1-1-2005

Water Resources Year in Review - Winter 2005, Vol. 18, No. 2

Annis Water Resource Institute

2005 WATER RESOURCES YEAR IN Review

Grand Valley State University | R. B. Annis Water Resources Institute | Winter 2005 | Volume 18, Number 2

As a business owner and resident of west Michigan, I am very interested in preserving our water resources. Besides attracting tourism to the area, our lakes, rivers and streams offer us a rich and wonderful quality of life. The Annis Water Resources Institute is a key player in helping us protect this important resource. Through their educational outreach programs and scientific research projects, they bring a high degree of professionalism and expertise into this community. Besides helping to correct past problems, AWRI has raised everyone's level of awareness. We are fortunate to have them here.

Gary Post
Muskegon Construction Company

Anticipating what lies ahead

Dr. Alan Steinman, Director

Next year marks four major anniversaries for the Annis Water Resources Institute. First and foremost, 2006 will be the 20th anniversary of the Institute's formation. In addition, AWRI's research and education vessels—the *W.G. Jackson* and the *D.J. Angus*—will mark their 10th and 20th years of operation, respectively, in 2006. Finally, 2006 is the five-year anniversary of our home in Muskegon: the Lake Michigan Center. Such an alignment of anniversaries naturally triggers thoughts about where we have come in the last 20 years.

From the start, AWRI has strived to be a comprehensive water resources institute. Our mission is not only to address research, education, and outreach, but perhaps more importantly, to integrate them. This integration process helps ensure that our programs do not operate in isolation, and that our research findings are applied, whether it is in the classrooms, communities, or the halls of Lansing or Washington, D.C.

Our education initiatives offer many opportunities for students, teachers, and community members to become more aware of, and care about, enhancing and preserving our natural resources. In addition to the undergraduate and graduate classes that our faculty teach, the AWRI vessel education and outreach program has instructed over 100,000 passengers about the Great Lakes during the past 20 years. These education and outreach programs are enhanced by our research initiatives, which provide our students with the most current and relevant findings regarding the status of the Great Lakes.

While our work over the last two decades has helped define us, it is always useful to reflect on where we have been, to assess where we are now, and to determine where we want to be in the future. This year, our Science Advisory Board reviewed our performance over the past two years, and offered suggestions on how we can improve. Their findings are thorough, insightful, and helpful. (See a summary of their report on the next page.) When we begin updating our strategic plan next year, much of what they recommend will serve as a blueprint.

In this Year in Review, we are profiling our principal investigators and some of the projects they have directed over the past year. As you read their stories, please remember that many others — technicians, student assistants, and support staff — have contributed valuable work to these projects. They are vital members of our team. With the passion and dedication of all, and the generosity of our funders, we will continue to fulfill the mission of the Robert B. Annis Water Resources Institute.

Integrating research, education, and outreach to enhance and preserve freshwater resources

Science Advisory Board Report:
Useful tool for future growth

AWRI's Science Advisory Board visited us in March 2005. This was their third review of AWRI. Their report contains a thorough and constructive analysis of the Institute's work and offers concrete recommendations for continued improvement.

The report states that AWRI "has undergone tremendous progress and maturation over the last two years and it appears the scientific productivity is growing.... We commend Dr. Alan Steinman for his leadership and the university administration for their heightened support for AWRI. These have truly combined to ensure the recent success of AWRI."

The report highlights the work of the Information Services Center, the Education and Outreach program, the individual research programs and faculty, and AWRI's scientific direction. They also commented on technical staff, the graduate program, faculty tenure, facilities, and the review process. The advisory team commended our efforts while pointing out ways each principal investigator might direct future efforts.

The report concluded with this summary: "We reiterate that the AWRI has made significant and outstanding advancements in their research (staff and facilities) and educational (M.S. Biology) capabilities over the past two years. Once the new staff and graduate program have an opportunity to further mature, we believe that the AWRI will be well poised to achieve its stated objectives." The complete report can be found on-line at www.gvsu.edu/wri/ under the Science Advisory Board Web page.

Members of the Science Advisory Board include:

- Stephen Brandt (Chair), Great Lakes Environmental Research Laboratory, National Oceanic and Atmospheric Administration (Ann Arbor, MI);
- Carol Johnston, Center for Biocomplexity Studies, South Dakota State University (Brookings, SD);
- Gary Lamberti, Department of Biological Sciences, University of Notre Dame (South Bend, IN);
- Peter Meier, University of Michigan (professor emeritus);
- Claire Schelske, Department of Geological Sciences, University of Florida (Gainesville, FL).

Institute Highlights for 2005

- The new Wipperfurth Scholarship, named for Bill and Diana Wipperfurth, will fund an undergraduate internship for one semester at the Institute each year.
- AWRI's Science Advisory Board concluded their 2005 report.
- The U.S. Department of Housing and Urban Development is providing $250,000 to begin the first phase of renovating AWRI's field station and making physical improvements to our site.
- AWRI faculty and staff made over 80 public presentations in 2005.
- The Lake Michigan Center hosted almost 100 events in 2005.
- AWRI faculty members were asked to provide expert testimony in environmental matters before state and federal governments.
- AWRI faculty and staff were awarded over $850,000 in grants and contracts in 2005.

Graduate student Jennifer Cymbola conducts tests in an AWRI lab.

