federal units. In addition, Yap is a part of a Small Island Developing State (SIDS) whose many low-lying yet densely-populated areas are at great risk of natural disasters and effects of climate change and sea-level rise. Sustainable development and effective management of resources, especially in the context of improving resiliency to the effects of climate change and responding to the risk of natural disasters and ameliorating their effects, requires geospatial information of the physical, environmental, and anthropogenic components of the entire system. Such information must be accurate, up-to-date, mutually compatible, and readily available. Yap has a great need for a unified, comprehensive, and user-friendly information management system for geospatial data.

We propose to create a web-based digital repository and dissemination system for GIS and other geospatial data related to Yap. The overall objective of the project proposed here is to create a robust, comprehensive, and versatile geospatial data server to support all geospatial aspects of planning, disaster risk reduction and emergency response, resource management, sustainable development, research and modeling, conservation, and education on Yap. Based on experiences from Guam and Pohnpei and results of comparable projects there, we plan to call the product proposed here the "Digital Atlas of Yap." It will be a counterpart of the intensively used and highly successful "Digital Atlas of Northern Guam" and "Digital Atlas of Southern Guam" created in several stages between 2009 and 2013, and a sister product of the "Digital Atlas of Pohnpei", which was developed by iREi and WERI in 2016-17 and is scheduled to go on-line on February 28, 2017. Selected screenshots from the Digital Atlas of Pohnpei are included with this application. The Digital Atlas of Yap will be web-based, permanently on-line, and act both as a repository of relevant GIS data and geospatial resources in other formats, as well as a digital point-of-contact and information-sharing hub for anyone involved in resource management, engineering, research, and decision-making in Yap. The data will be cataloged, indexed, and maintained so that they are easily amendable and upgradeable. Whenever interested individuals and agencies access it, they will be accessing the most up-to-date versions. The system will also keep track of metadata, data sources, data ownership, data confidentiality, and any access restrictions that may be imposed on certain datasets by individual parties.

Finally, the data will be revised to fit a common projection, and also made available in non-GIS file formats usable by individuals who have no GIS experience or software, but do have needs and responsibilities in areas where geospatial data and analyses are beneficial. This will include a range of pre-designed maps, georeferenced image overlays, geo-PDFs, and KML files for use in Google Earth. This will ensure that the Atlas is not just a GIS-data hub, but truly the information gateway for nearly any activity with geospatial component.



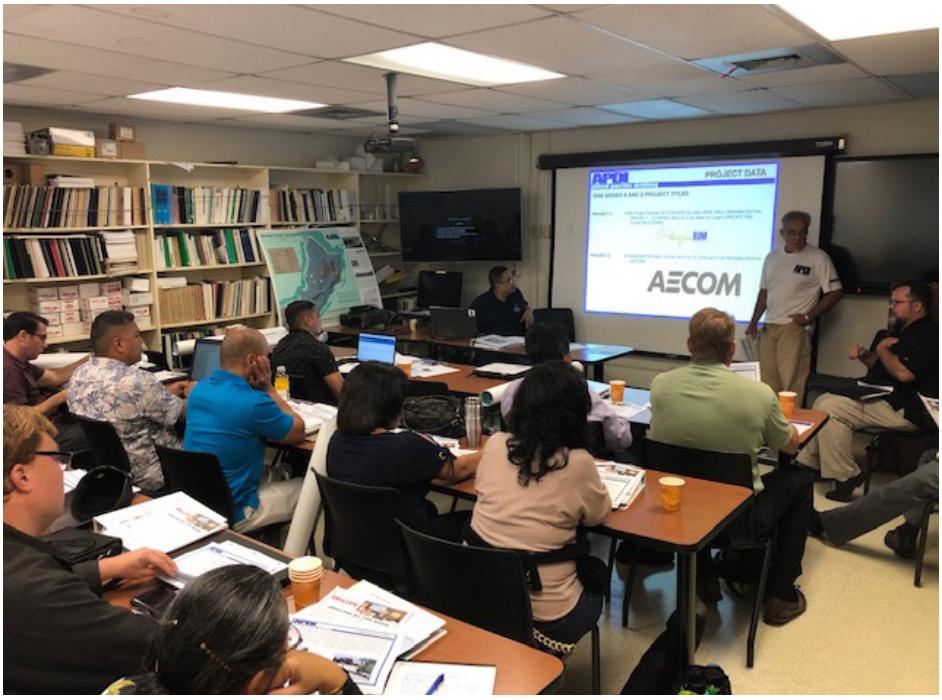
The atlas of Yap will be house on the Digital Atlas of Micronesia site upon completion.

Professional Workshop Series on Guam Groundwater Sources

Dr. Yong Sang Kim &
Dr. Nathan Habana
Funded by USGS and GHS

The anticipated addition of new US Marine Corps facilities on Guam and the accompanying additional economic growth on the island will increase demand for drinking water as much as 10% beyond current production. To achieve and maintain sustainable management of the aquifer, it is essential that policy-makers, agency heads, water resource professionals, and island educators be equipped with an accurate and up-to-date understanding of the essential characteristics of the island's aquifer and the factors that must be considered to frame and implement sustainable management practices.

Doc. No. 35GL-20-2107.*



WERI Professional Workshop Series featured short presentations and cross-talk forums between local water management agencies, private environmental firms, and WERI faculty and staff.

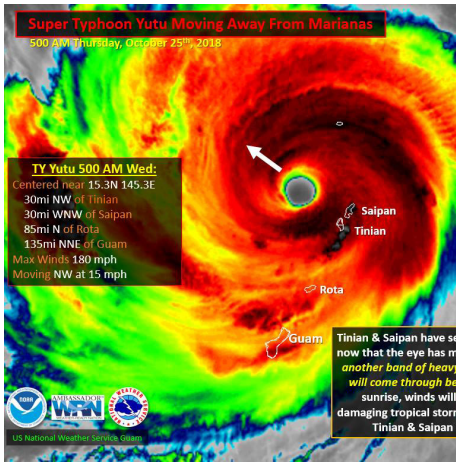
Professional people, however, have extremely limited time to engage in instructional opportunities. WERI will develop and deliver a series of short-course workshops and aquifer tour to local water resource professionals and educators. First, a two-day intensive workshop in 1) the Northern Guam Lens Aquifer Database and development and use of basement map of northern Guam: and 2) sinkholes and surface drainage of the aquifer, and salinity trends, patterns, and processes in the aquifer, and 3) production well rehabilitation in Guam and 4) an introductory workshop in basic GIS. The Aquifer field tour will involve a one-day intensive field trip to the Northern Guam Lens Aquifer, which will include a 3-D virtual tour of the aquifer. These workshop and field tour will be prepared for student researchers, faculty, policy makers and professionals working on groundwater and related problems. Instructional and media organization will be supported by Moodle websites containing the instructional materials plus additional references and links to other relevant and useful resources, and forums for maintaining continuing educational interaction and information-sharing. A new GHS website will accommodate the course resources such as the NGLA resources such as the NGLA database that will be useful for island water developers and managers.

Comprehensive Guam and CNMI WERI-Web-Based Comprehensive Rainfall Data Utility

Dr. Mark Lander
Funded by USGS

Rainfall and other climate data are required for studies of water quantity and water quality (WQ2) in our region. With the obvious importance of rainfall data, other climatic data with possible influence on WQ2 include (but not limited to): the typhoon distribution; local and regional sea level; the MAX and MIN temperature, and the effects of wind and amount of sunshine. A common request by local water resource managers (and outside environmental consulting businesses) involves acquiring storm data to assess return-period calculations for storm drain projects, stream-flow estimates, reservoir management, etc. Acquiring climate data for such projects is hampered by the multiplicity of sources, incomplete or missing data in official records, short periods of record, and an absence of metadata on recording sites.

This project will provide all local water resources managers, regulators, researchers and the public with:
1) a comprehensive collection of meteorological and hydrological data for Guam, Saipan, Tinian, and Rota;
2) a one-stop web site for accessing climatic and hydrologic data;
3) a presentation of derived products, such as recurrence intervals for storm-related parameters and high-quality graphics of data time series and derived products;
4) bounds and hard numbers describing rainfall distribution and impacts to be used as scenarios for modeling studies of island watersheds, groundwater and other sources of potable water;
5) a packaged seminar/outreach module dedicated to addressing the community need for reliable climatic and hydrologic data.



Screenshot of US National Weather Service October 25, 2018 posted on the USNWS social media showing the center of Super Typhoon Yutu. The strongest of eyewall winds had moved west of Saipan. Utilities and built infrastructure were heavily damaged. The island was without power and water for several months.

Doc. No. 35GL-20-2107.*

EDUCATION and OUTREACH

Sand Filtration Training in Yap

Dr. Joseph Rouse, Charles Falmeyog & Ken Rekdahl
Funded by USGS

Potable water quality is a serious issue for all utility agencies throughout the Western Pacific. The development of the modern water treatment systems and distribution networks for some of the more populated islands in this area started in 1970s. The slow, sand filtration plant used on the main island in Yap State is such on system, for which maintenance of a well-trained operational staff is an on-going challenge. Furthermore, recent turnovers in staff have heightened their concern that training is urgently needed.

This training is designed for 15 participants, and will have two parts. During class work, students will learn about the principal for water treatment including the equipment and accessories involved. Field training will include hands-on use with equipment as well as following a regimented reporting. The sessions were designed for operation and maintenance personnel working at the Yap State Public Services Corporation (YSPSC). The benefit will be assured quality of potable water and better management of one of Yap Island's most valuable resources, its water. Since the water systems in the other states are similar to the one in Yap, this training would also be meaningful to employees from the other states.



Wastewater treatment in Yap.



WERI's 2019 Guam Advisory Council Meeting, held at the Dusit Thani hotel.

Advisory Council Meetings

Dr. John Jenson
Funded by USGS

WERI's Three Advisory Councils. WERI maintains a separate advisory council for each of its three regional constituencies: 1) the US Territory of Guam, 2) the Federated States of Micronesia (FSM), and 3) the Commonwealth of the Northern Mariana Islands (CNMI).

Each council is built around a core of officials, managers, and technical experts from local agencies involved with water resources development, management, or regulation, who serve as more or less permanent members. Some have been formally appointed by their governments or agency heads. Others serve by invitation from WERI. The composition and appointment process for each council reflects the governmental and geographic conditions unique to each constituency:

The Guam Advisory Council core members include managers and technical experts from local agencies, and local offices of US federal agencies, including the local military civil engineering units and their contractors that deal with water resources. The core members of the councils for the CNMI and FSM include representatives from local government departments, as well as permanently-stationed employees of US federal agencies; United Nations, European Union and other international development aid agencies; Non-Governmental Organizations; and local colleges and schools.

WERI convenes each council annually for a day-long conference to review and update its agendas for research, information transfer, and educational projects. In addition to the core members, people invited to the meetings include government officials, private sector engineers and planners, educators, students, and other scientific and professional colleagues involved in ongoing projects and programs. The morning agenda includes presentations on recently completed projects and ongoing projects. Following lunch, there are plenary and focus-group discussions on critical needs, after which each participant fills out and submits a survey regarding directions of ongoing projects and prospective future projects.

Meeting participants frequently observe that WERI Advisory Council meetings are the sole venue in which all of the water resources professionals on their island meet together in a single group. The meetings are thus valued as unique forums for professional information-sharing and networking. Throughout each year, WERI uses council mailing lists to provide updates and announcements for events of common interest, including WERI research presentations, professional workshops, and thesis defenses.

Doc. No. 35GL-20-2107.*

Virtual Tour and Professional Field Trip of the Northern Guam Lens Aquifer

Dr. John Jenson, Dr. Nathan Habana & Dr. Yong Sang Kim
Funded by USGS and GHS

WERI Information Transfer projects include a one-day tour of Guam's principal aquifer with offerings tailored variously for policy-makers, agency heads, water resources engineers and other professionals, school teachers, and students from high-school through graduate level. The physical tour is preceded by a big-screen, GIS-based 3-D graphical virtual tour of the aquifer. The *Virtual Tour of the NGLA* is a computer graphics 3-D hydrology of Guam that allows the audience to understand hard-to-visualize concepts and features not accessible on the physical tour (*Professional Tour of the NGLA*), and virtually fly through the subterranean boundaries between fresh water, salt water, limestone bedrock, and volcanic basement rock.

Relationships to the aquifer's actual water production wells, urban areas, roadways, sewer lines, and septic tanks are also highlighted. Developed originally to support the physical tour, the virtual tour is also now presented for classroom instruction and at workshops and public presentations independent of the physical tour. Plans are in place to make it available as an interactive web-based educational resource and to develop a version for younger audiences.



Executive members of federal and local agencies explore the porosity features (matrix, fractures, and faults) in the core of the NGLA (Barrigada Limestone) at the Department of Public Works Quarry.

Guam Water Kids

Arretta Ann Card, Kaylyn Bautista & Dr. John Jenson
Funded by Ford Motor Company, USGS and RCUOG

The Guam Water Kids Program provide classroom and online resources for K-12 teachers and students for instruction on the origin and sustainable management of fresh water resources of Guam and the Northern Mariana Islands. Topics include: *Why Fresh Water is Important*, *Where Guam's Fresh Water Comes From*, *The Water Cycle*, and *What Kids Can Do*. Joint funding from the US Geologic Survey and Ford Motor Company's Global Giving Grant covered the development of educational materials; instructional workshops for teachers; presentations at public, private, and military schools; and interactive websites at: http://www.guamwaterkids.com.



High school students facilitated a hands-on aquifer contamination demonstration to 5th graders.



Educational information for students can be found in the forms of narrated videos, flash cards, quizzes, and a link to the Guam Water Kids Facebook site for up-to-date media posts and announcements (https://www.facebook.com/guamwaterkids/).

Guam Water Kids has provided three Educator workshops and three Professional Tours of the NGLA catered to science teachers and other interested educators; provided orientation and mentoring for high school level educators and students to learn about freshwater and to have an organized experience in sharing this information with younger students; and provided community materials at outreach events.

Doc. No. 35GL-20-2107.*

UNIVERSITY OF GUAM PROGRAMS SUPPORTED BY WERI

Environmental Science Graduate Program

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 option 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.

The Environmental Science Program strives to promote educational and service projects within island communities of the Western Pacific, and attract a broadly based group of scholars committed to seeking answers to the many environmental questions that are arising in developing island nations of the tropical Pacific Basin. Areas of faculty expertise center around three broad areas of concentration namely, biology-ecology, geosciences-engineering, and economics-management.

Further information may be obtained from the Environmental Science Program Chair, Dr. Romina King, phone: 735-2874, e-mail: roking@triton.uog.edu.

School of Engineering

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 in 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.

The School of Engineering at the University of Guam (UOG), which was established in 1989 (as the Pre-Engineering Program), parallels the curricula of the first two years of the engineering programs offered at major colleges and universities in the US and abroad. After completing the required coursework in this program, students transfer to other universities that offer degrees in engineering in order to complete their studies. In 2013, a cooperative agreement was signed with the Universities of Iowa, Mapua Institute of Technology (Manila, Philippines) for student and faculty exchange. The courses offered by the program at UOG have been accepted by these institutes. Therefore, it provides for an easy transfer of students, thus enabling them to complete their degree.

On October 29, 2009, the President of the University of Guam expressed his vision for establishing a four-year accredited engineering degree program to help meet current and growing demand for engineering expertise in Guam's private and public sectors. The anticipated rapid economic growth and development in our community and region over the next decade will produce an acute need for engineering talent to support new construction, repair and rehabilitation of aging infrastructure, development of natural resources, and environmental protection and preservation. It is therefore envisioned that the engineering curriculum will focus, at least initially, on civil and environmental engineering.

For more information about the Civil and Environmental Engineering Programs of the School of Engineering at the University of Guam, contact the Interim Dean, Dr. Shahram Khosrowpanah, phone: 671-735-2694, e-mail: khosrow@triton.uog.edu.

UNIVERSITY OF GUAM
UNIBETSEDÅT GUÅHAN

Doc. No. 35GL-20-2107.*



Northwest coastline field work with thermal infrared.



Composting for sewage treatment plant in Yap.



WERI was one of 12 of the nation's 54 state water resource research institutes that was rated outstanding by the USGS for the 2011 to 2015 evaluation period.



Measuring slope failures along volcanic ridges.



Surveying passageways in a coastal cave.

Doc. No. 35GL-20-2107.*

THE JOSEPH D. ROUSE SCHOLARSHIP FOR PROFESSIONAL EXCELLENCE AND INTEGRITY





The career of Dr. Joseph D. Rouse, Professor of Water Resources and Environmental Engineering and member of the faculty of the Water and Environmental Research Institute of the Western Pacific, University of Guam, from 2011 to 2019 epitomized the values of competence and integrity in professional science and engineering. Dr. Rouse's contributions to the University of Guam included leading its graduate Environmental Science Program, teaching and advising environmental science students in course work and thesis research, and voluntarily assisting the new School of Engineering in developing its curricula, recruiting its faculty, and securing its accreditation. It is fitting, therefore, that the University establish this scholarship to honor Dr. Rouse's memory and preserve his legacy as a role model for new environmental scientists and engineers whose careers are beginning with their education and training at the University of Guam.

The scholarship shall be an endowed scholarship with a base of at least $25,000 to produce an anticipated annual return of about $1000. A commensurate award may thus be given annually to a graduating environmental science or engineering student who has served as a graduate or undergraduate research assistant on a project that has produced results worthy of presentation at a professional conference or publication in the peer-reviewed professional literature; whose contributions to the project merit lead authorship or co-authorship of the presentation or report on the project; and whose academic performance and personal character exemplify the virtues of professional excellence and integrity that Dr. Rouse stood for. The award shall be used to support registration or travel to a professional conference, or publication costs of an article for a conference proceedings volume or a peer-reviewed professional journal. No more than one award shall be given each year, and no award shall be given unless at least one candidate is found who meets all of the criteria for top-quality research production and publication, outstanding academic performance, and exemplary personal character.

The WERI faculty shall establish specific criteria for eligibility and selection based on the principles cited above. The WERI Director shall issue an annual call for nominations in February, which will invite the Environmental Science Program Executive Committee and School of Engineering Faculty to nominate worthy candidates by the end of March. The winner shall be selected by vote of the WERI faculty convened by the WERI Director by the end of April. The award will be presented by the WERI faculty at the University Awards Ceremony in May.

CONTRIBUTIONS

The University of Guam Endowment Foundation
303 University Drive, Mangilao, GU 96913
Ph : +1-671-735-2956/7
SUPPORTUOG.ORG

FY2021 Guam Hydrologic Survey Budget Request

Budget requests for personnel, equipment and supplies, and external services are described below and summarized in Table 1.

GHS Operations Team. The GHS Operations Team carries out the daily activities, conducts the ongoing analyses, and prepares the annual reports mandated by PL 24-247. Its core activities thus include maintaining the GHS databases and websites, including the computer platforms, networks, and software; receiving and entering new data; preparing the annual GHS reports; and responding to short-notice requests for information or technical advice from island policy-makers, regulators, water-resource managers, educators, and news reporters. Team activities are managed by a WERI faculty member for whom two months of his research salary is paid for his work as GHS Operations Manager. The Operations Team includes two interns (graduate students or recent graduates) on fixed-term appointments—Operations Analyst and Product Developer—and a student research assistant who serves as Web Developer. The principal duties of each are summarized below:

Personnel	Description of Duties	Amount
Operations Manager (faculty)	Manages daily operations of GHS activities: databases, websites. Responsible for meeting annual GHS mandates for reporting and outreach (e.g., professional and educational workshops and field trips). Advises director in preparing annual GHS research agenda and budget.	$12,215
Operations Analyst (intern)	Maintains the GHS databases. Responsible for CWMP data entry and coordination with USGS. Conducts routine analyses mandated by GHS. Prepares annual GHS reports and presentations. Provides technical support to researchers for data archiving and analyses.	$45,860
Product Developer (intern)	Compiles technical reports and annual GHS and WERI activity reports and provides technical support to research teams in preparing and publishing reports and presentations. Maintains equipment and assists researchers in the field as needed. Principal point of contact with other local and federal agencies on technical matters. Organizes meetings, workshops, and seminars and coordinates outreach events.	$45,860
Web Developer (graduate student)	Maintains and updates GHS website and its connections to internal databases.	$23,719

GHS Research Projects. Up to three research projects are normally selected by WERI each year to meet GHS mandates for timely research on issues of particular interest or urgency, based on advice from island policy-makers, regulators, and water-resource managers. Research projects are typically led by WERI or other UOG faculty, who serve as principal investigator (PI) and co-investigator (Co-PI), and derive two to six weeks of their annual salary from the project. Faculty salary comprises about 25% of the GHS personnel budget; the other 75% is invested in students and interns. Current and anticipated GHS research topics include water supply, sustainable yield, contaminants, wastewater, and hydrogeologic mapping (aquifer, sinkholes, salinity, nitrates). Topics for each year are selected in October-November from proposals submitted as part WERI's annual research funding cycle.

Personnel	Amount
Principal Investigator 1	$13,600
Co-Investigator 1	$7,600
Principal Investigator 2	$13,600
Co-Investigator 2	$7,600
Principal Investigator 3	$13,600
Co-Investigator 3	$7,600

Student Research Assistants. Student Research Assistants (RAs) are graduate and undergraduate students hired on an annual basis to assist the Program Operations Team and principal investigators on GHS-sponsored research. Student RAs work part-time during the semesters and full-time during the summer and winter sessions. Research assistantships may be integral with or separate from the student's graduate thesis research, but are usually done in combination with thesis work, with the project principal investigator also serving as the student's thesis advisor. Current research assistant needs are summarized below:

Personnel	Description of Duties	Amount
Modeling Research Assistant (graduate student)	Maintains WERI groundwater modeling platform and assists in ongoing modeling research.	$23,719
CWMP Research Assistant (graduate student)	Assists USGS CWMP teams in the field. Performs data entry for GHS databases. Collects, compiles, reviews, enters, and checks data. Performs data quality-control and database updates as directed.	$23,719
Digital Research Assistant (undergraduate student)	Responsible for entry and upkeep of digital information on websites, including downhole videos and geophysical data on wells, instructional materials, and research databases.	$10,813
Project Research Assistant II (graduate student)	Assists with one or more of the principal GHS-sponsored research projects.	$23,719
Project Research Assistant I (undergraduate student)	Assists with one or more of the principal GHS-sponsored research projects.	$10,813

Fringe Benefits: Intern and Research Assistants x 22% Retirement and PI/Co-Pi x 1.45% $46,908

Equipment and Supplies. Equipment and supplies specifically dedicated to GHS research, data keeping, and analyses are listed below. Equipment and supplies account for about 10% of the total budget.

Equipment	Description	Amount
Computer lab maintenance	Upkeep, repair, and replacement of computers, software, printers, plotters, and other lab equipment. Supplies include printer and plotter paper and cartridges, batteries, etc.	$11,500
GIS annual unlimited license	WERI maintains a full GIS license to support educational, research, and engineering work.	$5,000
GPS hardware & software updates	Maintenance and updates of GPS equipment and software.	$8,000
UAV maintenance	Maintenance and updates of Unmanned Aerial Vehicle (drone) equipment and software.	$4,200
ESRI Drone2Map license	Annual software license.	$5,000

Services. Services retained by WERI to support GHS research, education, and outreach are described below. These constitute about 5% of the total budget.

Services	Description	Amount
UOG Professional & International Programs Office	Logistical and administrative support for WERI's annual aquifer tours for island leaders and educators.	$7,500
USGS Modeling Support	Technical support and collaboration with USGS for use of their groundwater modeling software.	$10,000

Guam Hydrologic Survey Component	Position/Service	Amount
Program Operations		
Operations Manager	Faculty	$12,215
Operations Analyst	Intern	$45,860
Product Developer	Intern	$45,860
Web Developer	Graduate student	$23,719
Research Projects		
Project 1 Principal Investigator	WERI or UOG Faculty	$13,600
Project 1 Co-Investigator	WERI or UOG Faculty	$7,600
Project 2 Principal Investigator	WERI or UOG Faculty	$13,600
Project 2 Co-Investigator	WERI or UOG Faculty	$7,600
Project 3 Principal Investigator	WERI or UOG Faculty	$13,600
Project 3 Co-Investigator	WERI or UOG Faculty	$7,600
Student Research Assistants		
Modeling Research Assistant	Graduate student	$23,719
CWMP Research Assistant	Graduate student	$23,719
Digital Research Assistant	Undergraduate student	$10,813
Project Research Assistant II	Graduate student	$23,719
Project Research Assistant I	Undergraduate student	$10,813
FRINGE BENEFITS		
Faculty and Technical and Research Assistant		$46,908
Equipment and Supplies		
Computer lab maintenance		$11,500
GIS annual unlimited license		$5,000
GPS hardware & software update		$8,000
UAV maintenance		$4,200
ESRI Drone2Map license		$5,000
Services		
UOG Professional & International Programs Office	Logistical support	$7,500
USGS Modeling support	Technical support	$10,000
	Grand Total	$398,947

Table 1. Summary of FY2021 Budget Breakdown for the Guam Hydrologic Survey Program.

