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

Annual Technical Report
2018

General Information

Products

Bautista, K., Jenson, J.W., Habana, N.C., Kim, Y.S. (2018) Guam Water Resources Monitoring Program, National Groundwater Association (NGWA), Poster Presentation, 3-6 December 2018, Las Vegas, Nevada.

Denton, Gary; Carmen Sian-Denton, Kim, Yong Sang; Jenson, John, Habana, Nathan , Lander, Mark. June 2018, “Perfluorooctane Sulfonate (PFOS): A Contaminant of Emerging Concern in Guam’s Groundwater. Proceedings of the Institute of Research Engineers and Scientists (IRES) 125th International Conference, Beijing, China, 29-30.

Denton, Gary; Cruz, Jennifer; Duenas, Mallary; Gawel, Michael; Mills, Justin; Brookins, Karl. 2018, Heavy Metal Assessment of Sediments and Selected Biota from American Memorial Park Nearshore Waters, Saipan Commonwealth of the Northern Mariana Islands. Technical Report, No. 162, Water and Environmental Research Institute (WERI) of the Western Pacific, University of Guam, Mangilao, 95pp.

Denton, Gary; Cruz, Jennifer; Trianni, Michael; Tenorio, Michael; Masga, Ray. June 2018, “Impact of WWII and Stormwater Discharges on the Mercury Status of Fish from Saipan Lagoon, Saipan, CNMI.” Proceedings, International Workshop on Environmental Management, Science and Engineering, Xiamen, Fujian, China, p16-17.

Denton, G.W, Sian-Denton, C., Kim, Y.S. Jenson, JW., Habana, N.C., Lander, M.A. (2018) “Perfluorooctane Sulfonate (PFOS): A Contaminant of Emerging Concern in Guam’s Groundwater. Proceedings of the Institute of Research Engineers and Scientists (IRES) 125th International Conference, Beijing, China, pp. 29-30.

Dougher, B., Habana, N.C., Jenson, J.W., and Lander, M.A. (2019) Dynamic Response of a Freshwater Lens to Natural Variations in Recharge, Conference Proceedings, International Academy of Science, Technology, Engineering, and Management – International Conference on Environment and Natural Science, Seoul, South Korea.

Dougher, B., Habana, N.C., Jenson, J.W., Lander, M.A., and Ho, K. (2018) Dynamic Response of the Freshwater Lens to Natural Variations in the Northern Guam Lens Aquifer, Yigo-Tumon Basin, National Groundwater Association (NGWA), Poster Presentation, 3-6 December 2018, Las Vegas, Nevada.
Habana, N.C., Heitz, L.F., and Ziobro, M. (2019) Development of a GIS Based Imagery Database for Groundwater Recharge Areas and Key Reaches of Streams on Guam, WERI Technical Report 166.

Habana, N.C. and Jenson, J.W. (2018) The Northern Guam Lens Aquifer Map, National Groundwater Association (NGWA), Poster Presentation, 3-6 December 2018, Las Vegas, Nevada.

Kim, Y.S., Duenas, M., Becanova, J., Lohmann, R., Habana, N.C., Lander, M.A., Denton, G.W., Jenson, J.W., (2019) Potential PFASs Contamination Sites in Guam, Per- and Polyfluoroalkyl Substances: Second National Conference, Boston, Massachusetts, June 2019.

Kim, Y.S., Duenas, M., Habana, N.C., Denton, G.W., Jenson, J.W., Lander, M.A. (2019) Groundwater Contamination by Polyfluoroalkyl Substances (PFAS) in Guam, Proceedings of the 186th IASTEM International Conference, Seoul, South Korea, July 2019, p. 40.

Kim, Y.S., Jenson, J.W., and Habana, N.C. (2018) Consideration of Factors of Production-Well Rehabilitation Assessment on Guam, National Groundwater Association (NGWA), Poster Presentation, 3-6 December 2018, Las Vegas, Nevada.

Kim, Y.S., Jenson, J.W., Habana, N.C. (2018) GWA production-well rehabilitation assessment: Major reasons why production wells are shut down, WERI Annual Guam Advisory Council Meeting, Tumon, Guam, November 2018.

Superales, D.G., Habana, N.C., Jenson, J.W., and Gingerich, S.B. (2018) Defining and Evaluating Groundwater Production Capacity for an Island Aquifer: Production Well System in the Parabasal Zone, Northern Guam Lens Aquifer, National Groundwater Association (NGWA), Poster Presentation, 3-6 December 2018, Las Vegas, Nevada.