Students provide assistance

As part of Grand Valley State University, the Annis Water Resources Institute and its principal investigators (PIs) have always had a strong educational focus both in and out of the classroom. With the recent addition of AWRI's graduate program, the connection between research and education became even stronger. While graduate students gain valuable experience through hands-on learning and supervision by AWRI scientists, they also provide much needed support to AWRI's research projects, enabling PIs to pursue and accomplish more.

Throughout this past year, the following students have participated in AWRI's graduate program: **Matt Breen, Jennifer Cymbola, Keto Gyekis, Royce Hughes, Janel Hagar, Elaine Isely, Stephanie Januchowski, Jennifer Jones, Aaron Parker, Michael Shoemaker, Allison Trumble,** and **Dana Van Haitsma.**

We would also like to recognize the following students for special honors they received this past year: **Cindy June**, who won second place for her presentation at a regional meeting, and **Matt Breen** and **Melissa Reneski**, who were selected from a strong pool of applicants to receive the Fenske Award at the Midwest Fish and Wildlife Conference.

Profile: Dr. Bopaiah Biddanda

Getting to the bottom of things

You wouldn't think that exploring the bottom of a deep lake would uncover anything other than silt, sand, and debris. But in 2003 researchers made an unusual and highly interesting discovery; they found a submerged sinkhole about 93 meters (305 ft) below the water's surface in Lake Huron.

"We are more familiar with sinkholes as they appear on land; discovery of a submerged sinkhole is not that common," says Dr. Bopi Biddanda, AWRI scientist and a member of the multidisciplinary exploratory team that made the discovery.

"In this extreme environment, the sinkhole creates a unique ecosystem. Instead of photosynthesis, the microbes and bacteria that flourish in the dark, deep water surrounding the sinkhole depend on chemosynthesis, using chemical energies to sustain life. These sinkholes are biochemical hot spots. They provide unusual opportunities for research," he explains.

The sinkholes, called karst formations, are a result of the dissolution of Paleozoic bedrock that is about 400 million years old. When that bedrock erodes, the groundwater in these deep aquifers is released, forcing its way into whatever lies above it.

That plume of groundwater or vent water contains high levels of dissolved chemicals, such as phosphorus, sulfates, and chlorides, creating an ecosystem with biological organisms that are entirely different from the surrounding lake environment. It is warmer in the sinkhole ecosystem — 7.0 °C (44.6 °F) compared to lake water — 3.5 °C (38.3 °F), which is likely to enhance microbial metabolism. The area is also marked by high conductivity — a result of enhanced dissolved ions present in the groundwater.

Finding small submerged sinkholes in the bottom of a large lake, and then collecting samples and measuring important information such as flow, light, dissolved gasses, temperature, and chemical composition is not an easy thing to do — impossible, in fact, without the aid of the University of Michigan's remotely operated vehicle for education and research, the M-ROVER. Dr. Biddanda and the rest of the exploratory team will use M-ROVER to explore other submerged sinkholes throughout the bay and compare data.

"Sinkholes are biochemical hot spots. They provide unusual opportunities for research."

"There is so much we don't know about submerged sinkholes," he comments. "How does this ecosystem operate, and who are the major players? Will it have an impact on the rest of the lake? How vulnerable are they? Further research will help us uncover these unknowns."

For more information, contact Dr. Biddanda at biddandb@gvsu.edu or 616-331-3978 or log on to gvsu.edu/wri/biddanda.

About 93 meters below the surface of the water, this submerged sinkhole in the Lake Huron Basin creates an amazingly unique ecosystem that is relatively rich in sulfates, chlorides, and nutrients from groundwater. The light area at the top of the photo is actually a thick plume layer comprised of dissolved and particulate organic carbon. Wood and rock debris litter the bottom of the lake.

Profile: Dr. Xuefeng (Michael) Chu

Analyzing the flow

"An accurate and comprehensive hydrologic model is key to fully understanding what is going on in an aquatic system."

Identifying contaminants or pollutants in a water system is important. Yet you can't get an accurate picture of what is really happening in that system unless you understand how substances flow throughout the watershed. Being able to quantitatively chart, define, and predict what happens in a flowing system is called hydrologic modeling — a vital tool in comprehending and forecasting hydrologic processes in a water system.

Developing and calibrating a computer-based hydrologic model requires extensive data collection. This past year, Dr. Xuefeng (Michael) Chu has worked on several AWRI projects to create sophisticated hydrologic and environmental models.

In the Mona Lake watershed, his team set up five data collection sites in 2005, in addition to the five sites set up in 2004. Special sensors housed in PVC piping record information such as temperature and pressure every 10 minutes, 24 hours a day. The research team also takes measurements of the stream's discharge and cross-sectional area at each site. The generated stream data are downloaded and processed for an accurate hydrologic model. This effort will continue until June of next year, at which time Dr. Chu will report his findings.

Dr. Chu was also involved with developing an environmental model for metal contamination within the Mona Lake watershed. Both Black Creek and Little Black Creek were contaminated years ago with heavy metals and organic chemicals from superfund sites and industrial facilities. The project focuses on evaluating metal and sediment contamination in Little Black Creek and creating a model to quantify surface runoff and erosion in the watershed. It will simulate sediment and metal, specifically cadmium, transport in the stream-wetland system.

"We know the source of the cadmium contamination, but it's not contained in that one area. Cadmium shows up downstream as well, and in higher concentrations in some places than in others," comments Dr. Chu. "These models will show how cadmium is transported along the stream channel. We can also use these models to predict how the cadmium will be transported in the future."