United States Department of the Interior

U.S. Geological Survey

Pacific Islands Water Science Center
Inouye Regional Center
1845 Wasp Blvd., Bldg 176
Phone: (808) 690-9600 Fax: (808) 690-9599

June 29, 2020

Dr. John Jenson, Director
Water and Environmental Research Institute of the Western Pacific
University of Guam, UOG Station
303 University Drive
Mangilao, Guam 96923

Dear Dr. Jenson:

Subject: Joint Funding Agreement to continue our cooperative water-resource monitoring program for the period October 1, 2020 to September 30, 2021

Enclosed is a Joint Funding Agreement (JFA) between the University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) and the U.S. Geological Survey (USGS) to continue our cooperative water-resource monitoring program during the period October 1, 2020 to September 30, 2021. The total cost of the agreement is $256,980, of which $162,793 will be contributed by WERI and $94,187 will be contributed by USGS.

The purpose of the water-resource monitoring program is to collect data needed to evaluate the status and trends of surface-water and groundwater resources on Guam. Since the 1950's, the USGS has collected water-resource data at selected rainfall, streamflow, and groundwater monitoring stations in cooperation with the Guam Water Works Authority, Guam Environmental Protection Agency, and most recently, the WERI. Data are collected by the USGS in accordance with well-documented techniques and quality-assurance procedures. Data are stored in the USGS National Water Information System database and are publicly available on the internet website (http://hi.water.usgs.gov). The number and type of monitoring stations is periodically adjusted to meet current priorities and available funds.

This program is part of the Guam Comprehensive Water Monitoring Program (CWMP) that provides critical information needed to achieve a balance between sustainable population and economic growth and the protection of water resources. Data from this program are essential for managing water resources and assessing the effects of climate and land-use changes on Guam. The importance of this program to the nation is exemplified by the fact the USGS provides Cooperative Matching Funds to help share in the total cost. Significant reductions in funding to this program will limit the ability of water-resource managers to make informed decisions regarding the physical and economic development of water resources for the benefit of present

and future generations. Continued support for the Guam Hydrologic Survey and CWMP is critical, particularly at this time given the planned military buildup on Guam.

A complete list of monitoring stations and associated costs for the period October 1, 2020 to September 30, 2021 (Federal Fiscal Year 2021) is attached to the Joint Funding Agreement. There are no changes to the network in FY 2021 from FY 2020.

If you are in agreement with this program, please sign and return a copy of the enclosed Joint Funding Agreement.

The legal authority for the USGS to enter into this agreement is 43 USC 36C, 43 USC 50, and 43 USC 50b. Work performed with funds from the agreement will be conducted on a fixed price basis. Your agency will be billed using form DI-1040, according to the terms of the agreement.

The results of the work under this agreement will be available to the USGS for publication and use in connection with related work. In addition, the USGS may provide unpublished USGS data or information to your office for review during the course of this jointly planned activity and partnership. Guidance concerning USGS's non-disclosure policy will be provided with any review material and is further explained in USGS Circular 1367, Fundamental Science Practices, available at http://pubs.usgs.gov/circ/1367/pdf/C1367.pdf.

If you have any questions, or would like more information about this program, please contact Brian Loving at 808-690-9603 or by e-mail at bloving@usgs.gov. Thank you for your continued interest in working with the USGS to provide water-resource information for Guam.

Sincerely,

John P. Hoffmann

John P. Hoffmann
Acting Center Director

Enclosures/Attachment

Attachment 1

SCOPE OF INVESTIGATIONS
WATER-RESOURCE MONITORING PROGRAM, GUAM

The purpose of the water-resource monitoring program is to collect data needed to evaluate the status and trends of surface and groundwater resources in Guam. Since the 1950's, the USGS has collected water-resource data at selected rainfall, streamflow, and groundwater monitoring stations in cooperation with the Guam Water Works Authority, Guam Environmental Protection Agency, and most recently, the WERI. Data are collected by the USGS in accordance with well-documented techniques and quality-assurance procedures. Data are stored in the USGS National Water Information System database and are publicly available on the internet website (http://hi.water.usgs.gov). The number and type of monitoring stations is periodically adjusted to meet current priorities and available funds. The monitoring stations and associated costs for the period October 1, 2020 to September 30, 2021 are as follows:

MONITORING STATIONS	WERI	USGS	TOTAL
Rainfall Monitoring – Continuous-record stations			
• Umatac Rain Gage at Umatac o Long-term rainfall station in southern Guam operated since 1998. o Site equipped with continuous recording rain gage. Satellite telemetry to provide real-time data will be added if field conditions allow. o Data used to estimate groundwater recharge and determine existence and severity of drought conditions.	6,686	3,869	10,555
• Mount Chachao Rain Gage near Piti o Long-term rainfall station in western Guam operated since 1998. o Site equipped with continuous recording rain gage. Satellite telemetry provides real-time data. o Data used to estimate groundwater recharge and determine existence and severity of drought conditions.	6,686	3,869	10,555
• Windward Hills Rain Gage near Talofofo o Long-term rainfall station in south-central Guam operated since 1974. o Site equipped with continuous recording rain gage. Satellite telemetry provides real-time data. o Data used to estimate groundwater recharge and determine existence and severity of drought conditions.	6,686	3,869	10,555
• Mt. Santa Rosa Rain Gage o Rainfall station in northern Guam operated since 2001 o Site equipped with continuous recording rain gage. Satellite telemetry to provide real-time data will be added if field conditions allow. o Data used to estimate groundwater recharge and determine existence and severity of drought conditions.	6,686	3,869	10,555
• Dededo Rain Gage at Dededo o Long-term rainfall station in north-central Guam that was operated from 1988-2008. o Site will be equipped with continuous recording rain gage. Satellite telemetry to provide real-time data will be added if field conditions allow. o Data used to estimate groundwater recharge and determine existence and severity of drought conditions.	6,686	3,869	10,555
• Geomagnetic Observatory Rain Gage near Yigo o New rainfall station in northwest Guam to fill gap in spatial coverage. o Site will be equipped with continuous recording rain gage. Data used to estimate groundwater recharge and determine existence and severity of drought conditions.	6,686	3,869	10,555
Rainfall Monitoring – TOTAL	**40,116**	**23,214**	**63,330**

MONITORING STATIONS, Continued	WERI	USGS	TOTAL
Streamflow Monitoring – Continuous-record stations			
• La Sa Fua River near Umatac o Long-term streamflow monitoring station in watershed unaffected by human activity. o Site equipped with continuous stage recorder. Satellite telemetry to provide real-time data will be added if field conditions allow. o Data used to assess surface-water availability and effects of climate change on water resources.	15,333	8,872	24,205
• Ugum River above Talofofo Falls near Talofofo o Long-term streamflow monitoring station in a watershed unaffected by human activity. o Site equipped with continuous stage recorder. Satellite telemetry to provide real-time data will be added if field conditions allow. o Data used to assess surface-water availability and effects of climate change on water resources.	15,333	8,872	24,205
• Pago River near Ordot o Long-term streamflow monitoring station in a watershed unaffected by human activity. o Site equipped with continuous stage recorder. Satellite telemetry to provide real-time data will be added if field conditions allow. o Data used to assess surface-water availability and effects of climate change on water resources.	15,333	8,872	24,205
Streamflow Monitoring – TOTAL	**45,999**	**26,616**	**72,615**

MONITORING STATIONS, Continued	WERI	USGS	TOTAL
Groundwater Monitoring – Continuous water-level stations			
• A-20, Ordot	4,837	2,798	7,635
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Agana subbasin, NGLA.			
• BPM 1, Mangilao	4,837	2,798	7,635
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Agana subbasin, NGLA.			
• A-16, Barrigada	4,837	2,798	7,635
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Agana subbasin, NGLA.			
• M-10A, Harmon Loop School, Dededo	4,837	2,798	7,635
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Yigo subbasin, NGLA.			
• EX-7A, Wettengel	4,837	2,798	7,635
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Yigo Subbasin, NGLA.			
• EX-10, Finegayan	4,837	2,798	7,635
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Finegayan Subbasin, NGLA.	4,837	2,798	7,635
• MW-2, Marbo			
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder.			
o Data used to assess groundwater resources in the Yigo subbasin, NGLA.	4,837	2,798	7,635
• EX-8, Andersen AFB			
o Groundwater-level monitoring site in island's most important drinking-water aquifer.			
o Site equipped with continuous water-level recorder			
o Data used to assess groundwater resources in the Finegayan subbasin, NGLA.			
Groundwater Monitoring – Continuous water-level stations – TOTAL	**38,696**	**22,384**	**61,080**

MONITORING STATIONS, Continued	WERI	USGS	TOTAL
Groundwater Monitoring – Periodic water-level and conductivity, temperature, depth (CTD) profile stations			
• EX-1, Chochogo	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water-level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Agana Subbasin, NGLA			
• EX-4, Mangilao	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water-level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Agana Subbasin, NGLA			
• EX-7A, Wettengel	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water-level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Yigo Subbasin, NGLA			
• EX-8, Andersen AFB	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water-level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Finegayan Subbasin, NGLA			
• EX-9, Barrigada	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water-level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Agana Subbasin, NGLA			
• EX-10, Finegayan	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Finegayan Subbasin, NGLA			
• GHURA, Dededo	5,426	3,139	8,565
○ Groundwater-level and CTD profile monitoring site in island's most important drinking-water aquifer			
○ Water-level measurements and CTD profiles collected two times per year			
○ Data used to assess groundwater resources in the Yigo Subbasin, NGLA			
Groundwater Monitoring – Continuous water-level stations – TOTAL	**37,982**	**21,973**	**59,955**

MONITORING STATIONS – TOTAL	**162,793**	**94,187**	**256,980**

Form 9-1366
(May 2018)

U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations

Customer #: 6000001181
Agreement #: 21ZHJFA00000013
Project #: ZH00GSN
TIN #: 98-0032933

Fixed Cost Agreement YES[X] NO[ ]

THIS AGREEMENT is entered into as of the October 1, 2020, by the U.S. GEOLOGICAL SURVEY, Pacific Islands Water Science Center, UNITED STATES DEPARTMENT OF THE INTERIOR, party of the first part, and the UNIVERSITY OF GUAM WATER AND ENVIRONMENTAL RESEARCH INSTITUTE OF THE WESTERN PACIFIC, party of the second part.

1. The parties hereto agree that subject to the availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation water-resource monitoring program according to the list of stations provided in Attachment 1, herein called the program. The USGS legal authority is 43 USC 36C; 43 USC 50, and 43 USC 50b.

2. The following amounts shall be contributed to cover all of the cost of the necessary field and analytical work directly related to this program. 2(b) include In-Kind-Services in the amount of $0.00

(a) $94,187 by the party of the first part during the period October 1, 2020 to September 30, 2021

(b) $162,793 by the party of the second part during the period October 1, 2020 to September 30, 2021

(c) Contributions are provided by the party of the first part through other USGS regional or national programs, in the amount of: $0

Description of the USGS regional/national program:

(d) Additional or reduced amounts by each party during the above period or succeeding periods as may be determined by mutual agreement and set forth in an exchange of letters between the parties.

(e) The performance period may be changed by mutual agreement and set forth in an exchange of letters between the parties.

3. The costs of this program may be paid by either party in conformity with the laws and regulations respectively governing each party.

4. The field and analytical work pertaining to this program shall be under the direction of or subject to periodic review by an authorized representative of the party of the first part.

5. The areas to be included in the program shall be determined by mutual agreement between the parties hereto or their authorized representatives. The methods employed in the field and office shall be those adopted by the party of the first part to insure the required standards of accuracy subject to modification by mutual agreement.

6. During the course of this program, all field and analytical work of either party pertaining to this program shall be open to the inspection of the other party, and if the work is not being carried on in a mutually satisfactory manner, either party may terminate this agreement upon 60 days written notice to the other party.

7. The original records resulting from this program will be deposited in the office of origin of those records. Upon request, copies of the original records will be provided to the office of the other party.

8. The maps, records or reports resulting from this program shall be made available to the public as promptly as possible. The maps, records or reports normally will be published by the party of the first part. However, the party of the second part reserves the right to publish the results of this program, and if already published by the party of the first part shall, upon request, be furnished by the party of the first part, at cost, impressions suitable for purposes of reproduction similar to that for which the original copy was prepared. The maps, records or reports published by either party shall contain a statement of the cooperative relations between the parties. The Parties acknowledge that scientific information and data developed as a result of the Scope of Work (SOW) are subject to applicable USGS review, approval, and release requirements, which are available on the USGS Fundamental Science Practices website (https://www.usgs.gov/about/organization/science-support/science-quality-and-integrity/fundamental-science-practices).

Form 9-1366
(May 2018)

U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations

Customer #: 6000001181
Agreement #: 21ZHJFA00000013
Project #: ZH00GSN
TIN #: 98-0032933

9. Billing for this agreement will be rendered **quarterly**. Invoices not paid within 60 days from the billing date will bear Interest, Penalties, and Administrative cost at the annual rate pursuant the Debt Collection Act of 1982, (codified at 31 U.S.C. § 3717) established by the U.S. Treasury.

USGS Technical Point of Contact

Name:	Brian Loving Assistant Center Director
Address:	USGS-PIWSC 1845 Wasp Boulevard Honolulu, HI 96818
Telephone:	(808) 690-9603
Fax:	(808) 690-9599
Email:	bloving@usgs.gov

Customer Technical Point of Contact

Name:	John Jenson
Address:	UOG-WERI 303 University Drive UOG Station Mangilao, Guam 96923
Telephone:	(671) 735-2689
Fax:	
Email:	jjenson@triton.uog.edu

USGS Billing Point of Contact

Name:	Steven Ancheta Budget Analyst
Address:	USGS-PIWSC 1845 Wasp Boulevard Honolulu, HI 96818
Telephone:	(808) 690-9566
Fax:	(808) 690-9599
Email:	sancheta@usgs.gov

Customer Billing Point of Contact

Name:	Gema Payumo
Address:	UOG-WERI 303 University Drive UOG Station Mangilao, Guam 96923
Telephone:	(671) 735-2685
Fax:	
Email:	capatigp@triton.uog.edu

U.S. Geological Survey
United States
Department of Interior

Signature

By John P. Hoffmann **Date:** 6/29/20
Name: John P. Hoffmann
Title: Acting Center Director

University of Guam - Water and Environmental Research Institute

Signatures

By_____ **Date:** _____
Name:
Title:

By_____ **Date:** _____
Name:
Title:

By_____ **Date:** _____
Name:
Title:

Refer to
Legislative Secretary

CARL T.C. GUTIERREZ
GOVERNOR OF GUAM

Office of the Speaker
ANTONIO R. UNPINGCO
Date: 8/17/98
Time: 11:15am
Rec'd by:
Print Name: ANNIE FRANCISCO

AUG 14 1998

The Honorable Antonio R. Unpingco
Speaker
Mina'Bente Kuåttro na Liheslaturan Guåhan
Twenty-Fourth Guam Legislature
Guam Legislature Temporary Building
155 Hesler Street
Hagåtña, Guam 96910

OFFICE OF THE LEGISLATIVE SECRETARY
ACKNOWLEDGMENT RECEIPT
Received By:
Time: 8:45am
Date: 8/18/98

Dear Speaker Unpingco:

Enclosed please find Substitute Bill No. 652 (LS), "AN ACT TO ESTABLISH THE GUAM HYDROLOGIC SURVEY AS A PERMANENT PROGRAM TO BE ADMINISTERED BY THE WATER AND ENERGY RESEARCH INSTITUTE OF THE WESTERN PACIFIC, UNIVERSITY OF GUAM", which I have **signed** into law today as **Public Law No. 24-247.**

The General Appropriation Act for Fiscal Years 1998-99 directed the Water and Energy Research Institute of the Western Pacific (WERI), located at the University of Guam, to establish the Guam Hydrologic Survey, and appropriated $200,000 for 1998 only.

The duties of WERI under this legislation are essentially the same, which is to conduct the Guam Hydrologic Survey, however, this legislation is more specific by including the respective roles of WERI, Guam Environmental Protection Agency, and the Guam Waterworks Authority.

The legislation directs WERI to create and administer the Guam Hydrologic Survey, and appropriates $265,000 for Fiscal Year 1999. The intent section states that the legislation is to establish a permanent program for collecting, consolidating and storing all of the water resource data on Guam, and making all of this information readily retrievable for use by the people of Guam. The "permanency" established is the provision that WERI

00963

prepare and submit an annual budget request for the Guam Hydrologic Survey to the Legislature by August 1st of each year.

Very truly yours,

Carl T. C. Gutierrez
I Maga'lahen Guåhan
Governor of Guam

0363

Attachment: copy attached for signed bill
original attached for vetoed bill

cc: The Honorable Joanne M. S. Brown
Legislative Secretary

MINA'BENTE KUATTRO NA LIHESLATURAN GUAHAN
1998 (SECOND) Regular Session

CERTIFICATION OF PASSAGE OF AN ACT TO *I MAGA'LAHEN GUAHAN*

This is to certify that Substitute Bill No. 652 (LS), "AN ACT TO ESTABLISH THE GUAM HYDROLOGIC SURVEY AS A PERMANENT PROGRAM TO BE ADMINISTERED BY THE WATER AND ENERGY RESEARCH INSTITUTE OF THE WESTERN PACIFIC, UNIVERSITY OF GUAM," was on the 29th day of July, 1998, duly and regularly passed.

ANTONIO R. UNPINGCO
Speaker

Attested:

JOANNE M.S. BROWN
Senator and Legislative Secretary

This Act was received by *I Maga'lahen Guahan* this 3rd day of August, 1998, at 9:05 o'clock 9 .M.

Assistant Staff Officer
Maga'lahi's Office

APPROVED:

CARL T. C. GUTIERREZ
I Maga'lahen Guahan

Date: 8-14-98

Public Law No. 24-247

MINA'BENTE KUATTRO NA LIHESLATURAN GUAHAN
1998 (SECOND) Regular Session

Bill No. 652 (LS)
As substituted by the Committee
on Natural Resources and amended
on the Floor.

Introduced by:

J. M.S. Brown
T. C. Ada
A. C. Blaz
F. B. Aguon, Jr.
Francisco P. Camacho
Felix P. Camacho
M. C. Charfauros
E. J. Cruz
W. B.S.M. Flores
Mark Forbes
L. F. Kasperbauer
A. C. Lamorena, V
C. A. Leon Guerrero
L. A. Leon Guerrero
V. C. Pangelinan
J. C. Salas
A. L.G. Santos
F. E. Santos
A. R. Unpingco
J. Won Pat-Borja

AN ACT TO ESTABLISH THE GUAM HYDROLOGIC SURVEY AS A PERMANENT PROGRAM TO BE ADMINISTERED BY THE WATER AND ENERGY RESEARCH INSTITUTE OF THE WESTERN PACIFIC, UNIVERSITY OF GUAM.

BE IT ENACTED BY THE PEOPLE OF GUAM:

Section 1. Legislative Intent. *I Liheslaturan Guahan* recognizes the need for accurate baseline data and up-to-date analyses of Guam's water resources. As Guam's population and economy continue to grow, the Island must develop new sources and improve existing sources of drinking water. There is currently no permanent and comprehensive program in place to ensure information on Guam's water resources is systematically collected, stored, analyzed and reported so that the people of Guam can be supplied with up-to-date and accurate information and scientific advice.

Public Law Number 24-161, which instituted the Guam Drought Management and Comprehensive Water Conservation Plan, took an important first step toward alleviating some crucial shortfalls in basic data collection by establishing the Comprehensive Monitoring Program, which rehabilitates and re-activates the joint, fifty percent (50%) matching Federal funds, program under which the U.S. Geological Survey ("USGS") will collect key data on rainfall across the Island, ground water levels, salt water intrusion and water lens thickness in northern Guam, and stream flow in southern Guam. Important deficiencies remain, however. In particular, there is no standard for collecting and interpreting geologic data on new wells drilled on Guam. Such data are crucial for locating new sources of fresh water and for determining where the fresh-water lens is vulnerable to contamination by salt water or surface contaminants.

The most important deficiency, however, is that Guam has no permanent program in place to consolidate and preserve the data that are being collected so that they can be readily retrieved to support local scientific and engineering

analyses, or other needs of local decision-makers and citizens for timely information on Guam's water resources. Data collected by the USGS are currently archived in Hawaii or on the Mainland. Data collected by local agencies currently accumulate in various repositories without being systematically cataloged or archived so that potential users can find it when they need it, or even determine what data are available. There is thus no means for rapidly and economically locating and retrieving hydrologic data for use by scientists, engineers, public agencies, private businesses, educators, or the general public to support scientific analyses, public or private projects, or educational programs on Guam.

The intent of this legislation is to establish a permanent program for not only collecting, but also for consolidating and storing all of the water resource data on Guam, and for making all of it readily retrievable for use by the people of Guam. The program established under this legislation will also ensure that ongoing analyses of local water resource concerns are conducted by local scientists so that the Island's water resource policy-makers, managers, regulators, educators, businesses, and citizens have timely information and readily accessible advice for sound decisions regarding use, conservation and development of Guam's water resources.

Section 2. Establishment of a Permanent Guam Hydrologic Survey Program. The Water and Energy Research Institute of the Western Pacific ("WERI") shall create and administer the Guam Hydrologic Survey ("GHS"). The mission of the GHS shall be to:

a. locate, inventory and evaluate all hydrologic data pertaining to

Guam and consolidate the data into a single computer-based data library from which information can be easily accessed and retrieved;

b. establish a direct working relationship with each organization collecting hydrologic data important to Guam, and maintain a permanent flow of new data from each organization to keep the data library up to date;

c. conduct analyses to assess the status of Guam's water resources, and publish annual and other regular concise reports on water use, trends and key concerns for use by *I Maga'lahen Guahan, I Liheslaturan Guahan*, public agencies and private business, and citizens of Guam;

d. provide educational materials and regular forums for Island educators and the general public to raise the level of public understanding of Guam's water resources, problems and the issues that must be addressed to solve them; and

e. conduct research into selected water resource problems of current concern, and publish reports to provide scientific data on which to base sound corrective policy, regulations and management decisions.

Section 3. Exchange of Data. (a) Comprehensive Monitoring Program. WERI shall determine data collection requirements and administer the joint WERI-USGS Comprehensive Monitoring Program on Guam, as mandated by Public Law Number 24-161. WERI shall coordinate with the USGS and other Federal agencies to ensure that data collected by Federal agencies are immediately accessible to the Guam Hydrologic Survey. All government of Guam agencies shall provide WERI and USGS access to such public property and facilities as are required to implement the Comprehensive Monitoring Program.

(b) Guam Hydrologic Survey. All government of Guam agencies, including, but not limited to, the Guam Environmental Protection Agency ("GEPA") and the Guam Waterworks Authority ("GWA"), shall transmit a copy of all nonproprietary data to WERI for consolidation by GHS. Each agency collecting water-related data shall maintain an active point of contact with the GHS regarding the collection, transmission and archiving of data. Agencies may execute a Memorandum of Understanding ("MOU") with WERI to facilitate scientific hydrologic data collection.

(c) Drilling and Geophysical Data Collection. WERI shall assist GEPA in preparing and maintaining a standard for geologic data collection during drilling on Guam. Prior to the start of the drilling, the permit applicant shall coordinate with WERI so that on-site data collection can be supervised by a WERI geologist and recorded by the GHS. A copy of any down-hole or geophysical data collected on Guam shall be archived with the GHS.

Section 4. Appropriation for Guam Hydrologic Survey. Two Hundred Sixty-five Thousand Dollars ($265,000.00) is appropriated from the General Fund to WERI for the continued implementation of the Guam Hydrologic Survey, as created by §29 of Chapter III of Public Law Number 24-59 for Fiscal Year 1999. Henceforth, WERI shall prepare and submit the annual budget request for the Guam Hydrologic Survey to *I Liheslaturan Guahan* by August 1st of each year.