Taborosi, D. (2019) Digital Atlas of Micronesia, Island Research and Education Initiative & Water and Environmental Research Institute of the Western Pacific: http://islandatlas.org/#/

Wen, Y. and Jenson, J.W. (2019) Impacts of Sinkholes on Salinity Level of Groundwater in Finegayan Area, Guam, USA, Proceedings of the 29th International Laser Radar Conference, Hefei, China, June 24-28, 2019.

Information Transfer Program

WERI's Information Transfer Program sent three graduate students—Maria Villareal, Mallary Duenas, and Thomas Aguilo—in the University of Guam's Environmental Science Program to the 27th International Karstological School on Classical Karst, "Karst Hydrogeology—Research Trends and Applications," in Postojna, Slovenia, 17-21 June, and Short Course on Visual KARSYS, 22 June 2019. Upon their return, the three students prepared and presented a two-and-a-half-hour seminar on the workshops for WERI faculty and students on each of 24 and 31 July. Their presentations are posted on WERI's website at the link below. All three students are conducting hydrogeological thesis research related to Guam's island-karst aquifer, and are applying what they learned to developing better conceptual models of the aquifer and more precise understanding of the processes that control transport and fate of contaminants in it. The Information Transfer Program also supported the attendance of WERI's GIS specialist, Dr. Yuming Wen at the 29th International Laser Radar Conference, in Hefei, China, 24-28 June 2019, where he presented results from his current project, "Impacts of Sinkholes on Salinity of Groundwater, Finegayan Basin, Guam." It also supported the participation of WERI hydrogeologist, Dr. John Jenson, in the National Groundwater Association Summit, Las Vegas, Nevada, 3-6 December 2018, to which he led a team of graduate students and faculty, and presented a poster on WERI's Hydrogeological Map of the Northern Guam Lens Aquifer—which is the culmination of two decades of USGS 104B-funded research and ongoing collaboration with the USGS Pacific Island Water Science Center. https://guamhydrologicsurvey.uog.edu/index.php/library/library-presentations/.

Oral presentation of results for ongoing project on: Sustainability of Sewage and Sludge Treatment Systems on Yap. At CNMI Advisory Council Meeting in Saipan. Sept. 6, 2018.

Oral presentation of results for ongoing project on: Sustainability of Sewage and Sludge Treatment Systems on Yap. At FSM Advisory Council Meeting in Pohnpei. Oct. 18, 2018.

Oral presentation of results for ongoing project on: Sustainability of Sewage and Sludge Treatment Systems on Yap. At GUAM Advisory Council Meeting in Tumon, Guam. Nov. 15, 2018.

Conference Proceedings
Kim, Yong Sang; Jenson, John; Habana, Nathan, December 2018, "Consideration factors of production-well rehabilitation assessment on Guam", NGWA Groundwater week, Las Vegas, Nevada.

Other Publications (presentations)
Kim, Yong Sang; Jenson, John; Habana, Nathan, November 2018, "GWA production-well rehabilitation assessment: Major reasons why production wells are shut down", WERI Annual Guam Advisory Council Meeting, Tumon, Guam.

Student Support

Graduate students: 6
Undergraduate students: 2

Notable Achievements and Awards

Bekah Dougher, 2018 Farvolden Award, National Groundwater Association Groundwater Summit, 3-6 December 2018, Las Vegas, Nevada. For outstanding student presentation.
https://www.uog.edu/news-announcements/2018-2019/2019-graduate-student-wins-award-for-first-historical-study-of-its-kind-on-aquifer.php

Bekah Dougher, 2019 University of Gum President's Award for the Outstanding Graduate Thesis, Academic Year 2018-2019. "Dynamic Response of the Freshwater Lens to Natural Variations in Recharge, Northern Guam Lens

Aquifer, Yigo-Tumon Basin."

Coordination with Guam Weather Forecast Office to develop historical climatic time series of rainfall, temperature and typhoon distribution for the main islands of the CNMI (Rota, Tinian and Saipan). This coordination led to the inclusion of the CNMI in the U.S. National Drought Monitor, with criteria developed for assessment of the severity of drought conditions (e.g., D1, D2, D3, etc).