Generating a hydrologic/environmental model has many benefits. With this tool, scientists can get a good handle on how water, sediments, and contaminants flow throughout the system. They can accurately assess the environment and determine its contamination potential.

"An accurate and comprehensive hydrology model is key to fully understanding what is going on in an aquatic system. How are sediments or heavy metals being transported? Where do they end up? What portion of the stream or lake are they affecting? We need to use computer modeling to answer questions like these," says Dr. Chu.

For more information, contact Dr. Chu at chux@gvsu.edu or 616-331-3987.

Special sensors installed in Little Black Creek record important information such as temperature and pressure 24 hours a day.

Profile: Dr. Mark Luttenton

Looking at nutrient loading

Plants are an integral part of the balance of life within an aquatic environment. When they become too plentiful, they destroy that delicate balance and create problems within the ecosystem.

That's what has been happening at White Lake. Over the past few years, aquatic vegetation has grown considerably, negatively affecting not only property owners, who spend lots of money on herbicides to decrease the weeds, but also fish communities, which are impacted by the change. Higher plant densities, for example, can actually stunt the growth of blue gills. Excessive weeds make it hard for predator fish to hunt blue gills, thus increasing the population. As the number of blue gills increases, their size decreases.

The reason for the increased plant growth is not a mystery. Basically, the plants are getting more light, thanks to the clearing of the water column by zebra mussels, and too many nutrients — what scientists call "nutrient loading." What is not well known, though, is how those nutrients are finding their way into the lake.

For the past year, AWRI research scientist Dr. Mark Luttenton has collected data from the watershed surrounding White Lake to try and determine the sources of excess nutrients. Sampling sites are on the White River, which feeds into White Lake. Dr. Luttenton and his team have isolated a historic wetland area and observed the flow of nutrients throughout the different seasons. They have looked at the role groundwater plays in possibly carrying excess nutrients into the lake. What they discovered helped pinpoint the problem.

"The results of our study indicate that the groundwater was carrying high concentrations of nutrients and chemicals such as phosphorus, which stimulates plant growth," explains Dr. Luttenton. "Since most aquatic plants take up nutrients through their root system, it seems likely that at least part of the nutrient loading is coming from the groundwater, not just from the river or the wetlands."

How are those nutrients getting into the groundwater?

Many parts of White Lake are overrun with excessive plant growth caused by nutrient loading.

"It seems likely that the nutrient loading is coming from the groundwater."

"Our research shows that the groundwater in residential areas has higher concentrations of nutrients than in nonresidential areas. Those nutrients are likely coming from lawn fertilizers and leaky septic tanks. Excess nutrients seep into the groundwater, which is quickly carried to the lake because of the sandy soil," he says. "It's not a huge amount. Rather, it is an accumulation over time. Yet, that accumulation is definitely having an impact on the lake itself."

The results of this study will help community leaders decide on the best course of action to take. As Dr. Luttenton points out, switching to a phosphorus-free fertilizer and maintaining septic tanks will help reduce the amount of nutrients entering the groundwater. "Understanding how the watershed system operates is a critical part of assessing the situation," he says. "Before you can even consider a solution, you need an accurate and complete picture, which proper research provides."

For more information, contact Dr. Luttenton at luttentm@gvsu.edu or 616-331-8795.

Profile: Dr. Rick Rediske

Cleaning up

"It is far less expensive and time-consuming to prevent contamination than it is to clean it up."

It's been ten years since Dr. Rick Rediske conducted tests on Ruddiman Creek in the Muskegon Lake watershed and documented the presence of hazardous chemicals in the ecosystem. Sediments in the creek contained high levels of PCBs, heavy metals, and petroleum biproducts — pollutants from foundries, plating and other heavy manufacturing industries that were discharged over the course of many years. Although the industries are no longer in business, the contaminants from their waste discharges still remain, causing adverse impacts to the aquatic environment.

Dr. Rediske's original report contained recommendations for remediation and restoration of the creek, yet it has taken a decade to assemble the support and the funds needed to conduct the clean up.

This past year, an effort was initiated to restore Ruddiman Creek, which involves removing about 80,000 cubic yards of contaminated sediment, rendering it nonhazardous by the addition of lime, hauling it to a landfill, and also restoring the native plants and habitats in the creek and surrounding wetlands.

"It took a long time, but we are now seeing results," says Dr. Rediske, who serves as chair of the Public Advisory Council in Muskegon, the organization that manages the restoration of the Muskegon Lake Area of Concern. "Science provided the information that remediation was necessary, but we had to secure enough support from the community, the state, and the federal government to secure the funds for the clean up. Ruddiman Creek is a real success story for the environment and the community."

One reason for the long delay was obtaining the funding. It requires a large amount of technical and financial resources to design and conduct remediation and restoration projects. Cost estimates for the Ruddiman Creek project are at $10 million. The federally-funded Great Lakes Legacy Act provided 65% of the funds with the remainder coming from the State of Michigan's Clean Michigan Initiative. Ruddiman Creek was the third project to receive Great Lakes Legacy Act funding.

The remediation of Ruddiman Creek is just one part of restoring the environmental health in Muskegon Lake and having it removed from the Area of Concern list. Part of the delisting process includes setting restoration targets for nutrient levels, aquatic and terrestrial habitats, fisheries, benthic invertebrates, fish and wildlife populations, aesthetics, and fish consumption advisories. Dr. Rediske is currently the principal investigator of a grant from the U.S. EPA to develop numerical delisting targets for Muskegon Lake and White Lake. The targets will be established using scientific data and undergo peer review.