Section 5. Comprehensive Monitoring Program. In accordance with Public Law Number 24-161, WERI will work with the USGS to prepare the annual work plan on budget for the Comprehensive Monitoring Program. WERI

will submit the annual budget request for Guam' fifty percent (50%) to the Comprehensive Monitoring Program to *I Liheslaturan Guahan* by August 1st of each year.

24-247

Office of Senator

Joanne M. Salas Brown

Twenty-Fourth Guam Legislature

July 22, 1998

Speaker Antonio R. Unpingco
Twenty-Fourth Guam Legislature
155 Hesler Street
Agana, Guam 96910

Dear Speaker Unpingco:

The Committee on Natural Resources, to which Bill No. 652 - An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Research Institute of the Western Pacific, University of Guam was referred, wishes to report back to the Legislature its recommendation **TO DO PASS** as substituted.

The voting sheet is as follows:

TO PASS	7
NOT TO PASS	0
ABSTAIN	0
TO PLACE IN ACTIVE FILE	0

Copy of the Committee Report and other pertinent documents are enclosed.

Thank you for your attention to this matter.

Sincerely,

JOANNE M. SALAS BROWN
Senator

Office of the Speaker
ANTONIO R. UNPINGCO
Date: 7-23-98
Time: 1120
Received By:

Enclosures

Legislative Secretary Chairperson, Committee on Natural Resources
Suite 200 • 130 Aspinall Street • Agana, Guam 96910 Phone: 472-3450 • Fax: 472-4090

Document No.: 856L-20-24[illegible]*

Office of Senator
Joanne M. Salas Brown
Twenty-Fourth Guam Legislature

July 22, 1998

MEMORANDUM

To: Committee Members

From: Chairperson, Committee on Natural Resources

Subject: Public Hearing on Bill No. 652 As Substituted by the Committee on Natural Resources - An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Research Institute of the Western Pacific, University of Guam.

Transmitted herewith for your consideration and action is our Committee Report on the above subject matter.

Please indicate your choice on the attached Voting Sheet and return the documents to my office for transmittal to other members.

Your attention and cooperation in this matter is greatly appreciated.

JOANNE M. SALAS BROWN

Attachments

Legislative Secretary Chairperson, Committee on Natural Resources
Suite 200 • 130 Aspinall Street • Agana, Guam 96910 Phone: 472-3450 • Fax: 472-4090
Printed on recycled paper.*

Office of Senator

Joanne M. Salas Brown

Twenty-Fourth Guam Legislature

Committee on Natural Resources
Joanne M.S. Brown
Chairperson

VOTING SHEET

Bill No. 652 As substituted by the Committee on Natural Resources - An Act To Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Research Institute of the Western Pacific, University of Guam.

MEMBER COMMITTEE	TO DO PASS	PASS	ABSTAIN	TO PLACE IN INACTIVE FILE	SIGNATURE
Joanne S. Brown Chairperson	✓				
Tony Lamorena Vice Chairman	✓				
Tom Ada Member	✓				
C. Leon Guerrero Member	✓				
Mark Forbes Member					
Francis Santos Member					
M. Charfauros Member	✓				
Anthony Blaz Member	✓				
J. Won Pat-Borja Member					
A.R. Unpingco Speaker Ex-Oficio Member	✓				

Legislative Secretary Chairperson, Committee on Natural Resources
Suite 200 • 130 Aspinall Street • Agana, Guam 96910 Phone: 472-3450 • Fax: 472-4090

Printed on recycled paper

Committee on Natural Resources
Senator Joanne M. S. Brown, Chairperson

Public Hearing

Bill No. 652 - An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Energy Research Institute of the Western Pacific, University of Guam.

July 9, 1998
10:00 a.m.

Committee Report
Summary

The Committee on Natural Resources held a public hearing on Bill No. 652, An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Energy Research Institute of the Western Pacific, University of Guam.

Present were: Senator Joanne M. S. Brown
Senator Tom Ada
Senator Frank Camacho
Senator Frank Aguon, Jr.

Senator Brown commenced hearing on Bill No. 652 and requested Mr. Bert Johnston to come forward to begin testimony and encouraged others who have not signed up to do so.

Mr. Herbert Johnston stated his name for the record, representing Guam Waterworks Authority, Richard Quintanilla and the Board of Directors. He read the written testimony and stated the Authority, and Board of Directors strongly support passage of Bill No. 652. (For more detailed information, see attached)

Senator Ada inquired into the private well fees and is GWA collecting on the fees?

Mr. Johnston responded GWA submitted the proposed rate fees to PUC, and received approval for the interim rates, but not the private water wells as well as the system development charge rates.

Senator Ada questioned the tariff showing the per thousand gallon water rates. It showed fees charged and also the system development charge which was used to base the decision on the lawsuit filed by the Palace Hotel.

Mr. Johnston agreed, but further stated that the PUC did not approve either of the two tariffs. The PUC order specifically stated there was not enough evidence to support the two rates, and will entertain them when GWA have the evidence presented to them.

Senator Ada requested to have a copy of PUC's response provided to the committee because there was no evidence submitted for the water rates other than that. GWA needed $31M dollars, and worked backwards to determine how much the water rates had to be to arrive at $31M.

Mr. Johnston responded it was correct, and that PUC is reviewing GWA's existing rates. GWA did a rate study some time ago and concluded there was not enough financial information and needed to do several things to support and justify the rates.

Senator Ada continued to say that is the reason why the PUC allowed GWA an extension on their interim water rates. Surprised to learn that GWA is not collecting monthly fees from companies such as Foremost, which operates a private water well, from the golf courses and other water well operators. These fees were to go into a fund that will be used as a source for water research to fund conservation programs and others. What he was alluding to is that Bill 652 does not have a funding source for the program. If the bill can be placed on track, then it will provide an assured funding source for the program and not have it funded at the whim of the General Fund may have to offer at the time. The program is in safe hands as long as Senator Brown is the Chair, but if she is not, and somebody takes over the committee who is not as strong about these issues, the program could go by the wayside as it did many years ago.

Senator Brown inquired if there were any more questions of Mr. Johnston. She

stated the issue was a follow-up to a bill Senator Ada authored in the 22nd Guam Legislature. The intent of the bill was to collect monthly fees for these purposes, And reiterated Senator Ada's request to provide a copy of PUC's response to the committee. The committee will need to get an idea of how much is to be charged, and how much are they looking at generating and determine if the fees are adequate to fund the program. Funding of this program is estimated to be about $300,000 or more a year.

Senator Ada inquired how many exploratory wells have been drilled this year and Mr. Johnston responded 11. Out the 11 wells, five (5) are productive. He also inquired into the basis of where GWA goes to drill for exploratory wells.

Mr. Johnston responded GWA works with GEPA and WERI to help determine the most prominent areas. The largest overriding factor was making sure it was on government property.

Senator Brown commented that with the information and resources we have available, there is probably a way we can ensure that when GWA drills there is 80% -90% chance of ensuring that you will come up with a successful well. There talent in this room to make sure that happens.

Mr. Johnston stated that some of the exploratory wells program is working with WERI to make sure that the information that GWA gather from this exploratory well sites is used by them to improve the accuracy.

Senator Brown inquired if a Memorandum of Understanding (MOU) between GWA and WERI has been finalized to have WERI assist GWA in the identification of potential well drilling sites.

Mr. Johnston responded as far as he knows, the MOU was not finalized. GWA was looking at a three year plan.

Senator Brown inquired if GWA is still going to look at getting the MOU finalized.

Mr. Johnston responded that GWA needs to.

Senator Camacho commented that he was at the ground-breaking ceremony with

Earth Tech, Inc. and inquired how long is the program to build the 3M gallon per day well. Is that a 2 year project?

Mr. Johnston responded it was not. They are accelerating the project and are looking at getting first drop in the tap within three months. This will improve water sources.

Senator Ada inquired if GWA is going to reduce purchase from the Navy by the same amount.

Mr. Johnston responded, a fraction of that because the water that is being produced in the north cannot be moved to areas that are being serviced entirely by Navy water, which is Agat and Santa Rita.

Senator Brown informed the members of the committee that GWA will have an oversight hearing on the 23rd of July, and took the privilege of relieving Mr. Johnston because he was only there to testify on Bill 652.

Mr. Salas was there to testify on behalf of EPA on Bill 652

Mr. Jesus Salas stated his name for the record and read his written testimony. Guam EPA supports Bill 652 if the following sections of Bill 652 are modified.
(Please refer to attached testimony for more detailed information).

Senator Ada inquired with reference to paragraph 3 of his testimony regarding the geologist, and asked if WERI, in fact, has a geologist.

Mr. Jensen responded he and Dr. Galt Siegrist are geologists.

Senator Ada commented that GWA does not drill wells every day and was concerned that projects do not get held up because of a lack of geologist being on site to supervise the drilling.

Mr. Salas added that WERI has to coordinate with GEPA on weekend to work with them. That is the reason why GEPA stipulated the additional paragraph of the MOU. He brought to the committee members' attention that aside from having a territorial hydrogeologist or Guam hydrogeologist on staff, GEPA is looking at picking up

another geologist.

Senator Brown stated that WERI will elaborate on more on the issue. Some of the problems drilling for water wells is that data has never been collected and is not sure whether they are properly securing the dry hole. A more collective effort is to ensure that data is maintained because the amount of study that can be gained from these different boreholes is lost. Through the coordinated process, GEPA cannot only gain for regulatory things that are needed as far as approving these things, but continue to get the amount of information needed as far as keeping the data and start evaluating our water system. Hoped that through this legislation, it will become a formalized process and actually institute the program and make it more permanent of WERI's operations, and build a collective relationship with Guam Waterworks Authority, Guam EPA, and USGS.

Senator Aguon shared the very same concern that Senator Ada stated earlier with reference to the actual supervision and also the geologist. He inquired if it can be rephrased to read "to be supervised by WERI", because there are students that could possibly assume that particular responsibility, whether it be in a temporary nature.

Dr. Jensen stated that WERI worked with GEPA to choose the words very carefully, so that it reads "on-site data collection can be supervised by the word "geologist". This does not mean the geologist has to be on site during the whole time. Our plan is to train some of our graduate students who will be on site along with the drillers. The drillers are responsible under the regulations that GEPA has in place to collect data and have a person who is responsible for actually stepping up to the drill stem and scooping up the samples out of the boreholes. As long as it is being done correctly and data is collected, both GEPA and WERI's needs are satisfied.

Senator Aguon stated that his interpretation on the use of the term "on-site" gave the general impression that the geologist has to be "on-site" doing the supervision of the collection of the data. He would like to give WERI the flexibility so that the students can carry out some of those responsibilities. If the term was acceptable to WERI and Guam EPA, then it was fine.

Dr. Jensen stated that he was asked by **Mr. Mark Cramer** who faxed his testimony to read his statement for the record. Mr. Cramer is the Regional Office Manager for **Earth Tech, Inc.** and supports Bill No. 652. (Please refer to his testimony for

detailed information).

Dr. Jensen also read **Dr. Galt Siegrist's** testimony who is off-island and supports passage of Bill No. 652. (Please refer to written testimony for detailed information).

Dr. Jensen read his testimony in support of Bill No. 652. He pointed out how important it is for the island to have hard data on the amount of rainfall. (Please refer to written testimony for detailed information).

Ms. Julianne T. Duwel, P. E. submitted written testimony in support of Bill No. 652. (Please refer to written testimony for detailed information).

After **Dr. Jensen** read his testimony, he proudly introduced the graduate students and identified the type of research program they are involved with at WERI. He concluded his introduction by calling upon Mr. John Jocson to start off the presentation.

Each student came forward to give a brief synopsis of their research project and answered questions asked by committee members.

Mr. John Jocson explained the six types of data collection each student had worked on. They are: (1) Meteorlogical, (2) Ground Water, (3) Coastal Water, (4) Surface Water (5) Water Distribution and (6) Geologic Data. The students are developing data reports and analysis starting with data library.

WERI will be conducting a mini-conference on July 15, 1998 on water resources on Guam, which is part of the hydrologic survey. Some of the research projects the students have been involved in is the revision of the basement volcanics, chloride levels and production wells, evaluation and trends, revision of the Guam Northern lens sustainable yield.

Peter Dumaliang gave a presentation on the meteorological data collection for Guam and pointed out on the illustration which stations collect and record daily rainfall data. Contributors of data include USGS , National Weather Service, military, private sector, and UOG. Study concluded that distribution of meteorological data collection can be found in these stations. The data is important for ground water and drought studies and current and proposed meteorological sites need to be retrofitted to

withstand high winds such as typhoons.

Dave Dawn gave a presentation on surface water and water distribution as stream flow gauging. Stream gauging has dual purposes on Guam: (1) provides data that allows scientist at USGS and at the local level to determine how much of the rainfall at the south actually leaves the island. This information is used by water managers to model the Fena water shed and reservoir's potential and gives an overall picture of the water budget. (2) Information is used to determine the potential yield of any number of watersheds in the south, if sources were to be developed.

Mauryn Quenga gave a brief synopsis on chloride. Her project included tracking down three main types of water data: (l) water level measurement to see how the top of the aquifer responds to well production; (2) well production data, to see exactly how much water they are extracting from the aquifer and (3) chloride concentration, to see where they are having problems with salt water intrusion. She referred to the map and pointed out the observation wells owned by GWA & GEPA. Out of the 6 water sub basins, only two are being measured for water levels..

Senator Ada raised a concern with reference to the monitoring of private water wells.

Mauryn Quenga responded that every year the water resource management program at GEPA conducts annual inspections of all the production wells on Guam. Any discrepancies are noted and owners are asked to correct the discrepancies. Every 5 years when a permit is removed, the well owners are required to test their water for certain parameters. Every year all production wells on Guam are tested for chlorides and GEPA monitors certain wells to see if there is salt water intrusion.

Senator Brown inquired if the use of her data will help GWA facilitate and identify as to whether or not some of the wells should be shut down or decrease the level of water being pumped? How is this impacting the overall water lens in that particular sub basin?

Mauryn Quenga responded her research work is actually looking at each well to see what is happening at the source rather than what is coming out of the tap at the end of the line, instead of looking at the sub basin or the distribution system. By doing this, we can determine what effect it is having on the aquifer.

Senator Ada commented regarding Mr. Mark Cramer's linear curve developed a couple of years ago on the ground water capacity which projected where we are at now and how much water is being drawn and the assumed capacity of the aquifer. If GWA continues drilling at the rate of 30 wells, the limit of the aquifer will probably be reached. Secondly, is the possibility of a funding source for this program. Asked the Chairperson to put the funding provision in the bill, and if WERI can come up with a reasonable formulation, would want to see some of the funds put aside for water conservation program.

Mr. Dongco Tabowrosi presented his research on the geologic data on Guam. Geologic data is extremely important in a hydrologic sense because it influences the recharge of the aquifer. Presently, physical access of data is available at locations where stored, but will become available through the Guam Hydrologic Survey web page. Two main types of geologic data that are hydrologically significant are basement volcanics and the surface geology.

Senator Aguon inquired with reference to time frame as to when the capacity of the aquifer will be exhausted.

Dr. Jensen responded that the research work the students are involved with will give WERI the capability of forecasting more precisely when problems will be encountered at a given place and time. WERI's objective is to have a regular report, on the state of the aquifer, surface water resources and southern Guam, so policy makers, regulators, and decision makers will have the latest information on the forecast. Forecast will be revised when the development needs change. The first report should be available in approximately 6-8 weeks when they have the FY'98 findings. He continued to say that the advantage of having the hydrologic survey in place and making it permanent is that the scientific data collection and analysis are being done by people who live here are raising their families here and who drink the water.

Dr. Camacho made the following comments:

- She testified as the Dean of Graduate School and Research to round out the representation from the University of Guam to support Bill No. 652.
- She is the Administrator that oversees WERI and from the very beginning when she heard Senator Brown was working with the

Director and the Faculty at WERI to establish the Guam Hydrologic Survey, she was in support of it and has continued to communicate with the President, the Academic Vice-President and the Board of Regents that they need to support this project.

- Results that are coming forward at this point are very encouraging and need to go forward and have Bill 652 go before the Legislature and be passed.
- In agreement with small changes that Dr. Jensen and Mr. Salas worked through and also noticed that Mr. Salas is proposing the MOU and will take the information back to the President and make certain that their legal counsel and President are a part of the MOU as it is developed.
- Noticed Mr. Jocson had a Section IV that he wanted to deal with in terms of the budget. Need to concern ourselves with budget. The proposal to come forward with that money once a year on the 1st of August is a good suggestion.
- Encouraged everyone to go forward with the passage and the permanent establishment of the Guam Hydrologic Survey.

Senator Brown appreciated testimony because it is important to have the support of the University, the Board of Regents, and the President. Important thing is to address funding for this program for this upcoming fiscal year because the money that was appropriated is expiring. Recommended that they schedule an appointment to meet with Vice-Speaker Blaz, who is the Chairman of Finance & Taxation, and has been supportive in funding WERI, and also the drought legislation and provided the money for the USGS funding. Hopefully, the funding can be addressed for this upcoming October 1st fiscal year for WERI so that you can continue to work. Need to make this a permanent part of our operations. Very impressed with the work and the presentations that were done.

Senator Ada inquired into the sustainable yield.

Dr. Jensen referred to the map which showed six hydrologically distinct sub-basins. Geologically, the conditions are such that water that is kept captured in one sub-basin flows from its sources to where it is discharged and does not interact with the water in the other sub basins. With the limestone aquifer, this may not be true with the water coming down from the surface into the lens. It is being studied. For planning purposes, WERI can evaluate sub-basin by sub-basin, what is the sustainable yield

for a given set of conditions (refer to chart). 60% of the aquifer is being utilized. Yigo, Tumon sub-basin accounts for about 30%, The production being taken out of the aquifer now accounts for about 75% of the estimated sustainable yield. This is the heavily used sub-basin.

Senator Ada inquired into the 1982 sustainable yield and asked if it has been updated given the physical changes that have taken place on the land.

Dr. Jensen responded that in 1992, the same firm, Barrett Harris, in particular, John Mink, who oversaw the geologic study on the first report update and provided a report that did not get circulated widely in 1992, and the chart showed the current production by each sub-basin. 1992 sustainable estimates were higher and purposely conservative and based on estimating the recharge or by taking the rainfall, the span of evaporation rate for each sub-basin, and arbitrarily saying 60% of that recharge is probably available for production, and that is how those figures were arrived.

Senator Aguon inquired if the figures were also conservation in terms of taking into consideration the same factors in 1992 report.

Dr. Jensen responded that they took the 1982 report and used the computer model of ground water by which they were able to take the same data and based on the way they expected the wells to behave dynamically, they said we probably could pump more out of these wells.

Earth Tech contributed with WERI, the first time, WERI will be assisting an organization in locating the sites for their wells before they send to assist the driller to the site. Sub-basins should be left alone for now because it is expensive to develop and the capacity is small and high risk.

He concluded by showing the long term 14 year averages of monthly rainfall for northern Guam. He pointed out between what the rainfall has been and the normal rainfall over the 14 year period and has heard stated that the El Nino is over. In order to get a normal amount of storage back into the Fena reservoir, you have to get rain fall above normal in order to make up for the fact that we have been below normal rainfall for a long time. This is more the reason to continue to be vigilant and conserve the water resources.

Senator Brown thanked the audience for coming out for both the confirmation hearing of Ms. Miriam Gallet and Bill No.652. Confirmation hearing and Bill No. 652 will be on the session agenda at the end of this month.

Public Hearing adjourned at 12:50 p.m.

Website Address for the Guam Hydrologic Survey is: uog2.uog.edu/weri/ghs

TWENTY-FOURTH GUAM LEGISLATURE
COMMITTEE ON NATURAL RESOURCES

Senator Joanne M. S. Brown, Chairperson

Public Hearing
Thursday, July 9, 1998
10:00 a.m.

Bill No. 652 - An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Energy Research Institute of the Western Pacific University of Guam.

Sign In Sheet

Names	*Representing*	*Oral Testimony*	*Written Testimony*	*In Favor of*	*Opposed*
Maurya Quenga	WERI	✓		Bill 652	
John Jenson	WERI	✓	—	Bill 652	
John Jocson	Weri	✓	✓	Bill 652	
Danko Taborosi	WERI	✓		BILL 652	
Peter G. Dumaliang	WERI	✓		Bill 652	
Jon Jon Kaye	GEPA	—		Bill 652	
Jesus Salas	GEPA		✓	Bill 652	
David Vana	WERI	✓		Bill 652	
MARILOU YAMAMURA	GEPA			Bill 652	
NARCISO CUSTODIO	GEPA			Bill 652	
SALLY MARQUES	GEPA			Bill 652	

TWENTY-FOURTH GUAM LEGISLATURE
COMMITTEE ON NATURAL RESOURCES

Senator Joanne M. S. Brown, Chairperson

Public Hearing
Thursday, July 9, 1998
10:00 a.m.

Bill No. 652 - An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Energy Research Institute of the Western Pacific University of Guam.

Sign In Sheet

Names	*Representing*	*Oral Testimony*	*Written Testimony*	*In Favor of*	*Opposed*
Bert Johnston	GWA		✓	Bill 652	
MARK LALUMIERE	W.E.R.I.			Bill 652	
JOYCE M. CHAMACHO	UOG	✓		Bill 652	

TWENTY-F0URTH GUAM LEGISLATURE
COMMITTEE ON NATURAL RESOURCES
Senator Joanne M. S. Brown, Chairperson

PUBLIC HEARING
Thursday, July 9, 1998
10:00 a.m.

Re-Appointment of Ms. Miriam S. Gallet, Member
Board of Directors, Guam Environmental Protection Agency

Bill No. 652 - An Act to Establish the Guam Hydrologic Survey as Permanent Program to be Administered by the Water and Energy Research Institute of the Western Pacific University of Guam.

A G E N D A

1. **Introduction of Committee Members**

2. **Commencement of Public Hearing**
   1) **Re-appointment of Ms. Miriam S. Gallet**
   2) **Bill No. 652**

3. **Public Comment**

4. **Adjournment**

GUAM WATERWORKS AUTHORITY

Government of Guam
Post Office Box 3010, Agana, Guam 96932
Phone: (671)479-7823 Fax: (671)479-7879

HEARING ON BILL NO. 652
COMMITTEE ON NATURAL RESOURCES
TWENTY-FOURTH GUAM LEGISLATURE

Testimony by:

RICHARD A. QUINTANILLA
General Manager

GOOD MORNING MADAM CHAIR AND MEMBERS OF THE COMMITTEE ON NATURAL RESOURCES, FOR THE RECORD, MY NAME IS RICHARD A. QUINTANILLA, GENERAL MANAGER OF THE GUAM WATERWORKS AUTHORITY. I AM HERE TODAY TO SUPPORT THE PASSAGE OF BILL NUMBER 652: AN ACT TO ESTABLISH THE GUAM HYDROLOGICAL SURVEY AS A PERMANENT PROGRAM ADMINISTERED BY "WERI" (WATER AND ENERGY RESEARCH INSTITUTE).

THE BOARD OF DIRECTORS AND MANAGEMENT OF THE AUTHORITY AGREE WITH THE LEGISLATIVE INTENT STATED IN THIS BILL. THE ESTABLISHMENT OF A PERMANENT HYDROLOGICAL SURVEY PROGRAM PROVIDES A FOUNDATION OF INFORMATION TO HELP US MANAGE THE USE OUR ISLAND'S MOST PRECIOUS RESOURCE – OUR WATER.

WHILE THERE IS MUCH WE ALREADY KNOW ABOUT OUR AQUIFER, THERE IS MUCH MORE THAT WE NEED TO KNOW IN ORDER TO MAKE PRUDENT AND INFORMED MANAGEMENT DECISIONS. THIS IS EVIDENCED BY OUR SUCCESS RATE OF EXPLORATORY WELL DRILLING PROGRAMS.

THE PRUDENCY OF ANY MANAGEMENT DECISION IS IN DIRECT PROPORTION TO THE LEVEL AND ACCURACY OF INFORMATION AVAILABLE. GIVEN OUR DEPENDENCE ON OUR FINITE WATER RESOURCES, THIS COMMUNITY NEEDS TO MAINTAIN A COORDINATED EFFORT TOWARD INSURING THE INTEGRITY OF OUR WATER RESOURCES.