Projects

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

Project Type: Annual Base Grant **Project ID:** 2018GU321B

Project Impact: Proper management of a region's water resources requires water managers and water resources researchers to have accurate baseline and long-term variability information on the geomorphological and ecological health of surface water streams and groundwater recharge areas in a region. Recent advances in commercially available sUAS (Small Unmanned Aerial Systems) technology have made it possible to provide this baseline and variable data using low cost, highly accurate, sub- meter resolution aerial imagery. This first phase was to evaluate and determine which sUAS drones, cameras and analysis software would be most appropriate for the stream and groundwater recharge study areas. Three drones were acquired and tested on the field, resulting in the DJI Inspire 2 as the selected UAS for its best stability against winds strongest at the coast and river outlets. It also carried a sophisticated high resolution camera, and had the best battery-flight longevity of 30 minutes, which means larger area coverage. The small drones were useful under the vegetation canopy. All three drones made available a large capacity SD card slot to store up to 64 GB of imagery files, that can be easily uploaded in a post processing software. Two river watersheds were mapped in Southern Guam, Geus and Inarajan rivers; and two low depression areas in Northern Guam's limestone Aquifer. The results in post processing required accurate GPS marked control points to accurately position and layout the flight collected imagery. Upgrade in GPS real time correction required much improvement and will be the focus in Phase II.

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

Project Type: Annual Base Grant **Project ID:** 2017GU315B

Project Impact: The Digital Atlas of Micronesia (islandatlas.org) is an ongoing project of WERI and Island Research & Education Initiative (iREi). This past year, iREi has worked on the module for Yap, gathering data, verifying accuracy and attributes, ensuring completeness, creating new layers, re-projecting and aligning layers to the common coordinate system, building the database, creating thematic static maps, and developing the user interface. The key characteristics of the Atlas are 1) digital accessibility, 2) dedicated internet domain, 3) attractive design, 4) user-friendly interface and, most importantly, 5) accurate, comprehensive, reliable, and updatable geospatial content. The project builds on previous products, including the Digital Atlas of Northern Guam and the Digital Atlas of Southern Guam and the other already completed modules of the Digital Atlas of Micronesia: Pohnpei and Kosrae. The ultimate product will also include Chuuk, and will be available for use by state and national government agencies in the FSM; US government agencies with regional responsibilities (e.g., USDA, NOAA, USGS, NRCS); international agencies charged with emergency response and relief; government and non-governmental organizations involved in resource management, habitat conservation, research, and education; as well as the general public. Like the other modules, the Yap module will be fully functional for use via tablet computers and smartphones, so as to make it readily accessible for informational and educational applications at all levels. It is WERI and iREi's intent to keep the Digital Atlas of Micronesia up to date and to expand it over time according to demand and availability of resources.

Exploring the Northern Guam Lens Aquifer limits via 3-D groundwater model: Phase 5 – model update and calibration

Project Type: Annual Base Grant **Project ID:** 2017GU310B

Project Impact: The Northern Guam Lens Aquifer is an island aquifer composed of a freshwater lens underlain by saltwater. Production rate is limited to 250 ppm of chloride as saltwater may be updrawn from high volume. Past WERI technical reports had observed and determined the aquifer of least vulnerability to saltwater intrusion were at the parabasal and suprabasal zones, because it is underlained by a vocanic basement rather than saltwater - as the situation in basal zones. The island's potable water producers have about 130 active wells scattered in all three zones. This project determined improving the sustainable yields and production increase by moving all the wells into the parabasal zone. Groundwater models are useful for determing optimal production well configurations. A numerical

groundwater model of the Northern Guam Lens Aquifer developed by USGS and WERI was used to study the potential capacity of the freshwater lens. 130 vertical wells were placed, 0-40 feet length of draw, into the saturated freshwater para-basal zone. Pumping scenarios were selected, incrementing 25 gpm, starting from 100 gpm to 500 gpm. Modeled results from 222 gpm, totaling actual equivalent of 41mgd, produced an overall average weighted chloride concentration of 50 mg/L compared to 320 mg/L of the observed 2010 system. Graph of production vs chloride reveals 88 million gallons per day (mgd) can be extracted from the aquifer while maintaining average salinity about the 250 mg/L. This gives water managers valuable insight regarding the potential performance of the Northern Guam Lens Aquifer para-basal zone.

Guam Waterworks Authority (GWA) production-well rehabilitation assessment: Lessons Learned/Manual for Well Exploration and Development

Project Type: Annual Base Grant **Project ID:** 2018GU321B

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

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

Project Type: Annual Base Grant **Project ID:** 2017GU316B

Project Impact: 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 embayments. Mercury levels in a popular table fish (Lethrinus harak) from each embayment were therefore of interest. 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.