"It is far less expensive and time-consuming to prevent contamination than it is to clean it up," remarks Dr. Rediske. "Ruddiman Creek is an example of just how extensive that process is. On the other hand, the project demonstrates that with a combination of scientific data and public involvement, communities can be successful in obtaining the resources necessary to conduct environmental restoration projects."

For more information, contact Dr. Rediske at redisker@gvsu.edu or 616-331-3047.

Heavy equipment removed about 80,000 cubic yards of contaminated sediments from Ruddiman Creek.

Profile: Dr. Carl Ruetz

Catching fish

Three years ago, AWRI initiated a long-term monitoring program on Muskegon Lake in order to develop a quantitative database that will be used to assess its ecological health. AWRI scientists continue to collect a broad spectrum of information about the lake, including vegetation, nutrients, plankton, invertebrates, and fish. Obtaining samples of many of these items is relatively straightforward. But with fish, it's a different story. They are, as you might expect, hard to count.

"Getting a good idea of how many and what species of fish are in the lake is an important part of assessing its health," remarks Dr. Carl Ruetz, AWRI scientist who specializes in fisheries ecology and management. "None of the capture methods we use is perfect, but we can get a fairly reliable picture of what's going on in the fish communities."

For the past three years, Dr. Ruetz and his staff have sampled sites throughout the lake using fyke nets — long, narrow nets that remain in the water for 24 hours. Fish swim in easily yet have a harder time swimming out.

Results this past year were interesting, especially regarding the yellow perch population. In both 2003 and 2004, AWRI researchers caught less than 10 adult perch at the study sites. This year, that number jumped to over 500 mostly juvenile yellow perch. Dr. Ruetz suspects that the startling increase is due to an ideal mix of breeding and feeding conditions, but no one really knows for sure.

"That's one of the reasons why long-term monitoring is important," he comments. "It allows us to discover trends or patterns over time."

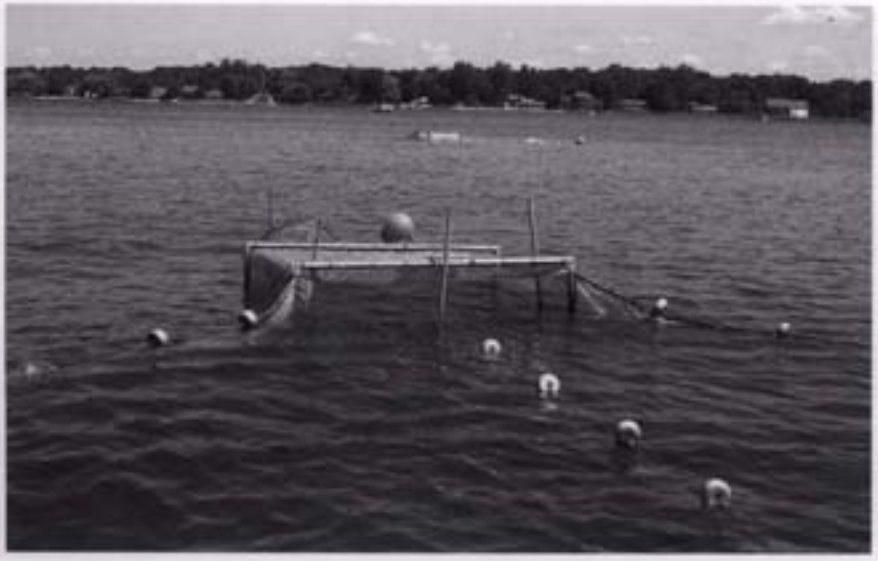
He has also started research on what he calls "gear bias," conducting experiments on capture methods to help discern their limitations and increase data reliability. With the help of GVSU student Matt Breen, he conducted a series of experiments to address the following questions: Do more fish enter the net when other fish are present? Do more fish escape the longer the net is in the water? What happens when a predatory fish enters the net? Do certain fish have higher escape rates than others? The answers to those questions are being published in a scientific article in the *North American Journal of Fisheries Management.*

Because the fyke nets they use primarily capture small fish, Dr. Ruetz also uses electrofishing at night to temporarily stun fish before they are captured and released. The method is widely used by scientists and causes little harm to the fish. It generally works best on larger fish that swim near the surface. The two methods appear to complement each other well, and Dr. Ruetz is working on a scientific article with several colleagues that will summarize these findings.

"Getting a good idea of how many and what species of fish are in the lake is an important part of assessing its health."

Additionally, Dr. Ruetz studies invasive species (primarily round gobies) in the Great Lakes and the effects of stream fish on organisms lower in the food chain. He recently completed a study to evaluate improved technology for marking small fish. Dr. Ruetz experimented with small electronic devices, called passive integrated transponder tags that are injected into a fish's body cavity and used to track its location. "The technology should be very helpful in tracking the movements of small fish, including the invasive round goby," he says.

For more information, contact Dr. Ruetz at ruetzc@gvsu.edu or 616-331-3946.



Dr. Ruetz and his team placed several fyke nets throughout Muskegon Lake.

"The major contribution of pollution to our waterways has changed from point source to nonpoint source pollution."

Years ago, the most evident and immediate threat to the health of the nation's water resources was "point source" pollution. Point source pollution is broadly defined by the U.S. EPA, but it usually refers to discharges coming from any obvious conveyance structure, such as a pipe, ditch, or container. In other words, there is usually a traceable, originating source. The Clean Water Act, enacted in 1972, helped to minimize this risk.