ON BEHALF OF THE BOARD OF DIRECTORS AND MANAGEMENT OF THE GUAM WATERWORKS AUTHORITY, WE STRONGLY SUPPORT THE PASAGE OF BILL 652.

THANK YOU.

RICHARD A. QUINTANILLA
General Manager

GUAM ENVIRONMENTAL PROTECTION AGENCY

AHENSIAN PRUTEKSION LINA'LA GUAHAN

P.O. BOX 22439 GMF • BARRIGADA, GUAM 96921 • TEL: 472-8863 • FAX: 477-9402

uced at Government of Guam expense

Testimony of
Jesus T. Salas
Administrator, Guam Environmental Protection Agency
Before the Committee on Natural Resources

Hearing on Bill 652 (LS): An Act to Establish the Guam Hydrologic Survey as a Permanent Program to be Administered by the Water and Energy Research Institute of the Western Pacific University of Guam.

July 09, 1998

Bill 652's intent to establish a permanent program to systematically collect, store, analyze and report information on Guam's water resources so that the public can be supplied with up-to-date and accurate information and scientific advice is an excellent mandate. Guam EPA is tasked with water resources management and WERI is an excellent research institute. However, WERI is not a regulatory agency, like Guam EPA, capable of enforcing its findings on other agencies.

Guam EPA supports Bill 652 if the following sections are modified:

1. On page 3, line 15, please clarify the directive to publish regular concise reports. Are these to be monthly, quarterly or annually? Guam EPA recommends the term "regular" be changed to "annual."

luced at Government of Guam expense

2. On page 4, section 3(b), lines 9 and 10 - after discussion's with WERI, it is recommended that this line be changed to read as follows:

"Authority ("GWA"), shall transmit a copy of all nonproprietary data to WERI for consolidation by the GHS."

3. It should be noted that Guam EPA does have standards for geologic data collection during bore hole drilling in its regulations and permit requirements; therefore, on page 4, section 3(c), after discussion's with WERI, it is recommended that this paragraph be changed to read as follows:

"WERI shall assist Guam EPA in preparing and maintaining a standard for geologic data collection during drilling on Guam. Prior to the start of drilling, the permit applicant shall coordinate with WERI of the proposed well drilling so that on-site data collection can be supervised by a WERI geologist and recorded by the GHS. A copy of any down-hole or geophysical data collected on Guam shall be archived with the GHS."

4. Finally, Guam EPA would like to request that the following subsection be added:

"3(d) To implement 3(b) and 3(c) above, WERI and USGS shall execute an MOU with Guam EPA specifying each agency's jurisdictional scope of responsibilities in the collection of data to maximize their efforts to ensure the most efficient and effective way to collect vital information regarding Guam's water resources."

duced at Government of Guam expense

The changes recommended above will assist in clarifying that WERI's role in Bill 652 is strictly to consolidate and archive data and not to overlap with Guam EPA's regulatory prerogatives.

Thank you Madam Chairwoman and members of the Committee for the opportunity to testify before you today.

JESUS T. SALAS

M E M O R A N D U M

Date: July 09, 1998

To: Twenty-Fourth Guam Legislature

From: Mark Cramer, PE, Regional Office Manager

Subject: Bill No. 652 - Public Testimony

As an engineer in the water resource industry here on Guam, I have utilized data collected by USGS, WERI, GEPA extensively in my work in planning surface and ground water resource development. The availability of sound data provides the opportunity to calibrate empirical calculations to historical events, as opposed to the use of gross assumptions and other methods of educated guesswork. We missed a great opportunity by not obtaining groundwater data during the recent drought event.

Furthermore, I have advocated the creation of a central repository for water resource information for several years. WERI is the most logical location for this repository. The quest for existing data is a very time consuming undertaking that must be budgeted into each project. The availability of a central repository will reduce costs to both government and private sector clients and reduce the likelihood that critical data is [illegible] the process.

[illegible] comment, I do not believe the exchange of information should be tied to the issuance of a drilling permit, as indicated in Section 3(c). GEPA is the regulatory agency in responsible charge of well [illegible]lopment. A better approach would be to require the applicant to [illegible]m WERI of the site and when drilling will commence. This could [illegible]accomplished by either adding it as a condition of the permit or by [illegible]modification to the existing regulations. The exchange of information between GEPA, GWA, and WERI could be accomplished by a [illegible]emorandum of Understanding, as opposed to legislative action.

EARTH TECH

UNIVERSITY OF GUAM
UNIBETSEDÅT GUAHAN

WERI

WATER AND ENERGY RESEARCH INSTITUTE OF THE WESTERN PACIFIC

303 University Drive
UOG Station, Mangilao, Guam 96923
Tel: (671) 735-2685 / 2688 • Fax: (671) 734-8890

July 9, 1998

Senator Joanne M.S. Brown, Chairperson
Committee on Natural Resources
Twenty Fourth Guam Legislature
Suite 200, 130 Aspinall Street
Agana, Guam 96910

Dear Senator Brown,

I am pleased to be able to respond to your invitation to present testimony on July 9, 1998 on Bill No. 652 – **An Act to Establish the Guam Hydrologic Survey As a Permanent Program to be Administered by the Water & Energy Research Institute of the Western Pacific, University of Guam**. Unfortunately, however, I will be off-island from June 29-July 24, so I will submit the following testimony for reading at the hearing.

Chairperson Brown
Distinguished Senators

I am Galt Siegrist, Director of the Water & Energy Research Institute of the Western Pacific (WERI) at the University of Guam

The Guam Hydrologic Survey has been in operation about nine months. In that short time it has made impressive strides in successfully completing its first year's mandated objectives.

These objectives can be summarized as follows:

1) Seek out and compile into data base format all available historical data pertinent to our island's surface and groundwater resources. This effort required the activity of three full time graduate students, working under the whip of Dr. John Jenson, but was successful only because WERI enjoyed total cooperation from a number of Guam agencies and private firms that are treasure troves of historic data.

2) Summarize and distribute the available data in forms and products that will be useful to a variety of stakeholders, such as educators, students, planners, and researchers at

WERI and elsewhere, key agencies, and our elected representatives. To that end, WERI has already sponsored a number of seminars, a workshop, and later this year, will introduce a 3-credit graduate evening course at UOG for our island schoolteachers. This course will be called *Water Resources of Pacific Islands*, and I have attached a course flyer to your copies of my testimony. As you can see, it involves the entire WERI faculty. WERI is presently compiling about twenty colored GIS maps, additional hydrologic diagrams, and supporting text that, when bound, will constitute the first edition of the *Guam Hydrologic Atlas*. This publication will be made available throughout the island by the end of this year. Another nearly completed effort under this Objective is the total restructuring and updating of our Institute Web Page to reflect WERI's newest water resource initiatives and capabilities, and to present information compiled by the Guam Hydrologic Survey.

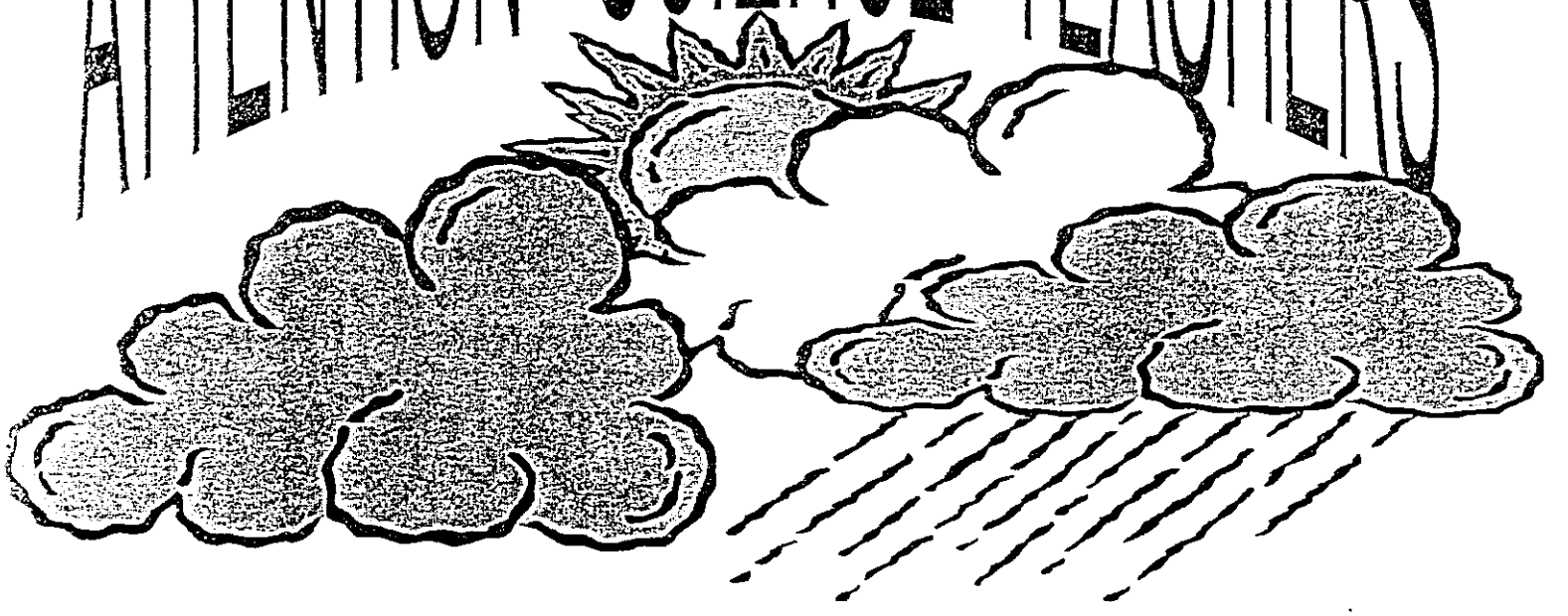
3) Develop institutional mechanisms and protocols for retrieving, integrating, and analyzing our island's water resource data in the future. In six months, WERI has organized the computer and student firepower, and gained the experience required to maintain this program at its current, first-year level. This level will annually support a variety of educational and training programs described above, and several highly focused research projects dealing with pressing water resource needs of the island. Our initial research thrusts under the GHS will be to i) attack the problem of chloride contamination in certain production wells, ii) develop better strategies for successful siting production wells by mapping karst features in northern Guam, iii) undertake a critical examination of water distribution problems in the Mangilao area, iv) establish the role of the large Pago Point-Adelup fault in controlling groundwater production, and surface and groundwater contamination, and v) derive a more accurate water budget for northern Guam by quantifying soil moisture losses.

Madam Chairperson, thanks to your early and continuing interest and the strong legislative support that you spearheaded, the new Guam Hydrologic Survey is proving to be a model program, one that is providing the citizens of Guam real value for their tax dollars.

Information is power: Through the Guam Hydrologic Survey Program, WERI faculty are able to give back to the community the needed information and level of service that will empower it to manage wisely this most valuable of island resources. Indeed, as was often repeated to me recently in a meeting of State Water Institute Directors in Atlanta, Georgia, the GHS it is one of only a handful of similar programs nationwide, and by far the most successful, if I can believe their comments.

I congratulate you on the original idea, and obviously support strongly the Guam Hydrologic Survey becoming a permanent addition to WERI and, more importantly, to the island. Thank you.

ATTENTION SCIENCE TEACHERS

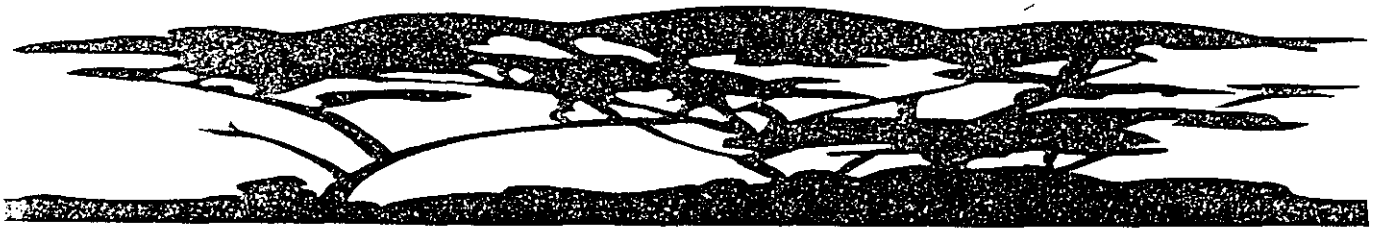


A Course in Water Resources of Pacific Islands

(September 8, 1998 - October 27, 1998)

A study of freshwater water resources on high and low islands of the tropical western Pacific, with special emphasis on Guam and the Marianas Islands. This course is aimed at schoolteachers at all levels. Prerequisites: none.

Course #: EV894: Water Resources of the Pacific Islands, 3.0 credits
Days/Times: Tuesdays & Thursdays, 4:00-6:45PM
Site: WERI Building (Next to Marine Lab), Room 105
Tuition: $60.00
Instructors: G. Siegrist, G. Denton, C. Guard, L. Heitz, J. Jenson, S. Khosrowpanah, M. Lander, R. Wood



Registration processing is at the Center for Continuing Education & Outreach Programs, 2nd floor, MARC/Computer Center Building. If you have any questions, please feel free to visit the Center or call 735-2600-4 for assistance.

UNIVERSITY OF GUAM
UNIBETSEDÅT GUAHAN
WATER AND ENERGY RESEARCH INSTITUTE
OF THE WESTERN PACIFIC
303 University Drive
UOG Station, Mangilao, Guam 96923
Tel: (671) 735-2685 / 2688 • Fax: (671) 734-8890

July 9, 1998

Statement of Dr. John Jenson, Acting Director of WERI & Program Manager of the Guam Hydrologic Survey Program, WERI, University of Guam

To: 24th Guam Legislature, Committee on Natural Resources

Madame Chairwoman and Senators:

I would like to follow Dr. Siegrist's remarks with a few of my own. Then I'll introduce the really important people from our program--those who do the hard work,...that is, our Survey Staff Hydrologist and his team of graduate research assistants.

I, too, want to commend you and your colleagues in the 24th Guam Legislature for your initiative to put in place a program that will finally provide the people of Guam with a permanent, centralized source of adequate scientific information on our local water resources. Moreover, you have recognized that scientific data on our water sources must be timely, accurate, and locally accessible if it is to support ongoing development, policy and regulatory decisions, and education on water resource use. Rounding up over 50 years accumulation of data from the various sources around the island,...putting the data into a single library which can be accessed by anybody from research scientists in Frankfurt to first-graders at Price Elementary School,...and keeping it up to date...is a huge step forward for properly managing our limited water resources.

I also want to commend you for restoring the 50-50 federal matching program with the US Geological Survey under PL 24-161 to provide the hydrographic data that we need on rainfall,...pan evaporation,...groundwater water levels and saltwater interaction,...tidal levels,...and streamflow and sediment transport. In consonance with the other ongoing and planned data collection programs on the island--most notably groundwater quality data collection by Guam EPA,...weather data collection by the National Weather Service,...and surface water data collection by the Navy in their cooperative program with USGS--we will soon have in place a data collection program that promises to meet our current needs for scientific data. We must keep in mind, of course, that we will need to expand these programs to incorporate new coverage as newly parts of the island are developed.

Doc. No. 35GL-20-2107.*

I can't stress enough how important it is for the island to have hard data on how much rain we get in the various places around the island...and how much of it probably evaporates before going into the ground...how the volume of water in our northern water lens and southern streams responds to rainfall and drought...how the tidal variations affect the water levels in our wells,...and how much sediment is being washed of from our land surface and carried to the reefs by our streams. This information is absolutely essential for making accurate estimates of sustainable yield from ground and surface sources,...for designing storm water management systems to control flooding,...for determining appropriate land use practices,...and a host of other decisions and activities.

We also need a reliable picture of the bedrock and basement geology of northern Guam so that developers can locate new sources of groundwater...and avoid unnecessary—and very expensive--exploratory drilling. (This is getting harder to do as the "easy" sites have already been tapped.) We need to understand the natural "plumbing" of our limestone aquifer better in order to accurately determine how the lens is affected by surface contamination such as effluent from septic tanks, leaky sewer lines, or agricultural chemicals. Finally, we need to have accurate, up-to-date geographic data—all in one place--on our own plumbing,...that is on the distribution lines of GWA and the military systems so that engineers will have the data they need to more easily correct current problems and optimize the system to meet future needs.

A third noteworthy achievement of this legislation is the commitment that it makes to provide local funding for work on local problems. I must point out that unilateral federal funding is no longer something we can take for granted. The federal government has made it clear that they will fund only work on national or regional problems—problems like global warming or El Nino. No one in Washington cares about the Northern Guam Lens Aquifer. On the other hand, for local governments that make a commitment to help themselves, matching funding is forthcoming. USGS is matching our commitment to the data collection program 50/50 and has contracted to do so indefinitely so long as we hold up our end. In addition, because of the current funding that you provided for startup of this program last fall, and the preliminary results we have been able to show, WERI obtained two additional grants from USGS last month that will support local research work on water infiltration through the bedrock and water catchment design on Guam for the next two years. Your investment is already paying off!

As Dr. Siegrist pointed out in his remarks, we already have team of people at WERI up and running on this program. They are here with me today, and you can see a few examples of their work, which we will be formally presenting in a few weeks when the first year's reports are complete for FY98. I've asked each of them to be prepared to give you a brief report on their work to date if you have time.

Finally, I would like to recommend some minor changes to the wording of Section Three of the bill in order to clarify that WERI's role in the data collection process is strictly to consolidate and archive data, and that it in no way is to overlap into Guam EPA's regulatory prerogatives:

Section 3(b) Change as follows:

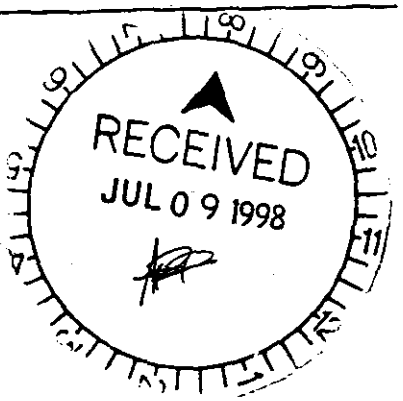
All Government of Guam agencies, including but not limited to the Guam Environmental Protection Agency and Guam Waterworks Authority, shall transmit a copy of all non-proprietary data ~~available~~ to WERI for consolidation by the GHS. Each agency collecting water-related data shall maintain an active point of contact with the GHS regarding the collection, transmission, and archiving of data.

Section 3(C) Change as follows:

WERI shall assist ~~and~~ GEPA in preparing and maintaining ~~shall prepare and maintain~~ a standard for geologic data collection during drilling on Guam. Prior to the start of drilling, ~~Before a drilling permit is issued, GEPA and~~ the permit applicant shall notify ~~report the proposed well drilling to~~ WERI so that on-site data collection can be supervised by a WERI geologist and recorded by the GHS. A copy of any down-hole or geophysical data collected on ~~bore holes installed on~~ Guam shall be archived with the GHS.

P.O. Box 5419
Agana, Guam 96932
671-472-1896
Fax: 671-472-1897
e-mail: jtd@kuentos.guam.net
Please note new telephone numbers!

FAX TRANSMISSION COVER SHEET



Date: *July 9, 1998*

To: *Senator Joanne M.S. Brown*

Fax: *472-4090*

Re: *Bill 652–Guam Hydrologic Survey*

Sender: *Julianne T. Duwel, P.E.*

YOU SHOULD RECEIVE Two (2) PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL 671-472-1896.

Hafa adai, Senator Brown!

I am sorry that I will not be able to attend this morning's public hearing on Bill 652, An Act to Establish the Guam Hydrologic Survey...., and am hoping that you will consider the following in your deliberations.

I applaud the intent of this bill!!! The people of Guam, and in particular, our scientists, engineers, developers, and scholars, **DO** need access to a comprehensive encyclopedia of Guam's water resources data. This will greatly enhance the abilities of our policy-makers, and will also enable developers to make informed decisions as related to the consumption of our precious water resources. Certainly the Water and Energy Research Institute is one appropriate body to maintain this information and make the data available to the people of Guam.

I have several questions, however, related to the language in this bill.

- The bill states "...there is no standard for collecting and interpreting geologic data on new wells drilled on Guam." While I do believe that little interpretation is performed on a regular basis due to their lack of manpower resources, it should be noted that the Guam Environmental Protection Agency has a rather aggressive program to ensure that information is collected each and every time a well is drilled on this island. As a consultant, I have personally experienced this and can verify that their personnel have been ensuring that these requirements are met. A great deal of data is required to be submitted to the Agency for every well-drilling permit issued, and again for every well-operating permit which is issued. As a result, I believe that there is already a permanent program in place for collecting and storing water resource data related to wells.

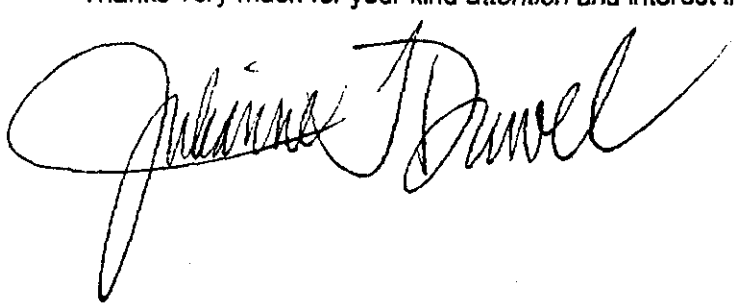
JUL-09-1998 08:09 JULIANNE T DUWEL 6714721897 P.01

- "WERI shall determine data collection requirements..." I am concerned that contractors, developers, and consultants will now experience the frustration of having to deal with both the University of Guam and the regulator--the Guam Environmental Protection Agency. Why not simply have copies of the well permit applications provided to WERI? If I, as a small business owner, property owner, consultant, or contractor, have to answer to two or more masters, it will only drive consumer costs further upward. I would suggest that WERI evaluate the data currently being collected by the Guam EPA to determine if this information will suit their needs, and if so, we leave this part of the current program as it is. Should it be appropriate, perhaps the GEPA could agree to revise its requirements so that we all have only one agency to which we report. I believe that any changes to the current program will certainly cost money, and while I do not wish to delude anyone into thinking our water is "free" I would like to point out that there are a number of enterprises which could be affected by a change in the reporting requirements, be they golf courses, or government agencies who own and maintain wells.

- I am concerned that this bill will result in an increase in workload for the Guam Environmental Protection Agency, without providing them the tools they need to make the flow of data happen on a timely basis. We are all well aware of the shortage of manpower that the Agency currently has on board, and the fact that it is difficult for them to take on more and more work without additional assistance of some kind. The Agency is in the process of becoming more computerized and I believe that this will happen eventually. Perhaps this bill should include a provision that the well data that the Agency maintains and monitors on a regular basis be computerized, to include data entry, hardware, and appropriate software development. This would allow the Agency to continue their computerization program, and would also provide a means for them to provide data to others (including WERI, the internet, etc.) quickly and easily through use of their computerized databases.

- The bill does not address the issue of cost to access this data. Will it be made available to the general public free of charge, or will WERI be authorized to "sell" this information to those who need it?

Thanks very much for your kind attention and interest in Guam's water resources!!!!



JUL-09-1998 08:10 JULIANNE T DUWEL 6714721897 P.02

UNIVERSITY OF GUAM
UNIBETSEDÅT GUAHAN

WATER AND ENERGY RESEARCH INSTITUTE
OF THE WESTERN PACIFIC

303 University Drive
UOG Station, Mangilao, Guam 96923
Tel: (671) 735-2685 / 2688 • Fax: (671) 734-8890

July 9, 1998

Statement of Mr. John Jocson, Staff Hydrologist, Guam Hydrologic Survey Program, WERI, University of Guam

To: 24th Guam Legislature, Committee on Natural Resources

Madame Chairwoman and Senators:

To support the Guam Hydrologic Survey Program in coming years, I recommend the following amendment to Bill 652:

Section 4. Budget Preparation.
a) Henceforth, WERI shall prepare and submit the annual budget for the Guam Hydrologic Survey to the Legislature by August 1st of each year.

b) In accordance with Public Law 24-161, WERI will work with the USGS to prepare the annual budget for the Comprehensive Monitoring Program. WERI will submit the annual budget for Guam's 50% to the Comprehensive Monitoring Program to the Legislature by August 1st of each year.