Information Transfer Program

Project Type: Annual Base Grant **Project ID:** 2017GU319B

Project Impact: WERI's Information Transfer Program sent three graduate students—Maria Villareal, Mallary Duenas, and Thomas Aguilo—in the University of Guam's Environmental Science Program to the 27th International Karstological School on Classical Karst, "Karst Hydrogeology—Research Trends and Applications," in Postojna,

Slovenia, 17-21 June, and Short Course on Visual KARSYS, 22 June 2019. Upon their return, the three students prepared and presented a two-and-a-half-hour seminar on the workshops for WERI faculty and students on each of 24 and 31 July. Their presentations are posted on WERI's website at the link below. All three students are conducting hydrogeological thesis research related to Guam's island-karst aquifer, and are applying what they learned to developing better conceptual models of the aquifer and more precise understanding of the processes that control transport and fate of contaminants in it. The Information Transfer Program also supported the attendance of WERI's GIS specialist, Dr. Yuming Wen at the 29th International Laser Radar Conference, in Hefei, China, 24-28 June 2019, where he presented results from his current project, "Impacts of Sinkholes on Salinity of Groundwater, Finegayan Basin, Guam." It also supported the participation of WERI hydrogeologist, Dr. John Jenson, in the National Groundwater Association Summit, Las Vegas, Nevada, 3-6 December 2018, to which he led a team of graduate students and faculty, and presented a poster on WERI's Hydrogeological Map of the Northern Guam Lens Aquifer—which is the culmination of two decades of USGS 104B-funded research and ongoing collaboration with the USGS Pacific Island Water Science Center. https://guamhydrologicsurvey.uog.edu/index.php/library/library-presentations/.

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

Project Type: Annual Base Grant **Project ID:** 2017GU313B

Project Impact: Perfluorooctane sulfonate (PFOS) is a fully fluorinated aliphatic compound that was once widely used in industry. It is very persistent and has substantial bioaccumulation and biomagnification properties, particularly in humans. It is also moderately water soluble (~600 mg/L) and has recently emerged as a drinking water contaminant of concern, having so far been detected in about 2% of U.S. public water systems. In May 2016, USEPA lowered the drinking water health advisory for PFOS from 200 ng/L to 70 ng/L. Guam Waterworks Authority (GWA) began monitoring PFOS in Guam's groundwater in March 2015 in response to USEPA's third 'Unregulated Contaminant Monitoring Rule.' Five production wells were identified as PFOS contaminated, with highest levels confined to sister wells, A-23 (80-160 ng/L) and A-25 (220-410 ng/L), in the Agana sub-basin. Both wells were subsequently taken offline. In June 2017, WERI and GWA began monitoring PFOS in well A-25 on a monthly basis for the next two years. The primary objectives of this study were to identify temporal trends in PFOS levels in the well, and any relationships these trends might have to dominant climatic factors. PFOS levels encountered in A-25 over this time frame ranged from 210-480 ng/L. A strong correlation with cumulative rainfall was evident with a time delay of approximately three months (coefficient: 0.698). Variations in rainfall intensity and duration were found to have the greatest influence on this estimate. The absence of convincing attenuation data suggests that remediation or closure of well A-25 are GWA's only long-term management options.

Phase 2: Development of representative rainfall time series for CNMI hydrological applications

Project Type: Annual Base Grant **Project ID:** 2017GU318B

Project Impact: There are very few locations on the main islands of the CNMI (Rota, Tinian and Saipan) where rainfall and other climatic variables have been measured in a consistent manner for any appreciable length of time. A continuous 30-year daily rainfall record is often considered sufficient to compute baseline monthly and annual averages, and to make accurate estimations of the recurrence intervals of extreme rainfall events. Unfortunately, no location in the CNMI has a continuous daily rainfall database that is anywhere close to 30 years for any location. Statistics for rainfall in the CNMI must therefore be constructed from a concatenation of existing local data and from similarities to the properties of the rainfall on Guam. Using all available climatic data for the main islands of the CNMI, some general statistics (means, extremes, ENSO variations, and recurrence intervals) can be generated. The data bases of CNMI climatic data need extensive scrutiny. Errors in the official records have been identified (e.g., missing typhoon rainfall, deficient rain recordings from the Saipan Airfield ASOS automated rain gauge and improper summations in the CNMI's Fischer-Porter hourly rainfall records). The cleaned climatic time series can be used to recomputed and update many important hydrologic indices (e.g., R-Factor and Drought Severity Index), thresholds (e.g., Fire Risk) and benchmarks (e.g., the 25- and 50-year storm). Accurate time series of hydrologic data are needed to properly inform and assess climate change projections.