Now, our main source of pollution comes from nonpoint sources, which are not easily traced to a single, originating source. Nonpoint source pollution (NPS) often is the accumulation of many different sources from many different pathways. Excess fertilizer and pesticides that are not utilized, oils and greases from roadways that end up in the storm drain, and runoff from impervious surfaces that directly feed into a waterway instead of being filtered through the ground, are all examples of NPS. And the accumulation of these assaults is taking its toll.

Mary Ogdahl collects water samples for testing in the lab on how nonpoint sources of pollution are affecting aquatic life.

Profile: Dr. Alan Steinman

Tackling nonpoint source pollution

"In the last 30 years, the major contribution of pollution to U.S. waterways has changed from point source to nonpoint source pollution, which now makes up about 70% of the impact," says Dr. Alan Steinman. "In addition to chemicals such as phosphorus and nitrogen that enter the system through nonpoint sources and stimulate algal blooms, there is an emerging concern over road salt, which has been salinizing our waterways. Increased salinity of our fresh water may negatively impact the environment, as well as impair our drinking water supplies."

This past year Steinman has led a research team, including Dr. Bopi Biddanda, Dr. Don Uzarski, post-doctoral research associate Dr. Kelly Wessell, and research technicians Scott Kendall, Matt Cooper, Mary Ogdahl, and Lori Nemeth, that has begun collecting data on the impacts of these substances on the lower trophic levels in several parts of the lower Muskegon River and Muskegon Lake. The results of their research will help answer important questions relating to the impacts of NPS.

There are certain attributes that make this research unique, says Dr. Steinman. First, the team is looking at effects in three very different habitats that are hydrologically connected — the river, wetland, and lake. Second, data collection will take place throughout the entire year, including winter months. In addition to integrating across space and time, AWRI researchers are also studying three different trophic levels — bacteria, algae, and macroinvertebrates —something that is rarely done. The three-year study is funded by the U.S. Department of Education.

"After compiling and analyzing the information over the course of the next three years, we'll have a better handle on how much of a problem this really represents," comments Dr. Steinman. "There are several entities interested in our findings — the Michigan Department of Environmental Quality, the Muskegon River Watershed Assembly, advocacy groups, and local sportfishing associations. The study will help us determine the potential impacts of these types of pollutants, and how to address this type of pollution in the future."

For more information, contact Dr. Steinman at steinmaa@gvsu.edu or 616-331-3749.

Profile: Dr. Don Uzarski

Valuing coastal wetlands

The ebb and flow of water levels on the Great Lakes is a natural occurrence. Some years they are high; other years they are low. Too much in either direction triggers problems for residents and property owners, who may try to control or alter this natural process.

Over the past few years, water levels in Lake Michigan have receded, exposing areas that were historically wetlands. To the casual observer, these areas are nothing more than weedy marshlands that reduce the shoreline's desirability. In 2003 organizers lobbied the state to allow removal of the vegetation, a process called grooming. The state agreed, yet legislators wanted to see what impact grooming would have on the environment.

In 2004, the Michigan Department of Environmental Quality funded AWRI scientist Dr. Don Uzarski and his research team (including graduate students Keto Gyekis and Matthew Cooper) to gather data in Saginaw Bay and Grand Traverse Bay. Since then, they have collected water quality data, as well as data on plant, macro- and micro-invertebrate, and fish communities in undisturbed areas and in groomed areas. So far, the results of that research are telling.

"The Great Lakes have lost over 50% of coastal wetlands since the 1900s, and that loss is definitely impacting the natural environment," states Dr. Uzarski. "The communities we have sampled are basically changing, due to the elimination of the wetland areas."

As Dr. Uzarski explains, removing the vegetation results in several changes in the natural habitat. For one, wetland plants help to hold sediment in place and dissipate erosive wave energy. Without the plants, the sediment erodes quickly, washing away the shoreline and creating problems in the Great Lakes.

Wetland areas also contain several communities of micro-invertebrates that work to break down pollutants. In essence, wetlands act as "filters," processing impurities. Without these natural filters, the potential for pollutants entering the surrounding ecosystem increases.

Plus, wetlands serve as natural spawning and feeding grounds for a host of different fish communities. Without their natural habitat, these communities will decrease or even eventually die out — a change that will be felt all the way up the food chain.

"The Great Lakes have lost over 50% of coastal wetlands since the 1900s, and that loss is definitely impacting the natural environment."

AWRI has catalogued more than 260 invertebrate specimens and 60 different fish species. GVSU graduate technicians Adam Bosch and Aaron Parker were instrumental in identifying these organisms.

"The numbers indicate that wetlands are diverse and dynamic systems," notes Dr. Uzarski. "Now that we understand these delicate coastal wetland systems better, we also realize how important they are to the entire Great Lakes ecosystem."

For more information, contact Dr. Uzarski at uzarskid@gvsu.edu or 616-331-3989.

Many coasts along the Lake Michigan shoreline, such as this one in northern Lake Huron, are reverting back to a more natural wetland environment.

"We now have the ability to take our GIS technology along with our hydrologic and population models and bundle this information into a useful package for decision-makers."

Imagine designing a community that doesn't exist. Everything is in place — streets, landscaping, homes, commercial and retail buildings, even the residents are going about a typical day in a normal fashion. Sounds like a computer Sims game, right? In many ways, it is, but in this "game" there are real life implications.

This past year the Information Services Center (ISC) at AWRI received two grants to help decision-makers visualize how future development might impact their community.