BUREAU OF BUDGET & MANAGEMENT RESEARCH
OFFICE OF THE GOVERNOR
Post Office Box 2950, Agana, Guam 96910

CARL T.C. GUTIERREZ
GOVERNOR

MADELEINE Z. BORDALLO
LT. GOVERNOR

JOSEPH E. RIVERA
DIRECTOR

FRANCES J. BALAJADIA
DEPUTY DIRECTOR

JUL 07 1998

The Bureau requests that Bill No(s). 652 (LS) be granted a waiver pursuant to Public Law 12-229 for the following reasons:

"The intent of this legislation is to establish a permanent program for not only collecting, but also for consolidating and storing all of the water resource data on Guam, and for making all of it readily retrievable for use by the people of Guam." The program administrator responsible for subject legislation is WERI (Water and Energy Research Institute) of the University of Guam working in conjunction with two GovGuam agencies, GEPA and GWA, and USGS (United States Geological Survey) and other federal agencies.

It should be noted that the intent of the proposed legislation is administrative in nature and poses no fiscal impact on the General Fund at this time.

7/6 Frances J. Balajadia
FRANCES J. BALAJADIA
Acting
FP. 7/6/98

BUREAU OF BUDGET & MANAGEMENT RESEARCH
OFFICE OF THE GOVERNOR
Post Office Box 2950, Agana, Guam 96910

CARL T.C. GUTIERREZ
GOVERNOR

MADELEINE Z. BORDALLO
LT. GOVERNOR

JOSEPH E. RIVERA
DIRECTOR

FRANCES J. BALAJADIA
DEPUTY DIRECTOR

JUL 07 1998

The Bureau requests that Bill No(s). 652 (LS) be granted a waiver pursuant to Public Law 12-229 for the following reasons:

"The intent of this legislation is to establish a permanent program for not only collecting, but also for consolidating and storing all of the water resource data on Guam, and for making all of it readily retrievable for use by the people of Guam." The program administrator responsible for subject legislation is WERI (Water and Energy Research Institute) of the University of Guam working in conjunction with two GovGuam agencies, GEPA and GWA, and USGS (United States Geological Survey) and other federal agencies.

It should be noted that the intent of the proposed legislation is administrative in nature and poses no fiscal impact on the General Fund at this time.

7/6 Frances J Balajadia
FRANCES J. BALAJADIA
Acting
7/6/98

CARL T.C. GUTIERREZ
GOVERNOR OF GUAM

OFFICE OF THE LEGISLATIVE SECRETARY
ACKNOWLEDGMENT RECEIPT
Received By Tina Gumataotao
Time 4:00 p.m.
Date 4.9.98

APR 09 1998

Refer to Legislative Secretary

The Honorable Antonio R. Unpingco
Speaker
Twenty-Fourth Guam Legislature
Guam Legislature Temporary Building
155 Hesler Street
Agana, Guam 96910

Dear Speaker Unpingco:

Enclosed please find a copy of Substitute Bill No. 487 (COR), "AN ACT TO ADD A NEW CHAPTER 14 TO DIVISION 1 OF TITLE 12 OF THE GUAM CODE ANNOTATED, RELATIVE TO ESTABLISHING A DROUGHT MEASUREMENT AND COMPREHENSIVE WATER CONSERVATION PLAN", which I have **signed** into law today as **Public Law No. 24-161.**

On March 18, 1998, I directed the various departments and agencies of the government to implement the Drought Preparedness & Response Plan adopted by the Drought Response and Water Utilization Coordinating Committee, created on October 14, 1997 by Executive Order No. 97-25.

Substitute Bill No. 487 adopts by statute the U. S. Navy Public Works Center's Water Conservation Levels established by USCINCPAC REP GUAM/CNMI/FSM/ROP INSTRUCTION 11330.1, including any amendments to this instruction, as Guam's drought condition standards and levels of severity.

This legislation provides for the development and adoption of standards for low groundwater (water wells) level conditions, plus severity alert phases. Guam Waterworks Authority is also directed to develop rules and regulations on various water conservation measures and penalties for violating these measures

00739

Office of the Speaker
ANTONIO R. UNPINGCO
Date: 4-9-98
Time: 4:00
Rec'd by:
Print Name: Charlene Dueñas

This legislation also provides for monitoring and maintaining the integrity of Guam's Northern Lens by both government agencies and by the Water and Energy Resource Institute ("WERI") of the University of Guam..

Very truly yours,

Carl T. C. Gutierrez

Attachment

cc: The Honorable Joanne M. S. Brown
Legislative Secretary

TWENTY-FOURTH GUAM LEGISLATURE
1998 (SECOND) Regular Session

CERTIFICATION OF PASSAGE OF AN ACT TO THE GOVERNOR

This is to certify that Substitute Bill No. 487(COR), "AN ACT TO ADD A NEW CHAPTER 14 TO DIVISION 1 OF TITLE 12 OF THE GUAM CODE ANNOTATED, RELATIVE TO ESTABLISHING A DROUGHT MEASUREMENT AND COMPREHENSIVE WATER CONSERVATION PLAN," was on the 27TH day of March, 1998, duly and regularly passed.

ANTONIO R. UNPINGCO
Speaker

Attested:

MARK FORBES
Senator and Acting Legislative Secretary

This Act was received by the Governor this 3rd day of April, 1998, at 10:30 o'clock A.M.

Assistant Staff Officer
Governor's Office

APPROVED:

CARL T. C. GUTIERREZ
Governor of Guam

Date: 4-9-98

Public Law No. 24-161

TWENTY-FOURTH GUAM LEGISLATURE
1998 (SECOND) Regular Session

Bill No. 487 (COR)
As substituted on the Floor.

Introduced by:

J. M.S. Brown
T. C. Ada
F. B. Aguon, Jr.
A. C. Blaz
Felix P. Camacho
Francisco P. Camacho
M. C. Charfauros
E. J. Cruz
W. B.S.M. Flores
Mark Forbes
L. F. Kasperbauer
A. C. Lamorena, V
C. A. Leon Guerrero
L. Leon Guerrero
V. C. Pangelinan
J. C. Salas
A. L.G. Santos
F. E. Santos
A. R. Unpingco
J. Won Pat-Borja

AN ACT TO ADD A NEW CHAPTER 14 TO DIVISION 1 OF TITLE 12 OF THE GUAM CODE ANNOTATED, RELATIVE TO ESTABLISHING A DROUGHT MEASUREMENT AND COMPREHENSIVE WATER CONSERVATION PLAN.

BE IT ENACTED BY THE PEOPLE OF GUAM:

Section 1. A new Chapter 14 is hereby added to Division 1 of Title 12 of the Guam Code Annotated to read as follows:

"CHAPTER 14.

DROUGHT MANAGEMENT AND COMPREHENSIVE WATER CONSERVATION PLAN.

Section 14301. Title. This Chapter shall be known as the *'Guam Drought Management and Comprehensive Water Conservation Plan.'*

Section 14302. Findings. The findings of the Guam Legislature are that:

(a) Guam has two (2) major seasons: wet and dry; and two (2) secondary seasons, referred to as transitional seasons, that can be either rainy or dry. Some years bring torrential typhoon storms while others bring droughts, thus causing a wide variation in annual rainfall figures. The extent of Guam's weather changes is greatly affected by climatic changes that occur in the vast Pacific Ocean, most notably by a weather condition known as *'El Nino,'* characterized by a rise in ocean water temperatures in the central and eastern equatorial Pacific Ocean.

(b) Worldwide climatologists have recently begun to understand the widespread effects that an *El Nino* event has on global weather patterns. Occurring every three (3) to seven (7) years, *El Nino* begins with an eastward shift of warm Pacific Ocean waters, which disrupts normal atmosphere wind patterns and thus upsets normal patterns of wet and dry weather. Some areas that do not usually get rain are hit hard, while many normally wet areas dry up. The Western Pacific is especially susceptible

to these dry periods.

(c) The effects of *El Nino* on Guam's wet and dry seasons have been significant. The 1982-1983 event, which cost global damage estimated at Thirteen Billion Dollars ($13,000,000,000) and claimed nearly two thousand (2,000) lives, was one (1) of Guam's most severe dry period. During this period, the Island's municipal water system was unable to adequately meet Island-wide water demands, particularly for fire fighting. Severe water shortages and outages were experienced in the villages of Merizo and Umatac as springs and surface water sources dried up. While a less severe *El Nino* drought followed in 1986, which lasted through 1987, the Guam Waterworks Authority ('GWA') fell short of meeting normal daily water demands. A prolonged *El Nino* event from 1991 to 1995 again resulted in the Island's water system's inability to meet demands during abnormally dry spells. The Island's current water system is not able to meet current peak demands and will have a difficult time meeting future non-peak demands without development of additional water source alternatives.

(d) Because previous *El Nino* events have been met with short-term crisis, intervention measures, such as water rationing and scheduled water outages, it is recognized that a long-term water resource management plan is non-existent. The lack of such a plan increases the Island's vulnerability to drought or water shortages due to extremely dry conditions. Since the scientific community has now come to understand that *El Ninos* are cyclical in nature and that certain weather changes are predictable, a plan is imperative so that management and allocation of our finite water resources

be balanced among the populace whenever disruptions in weather conditions and normal rainfall patterns threaten the availability of our water supply.

(e) While the Territorial Emergency Plan maintained and administered by the Guam Civil Defense includes 'drought' or 'water shortages' in its definition, the scope of the plan in this regard does not define, in specific terms and standard terminology, factors that trigger a drought condition, the severity of the conditions, and actions or measures to employ for each phase of severity.

(f) Because of the physical size and remoteness of Guam, it is imperative that the utilization of water resources among the military and civilian sectors be fair and equitable, and that measures employed to mitigate the effects of water shortages due to drought must be done so uniformly among the various sections of our Island community. No such plan exists to ensure uniformity and equity in the administration of water crisis mitigation measures.

Section 14303. Adoption of Drought Condition Standards and Low Groundwater Level Conditions and Severity Alert Phases.

(a) Fena Reservoir, owned and operated by the U. S. Navy Public Works Center ('PWC'), is the largest source of potable surface water supply on Guam. Currently, government of Guam's overall water production includes purchases of approximately seventy percent (70%) of Fena Reservoir's total production, and thus negative changes in Fena's water level reduces GWA's overall water supply for civilian users. Therefore, PWC's Water Conservation Levels ('WCL'), established by USCINCPAC

REP GUAM/CNMI/FSM/ROP INSTRUCTION 11330.1, including any amendments thereto, are hereby adopted as the Island's drought condition standards and levels of severity, and are to be made an integral part of the Guam Drought Management and Comprehensive Water Conservation Plan.

(b) Concurrently, and in addition to adoption of PWC's Fena-level WCL, standards for low groundwater (water wells) level conditions, plus severity alert phases, shall be developed and adopted as an integral part of the Guam Drought Management and Comprehensive Water Conservation Plan.

Section 14304. Governor's Powers. The Governor shall, due to the emergency drought conditions existing on Island, immediately develop the Guam Drought Management and Comprehensive Water Conservation Plan to respond to water crises and water shortages. Said plan shall be filed with the Guam Legislature no later than April 15, 1998 and shall be implemented on the filing date. The Guam Legislature may approve, disapprove or modify the plan.

Section 14305. Implementing Rules and Regulations. GWA shall enact the rules and regulations, which shall include: steps for instituting conservation measures and the interruption of the water supply; procedures for the protection of water resources pursuant to GWA's statutory role as operator of Guam's sole municipal water and wastewater systems; mandatory restrictions and procedures for control of water use during water shortages; procedures to alert the community on the severity phases pursuant to §14303 of this Article; and penalties for violations of the

rules and regulations.

Section 14306. Coordination, Guam Environmental Protection Agency, Private Well Owners, and Military. The Guam EPA, in coordination with GWA, the Department of Commerce, and all private and military well owners and operators, shall collect salinity and chloride on a monthly basis during drought conditions for use in determining low groundwater level conditions as required in §14303(b) of this Chapter and other such data as may be deemed necessary to monitor and maintain the integrity of Guam's sole source aquifer, the Northern Lens. GEPA's determination that drought condition exist shall be based on the best scientific advice from WERI, National Weather Service, National Oceanographic Atmospheric Administration and other appropriate agencies, that a rise in Pacific Ocean temperatures is indicative of the onset of drought conditions on Guam."

Section 2. Comprehensive Monitoring Program. Henceforth, the Water and Energy Resource Institute ("WERI") of the University of Guam shall conduct and administer a Comprehensive Monitoring Program regarding data collection on salt water intrusion, water lens thickness in the northern part of Guam, stream flow data in the southern part of Guam and related matters. Said program shall be administered in conjunction with the United States Geological Survey ("USGS") and monitoring program.

Section 3. There is hereby appropriated from the General Fund to the Water and Energy Research Institute ("WERI") of the University of Guam the sum of Three Hundred Twenty Thousand Dollars ($320,000.00) to provide for the immediate reinstatement and administration of the Comprehensive Monitoring

Program with the United States Geological Survey ("USGS") and WERI's obligations related thereto."

P.L24-161

Office of Senator
Joanne M. Salas Brown
Twenty-Fourth Guam Legislature

March 11, 1998

Speaker Antonio R. Unpingco
Twenty-Fourth Guam Legislature
155 Hesler Street
Agana, Guam 96910

Dear Speaker Unpingco:

The Committee on Natural Resources, to which **Bill 487(COR) An Act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan** was referred, wishes to report back to the Legislature its recommendation **TO DO PASS.**

The voting sheet is as follows:

TO PASS	9
NOT TO PASS	0
ABSTAIN	0
TO PLACE IN INACTIVE FILE	0

Copies of the Committee Report and other pertinent documents are enclosed.

Thank you for your attention to this matter.

Sincerely,

JOANNE M. S. BROWN
Senator

Enclosures

Legislative Secretary Chairperson, Committee on Natural Resources
Suite 200 • 130 Aspinall Street • Agana, Guam 96910 Phone: 472-3450 • Fax: 472-4090
Printed on recycled paper

Office of Senator

Joanne M. Salas Brown

Twenty-Fourth Guam Legislature

March 11, 1998

MEMORANDUM

To: Committee Members

From: Chairperson, Committee on Natural Resources

Subject: Bill 487(COR) An Act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan

Transmitted herewith for your consideration and action is our Committee Report on the above subject matter.

Please indicate your choice on the Attached Voting Sheet and return the documents to my office for transmittal to the other members.

Should you have any questions on the narrative report on the accompanying documents, I would be most happy to answer them.

Your attention and cooperation in this matter is greatly appreciated.

JOANNE M. S. BROWN

Attachments

Legislative Secretary Chairperson, Committee on Natural Resources
Suite 200 • 130 Aspinall Street • Agana, Guam 96910 Phone: 472-3450 • Fax: 472-4090

Printed on recycled paper

Committee on Natural Resources
Joanne M.S. Brown
Chairperson

VOTING SHEET

Committee Report Bill 487(COR)

COMMITTEE MEMBERS	TO DO PASS	NOT TO PASS	ABSTAIN	TO PLACE IN INACTIVE FILE	SIGNATURE
Joanne M.S. Brown Chairperson	✓				
Tony Lamorena Vice Chairman	✓				
E. Barrett-Anderson Member	✓				
Tom Ada Member					
C. Leon Guerrero Member	✓				
Mark Forbes Member	✓				
Francis Santos Member	✓				
M. Charfauros Member	✓				
Anthony Blaz Member	✓				
J. Won Pat-Borja Member	✓				
A.R. Unpingco Speaker Ex-Oficio Member					

Committee on Natural Resources

Public Hearing on

Bill No. 487(COR)

An Act to add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan.

Committee Report

The Committee on Natural Resources held a public hearing on Bill No. 487(COR), 'An act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan' on Thursday, March 5, 1998.

Present were: Senator Joanne M. S. Brown, Chairperson
Senator Frank B. Aguon, Jr.
Senator Frank Camacho
Senator Lawrence Kasperbauer

Senator Brown thanked everyone for their attendance despite their heavy schedule and began the hearing with testimonies relative to Bill No. 487. She called Dr. Leroy Heitz to begin the testimony and asked Mr. John Rosario, Mr. Jordan Kaye, Mr. Bert Johnston, and Dr. H. G. Siegrist to join the group.

Senator Frank Aguon was introduced.

Dr. H. G. Siegrist, Jr., Director of the Water & Energy Research Institute (WERI) of the Western Pacific , University of Guam, read his testimony in support of Bill No. 487(COR). He stated that WERI is contributing a share to solving what could easily evolve into a major water crisis, and considers this a serious business. His testimony pointed on various areas that can be affected through the El-Nino drought and called upon our legislators to make some tough decisions to protect our water supplies. (See attached for complete testimony)

Dr. Leroy Heitz, Water Resources Engineer and Researcher, also from the Water and Energy Research Institute (WERI) stated that the El Nino drought that is affecting our part of the Pacific is one of the strongest droughts in this century. He pointed out that as growth in demand stretches our fresh water supply more and more thinly, relative modest droughts will have increasingly severe effects on our island's water supply. Congratulated the committee on its efforts in the development of a formalized drought response plan for our island. Feels that the bill could be substantially strengthened if direct economic incentives were added to the strategies for promoting conservation, otherwise it would not be effective. Guam Waterworks Authority should be directed to develop such a conservation incentive rate structure as part of the total plan. In support of Bill No. 487 and hopes the committee will act favorably on their suggestions to strengthen this important bill.(See attached for complete testimony)

Senator Brown thanked Dr. Heitz for his testimony and called upon Mr. Johnston from the Guam Waterworks Authority.

Mr. Johnston asked of the Chair to have Mr. Clifford Guzman from the Governor's office join them and because of his tight schedule allowed him to go before him, and also, Mr. Roman Quinata, Acting Chairman, Guam Waterworks Authority, Board of Directors.

Mr. Clifford Guzman, Director, Bureau of Planning, stated he was there on behalf of the Governor to read his testimony. The Governor went on record in support of a new law to deal with the threat of a serious drought on Guam, and commended Senator Brown for introducing Bill No. 487(COR) which he endorses. (See attached testimony)

Senator Brown thanked Mr. Guzman for the Governor's written testimony and also extended her thanks to the Governor. She stated that there will be many issues which will be dealt with within the upcoming months, however, the issue of water resource and the protection of that and the insurance that our people are going to continue to have it rises above all issues. Appreciates the Governor for extending that hand of cooperation and will work with him in the upcoming months to implement this law when it gets in place and certainly brings up a very valuable point that the Governor has in his letter with regards to public outreach. There is not enough education out there and feels that we need to take the

disadvantage of this year and use it as an opportunity to get more public awareness out in the community because it is an issue that is going to face the community year after year.

Recognized Senator Aguon for any comments or questions for Mr. Guzman before he leaves.

Senator Aguon stated his biggest concern is:

- What needs to be done immediately to ensure that we can be able to have an effective water conservation program?
- What has to be done immediately and how can the community contribute to this process?

Mr. Guzman responded:

- The Drought Preparedness and Response Plan outlines some course of action in the immediate and long term.
- Community awareness and a concerted effort on everyone's part to make sure that conservation measures were imposed.
- On the economic development side, builders are being encouraged to use energy saving equipment.
- Everyone needs to do their part, and the Drought Preparedness and Response Plan submitted in its draft form will be an opportunity for everyone to work together to do what we can to make it better.
- WERI has been a big part of this and we are very pleased that they have been up front in their act of participation and congratulate them.

Senator Aguon commented that:

- The Executive Director of the Guam Hotel and Restaurant Association was posed a question by the students at the University of Guam with reference to conservation measures.
- The Executive Director responded to the students at the University of Guam that the hotels are already contributing to the conservation effort and they are all aggressive in terms of minimizing any excess use or unnecessary use of water here in our community.

- That needed to be said for the record.
- Feel very strongly that in addition to the Governor formulating a plan and having it implemented, from a personal viewpoint, it needs the reinforcement of law.
- Going to be a difficult decision on our part as policymakers, but it is a type of decision that we have to face. If we have to come together as a community, it may need to some extent a force of law so that our people can understand, and that there can be enforcement measures and mechanisms in place to ensure that conservation continues according to projected plans.

Senator Brown stated that Senator Aguon brought up a very valid point and further added:

- The crises is upon us and have not put a lot of focus or interest with regards to our water resource.
- Evident in the amount of support in funding that is given to do the kind of research that needs to be done, but at the same time do not want to look at it as a disadvantage.
- This is a prime opportunity to get awareness out there.
- With regards to incentives, we can put penalties for just incentives, but need to also put benefits for incentives. Perhaps if consumers out in the community are using less water than on average then they normally do, perhaps, a certain percentage off their bill can be given.
- With the big hotels, perhaps with qualifying certificates, this has not been a priority in the past, can be amended to include that any construction or facilities particularly like the size of a hotel, doing 500-600 rooms who are major consumers, can be given a tax break or tax incentive if they put conservation measures into the construction of their hotels in terms of to the type of bathroom facilities that are used, that will reduce the amount of water consumed. This is an opportunity for us to get this awareness out there, set the standards, because the doctors from WERI are telling us this is not something we are not just going to deal with in 1998 and go away.
- Recognized the concern and it is a crisis issue at this point.

Senator Frank Camacho commented that he would like to be updated or made aware of some of the wells that the water levels has been going down. He mentioned that the water level in one of the wells located in the golf courses has gone down considerably and it is not even pumping. The signs are all out there evident of the drought crisis and we have to make sure that an island-wide participation in conserving water is there.

Senator Brown recognized Mr. Roman Quinata, Acting Chairman, Guam Waterworks Authority.

Mr. Quinata testified in support of Bill No. 487(COR). He stated Bill No. 487 is a very important piece of legislation and should have been introduced a long time ago. He further stated that a plan is just merely a plan with no guarantee of its implementation, but if a plan is required by legislation, the plan carries the force of law and must be implemented. Bill 487 requires the Guam Waterworks Authority to come up with a Drought plan and spell out in specific terms how water distribution and uses are to be managed during an emergency shortage, as well as what actions are needed to ensure that the plan is followed. It also empowers the Guam Waterworks Authority on behalf of the Government of Guam to take the lead in instituting measures for the wise use of water and to prevent waste and abuse of this vital resource. (See attached for complete testimony)

Senator Brown thanked Mr. Quinata, and also introduced Senator Larry Kasperbauer. To continue on with the testimonies, she called upon Mr. Herbert Johnston.

Mr. Johnston stated his name for the record and was there representing Mr. Richard Quintanilla, General Manager of the Guam Waterworks Authority. Mr. Johnston testified in support of Bill 487 and stated it is a timely piece of legislation that is long overdue. Bill 487 will allow the authority to implement a course of action that will mitigate the effects of a prolonged dry period this year as well as prepare itself for future adverse climatic situations taxing our islandwide water system. Appreciates the provisions of Sections 14304 and 14305 which grants the executive branch the authority to establish and implement mandatory restrictions and procedures for control of water use during severe shortages, as well as impose fines and penalties for violators of the restrictions. The urgency created by El Nino necessitates that the Governor's powers be broadened to

implement restrictive and punitive measures in the shortest time possible and asked that Section 14304 be revised so that the last sentence is replaced with the following: "The Governor shall proceed with implementation of such plan, when required, without further legislative approval or PUC regulations in coordination with the Guam Waterworks Authority." and asked that the following be added to Bill 487: "Section 14308. Authorization to accept Military Conveyance of U. S. Navy "Ace Corp" Well and U. S. Air Force Tumon Maui Well, and General Authorization to Establish Mutual Cooperation and Coordination for System Integration and Interoperability. (See attached for complete testimony)

Senator Brown thanked Mr. Johnston for his testimony and asked Mr. Jordan Kaye, Guam Environmental Protection Agency, (GEPA) if he was the chief representative from EPA to do a presentation.

Mr. Kaye apologized for the Administrator, Mr. Salas' absence, who was on a medical appointment and stated that the agency is in support of the bill and have no objections to it. GEPA will work with Guam Waterworks Authority to make sure it is implemented and put in place once it becomes law.

Senator Brown directed her inquiry to Mr. Johnston with reference to GWA's proposal with the incentives or penalties:

- Inquired if the amounts have been determined;
- Are they different classes in terms of users during household use, hotel operation use, is there anything set out already that GWA would like to propose, or is it something that will need to be incorporated in the bill itself, or is it still being worked on.
- Would not like to hold off the passage of the bill with regards to setting the conditions and standards needed for El Nino, but specifically be able to do the monitoring and enforcement work, is GWA imposing penalties?
- The other senators would like to see that a balance is done with reference to incentives for the people who go the extra effort to reduce the amount of water they consume.