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

Aquiferfor

Project Type: Annual Base Grant **Project ID:** 2017GU309B

Project Impact: With potable water demand rising and concerns over water quality increasing in Guam, management of the Northern Guam Lens Aquifer (NGLA) has become a critical issue. Baseline data of contaminant levels are needed to determine any spatial and temporal trends of concern. Four selected active production wells for sampling were near sewered (Y-3, Y-6) and non-sewered (Y-15, Y-5) areas. A multi-probe analyzer was used to determine concentrations (in ppm) for nitrate-N and ammonia-N, including pH and temperature, every 2 weeks from July 2017 to April 2018. Wells Y-15, Y-3, and Y-5 averaged below 3 ppm nitrate-N. Y-6, next to a home averaged 3.6 ppm, and had a reading of 4.4 ppm during a rainy day. Septic tanks are commonly used over the NGLA and its effectiveness is an issue of concern. Effluent data from two septic tanks showed considerable variation where tanks A and B, respectively, had total-N of 83 and 33 mg-N/L, ammonium of 70 and 29 mg-N/L, and nitrate of 0.1 and 0.1 mg-N/L, suggesting that no nitrogen cycling was occurring. Conversely, in the same area, two sampling events approximately one year apart, of one packaged treatment unit that admittedly had not been well maintained demonstrated total-N of 30 and 6.3 mg-N/L, ammonium of 3.8 and 0.1 mg-N/L, and nitrate of 22 and 3.2 mg-N/L, respectively. These values suggest that considerable nitrification and, potentially, denitrification were occurring. It is considered that these units could be further developed to reduce the potential of contamination reaching the water table.

Program Management

Project Type: Annual Base Grant **Project ID:** 2018GU-ADMIN

Project Impact: WERI serves three constituencies: Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and the Federated States of Micronesia (FSM). It thus has advisory councils in each, and uses Program Management funds to engage the venues, pay for supplies and correspondence costs, and support travel of faculty, students, and advisory council members to the annual meetings. Normally, the CNMI meeting is held in Saipan each September. The FSM meeting is held on one of the four island states each October. The Guam meeting is held each November. For the FSM meeting, travel is supported for one representative from each of the three island states other than the one in which the meeting is held. At each meeting, principal investigators and research assistants deliver reports on their previous, ongoing, and proposed projects. The WERI director presents the current WERI Research Agenda. Council members provide feedback, suggestions, and advice regarding project execution and research directions.

Sustainability of Sewage and Sludge Treatment Systems on Yap

Project Type: Annual Base Grant **Project ID:** 2017GU314B

Project Impact: In Yap, pilot testing has been conducted at the island’s municipal sewage treatment plant to assess low-cost upgrades that might enhance treatment. Incorporation of a bio-carrier medium was demonstrated to be helpful, but 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. 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 sewage treatment plant. 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. It is interesting to note that the conductivity levels in the sewage lines 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.

Sustainability of Sewage and Sludge Treatment Systems on Yap

Project Type: Annual Base Grant **Project ID:** 2017GU314B

Project Impact: In Yap, FSM, pilot testing has been conducted at the municipal sewage treatment plant (STP) to assess the implementation of low-cost upgrades to enhance treatment power. Incorporation of a bio-carrier medium was demonstrated to be helpful, but is of limited value due to the relatively small amount of surface area for attachment of biofilm. 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. To further enhance sewage treatment, a hydroponic process is considered. A local lily plant (Eichornia crassipers) is compatible with the raw sewage and has already propagated in the treatment zone of the STP. Results of preliminary testing indicate that the conditions are favorable for the lily plant, which is known to be sensitive to high salt concentrations. During the late wet season, the conductivity of the sewage was approximately 930 (µS/cm), and during the dry season it was 3350 (µS/cm). The lower level during the wet season is probably due to dilution of the saltwater content of the sewage by intrusion of rain water into the collection lines. In the next phase of this project, further testing for removals of organic and nitrogenous compounds will be required to assess the use of the lily plants. In addition, sludge and compost materials will be tested for metals (e.g.: Cd, Hg, Pb, etc.) to address public safety concerns.