With a $5,000 grant from the W.K. Kellogg Foundation, administered by the MSU Land Policy Program, ISC is working with other GVSU researchers to develop a sustainability strategy for the Muskegon urban area. This strategy will address how to blend social, economic, and environmental goals in a sustainable fashion as Muskegon's downtown undergoes the process of redevelopment.

Profile: John Koches

A glimpse into our tomorrow

Another grant from the Fremont Area Community Foundation for $20,000 is funding a visualization tools project. By combining the power of the computer together with ISC's various databases and models, ISC staff members Kurt Thompson, Rod Denning, Brian Hanson, and others work to creatively display information so researchers and laypeople can easily understand and interpret results.

"It's taking a lot of pieces and putting them all together," comments ISC program manager John Koches. "We now have the ability to take our geographic information system technology along with our hydrologic and population models, and bundle this information in a useful package for decision-makers."

With a population allocation model that uses common census demographics and stakeholder preferences, ISC can project future residential growth based on countless development scenarios. Then, integrating the results with non-point source models, ISC can predict the impact of the new development on nearby lakes and streams. With the new technology and 3-D capability, planners can even walk through or fly over the imaginary landscape to see what this new community would look like and how it all fits together.

The visualization tools will be a tremendous help to planners who often have to deal with future unknowns. These sophisticated tools will assist them in the whole planning process, helping to focus land-use decisions and allowing people to be more sensitive to environmental constraints. They allow for more complete understanding of how the environment is connected to issues such as social justice and economic vitality.

"We are aware of the triple bottom line. Is it good for the environment; is it good for people; is it good for our economy? We're finally coming up with a platform and systems to test future land use from all three perspectives," he says. "It's going to have major implications for the entire west Michigan region and will impact what kind of community we will have in the future."

For more information, contact John Koches at kochesj@gvsu.edu or 616-331-3792.

New technology enables researchers to create digital images of what a community might look like in the future. This image is an aerial view of Ensley Township in Newaygo County.

Profile: Dr. Janet Vail

Learning on board

Reaching out into the community has always been a priority for the Annis Water Resources Institute. Since day one, AWRI has helped others understand and interpret scientific results so that the community as a whole can work together to solve problems and initiate change.

According to Dr. Janet Vail, who oversees Outreach and Education initiatives and has been with AWRI since 1990, "in simple terms, AWRI helps science become real, and its vessel program is an outstanding example of just how real that experience can be."

In 1965 Donald J. Angus generously donated a 50-foot, diesel-powered vessel to Grand Valley. For nearly 20 years the *Angus* served as a floating classroom and laboratory until the newly retrofitted *D.J. Angus*, designed especially for aquatic science research and instruction, replaced the *Angus* in 1986.

Within the next ten years, the *D.J. Angus* welcomed more than 31,000 students and visitors on board. The program's resounding success led to a capital campaign to build and endow another vessel, the *W.G. Jackson*. It is named after lead donor Dr. William Jackson, and it joined the *D.J. Angus* in 1996.

Since the program began, more than 100,000 passengers have been aboard the two vessels — about 65% have been students ranging from grade four to the university level. Adults and community groups from all around Lake Michigan make up the rest.

In addition to instructional cruises throughout the school year, the *Jackson* has reached 30 ports of call throughout the Lake Michigan basin on the U.S. EPA *Making Lake Michigan Great* tours during the summer months. Scientific research is conducted on the vessels, which are maintained and operated by fleet captain Tony Fiore and the vessel crew.

"It is amazing to see how this program has grown throughout the years," Dr. Vail says. "Once you get people, particularly children, out on the water, they begin to understand and truly appreciate this valuable water resource. It is an experience you don't forget."

While on board, participants sample contrasting water environments in an inland lake and, weather permitting,

"Once you get people, particularly children, out on the water, they begin to understand and truly appreciate this valuable water resource."

Lake Michigan. AWRI science instructors help students to measure various factors, such as dissolved oxygen, pH levels, conductivity, and turbidity, and to examine plankton and sediment composition. Students see results firsthand and draw conclusions about the condition of the lakes. Activities in the R.B. Annis Educational Foundation classroom complement the vessel experience.

"After more than 30 years of teaching high school biology, I strongly believe in the hands-on approach to learning science," says science instructor Chuck Vanderlaan, who has been with the program since 1993. "The response to the experience is nearly 100% positive — even for those who have never been on a boat."

"I've had individuals come up to me years after they were on one of the vessels and remark how much they enjoyed the experience," comments science instructor Roger Tharp. "They became more interested in the lakes' ecology, and some have even said they decided to pursue careers in scientific research because of that exposure."

For more information, contact Dr. Janet Vail at vailj@gvsu.edu or 616-331-3048.

Lead science instructor Chuck Vanderlaan assists students with life jackets on board the *W.G. Jackson*.

AWRI Faculty and Staff Highlights for 2005

Ecological Research Group

Dr. Bopaiah Biddanda (biddandb@gvsu.edu):

• Continued long-term collaborative work on pelagic metabolism in Lake Michigan with scientists using NOAA ship time.

• Continued exploration of a submerged sinkhole ecosystem in Lake Huron and surveyed it using the University of Michigan's remotely operated submersible. Funded by NOAA.

• Continued the Mecosta County groundwater study. Funded by the Ice Mountain Environmental Stewardship Fund.