Mr. Johnston responded:

- That the figures are being worked on, and agreed that penalties should be used as a last resort.
- GWA does not want to get in the business of being the water police. Would rather encourage people to take this under their own measures. Incentives are the right direction.
- The large water users have already taken those measures because it makes economic sense.
- It is the large residential customers that GWA needs to focus on and start providing incentives for them in terms of reworking the fixtures, and go after their misuse of water, get their behavior to be more water conscious.
- GWA does not like to use penalties and should be only there as a deterrent, but very carefully implemented.

Senator Brown inquired what is the timeline of when the penalties are to be completed so the committee members can look at them.

Mr. Johnston responded that it should be completed within a month.

Senator Brown referred to a question by Mr. Johnston that GWA should have an addition to the bill with regards to the procurement or acquisition of the Navy and Air Force well. She stated that:

- GWA would have to meet with all key players before the next session to discuss and come to some consensus on whether or not it is truly in our best interest to acquire those wells.
- Have reservations with the Navy and Tumon Maui well, especially, the Tumon Maui well because of concerns of contaminants in the well.
- Very apprehensive with the government of Guam acquiring property that will have to be dealt with issues of clean-up even though the Tumon Maui well does the air stripping process so the well will continue to supply water to the Andersen Air Force Base.
- This is a very serious issue and understands the desire of Guam Waterworks to obtain these properties, but at the same time wants to ensure that it is in the community's best interest that we acquire

property that we already have concerns with regards to contaminants. These are the issues that are going to accelerate the level of discussion in order to come to consensus is it in the best interest of our community to acquire property with known contaminants, otherwise, it will have to be addressed on a separate piece of legislation.

Senator Aguon inquired:

- What is the agency's request to reword the particular section which states "would grant the governor the opportunity to implement such a plan"?
- What is the status of the plan?
- Is it complete, or is it going to require an additional 2-3 weeks work?

Mr. Johnston responded that the draft copy of the plan had been submitted to the committee this morning.

Senator Aguon inquired:

- Is the draft is in its final form?
- What are we looking at in terms of time frame?

Mr. Johnston responded it is a draft, and again, should be completed within a month. The draft also gives the opportunity to be reviewed and give feedback to GWA.

Senator Aguon stated:

- Concern with the particular provision being placed in the draft plan because anytime a plan is formulated and penalties are going to be imposed, the other colleagues will come into play and should be provided with the final plan to review in order to make their decision.
- Understood the urgency of the situation at hand, however, he did not know that a draft plan had been provided to the committee and appreciated that as it would give the others the opportunity to review the plan.
- If the plan is completed before this particular proposal is entertained in session, the likelihood of it going through with the consent of his

colleagues would be much better in terms of being able to ensure a plan is consented to by the body itself.

- Another concern are the water leakages.
- What are we looking at in terms of water leakages that are under the jurisdiction of Guam Waterworks Authority?
- Are there aggressive efforts to ensure that at least all of them are discovered within the next 2-3 months?
- Has there been a plan implemented so that in fact we can put emphasis on that aspect in conjunction with the community effort?

Mr. Johnston responded:

- Discovery of the leaks have not been that difficult.
- The part of GWA's concern is how fast can they respond to the discovery of those leaks.
- Leak detection crews have gone through and implemented response to some trouble areas.
- GWA has a 24 hour crew that is responding to leaks as they are called in.

Senator Aguon suggested and also inquired:

- On top of the educational awareness to also incorporate a line 'to please call GWA if leaks are discovered.' This will remind people to place a call to GWA if they discover a leak.
- Based on GWA's assessment at this time, what percentages are we looking at in terms of possible leakages in the system?

Mr. Johnston asked for clarification if it was a percentage of water loss or percentage of leaks that have not been addressed?

Senator Aguon responded:

- A percentage of water loss that has not been accounted for that are not being paid by the consumers and are not being consumed by the consumers. Basically, leakages.

Mr. Johnston responded:

- GWA had a recent water audit and showed there were 20% leakages in some areas, and those areas that are serviced by galvanized pipes installed a long time ago are a little bit higher.
- GWA is aggressively addressing these situations. In other areas, waterlines had to be replaced because it made better sense, than it did to put a series of sleeves on the pipe.

Senator Aguon stated:

- We need to have a comfort level to ensure that GWA is proceeding with an aggressive program to address the leakages out in the system.
- Emphasis on that particular effort has to be increased or quadrupled to an extent because of the drought that is impending.
- GWA has to double the reinforcement on that particular program and aggressive efforts made to ensure no further leakages occur.
- Would like to see the plan completed before this particular proposal can be entertained in session as it would also assist the colleagues in moving forward and ensuring an acceptable plan is adopted.

Mr. Johnston responded:

- GWA shares the same concerns, but given the age of the system in some areas, there will always be leaks.
- It is incumbent upon GWA to clean up their act first, before they ask the community.
- Important part of the conservation program is their response. The leaks will always be there, but will try to track them as fast as we can and try to speed up the process, but the water loss is not as important as the image of the fact that our system is leaking.

Senator Aguon commented that when a very aggressive education awareness and conservation plan goes forth, calls will be heard going into K-57 and other media sources saying, 'here's GWA implementing a conservation plan and imposing all these penalties, and have a leak out in my home. That is why he made the suggestion

that in conjunction with the education program, that GWA also incorporate an aspect where in fact our consumers identify a leak, to please report it immediately to GWA.

Senator Brown stated:

- Some of those key provisions that were brought out in his testimony were omitted because he does not want to sabotage the rest of the bill. Experience on the legislative floor has dictated that things just go out very quickly.
- We are in the height of the political season and do not want key issues that we need passed this month to be held back.
- Senator Aguon brought up a good point that if the information is available before the session in a week and a half and are able to look at it, we can get a feel from the other colleagues as to whether or not this is something they want to entertain.
- Does not want to sabotage the key issues and would like to facilitate the bill. Mentioned that session is scheduled every month, even if the bill comes back a month later, it can be entertained the following month . If it is that serious and the Governor needs his Authority, then it can be looked at.

Senator Camacho suggested that:

- There should be some phases of implementation, such as a voluntary, mandatory, and enforcement time period.
- Notification process is probably needed, because radio and TV may not be enough.
- The mayors should be involved in the event there is going to be some penalty.
- If enforcement measures have reached a point where people are going to be penalized for usage that are not under the authorized uses, then each household is notified that the enforcement process starts.
- Very important that the word is out once enforcement is out and penalties are to be imposed.

Mr. Quinata stated:

- It is very difficult to set penalties, especially when GWA produces 44M production per day, and lose 19.36M gallons per day.
- GWA should start cleaning house first before they start penalizing people.
- Big percentage of unaccounted water is in the non-registry meter. The other is the fire-fighting usage under forestry. These are not metered, but GWA still has to come out with numbers.
- The water conservation dictates numbers as to what is 10 low, and maybe 15 or 20 high to educate many of the residential areas.
- Looking at assisting the farmers as far as irrigation is concerned. GWA can subsidize by means of pumps to get them off from using tap water because of its high expense.

Senator Camacho responded:

- Was referring towards the development of the plan where mandatory water usage is enforced if a certain shortage of water level is reached. The plan should address the worse.
- People from WERI have assisted the other neighboring islands of Micronesia to provide some kind of a catchment system. We're not that remote that we cannot start implementing the catchment system for the farmers.
- Wanted to ensure that we look at the phases of implementation through the educational and notification process as part of the plan when it is developed before we start penalizing.

Mr. Quinata stated the cooperation of the community is needed. The Navy can not develop any water supplies because they can not go out and drill more wells like government of Guam. FENA dam is there and that is how their plan is set.

Senator Camacho suggested that perhaps people from WERI can assist the farmers in some catchment system to supplement areas where water ration is mandatory. If it gets too severe, it may be possible to tap our water lens where stringent measures call for. This is something UOG can get involved in programs to develop and make those things available for our agricultural people.

Senator Brown stated a legitimate point has been brought up with the public outreach:

- We have to look at the realities, as there will be production of less surface water resources down south.
- The more information you give, the more people will be aware so they can be prepared to face the water crisis. The more work that is done to educate people and keep people aware, and working together, we can get through this. This is the message we have to get out there.
- Extra phone lines specifically dedicated to the water watch line be provided to report leakages and people abusing the use of water to call in If people are not manning it, then an answering machine should be made available. Make it more user friendly for people to get involved in the process. We can legislate all we want, but if we don't get the community's support, it is not going to happen. It is a very important component and look forward to your educational campaign, be it through informational leaflets or people informing them of set standards. These are important things that need to be done and have to go back and keep reenforcing because it is going to take a while to sink in.

Senator Kasperbauer commented areas of concern not addressed in the draft proposal.

- Part of the education process is having the public become aware of leaks that are highly visible, as an example major water lines in areas where the grass is so green.
- Very discouraging where pipe is ruptured like a geyser and has been reported, and the response time is so slow that thousands of gallons of water has gone.
- How rapid GWA can respond is very important for the image as well as saving the water.
- Other area is the leaks in the home (which he did not see addressed in the plan) Leaks in the shower because the washer is damaged. Also water leaks in government offices. Poor example in government offices when you see the leaks in the toilets running.
- Other concern is making sure we are educated on the balance between

the business and the consumer, let alone the difference between the military and local.

- How do we justify the water conservation of the golf courses and the hotels where there are signs on the tables on the restaurant, saying that water is a precious thing.
- Concern about washing our cars and how do we deal with businesses that make a living on using water, like car wash, etc. Was not referenced in the draft proposal, nor heard about farmers who irrigate their farms.

Senator Brown thanked Mr. Quinata, Mr. Johnston, Mr. Jordan Kaye for coming down to testify on Bill No. 487. She also inquired if anyone else who has not sign the Sign In Sheet wishes to come up and testify. She recognized Mr. Norbert Perez.

Mr. Perez stated his name for the record as the President of the Republic of Guahan. Testified orally in favor of this bill, however, extended some reservations as far as the intent of the bill. Believed it is a very good bill and long time coming. It should have been here many, many years ago. His concerns are the penalties involved that was mentioned in the testimony and even in the bill itself. That we are working out provisions for penalties to penalize people for wasting water. It concerns the whole republic, because the biggest waste management we have is Guam Waterworks Authority. If they are providing or pumping out 3 billon gallons of water and they are only billing 1 billion, there is a loss of X number of water, and where is that going to? This is why the republic is very concerned of the bill, although, they support the bill, it is a measure that needs to be done and implemented as soon as possible. Also applaud the effort that GWA has done in the recent past that they are trying to accommodate these issues and these situations, but they can do a lot more by coming around and do the type of monitoring that is needed so they can tell and do a statistical data on what type of water usage and usary, we can come up with a very progressive plan in trying to implement this conservation measure. Our main concern is the waste of water, and if GWA is going to advise the public that they are going to penalize $20 for wasting water when the government is the biggest waste, they are not going to buy it.

Senator Brown thanked Mr. Perez, and asked the next speaker to read his testimony.

Mr. Kramer testified in support of Bill No. 487 and stated his name for the record

as Mark Kramer of Earth, Tech, Inc., Office Regional Manager. Have always in the past advocated both working from the demand management side as well as the supply side. With respect to the penalties, realized that they are lot of problems within the system at Guam Waterworks Authority and worked with them a lot in trying to address them, but GWA is actively addressing a lot of the key issues. His thought was it should not be used as an excuse to allow the common citizen to go ahead and waste water blatantly. Believe that the conscientious citizen will do the voluntary conservation measures, and with a little incentive, the average citizen will too. But there is always going to be those people, that unless you have a disincentive, they are just going to ignore anything they ask them to do. The other thing he will like to see addressed is Section 14306, and would like to see it go further than that. Realized that for this drought situation, it is very good to give them and WERI the salinity and chloride data from all the wells, but also believe that there should be repository for information that is generated through any kind of well drilling operation. Have discussed this with GPA and would continue to be the managing authority, but with samples collected from cutting during drillings, these could be passed on to WERI and they could identify them a lot more clearer than what we can in the field as to what particular materials it is and then add it on to their GIS model. In conclusion, it was reported in the Pacific Daily News that Earth Tech is in the process of working an agreement where we are going to try to get 2 1/2M per day on line within about 90 days. At the same time, GWA is pursuing about 20 wells which will get 2-3M gals of water, but this will take time, but believe this bill should be put into law as soon as possible. Please pass this bill, and if you can put a little "teeth" or modify it a little bit, then all the better.

Senator Brown commented that Mr. Kramer does have a good point and also stated:

- That the committee has had meetings and will continue to have meetings to ensure continued dialogue between GWA, GEPA and WERI.
- Concern has been brought up time and time again with regards to being able to collect the information, be it GWA going out and hiring a driller to go out or some private company does it.
- No records have been kept in the past and information is not readily available.
- Meeting was held in January and another scheduled meeting in April to continue to dialogue and make sure the context that are being said between these key agencies and WERI at the University as being

maintained in that dialogue and sharing of information is maintained.

- The hydrogeologic survey is working to ensure that in the future information is readily accessible to those doing the study, those who are managing the utility, and those who are having to regulate it.
- Information should be ready to the students who wants to study in this field, and anyone in the general public who may want to study this issue. Again, this was not made a priority in the past, and it is something that we should, particularly with what we are facing.
- Make this a priority and makes sure this information is available, when the time comes to provide for additional funding, her colleagues will be supportive of it.

Senator Camacho commented with reference to the government buildings which have a lot of leakages. This is the first thing that GWA and the government of Guam should address. They have been detected, but it comes along with the attitude that "it is not their building and not paying the bill". These are the leakages that need the attention of GWA.

Senator Brown stated that Guam Waterworks has been tasked with a lot, the Governor's proposed plan can include that all departments and agencies are in full compliance with these conditions that we are setting up for the general public.

Mr. Perez stated he has been around visiting the wells and the pump stations and have come across several without any kind of security measures and the biggest thing is anybody can just go in there. We need to find a way to protect our people some way or another.

Senator Kasperbauer stated that although we talk about leakages in government buildings and homes, it is different level that is being discussed, and needs to be corrected.

Mr. Kramer responded:

- It is going to require a big combination of various number of activities to get us through this drought. Granted, one individual in and of himself that you are not talking a heck of a lot of water, but when you are talking 40,000 connections, it really adds up fast.

- Do not need to go and punish people, but with the proper incentives and disincentives with very little effort, people can save a considerable amount of money and water, and in some of the analysis done in the past, it could mean a difference of having to building surface water source in 2004 and being able to push out to 2008.
- The longer we can go without surface water sources and the higher cost of treatment, the better and that was without taking the El Nino into account. With the way the El Nino is developing rapidly, then there is a lot more critical nature into getting these things in place.

Senator Kasperbauer stated that his concern was not to focus only on the residents, or individuals, and let all the other wastage continue to go.

Mr. Perez responded, that he was more in tune of giving people incentives rather than billing or charging them, or putting them through paying off. (for example if their usage of water for this month is like 30,000 gals, then they are billed a certain way or given a disincentive). Looking more on incentives where people are given incentives for cutting back, reducing for conserving.

Senator Brown thanked Mr. Perez and inquired if there were any more testimony on Bill 487.

Public Hearing on Bill 487 adjourned at 11:25 a.m.

FISCAL NOTE
BUREAU OF BUDGET AND MANAGEMENT RESEARCH

BBMR-F7

Bill No.: 487 (COR)
Amendatory Bill: Yes

Date Received: February 20, 1998
Date Reviewed: March 12, 1998

Department/Agency Affected: Guam Waterworks Authority
Department/Agency Head: Richard A. Quintanilla
Total FY Appropriation to Date: $ -0-

Bill Title (preamble): AN ACT TO ADD NEW ARTICLE 3 TO CHAPTER 14, TITLE 12 OF THE GUAM CODE ANNOTATED RELATIVE TO ESTABLISHING A DROUGHT MEASUREMENT AND COMPREHENSIVE WATER CONSERVATION PLAN.

Change in Law: Adds new Article 3 to Chapter 14, tile 12 of the Guam Code Annotated.

Bill's Impact on Present Program Funding:
Increase: See attached **Decrease** _____ **Reallocation** _____ **No Change** _____
Bill is for:
Operations _____ **Capital Improvement** _____ **Other** _____

FINANCIAL/PROGRAM IMPACT

ESTIMATED SINGLE-YEAR FUND REQUIREMENTS (Per Bill)

PROGRAM CATEGORY	GENERAL FUND	OTHER	TOTAL
Utilities and Infrastructure	See attached comments.		

ESTIMATED MULTI-YEAR FUND REQUIREMENTS (Per Bill)

FUND	1st	2nd	3rd	4th	5th	TOTAL
GENERAL						
OTHER						
TOTAL						

FUNDS ADEQUATE TO COVER INTENT OF THE BILL? N/A **IF NO, ADD'L AMOUNT REQUIRED:** _____
AGENCY/PERSON/DATE CONTACTED: See attached comments.

ESTIMATED POTENTIAL MULTI-YEAR REVENUES

FUND	1st	2nd	3rd	4th	5th	TOTAL
GENERAL FUND						
OTHER						
TOTAL						

ANALYST Carlos P. Bordallo **DATE** 3/11/98 **DIRECTOR** JOSEPH E. RIVERA **DATE** MAR 12 1998

Comments on Bill 487 (COR)

While there is no outright appropriation entailed in Bill 487, there may be an adverse fiscal impact to revenues of the Guam Waterworks Authority if conservation measures and interruptions of water supply are implemented. The extent of any adverse fiscal impact would be dependent upon the limitation of water services imposed upon customers. In addition, businesses and individuals involved which are highly dependent upon a steady supply of water, such as the agriculture and hotel industry, may be affected.

The General Fund revenues available for appropriation, as adopted in Public Law 24-59, is $353,292,790 (includes $7,600,000 Autonomous Agency Fund, $7,000,000 Use Tax and $36,000,000 in Section 30 Funds). The appropriations for FY 1998 in P.L. 24-59 is $346,128,092 plus continuing appropriations for debt service of $2,504,141 for a total appropriation against of $348,632,234. Pursuant to P.L. 24-59, surplus FY1998 revenues available for appropriations is $4.6M.

However, it should be noted that Section 30 revenues are expected to be reduced by $1,047,129 and the expected combined collection from both the Autonomous Agency Fund and the Use Tax is only $3.0M, a reduction of $11.6M ($14.6 - 3.0=$11.6). Thus, it is anticipated that the FY1998 revenues will be reduced by $12.6M to a level of $340,692,790. As such, $340,692,790 in revenues less $348,632, 234 in appropriations leaves an **expected shortfall of ($7,939,444) as of P.L. 24-59.**

COMMITTEE ON NATURAL RESOURCES

Senator Joanne M. S. Brown
Chairperson

Public Hearing

Thursday, March 5, 1998
10:00 a.m.

AGENDA

1. **Introduction of Committee Members**

2. **Commencement of Public Hearing**

Bill No 487(COR)

'An Act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan'

Bill No. 504(C0R)

'An Act to Establish Rules and Regulations for the Guam Environmental Protection Agency for the Solid Waste Disposal'

3. **Public Comment**

4. **Adjournment**

UFISINAN I MAGA'LAHI
TERITORION GUAM

MAR 0 5 1998

The Honorable Joanne M. Salas Brown
Chairperson
Committee on Natural Resources
Twenty-Fourth Guam Legislature
130 Aspinal Street
Agana, Guam 96910

Dear Madame Chairperson,

I submit this testimony in support of Bill 487 (COR), "An Act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan."

I am pleased to go on record in support of a new law to deal with the threat of a serious drought on Guam. In the spirit of bi-partisan cooperation, I commend you for introducing Bill 487 (COR) which I write here to endorse. I have asked the Director of the Bureau of Planning, Mr. Clifford Guzman, to represent me at your bill's public hearing today, to emphasize my willingness to work closely with you in formulating and implementing aggressive drought response measures.

The threat of prolonged drought is very real. Extreme dryness from El Niño during this year's dry season months is expected to extend beyond September of this year, and promises to surpass any previous dry periods recorded for Guam. The absence of any significant rainfall will affect the Guam Waterworks Authority's surface and spring sources, diminishing the Authority's overall production yield for island residents. We are anticipating the worst, and therefore see an urgent need to institute mitigation measures islandwide.

Bill 487 (COR) provides uniform Guam standards for measuring the severity of drought conditions. The bill also establishes an islandwide alert system and response action. The measurement, alert and response system, set forth by Bill 487 (COR), has been successfully administered in Guam by the United States Navy for many years. The Guam Waterworks Authority voluntarily administers this system through an administrative agreement with the Navy. The system works and the time has come to make it mandatory.

Bill 487 (COR) also empowers the Governor to develop and implement a drought management and water conservation plan to respond to the water crises we perceive. On October 14, 1997, I issued Executive Order 97-25 to set up a Drought Response and

Doc. No. 35GL-20-2107.*

Water Utilization Coordinating Committee to begin drafting the Governor's plan. Just last week the Committee finalized its draft plan. And while we will be putting this plan into effect in the coming weeks, I also believe that the plan should have the force of law behind it. I have attached the draft plan for your consideration as Bill 487 (COR) is marked up.

The Guam Waterworks Authority (GWA) has been working to develop a conservation public education campaign. GWA is also working with large commercial property managers and government facility managers to institute voluntary conservation measures. I have also asked GWA to again reinforce our commitment to set an example at our agencies by cutting back all non-essential use of water. GWA has begun to reduce Navy water purchases in a cooperative effort to reduce the daily drawdown of water from the Fena reservoir.

On the Governor's authority, GWA has completed the RFP process, and has signed a memorandum of understanding with a private firm to develop new production wells. Once in place, this firm will begin immediate permitting and design work on new wells required to produce an additional 2.5 million gallons of water daily. Overall, we seek 8.5 million gallons per day to be produced from the newly developed well system.

Requirements for monthly salinity and chloride inspections provided in Bill 487 (COR) address my concern to protect and maintain the integrity of our northern aquifer. I have instructed the GWA Board and management that ground water protection is my top priority in the Chamorro Land Trust Development infrastructure program. It is crucial that our Chamorro ancestral land occupants are provided with the means, through an effective and efficient sewerage system, to prevent any type of pollutant from contaminating our very valuable sole-source aquifer. Appropriations to fund salinity and chloride monitoring may be necessary. The Water Energy Research Institute (WERI) of the University of Guam has specific recommendations along this line, which I hope you will support.

Thank you for this opportunity to add my support for Bill 487 (COR), and I look forward to working closely with your committee, the Drought Response Group, and the GWA Board and management as we cooperatively address this impending crisis.

Very truly yours,

Carl T. C. Gutierrez
Governor of Guam

DROUGHT
PREPAREDNESS & RESPONSE
PLAN

Prepared by:

Planning & Real Estate Administration
Guam Waterworks Authority
Government of Guam
Agana, Guam 96932

October, 1997

Doc. No. 35GL-20-2107.*

EXECUTIVE SUMMARY

Concerns from worldwide climatologists about catastrophic weather conditions as a result of El Niño's return in early 1997, prompted the Guam Waterworks Authority to examine these concerns and their significance to our locality. The conclusion was that there is a need for local concerns as extremely dry conditions are predicted for Guam and her sister islands in the region, and that the possibility of water shortages exists, particularly for southern villages, as surface water sources dry up. Moreover, it was learned that El Niño is a recurring weather phenomenon that surfaces every two to 10 years. As a result Guam can expect abnormally dry conditions to occur consistent with the return of an El Niño.

Previous El Niños have had adverse impacts on the island's water supply, taxing the Authority's ability to produce sufficient supply for all island residents. While additional water sources through an ongoing wells development program have increased our production capability, population and economic growth continue to rise causing a concurrent rise in water demand. As a result water deficits are not immediately expected to be a thing of the past and that, therefore, a systematic and comprehensive approach to water management are essential. The Authority does not currently have a water conservation or an operating plan to manage water shortages resulting from high user demand or climate-generated shortages. Consequently, the preparation of a comprehensive preparedness plan to guide the Authority in responding to water shortage crises is long overdue.

Both short-term and long-term measures are essential to any water resource management plan. Short-term measures provide immediate opportunities for dealing with extreme situations, while long-term measures span a time frame of multiple years before relief becomes apparent.

Five immediate responses are recommended in this report. First, a Public Awareness and Education program targeting specific user groups such as residential, commercial, and industrial is needed. A separate education program targeting students in all levels helps in developing good water habits in formative years that will hopefully become life-long habits.