• Participated in AWRI's long-term study of Muskegon Lake. Mapped Muskegon Lake floor and nearshore Lake Michigan using U of M's submersible. Funded by the Muskegon Lake Research Endowment Fund.

• Studied the fate of land-based carbon in streams and lakes of west Michigan. Cindy June, a student working on this project, was awarded 2nd place for her poster describing this work at the Michigan Space Grant annual conference. Funded by NASA-MSGC.

• Member of GVSU's College of Liberal Arts and Sciences Dean Search Committee and CLAS Staff Advisory Council. Supervisor of Water Quality Event for Science Olympiad. Member of the editorial board for *Journal of Plankton Research*.

Dr. Michael Chu (chux@gvsu.edu):

• Updated/upgraded the Windows-based hydrologic and environmental modeling software packages: IPTM-CS, IPTM-S, and HYDROL-INF.

• Set up ten hydrologic monitoring sites and two rain gauges in the Mona Lake watershed. Conducted hydrologic analysis and modeling. Funded by MDEQ.

• Continued development of the sediment and metal transport model in a stream system. The model will be used for simulating cadmium fate and transport in Little Black Creek. Funded by U.S. EPA.

• Participated in the hydrologic monitoring and modeling study in the Tamarack Creek watershed. Funded by MDEQ.

• Conducted aquifer analysis and groundwater mapping in the Mecosta County groundwater studies. Funded by the Ice Mountain Environmental Stewardship Fund.

Dr. Mark Luttenton (luttentm@gvsu.edu):

• Continued biological monitoring and assessment of the Henry's Fork River, Idaho. Funded by Henry's Fork Foundation.

• Examined the impact of zebra mussels on aquatic invertebrates in Muskegon River below Croton Pond.

• Evaluated the use of mitochondrial DNA to identify hatchery strains of brown trout (collaboration with Dr. Alex Nikitin, GVSU).

• Continued nutrient loading study of White Lake. Funded by MDEQ.

• Appointed to the American Fisheries Society - Michigan Chapter, Rivers and Streams Advisory Committee.

Nutrient experiments in the AWRI mesocosms.

Dr. Rick Rediske (redisker@gvsu.edu):

• Continued to investigate the nature, extent, and environmental effects of sediment contamination in the Mona Lake watershed. Funded by U.S. EPA.

• Continued monitoring program for *E. coli* concentrations at Lake Michigan and inland lake beaches with the Muskegon County Health Department, and Lake Michigan Beaches in Oceana and Mason Counties with the District 10 Health Department.

• Served as chair for the Muskegon Lake Public Advisory Council and worked with the White Lake Public Advisory Council. Developed numerical targets for delisting the lakes as an Areas of Concern. Funded by U.S. EPA.

• Conducted sediment toxicity evaluations of Ryerson Creek and Division Street Outfall in Muskegon Lake and Tannery Bay in White Lake. Funded by MDEQ.

• Obtained a grant from the MDEQ to investigate the occurrence of cyanobacteria blooms and related toxins in six west Michigan lakes.

• Member of MDEQ Environmental Monitoring Advisory Board and MDEQ Analytical Detection Limit Evaluation Board. Member of the Federal Detection and Quantitation Limit Advisory Committee and Technical Work Group.

Dr. Carl Ruetz (ruetzc@gvsu.edu):

• Continued long-term monitoring of fish populations in Muskegon Lake. Funded by Muskegon Lake Research Fund.

• Examined the distribution of round goby in coastal habitats of Lake Michigan in collaboration with Dr. Uzarski. Funded by US Fish and Wildlife Service.

• Studied the efficacy of marking sculpins with internal tags.

• Assessed gear bias of sampling fishes.

Dr. Alan Steinman (steinmaa@gvsu.edu):

• Six new grants funded as PI or co-PI ($775,000 total).

• Four peer-reviewed articles or book chapters published or in press.

• Invited to testify before Michigan Senate Committee on Natural Resources (July, 2005).

• Member of the Michigan Groundwater Conservation Advisory Council (Chair, sustainability subcommittee).

continued on next page

• Invited to serve as a Michigan Water Resource Fellow.

• 19 presentations (13 community; 6 professional: 2 invited, 4 contributed).

• Appointed Co-editor of *Journal of North American Benthological Society*.

• Received Muskegon Area Environmental Excellence Award (April, 2005).

Dr. Don Uzarski (uzarskid@gvsu.edu):

• Determining the effects of coastal wetland fragmentation on plant, fish, and invertebrate community composition. Funded by MDEQ and NOAA.

• Developing manuals and guidance documents for wetland bioassessment in Michigan. Funded by MDEQ.

• Exploring the idea of Great Lakes coastal wetlands as refuge for native fishes and determining if these systems are resistant to invasion by recent exotics. Funded by US Fish & Wildlife Service and MDEQ.

• Investigated the extent and ecological effects of sediment contamination in the Little Black Creek watershed. Funded by U.S. EPA.

• Assessed a Muskegon River wetland for fish habitat and food sources. Funded by Great Lakes Fishery Trust.

• Determining the impacts of nonpoint source pollution on invertebrate community composition in the Muskegon River ecosystem. Funded by U.S. Department of Education.

• Presented at two press conferences held in Traverse City and Bay City Michigan regarding Public Act 14 of 2003 'the Beach Grooming Bill'.

• Member of Project Management Team of the Great Lakes Coastal Wetlands Consortium. Member of GVSU's College of Liberal Arts and Sciences Faculty Development Committee.

Post-doctoral Research Associate Kelly Wessell collects water samples in the Muskegon River.