Second, a Drought Watch Water Utilization Group is essential to get the community involved. Without community involvement the chances of succeeding in any conservation goal is slim. More importantly, however, is the need for all water well owners and/or operators, e.g., GovGuam, military, and private, to collaborate on mutually beneficial ways to share and maximize water resources drawn from the Northern Lens should the need to do so arise.

Third, the business community particularly high water users in the different industries must be included as part of any water conservation plan. As businesses are the backbone of our island's economic well-being, it is important to ensure that any plans instituted by the Authority does not unnecessarily cause any financial hardships. A mutually beneficial water use and conservation plan would address economic and business sensitivities.

Fourth, mandatory measures may have to be implemented depending upon the severity of our water situation. Limiting water through pressure regulating efforts and other extreme actions should only be resorted to when conditions warrant their use in order to ensure public safety and health.

Finally, the fifth recommendation is a surcharge to penalize high consumption. While this final measure is negative in nature, it has been applied in mainland cities, such as San Diego for one, and has proven to work for that city.

Long-term measures are more structural in nature that require significant capital investments and lead time of five to ten years to accomplish. First, the development of

additional ground water source and surface water sources are recommended. Second, legislation for various water conservation policies are proposed for enactment. Third, institutionalize the drought watch coordinating groups through written memoranda of understanding so that the partnering effort being formulated is permanently established. Fourth, clean up "in house structural problems" through a system wide leak detection and repair program. Expecting the community to cooperate in changing its water use habits is unfair and unwise unless we first apply the standard of zero-tolerance for water waste to ourselves. Moreover, response time to reported leaks must be aggressively improved. Finally, a meter repair and replacement program must be implemented to properly account for all water produced and to capture revenues that are currently being lost because of defective meters.

TABLE OF CONTENTS

Page

INTRODUCTION .....

BACKGROUND & GENERAL HISTORY .....

Pacific Climatic Changes and Effects on Guam's Weather .....

Significance of EL NIÑO and its relation to Guam's Wet and Dry Seasons .....

Previous "Drought" Periods & How the Island Responded .....

The Need for a Comprehensive "Drought Preparedness/Response Plan .....

MEASURES TO CONSIDER IN A DROUGHT PREPAREDNESS/ RESPONSE PLAN .....

Immediate Measures .....

Long-Term Measures .....

RECOMMENDATIONS .....

INTRODUCTION

With much recent publicity from the scientific community about El Niño 1997 and the "nasty" global weather conditions predicted as a result, the Guam Waterworks Authority saw the need to prepare beforehand a comprehensive plan to respond to a dry spell anticipated to happen before the end of 1997 and intensifying to a drought-like condition through the first half of 1998. Therefore, the Authority's Planning Office was tasked to prepare this report for the purpose of examining the validity of metereological claims of an El Niño weather havoc, its significance to the island, and to recommend ways to prepare for and mitigate the effects of a drought predicted in 1998 for Guam and neighboring Micronesia islands.

The report is organized into three major sections. A background and general history section discusses the El Niño weather phenomenon, examines its relationship to Guam and nearby regions, and evaluates how the Guam Waterworks Authority handled or responded to previous drought conditions from past El Niños.

A second major section examines immediate- and long-term measures to consider in the preparation of a drought plan. The measures were gleaned from different jurisdictions in the United States and abroad who have adopted either a drought or conservation plan to deal with water shortages.

The third and final section of this report provides a matrix summarizing those measures that are recommended for implementation. Nearly all of the short- and long-term measures that were discussed in the previous section are seen as viable measures that may work in our community.

For this plan to succeed it is imperative that it be viewed not as a cure-all answer to water shortage problems, but rather as a **flexible plan** to guide the Authority's response to water shortage dilemmas and long-term management of our water resources. This means that as the measures in the plan are implemented, they must be evaluated for effectiveness and updated as may be required.

BACKGROUND & GENERAL HISTORY

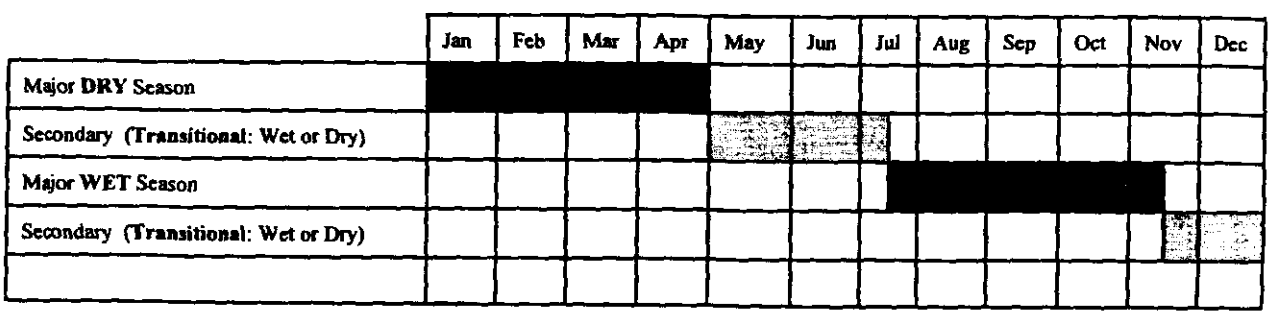
Pacific Climatic Changes and Effects on Guam's Weather

Guam is located in what is known as the Humid Tropical Domain. Because of its location, the island's weather is uniformly warm and humid throughout the year, with only slight variation in temperature and humidity. However, considerable changes to rainfall and wind factors give distinction to Guam's seasons.

There are two major seasons: wet and dry; and two secondary seasons referred to as transitional seasons that can be either rainy or dry. The months in which these seasons occur is shown in Table ____.

Table _____

Guam's Weather Characteristic
by Periods



Source: *Guam Surfact Water Development Study*, Volume I, August 5, 1994, prepared for Guam Waterworks Authority by Barrett Consulting Group, page I.3-5.

Guam's annual rainfall varies between 80 inches to 110 inches. Some years bring torrential typhoon storms while others bring droughts, thus causing a wide variation in annual rainfall figures. The extent of Guam's weather changes is greatly affected by climatic changes that occur in the vast Pacific Ocean, most notably by two weather conditions known as the *El Niño* and *La Niña*. The *El Niño* weather condition is characterized as a "warm event" that

involves a rise in ocean water temperature; while a *La Niña* is the opposite and is referred to as a "cool event" that involves a drop in ocean water temperature.

Climatologists and meteorologists worldwide and Guam's own scientists at the University of Guam Water and Energy Research Institute have only recently begun to understand the widespread effects of these Pacific weather systems have not only in our region, but worldwide. For Guam extreme variations occur in rainfall patterns, particularly during the dry season and transitional months.

Significance of *EL NIÑO* and its relation to Guam's Wet and Dry Seasons

El Niño is Spanish for "Christ child," a name dating back in time and given by Peruvian fishermen to describe a warming event of Pacific Ocean current which greatly affected Peru's productive fisheries and bird poulation. When an *El Niño* occurred warm ocean currents off Peru's coast prevented nutrient-rich cold water from rising, thus depriving the region's fish stock with food supply. As a result fish died and were washed up on Peruvian coast or went elsewhere in search of food. Because of its frequent late December appearance, the phenomenon was given its name--"Christ child" or *El Niño*--by Peruvians.

Today, climatologists know that *El Niño* is a global complex of weather conditions, which begin in the Pacific Ocean, occuring every two to seven years. The event throws normal global weather patterns off-balance, and introduces climatic dissaray to entire regions resulting in floods, droughts, pestilence, famine and illness on a global scale.

Normal global weather disruption under *El Niño* begins when Earth's warmest ocean waters found in the far western Pacific area takes a big eastward shift. This warm, ocean water supplies both moisture and energy for huge thunderstorms. These thunderstorms in turn feed

both moisture and wind energy into the upper atmosphere influencing "jet stream winds," which drive worldwide weather patterns. As the eastward shift occur, normal jet stream wind patterns are disrupted, which in turn move storms on different paths than usual and thus upsetting normal patterns of wet and dry weather. Some areas that don't usually get rain are hit hard, while wet areas dry up.

The effects of *El Niño* on Guam's wet and dry seasons has been significant. For example, the 1982-1983 *El Niño* event, which cost global damage estimated at $13 billion and claimed nearly 2,000 lives (see The Seattle Times, August 28 1997, by Erica Bulman, AP, entitled: "El Nino Phenomenon to Cause Global Weather Extremes, Experts Say"), was one of Guam's most severe dry period. Though information is unavailable to substantiate any economic impact the drought had on Guam, the Authority was unable to adequately meet islandwide water demands for fighting numerous grassfires which occurred. The villages of Merizo and Umatac in particular experienced **severe water shortages** as springs supplying their water dried up.

Since the worldwide devastation of the 1982-1983 *El Niño* event, the global scientific community has been carefully studying this phenomenon. Since that period sufficient data has been gathered to predict, with certain degree of reliability, the onset of *El Niño* and its intensity, but unfortunately not its duration or conclusion. Worldwide climatologists, meeting at a three-day U. N.-sponsored climate conference in Geneva, Switzerland, in August 1997, were in consensus that *El Niño* is back (began in spring of 1997) and could become "the climate event of the century," far surpassing the 1982-1983 event.

According to USA Today Weather Bulletin of 8/20/97, correspondent Jack Williams lists "some of the changes the current *El Niño* is causing or could be causing."

1. Peru's coastal water is 9 degrees warmer than normal, with warmer than normal water stretching west to the International Date Line.
2. Warm water and warm-water fish such as tuna have moved northward to California Coast.
3. Drought has begun in Indonesia.
4. Pakistan and northwest India are dry, with normal monsoon rains sparse.
5. Heavy rains in central and northern Chile in May and June, with flooding on the northern dessert.
6. Central America is starting to have less-than-normal rainfall for this time of year.
7. Drought in North Korea and parts of China related to the *El Niño*.
8. The wet, cool weather in central USA this summer and dryness in Mid Atlantic is suspected to be related to *El Niño*.
9. Papua New Guinea is expecting the worst drought in 50 years caused by the current *El Niño* and is on the verge of declaring a national state of emergency. It is expected that up to one million people would like face starvation.
10. California is seeking federal assistance to help potential victims get ready for a deluge of torrential rainstorms, mudslides, and crop failures. The Federal Emergency Management Agency has responded by hosting an October 14 summit in Lost Angelest on how to prepare for *El Niño* storms.
11. Representative Ken Calvert (California) has asked the House Appropriations Committee to fully fund $18 million in Natioinal Weather Service research programs that will focus on the effects of *El Niño* this year.

For Guam local meteorologists are anticipating an extremely dry period following *El Niño*. Forecasts for "Third Quarter-1997-University of Guam *Pacific* ENSO *Update*," prepared by Water and Energy Research Institute's meteorologist, Mr. Chip Guard, verify that an *El Niño* (warm event) is currently in process and that *La Niña* (cool event) conditions were likely to follow in 1998. According to the update the current *El Niño* has become one of the strongest of the century. Predictions for Guam are for dry conditions to develop beginning in the fall of 1997, as the southwest monsoon disappears. The winter of 1997 and the spring of 1998 are expected to be extremely dry, with dry conditions extending into the early summer. Drier than normal conditions will continue into July of 1998. While fall rainfall is predicted to be near normal for Guam, late winter and spring conditions will be extremely dry. During this winter-spring period, some months could be more than 75% below normal rainfall.

Previous "Drought" Periods & How the Island Responded

Drought is a condition where water level in grounds, lakes, reservoirs, and rivers are significantly below normal. The condition is accompanied by crop failure, increased forest fires, wind blown erosion of dry soil, and possibly animals dying of thirst.

A drought occurs when the Earth's water balance cycle take more water away from the Earth than percipitation adds. Ground water is lost through evaporation or natural use by plants (called transpiration). When there is not enough rain or any other form of precipitation to balance the loss, a drought occurs.

Drought-like conditions have occurred on Guam, although the magnitude is not of the kind found elsewhere resulting in famine due to crop failure or deaths due to lack of water. Even during extreme dry spells, Guam is fortunate to have an abundance of water in its natural

underground acquifer, or commonly known as the Northern Water Lens. The Northern Water Lens rests on top of salt water, but because of its depth the lens can provide the civilian community up to 60 million gallons of freshwater daily, during any given time of the year. The Authority has only tapped half of the Lens' full daily potential. Water availability on the island, or lack of, during previous *El Niño* years were primarily attributed to production, storage, transmission, and distribution problems.

National Oceanic & Atmospheric Agency (NOAA) Bulletin 97-37, issued June 17, 1997, identified five recent *El Niño* events: 1982-1983; 1986-1987; 1991-1993; and 1994-1995. The 1982-1983 was a strong event which caused billions of dollars worldwide, followed by a milder 1986-1987 event. A prolonged *El Niño* episode occured from 1991-1995.

Table ___ is a comparative analysis of water production and metered demands during each *El Niño* episode.

The 1982-1983 *El Niño* years have been described as very severe events by worldwide climatogolists. ~~The~~ Guam was hit with one of the worst dry spell, which resulted in most of the island's springs and rivers drying up, with the exception of Ugum. However, according to WERI scientists the water flow at Ugum was at one-half of normal flow. For both 1982 and 1983 the Authority was unable to meet both normal demands and was really crippled during peak demands. The villages that were hardest hit were the southern villages.

The next event occurred three years later in 1986 and lasted through 1987. In 1986 during non-peak hours there was a margin of half-million gallons of excess water. However, during peak demand periods water availability was short by almost 6 million gallons. As the event extended into 1987 the Authority was unable to even provide for non-peak demands and was in extremely short supply during peak hours. In 1987 the Authority (PUAG at the time)

Table _____

A COMPARISON BETWEEN WATER PRODUCTION & METERED DEMAND DURING SIGNIFICANT EL NIÑO YEARS
[expressed in millions of gallons per day (MGD)]

PRODUCTION vs DEMAND	EL NIÑO EVENTS								
	SEVERE		LESS SEVERE		LESS SEVERE BUT PROLONGED				
	1982	**1983**	**1986**	**1987**	**1991**	**1992**	**1993**	**1994**	**1995**
Total Production (incl military purchases)	17.71	20.76	24.29	24.0	30.09	30.21	33.99	35.9	37.0
Less Unaccounted Water	(6.51)	(9.55)	(11.18)	(9.85)	(12.64)	(11.97)	(14.95)	(16.34)	(16.65)
% Unaccounted Water	37%	45%	46%	41%	42%	37%	44%	45.5%	45%
Average Daily Metered Demand	11.30	11.70	12.60	16.25	17.34	19.20	19.0	16.36	20.5
Maximum Peak Demand	16.9	17.6	18.90	24.4	26.01	28.8	28.5	24.54	30.75

implemented a leak detection/repair program resulting in 5% drop in unaccounted water loss. However, even the recapture of 5% additional water, non-peak demand increased about 30% from the previous year. This occurred despite press releases offering conservation tips and urging the public to lower usage.

A dry period spanning 5 years began in 1991. The first year into the dry period the Authority was just barely able to meet average daily demand, but could not meet peak demand for the first year and each year thereafter. In 1992 the Authority could not even meet non-peak demands, being short by about 160,000 gallons of water daily. Also in 1992 average water demand during non-peak hours rose by about 11%. In 1993 the Ugum Water Dam came on line providing an additional 1.2 million gallons of water. However, unaccounted water loss rose that year, the total water supply remained the same as 1992. Non-peak water demand in 1993 dropped by 200,000 gallons. While water production rose in 1994 and 1995, the percentage of unaccounted water loss also rose. While non-peak demands in 1994 were met, water was in short supply in 1995.

During the prolonged dry period of 1991-1995 water purchases from the U. S. Navy increased every year. In 1991 the Navy sold GovGuam 4.37 mgd; 1992 - 4.10 mgd; 1993 - 5.11 mgd; 1994 - 6.1 mgd; and 1995 - 6.6 mgd. With the U. S. Air Force the amount of water purchased consistently remained at around 80,000 gallons of water daily, except in 1994 it increased to 500,000 gallons a day and in 1995 to 800,000 gallons.

During each *El Niño* years noted above, the Authority responded to the crises with short-term measures, primarily conservation measures. For example, in 1982 a 7-page "Water Conservation Proposal Plan" was prepared by an in-house committee consisting of the Wastewater Division Manager, Water Division Assistant Manager, the Superintendent of Service

Division, and an Acting Program Coordinator. The plan provided a cursory discussion of several conservation measures, their advantages and disadvantages. Among the measures were public education to include a school visitation program, islandwide meter replacement program, leak detection/repair program, pricing, and installation of water saving devices.

The plan was followed up with a "Drought Contingency Plan" in 1983 which consisted of three major efforts:

1. **Leaks** - all leaks were to be reported to PUAG for immediate repair;consumers were advised to repair leaks on private premises.
2. **Limit Use of Water** - customers were advised to re-cycle used water; water plants in the evening; car washing kept to a minimum of once a month; mayors were notified to assist in monitoring the use of water in their villages and to control mis-use of water.
3. **Water Rationing** - a water rationing or low water pressure schedule was prepared and distributed in advance to the public through village mayors, media, and radio stations.

Based upon estimated figures it is unlikely that the Authority can improve its response to water demands from the public, especially during peak demand hours. Table _____ shows that we will continue to experience water deficits during both peak and non-peak hours. Even with an ongoing wells development program, significant impact will not occur unless the Authority can concurrently reduce its water loss ratio to a manageable level. Industry standards from the American Water Works Association (AWWA) say that a system the size of Guam's that is well maintained should range between 15% to 20% of unaccounted water.

Table _____

An Analysis of Production vs. Demand
(expressed in million of gallons per day - MGD)

Water Sources	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Ground	24.7	25.28	26.8	27.38	26.8	27.49	27.12	27.20
Surface	0.76	0.74	2.0	1.95	2.8	2.25	2.25	2.31
Navy	4.37	4.1	5.11	6.1	6.6	7.2	6.25	6.54
Air Force	0.26	0.09	0.08	0.47	0.8	0.6	0.49	0.59
Less Water Loss	42%	37%	44%	45%	45%	45%	45%	44%
Avg Daily Metered Demand	**17.34**	**19.20**	**19.0**	**16.36**	**20.5**	**25.35**	**21.88**	**23.6**
Variance [+/(-)]	0.11	(0.17)	0.03	3.21	(0.15)	(4.7)	(2.04)	(3.45)
Maximum Peak Demand	**26.01**	**28.8**	**28.5**	**24.54**	**30.75**	**38.0**	**32.85**	**33.9**
Variance [+/(-)]	(8.56)	(9.77)	(9.47)	(4.97)	(10.4)	(17.35)	(12.99)	(13.75)

NOTE:
(a) 1996 surface source figure is estimated baed on average of 1993 through 1995 actual.
(b) Water loss ratio for 1997 and 1998 based on average of last four years actual.
(c) ~~1997 and~~ 1998 production figures are estimated based on last four years actual and does not include additional production from new wells. These figures may therefore be understated.
(d) Demand figures ~~for 1997 and~~ 1998 are estimated based on previous years actual. However, these estimates should be considered **unreliable** because of significant distortions in metered demands for 1996. Distortions were a result of high estimated billings that transpired over a 6-month period during the consolidation of water/sewer billing function with Guam Power Authority.

The Need For A Comprehensive "Drought Preparedness/Response Plan

Drought hits hardest when people place too high a demand on the water supply. People's unrealistic expectations during a crises contribute to overestimating the water supply. Drought can be mitigated by **balancing** demand with supply.

The abundance of rainfall that the island gets during wet season months make it difficult for Guam's residents to take the likelihood of a drought threat seriously. Extreme dry conditions and water shortages on Guam have been dealt with on a crises-management basis. That is, they were addressed as they occurred, and then quickly forgotten when the rains came. But, planning for drought should be a normal process that even a community such as ours with an abundance of water supply should undertake. Investing time and resources in planning allows a community to ease the effects of a next drought or a next dry season.

Planning for drought means action be taken ahead of time--essentially practicing **risk management**. More people need more water. As Guam's population grows, so does the amount of water needed for drinking, agriculture, and other uses. Therefore, our vulnerability to drought or "water shortages due to extremely dry conditions" increases along with population growth. It is important that we recognize and understand the stresses on our water supply.

Based on the scientific data collected on *El Niño* and *La Niña*, drought or drought-like conditions are inevitable for Guam and the global community. These disruptions in weather conditions and normal rainfall patterns, population growth, economic expansion, etc., are stress factors which challenge Authority's ability in managing and allocating its water resource. A comprehensive "Drought Preparedness & Response Plan" will enable the Authority to replace short-term emergency response with long-term mitigation practices--practicing risk management rather than crises management with respect to drought. By doing so two major accomplishments

can be realized: (1) We minimize any **dramatic and/or expensive effects** (e.g., **as a trigger of famine** it can devastate vulnerable population or devastate agriculture, livestock, and wildlife); and (2) decision makers have the chance to **relieve the most suffering at the least expense**.

MEASURES TO CONSIDER IN A DROUGHT PREPAREDNESS/RESPONSE PLAN

As reported in the Pacific Daily News of September 23, 1997, page 3, "El Niños are no aberration; they're a **routine part of nature** that occur every two to 10 years." (Emphasis added.) Therefore, planned measures should be adopted, implemented, and routinely updated, as needed, to mitigate any severe adverse effects that the events may pose to the island. Short-term measures and long-term measures are examined in this part of the report.

Short-term measures

Short-term measures are "interim" measures which provide the most immediate opportunities for dealing with extreme dry spells or drought-like conditions caused by *El Niños*. The measures are primarily in the realm of public education and technical assistance in promoting water use efficiencies. The goal of these measures is to change people's water use habits by making them more conscious about their attitudes on water use and educating them on ways to conserve.

Five short-term measures are discussed below. These measures are not new; they have been used in other communities. Some measures have been effective, while others have not. It is important to note that not all these measures will work in our community. Each measure should be tested, however, by putting them into practice, and then evaluated to detemine its effectiveness and ways to improve.

(1) **Public Awareness & Education Program** - provides the means to communicate message to water users and to form an alliance or partnership in support of whatever plans or programs the Authority institutes. It is essential for water users

to be knowledgeable about their water system and to be informed of any threats or disruption in its supply. An informed public makes the task of instituting water conservation measures less difficult for the Authority to implement because it empowers them to make the choice of participating or not in water conservation practices.

(a) **Conservation Program for Residential Users, Commercial Users, & Industrial Users** - Three separate programs should be designed for each category of water users. Brochures, pamphlets, and other written paraphernalia should be printed and distributed. They should contain a comprehensive listing of useful tips on ways to conserve and should emphasize wastewater re-use or re-cycling. The objective of the program should be to change poor attitudes and bad habits on water use and **promote wise water use**.

(b) Prepare separate **educational program** for students in grade school, middle school, and high school levels. Coloring books, pamphlets, brochures for each reading and comprehension levels should be utilized to educate students on how they can **save water for tomorrow**.

(2) **Military/Civilian (GovGuam) "Drought Watch" Water Utilization Coordinating Group** - Provides the opportunity to partner with other sectors in the community for more effective coordination and communication. Because of our remoteness and the small size of our island, water resource management under drought conditions **requires the cooperation** of a consortium of federal, government & local interests. The Consortium should include Navy, Air Force,

Guam Waterworks Authority, University of Guam - WERI, Guam EPA, Guam Fire Department, Civil Defense, and a representative from the Mayor's Council. The consortium should meet regularly to exchange information and to coordinate the dissemination of information or "drought advisories" to the public.

(3) **"Drought Watch" Water Utilization Group with Hotel Association and Golf Courses** - A separate "drought watch" coordinating group should be established with large water users, such as hotels and golf courses. It is imperative for the Authority to ensure lines of communication & information flow are not impeded in any way. The group should meet regularly with the Authority to discuss and implement ways to minimize any adverse economic effects during drought period. For example, it may be necessary to coordinate scheduling of hotel water storage tank refilling during peak period, if necessary, in order to maintain sufficient water pressure to the Tumon area during critical periods of the day.

(4) **Mandatory Water Conservation** - Limitation on water use may be implemented in stages as drought conditions intensify. First stage may take the form of notices to public asking to curb the use of water for non-essentials, i.e., car wash, hosing down driveway, etc. Second stage may include all of first stage plus encouragement for water users to re-cycle used water for watering plants, lawns, or vehicle wash. Third stage may include extreme measures such as water outages on a rotating basis, or decreased water pressure during certain hours of the day.

(5) **Water surcharge** - Finally, a surchage based on high consumption may deter people from wasting water and generate some new revenues for the Authority to offset the cost of implementing water conservation programs. A legal opinion is needed to determine if a surcharge requires special legislation or PUC approval.

Long-term measures

Long-term measures are structural actions that include construction of new water source facilities, repair and maintenance of facility deficiencies, and legislation promoting energy saving plumbing retrofits and new installations in exchange for cash or tax rebates.

Guam's abundance of water makes the island less vulnerable to droughts than its sister islands in the Marianas and in Micronesia. It is known that the combined use of ground and surface water provides more than sufficient quantities to support island activities and demands during abnormally dry spells. The island's vulnerability during adverse dry conditions lies in defective metering program, water production deficiencies, and distribution inadequacies. Therefore, capital investment in addressing these structural problems is the crux of any long-term measures that the Authority wishes to implement.

(1) **Develop Additional Water Sources** - Ground water source (Northern Lens) can provide up to 60 MGD of water. Only 57% of this daily yield has been tapped by the Authority. New production wells should be constructed so that the maximum yield of our ground water can be enjoyed by our community. Also, a number of wells have been abandoned for various reasons ranging from lack of repair parts to contamination. These abandoned wells should be examined for possible rehabilitation.

The importance of developing surface water sheds should not be overlooked. The abundance of rainfall during normal rainy seasons has resulted in millions of gallons of water discharging into the ocean. The use of surface water in conjunction with ground waters provides for a more effective and efficient year-round water resource management program. As the time frame from project concepcion to completion runs anywhere from 5 to 10 years, it is essential for the Authority to pursue the development of additional surface sources right away before the maximum daily yield of the Northern Lens is tapped. It has been recommended in Guam's *Vision 2001* Economic Plan that the Ylig watershed be developed at an estimated cost of about $7.0 million.

(2) **Enact legislation** for implementation of various water conservation policies for several essential reasons. First, as a rapidly growing community with a rapidly growing demand for water, Guam's residents must recognize that water conservation measures ensure the island's continued future growth and as such must be made a way of life regardless of whether it's a drought period, an extremely dry season, or a wet season. Second, legislation sends a signal to the community that water conservation is a serious matter connected to our future well being, and that the enactment into law transforms this policy into a community-wide cause. Third, legislation forges a partnership between the community and water resource managers as they collaborate on programs designed to reduce water waste. The last chapter of this report discusses and provides sample model legislations.

(3) Establish **Memorandum Of Understanding (MOU)** to institutionalize the "Drought Watch" Water Utilization Coordinating Group for Military and GovGuam and a separate one for the Guam Hotel & Restaurant Association (including Golf Courses) will enable any partnering efforts to outlast the short-term and take shape permanently over the long-term period. Getting businesses and other sectors of the community involved in policy-making in water resources uses goes a long way in winning people over to a conservation oriented lifestyle. After all that is what water conservation is really all about--modifying public behavior towards water uses.

(4) **Leak Detection & Repair Program** is vital to achieve any measurable impact of water conservation regardless of a drought or not. Currently, the Authority's unaccounted-for water level is estimated to be just under 50%. This means that for every gallon of water that the Authority produces, one-half gallon disappears somewhere. It is suspected that a large part of this unaccounted-for water loss may be a result of underground leakages from old water pipes that have exceeded their life expectancies. Many of these pipes are over 20 years old and have not been replaced because of funding constraints that preclude the Authority from establishing a consistent, system-wide replacement program. Also, because water pipes are buried, some as deep as 10' or more, water leaks are not seen and require special equipment to detect them before they can be dug up for repair. Again, funding problems have made it difficult for the Authority to invest in leak detection equipment. Moreover, it is difficult for the Authority to promote its

water conservation plan if it does not first clean up house. It is unfair and unwise to expect the community to implement water saving measures, when we in turn are not committed to reducing our unaccounted-for water level, which has over the past fifteen years or more ranged between 40% to 50%. Concurrently, effort must be made to increase our efficiency by improving our response time in repairing reported leaks. While most of our efforts are concentrated on repairing large water line breaks, it is essential that small leaks be treated with some (if not same) importance. In the final analysis, to quote a U. S. Geological Survey bulletin, "...it is the **little leak** that **keeps on leaking** that wastes water." (Emphasis added) Because the leaks are little or of minor importance, we have a tendency to ignore them concentrating only on large main line breaks. It's when we ignore the little leaks over a period of time that stretches into months, that this constant little leak turns into a big waste. If we can view all water leaks along these terms, then a truly successful leak detection and repair program can be a reality barring any funding constraints.

(5) **Meter Repair & Replacement Program** is equally important as leak detection and repair. Again, the emphasis is in reducing the level of unaccounted-for water and in generating additional revenues that are critically needed to off-set the costs of leak detection and repair, as well as other conservation programs. A large percentage of residential and business meters are under registering or not registering because of deficiencies stemming from the lack of a systematic maintenance, repair & replacement program. They are either in need of

calibration due to normal wear and tear or must be entirely replaced with new meters because they have exceeded their life expectancies.

RECOMMENDATIONS

Protecting our island community from water shortages and reducing the islandwide water system's vulnerability to drought or extreme dry conditions require implementation of permanent demand-reduction measures (e.g., conservation measures, education, etc.) and development of new water production sources, both surface and ground. Therefore, all the measures discussed in this report are recommended for implementation in the immediate or near future. These measures are summarized into 11 major programs or activities listed in the matrix that follows. Additionally, this chapter contains additional information for further development of each program and are appended according to its corresponding letter designation.

A	**Public Awareness Program** to alert public of predicted drought and ways to conserve													GWA Planning
	1. Joint WERI/GWA Public Seminar													
	2. WERI Presentation "Man, Land, & Sea" - KGTF													
	3. Public Announcement Spots-- Radio, TV, newspaper													
B	**Public Education Program** to promote water use efficiencies													GWA Planning
	1. Elementary													
	2. Middle													
	3. High School													
C	**Short-Term Mandatory Conservation Measures**													GWA Planning
D	**Establish Village Water Brigade**													GWA & Mayors
E	**Establish Drought Watch Water Utilization Coordinating Group**													GWA/Gov's Ofc
	1. Create Governing Group by EO	✓												
	2. Sign Mil/GovGuam MOU													

	3. Sign Hotel/Golf Course/GovGuam MOU													
F	**Implement System Wide Leak Detection/Repair Program**													GWA - AGM Operations
G	**Implement Islandwide Meter Repair Replacement Program**													GWA - AGM Operations
H	**Improve Leak Repair Response Time - Create "Leak Busters" Crew**													GWA - AGM Operations
I	**Prepare/Implement Water Use Plan with Guam Fire Department** (include fire hydrant leak check/repair and water truck use/flushing)													GWA Planning & AGM Operations
J	**Implement Water Surcharge**													GWA - AGM Admin/Fin.
K	**Legislation**													GWA Planning
	1. Rebate Program													
	2. Mandatory Conservation or Prohibition on wasteful uses of water													

BOARD OF DIRECTORS
GUAM WATERWORKS AUTHORITY
POST OFFICE BOX 3010
AGANA, GUAM 96932

BILL 487 (COR)

AN ACT TO ADD A NEW ARTICLE 3 TO CHAPTER 14, OF THE GUAM CODE ANNOTATED RELATIVE TO ESTABLISHING A DROUGHT MEASUREMENT AND COMPREHENSIVE WATER CONSERVATION PLAN

TWENTY-FOURTH GUAM LEGISLATURE
COMMITTEE ON NATURAL RESOURCES

TESTIMONY
Submitted by:
Roman Quinata, Acting Chairman
Board of Directors

March 5, 1998

Good Morning, Madame Chairwoman and members of the Committee on Natural Resources. For the record my name is Roman Quinata and I am the Acting Chairman of the Guam Waterworks Authority Board of Directors. I am here to testify in support of Bill 487 (COR): An Act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan. I wish to thank you for inviting the Guam Waterworks Authority to testify on this bill.

There has been so much discussion in the media and among the scientific community of El Niño and how seriously it is going to affect us on Guam in the months ahead. The prediction that we're in for a record dry spell is not something

that we should take very lightly. As a retired employee of what was once called PUAG, I can remember the 1983 and 1984 El Niño drying up our springs and surface water sources. The consequences was that southern villages were without water for many days at a time and highly elevated areas were affected with periodic water outages as well. Farmers were seriously affected and untold dollars in income were lost as water to irrigate crops became nothing more than a "trickle" from the tap.

Bill 487 is a very important piece of legislation that should have been introduced a long time ago. Nonetheless, I applaud you, Madame Chairwoman, for taking the initiative to come up with this Bill for it is vitally needed today.

A plan is just merely a plan with no guarantee of its implementation. But if a plan is required by legislation, then the plan carries the force of law and must be implemented. Bill 487 requires the GWA to come up with a Drought Plan and spells out in specific terms how water distribution and uses are to be managed during an emergency shortage, as well as what actions are needed to ensure that the Plan is followed.

Guam is an ever growing community and the once-thought of abundance of water is no longer true. Every one of us in the community, both civilian and military, have a responsibility to make sure that we do our part to prevent water

waste. However, the government must take the lead for the community. Bill 487 empowers Guam Waterworks Authority on behalf of the government of Guam to take the lead in instituting measures for the wise use of water and to prevent waste and abuse of this vital resource.

Richard Quintanilla, the Authority's General Manager, and his staff, are working very hard in putting together a water management plan for this community. With the support of the Governor, a Committee consisting of military, GovGuam, and private businesses was formed last year to develop a plan that would address the concerns of all three important sectors. This Committee has been meeting often and is now in the process of putting together a final draft for the Governor's consideration. It is encouraging to know that Bill 487 will give the Committee's Plan the clout it needs to be effectively implemented in our island.

Madame Chair and members of this Committee, thank you for your interest in the Guam Waterworks Authority. Bill 487 is just one example of your continued support of our activities and programs. Si Yu'os maase.

Respectfully submitted,

ROMAN QUINATA
Acting Chairman

BILL 487
AN ACT TO ADD A NEW ARTICLE 3 TO CHAPTER 14, TITLE 12, GUAM CODE ANNOTATED

TESTIMONY

Submitted By

Water and Energy Research Institute (WERI)
University of Guam

March 5, 1998

Good morning Madam Chairperson and members of the Committee on Natural Resources. For the record, my name is Leroy Heitz and I am a water resources engineer and researcher at the University of Guam, Water and Energy Research Institute commonly known as WERI. I am here to testify on behalf of WERI on Bill 487. I would like to thank you, the committee chairperson for inviting WERI to submit this testimony.

As part of my work at WERI, I have been involved with research and outreach activities concerning the El Niño drought that is affecting our part of the Pacific. At this point in time we are virtually assured that we are facing one of the strongest droughts in this century. Also we can be assured that this El Niño cycle will repeat itself on a 5-10 year interval guaranteeing that we will be seeing similar such droughts in the future. Furthermore, as growth in demand stretches our fresh water supply more and more thinly, even relatively modest droughts will have increasingly severe effects on our islands water supply.

I would like to congratulate the committee on its efforts in the development of a formalized drought response plan for our island. We are in agreement with the committee that there is a need for conservation of water throughout the drought period. We feel that the Bill could be substantially strengthened if direct economic incentives were added to the strategies for promoting conservation. It has been shown in other areas of the world that conservation programs without economic incentives are ineffective. On the other hand those programs that incorporate measures such as sliding scale rate structures are much more effective. Guam Waterworks Authority should be directed to develop such a conservation incentive rate structure as part of the total plan.

We agree with the committee that it is very important to measure the impact of droughts on Guam's water resources. We have to report, however, that the island is seriously lacking the measurement stations needed to accurately assess the full impact of the drought on groundwater and surface water supplies. We are currently facing the prospect of losing the data collection program administered by the US Geological Survey for over 20 years under a 50% cost-sharing arrangement with the Government of Guam. Many of the island's groundwater observation wells and stream gages have fallen into disrepair or have been abandoned over the last 20 years. For Example, following the 1982 Northern Guam Lens Study of the island's groundwater resources seven wells were installed across northern Guam to monitor the thickness of the lens and the occurrence of salt water in it. None of these is operating today--the last three fell out of service in 1996. Without this vital information there is no way to accurately monitor and therefore to manage our islands water resources. We urge this committee to add appropriate funding to this legislation to bring our monitoring capability back to at least where it was nearly 15 years ago.

Again we applaud your efforts at developing Bill 487. We hope that you will act favorably on our suggestions to strengthen this important bill. The steps to be taken under this bill will go a long way to insure that our people will make it through this drought with a minimal amount of suffering. At the same time it will protect the island's single most valuable natural resource it's water supply. Thank You.

Testimony on Bill 487
March 5, 1998
by
H.G. Siegrist, Jr., Director
Water & Energy Research Institute of the Western Pacific
University of Guam

I would like to say that WERI is delighted to be here this morning contributing a share to solving what could easily evolve into a major water crisis. We consider this serious business. A sustainable quantity of good drinking water is to my mind the defining factor as to whether or not Guam can continue as a major player in tourism, and more importantly, whether or not our quality of life can be maintained.

A protracted El Niño drought means a late-arriving and shortened wet season ahead this year, followed by another "normal dry season" So, over the next 16-18 months there will be a very low probability of normalizing our surface and groundwater supplies. Coupled to the potential stresses on water supplies from lack of rainfall and recharge, there is the situation of our own making: I refer to the 8.5 MGD of additional groundwater production that is targeted over, coincidentally, the next 18 months. At the end of 18 months from now we may be closing in on what the aquifer can yield without sacrificing quality.

A well that pulls up brackish water cannot be rejuvenated easily, quickly, or cheaply. As we have no comprehensive monitoring program in place for signaling day to day, weekly, monthly or longer cyclical changes in our aquifer, (and in most of our surface water supplies as well) the day could arrive in the near future when a production well or an entire well field will be producing water that is undrinkable, and that portion of the shrinking aquifer will have to be abandoned for years.

It is incumbent for you to make some tough decisions here and now to protect our water supplies, and I consider this bill to be a strong first step. Some people will be unhappy. But, I would rather be known as a Senator who made a few hundred (even a couple of thousand) citizens a little unhappy now, than a Senator who made 140,000 fighting mad later. Thank you.

BOARD OF DIRECTORS
GUAM WATERWORKS AUTHORITY
POST OFFICE BOX 3010
AGANA, GUAM 96932

BILL 487 (COR)

AN ACT TO ADD A NEW ARTICLE 3 TO CHAPTER 14, OF THE GUAM CODE ANNOTATED RELATIVE TO ESTABLISHING A DROUGHT MEASUREMENT AND COMPREHENSIVE WATER CONSERVATION PLAN

TWENTY-FOURTH GUAM LEGISLATURE
COMMITTEE ON NATURAL RESOURCES

TESTIMONY
Submitted by:
Roman Quinata, Acting Chairman
Board of Directors

March 5, 1998

Good Morning, Madame Chairwoman and members of the Committee on Natural Resources. For the record my name is Roman Quinata and I am the Acting Chairman of the Guam Waterworks Authority Board of Directors. I am here to testify in support of Bill 487 (COR): An Act to Add a New Article 3 to Chapter 14, Title 12 of the Guam Code Annotated Relative to Establishing a Drought Measurement and Comprehensive Water Conservation Plan. I wish to thank you for inviting the Guam Waterworks Authority to testify on this bill.

There has been so much discussion in the media and among the scientific community of El Niño and how seriously it is going to affect us on Guam in the months ahead. The prediction that we're in for a record dry spell is not something

that we should take very lightly. As a retired employee of what was once called PUAG, I can remember the 1983 and 1984 El Niño drying up our springs and surface water sources. The consequences was that southern villages were without water for many days at a time and highly elevated areas were affected with periodic water outages as well. Farmers were seriously affected and untold dollars in income were lost as water to irrigate crops became nothing more than a "trickle" from the tap.

Bill 487 is a very important piece of legislation that should have been introduced a long time ago. Nonetheless, I applaud you, Madame Chairwoman, for taking the initiative to come up with this Bill for it is vitally needed today.

A plan is just merely a plan with no guarantee of its implementation. But if a plan is required by legislation, then the plan carries the force of law and must be implemented. Bill 487 requires the GWA to come up with a Drought Plan and spells out in specific terms how water distribution and uses are to be managed during an emergency shortage, as well as what actions are needed to ensure that the Plan is followed.

Guam is an ever growing community and the once-thought of abundance of water is no longer true. Every one of us in the community, both civilian and military, have a responsibility to make sure that we do our part to prevent water

waste. However, the government must take the lead for the community. Bill 487 empowers Guam Waterworks Authority on behalf of the government of Guam to take the lead in instituting measures for the wise use of water and to prevent waste and abuse of this vital resource.

Richard Quintanilla, the Authority's General Manager, and his staff, are working very hard in putting together a water management plan for this community. With the support of the Governor, a Committee consisting of military, GovGuam, and private businesses was formed last year to develop a plan that would address the concerns of all three important sectors. This Committee has been meeting often and is now in the process of putting together a final draft for the Governor's consideration. It is encouraging to know that Bill 487 will give the Committee's Plan the clout it needs to be effectively implemented in our island.

Madame Chair and members of this Committee, thank you for your interest in the Guam Waterworks Authority. Bill 487 is just one example of your continued support of our activities and programs. Si Yu'os maase.

Respectfully submitted,

ROMAN QUINATA
Acting Chairman

CIVIL DEFENSE
Difensan Sibet
GUAM EMERGENCY SERVICES OFFICE
Ufisinan Setbision Diripente, Guåhan

GOVERNMENT OF GUAM
P.O. BOX 2877
AGANA, GUAM 96932
TEL: (671) 475-9600/01
FAX: (671) 477-3727

CARL T.C. GUTIERREZ
Governor of Guam
Maga' låhi

JUAN B. ROSARIO
Director
Direktot

MADELEINE Z. BORDALLO
Lt. Governor
Tiñente Gubetnadora

BENEDICT J.G. REYES
Deputy Director
Sigundo Direktot

March 4, 1998

Senator Joanne M.S. Brown
Suite 200 Biscoe Bldg.
130 Aspinal Street
Agana, Guam 96932

Dear Senator Brown:

Subsequent commitments preclude me from attending your public hearing on Bill 487. However, please accept my written testimony in support of your measure. Allow me to explain the chief elements of your legislation that I strongly support for solving the island's water crisis.

First, your bill offers the island's first ever comprehensive water management strategic plan. This is essential as the community prepares for the onslaught of the climatic phenomenon called, El Nino, that precipitates severe water shortages in our region.

Furthermore, your bill mandates equity and fairness in the utilization of scarce water resources between the military and civilian sectors. The equitable distribution of water resources ensures collective support of this legislation.

Moreover, your bill not only addresses the present crisis, but also provides a long-term water resources management plan that reduces the island's vulnerability to drought and short-term water shortages.

Lastly, but not the least, I firmly support the adoption of the drought condition standards and low groundwater level conditions and severity alert condition of readiness developed by the Navy Public Works Center.

Sincerely,

JUAN B. ROSARIO

31 July 2020

The Honorable Tina Rose Muña Barnes, Speaker
I Mina'trentai Singko Na Liheslaturan Guåhan
163 Chalan Santo Papa Juan Pablo Dos
Hagåtña, 96910, Guam

Subject: FY2021 Budget Requests: Guam Comprehensive Water Monitoring Program and Guam Hydrologic Survey Program

Dear Speaker Barnes:

1. In compliance with Guam Public Laws 24-161[1] and 24-247[2] (Attachment 1), WERI is pleased to submit this year's budget requests for the Guam Comprehensive Water Monitoring Program (Attachment 2) and the Guam Hydrologic Survey Program (Attachment 3).

2. In 1998, Public Law 24-161 established the Guam Comprehensive Water Monitoring Program (CWMP) to provide for Guam's continued participation in the National Groundwater and Streamflow Information Program (https://www.usgs.gov/water-resources/groundwater-and-streamflow-information), under which the US Geological Survey (USGS) offers matching federal funds (currently about 40% federal to 60% local) to the states and territories to collect data on the quantity, quality, and trends in their groundwater and surface water resources. For the data-collection program on Guam, WERI collaborates with the USGS Pacific Island Water Science Center in Honolulu, which sends teams of hydrogeologists and technicians every 90 days to service and download data from rain gauges, groundwater observation wells, and stream gauges installed across the northern aquifer and in the utilized southern watersheds. These data are processed by USGS and added to their national database.

3. A few months after Public Law 24-161 created the CWMP, Public Law 24-247 created the Guam Hydrologic Survey (GHS) Program to "establish a permanent program for not only collecting, but also for consolidating and storing all of the water resource data on Guam, and making all of it readily retrievable for use by the people of Guam." The intent was to ensure that not only the data collected by the CWMP, but historical information and data collected by other activities—such as drilling, logging, and pump testing of new wells—are captured and kept available in a permanent, locally maintained, and readily accessible archive to support sustainable management of Guam's water resources. Along with CWMP data, WERI has thus collected and archived five decades of historical hydrologic data that are permanently maintained in its GHS databases (http://www.guamhydrologicsurvey.uog.edu). These databases are continually updated, and provide WERI researchers information needed to track the amount of freshwater in the aquifer, the salinity of the water, and how the volume and salinity of our freshwater supply is responding to pumping, droughts, storms, and cyclical climatic changes in rainfall and recharge. The databases also support

[1] *An act to add a new Article 3 to Chapter 14, Title 12 of the Guam Code Annotated, relative to establishing a Drought Measurement and Comprehensive Water Conservation Plan*, 4/09/98.
[2] *An act to establish the Guam Hydrologic Survey as a permanent program to be administered by the Water and Energy Research Institute of the Western Pacific, University of Guam*, 8/14/98.

WERI's ongoing aquifer modeling program, which is also done in collaboration with the USGS, to determine sustainable limits and best management practices for drinking water production on Guam.

4. Public Law 24-247 further specifies that the intent of the legislation is to "ensure that ongoing analyses of local water resource concerns are conducted by local scientists so that the Island's water resource policy-makers, managers, regulators, and educators, businesses, and citizens have timely information and readily accessible advice for sound decisions regarding use, conservation and development of Guam's water resources." The statute thus also specifically mandates that WERI not only maintain a consolidated database of all hydrologic data pertaining to Guam, but that it coordinate with other agencies to keep the database up to date, conduct analyses of the status and trends of Guam's water resources and provide regular reports on them, provide educational materials on Guam's water resources, and conduct research into water resource problems of current concern. Attachment 4 is the current annual report of WERI's operations and products that meet these mandates. Additional information is available at the Guam Hydrologic Survey Website.

5. Public Law 24-247 directs WERI to work with the USGS to prepare an annual work plan and budget for the CWMP and to submit the annual budget request for Guam's share of the program *I Liheslaturan Guåhan* by August 1st of each year. The attached Joint Funding Agreement (JFA) between WERI and USGS (Attachment 2) will continue the CWMP from October 1, 2020 to September 30, 2021. The total cost of the CWMP for this year is $256,980, of which $94,187 will be contributed by USGS and $162,793 is to be contributed by WERI. WERI is therefore requesting $162,793 to support the CWMP.

6. Public Law 24-247 also directs WERI to "prepare and submit the annual budget request for the Guam Hydrological Survey to *I Liheslaturan Guåhan* by August 1st of each year." Attachment 3 contains a detailed breakdown of our FY2021 budget request for $$398,947 to support WERI's GHS mission for ongoing water resource data management, analysis and reporting, research, education, and outreach, as described above. WERI will soon be delivering this year's State of the Aquifer Report and will be contacting your office to schedule this year's presentations on the current operations and results of our GHS data collection, analysis, research, and education activities. We at WERI are available at your convenience to answer any questions regarding these requests or to provide additional information to support effective stewardship of Guam's freshwater resources.

Most respectfully yours,

John W. Jenson, Ph.D.
Director, WERI

Attachments
1. Public Laws 24-161 & 24-247
2. FY2021 WERI-USGS JFA for CWMP, 29 June 2020
3. FY2021 Budget Request for GHS
4. Annual WERI/GHS Report, February 2020

cc: UOG President, Dr. Thomas Krise
UOG Vice President for Accounting and Finance, Mr. Randall Wiegand
UOG, Vice Provost for Sponsored and Research Program, Dr. Rachael T. Leon Guerrero
Director, USGS Pacific Islands Water Science Center, Dr. John Hoffman
Associate Budget and Administrative Process Officer, Ms. Rachael F. Cubacub