Information Services Center

John Koches (kochesj@gvsu.edu)

• Continued work on the Muskegon River Watershed Transition Grant to implement BMP's, including installation of a rain garden at McBain School and the purchase of conservation easements in farmlands. Funded by MDEQ.

• Continued to support implementation activities undertaken by the Rogue River Watershed Council in the Rogue River watershed.

• Initiated a hydrologic study for Upper Tamarack Creek (Muskegon River Watershed). Funded by MDEQ.

• Helped the Muskegon River Watershed Assembly to implement portions of the Information and Education Strategy outlined in the Muskegon River Watershed Plan. Funded by Great Lakes Fishery Trust.

• Assisted project partners in the creation of a Grand River Watershed Council. Funded by MDEQ.

• Providing assistance to Grand Valley Metro Council as they identify sources of bacteria in tributaries to the Grand River. Funded by MDEQ.

• Began implementation of selected BMPs in the Sand Creek watershed as specified in the Sand Creek Watershed Plan. Funded by MDEQ.

• Completed work and collaboration with the Pierce Cedar Creek Institute regarding the development of a Geographic Information System database.

• Completed work with the Land Conservancy of West Michigan to create a Regional Green Infrastructure Vision Map for west Michigan. Funded by Kellogg Foundation.

• Completed work with Land Conservancy of West Michigan to develop a geospatial tool to help identify and prioritize potential natural areas within the Rogue River watershed. Funded by Land Conservancy.

• Concluded analysis of groundwater aquifers in Mecosta County. Funded by Ice Mountain Stewardship Fund.

• Continued development of a Watershed Interactive Map Viewer. Funded by Great Lakes Fishery Trust and MDEQ.

• Completed a Road/Stream Crossing Inventory for the Mona Lake Watershed and updated Land Use/Cover database using 2005 satellite imagery (IKONOS). Funded by MDEQ.

• Began a project for the Fremont Area Community Foundation to coordinate zoning ordinances in Newaygo County that support the Michigan Natural Rivers Act.

• Assessed and created a number of visualization tools intended to facilitate land use decision-making that is sensitive to environmental impacts and minimizes threats to water quality.

• Began the Muskegon Area Sustainability Project with assistance from the Kellogg Foundation and the MSU Land Policy Program.

continued on next page

AWRI staff helped to train students, such as this group from Muskegon Heights, in environmental monitoring.

Outreach and Education Initiatives

Dr. Janet Vail (vailj@gvsu.edu)

- Provided educational opportunities for over 6,000 people on the *D.J. Angus* and the *W.G. Jackson* research vessels.
- Celebrated the 30th port of call of the *Making Lake Michigan Great* tour. Funded by the U.S. EPA Great Lakes National Program Office.

- Hosted visitors from China, Poland, Japan, Brazil, and the Czech Republic, as well as numerous organizations including the American Water Works Association and MDEQ.

- Facilitated activities for over 700 students and others in the LMC's Education Classroom. Supported by the R.B. Annis Educational Foundation Outreach Program Endowment and the Michigan Space Grant Consortium.

- Organized the 10th Annual Hazardous Waste Management Workshop in partnership with MDEQ.

- Conducted educator training at venues such as the Global Change Workshop at Michigan Tech, the Michigan Alliance for Environmental and Outdoor Education conference, and the Michigan Science Teachers Association annual conference.

- Helped facilitate Michigan Project WET water festivals and trained 11 new Project WET facilitators. Funded by Nestle Waters.

- Dr. Vail is the author of the air quality unit for MDEQ's Michigan Environmental Education Curriculum Support project (MEECS).

- Trained a cadre of facilitators affiliated with math and science centers to deliver MEECS workshops.

- Dr. Vail serves as co-chair of the U.S. EPA Lake Michigan Forum and is on the Board of Directors of the Michigan Alliance for Outdoor and Environmental Education, Air & Waste Management Association West Michigan Chapter, and the Great Lakes Association of Science Ships. Member of the GVSU Grant Leadership Advisory Team, Center for Excellence in Science and Mathematics Education Advisory Board, and Regional Math and Science Center Advisory Board.

Publications

Peer-reviewed Publications

Biddanda, B.A., D.F. Coleman, T.H. Johengen, S.A. Ruberg, G.A. Meadows, H. VanSumeren, **R.R. Rediske**, and **S.T. Kendall**. In Press. Exploration of a submerged sinkhole ecosystem in Lake Huron. *Ecosystems*.

Cotner, J., W. Makino, and **B.A. Biddanda.** In Press. Temperature affects stoichiometry and biochemical composition of bacteria. *Microbial Ecology*.

Biddanda, B.A., P. Abreu, and C. Odebrecht. 2005. Algal blooms and bacterial interactions. In: Algal Cultures, analogs of Blooms and Applications, D. V. Subba Rao (ed). Science Publishers Inc. pp. 163-188.

Cotner, J.B., **B.A. Biddanda**, E. Stets, and W. Makino. 2004. Organic carbon biogeochemistry of Lake Superior. *Aquatic Ecosystem Health and Management* 7:1-14.

Ruberg S, D. Coleman, T. Johengen, G. Meadows, H. VanSumeren, and **B.A. Biddanda**. 2005. Groundwater plume mapping in a submerged sinkhole in Lake Huron. *Marine Technology Society Journal* 39:65-69.

Chu, X. and M.A. Mariño. 2005. Determination of ponding condition and infiltration into layered soils under unsteady rainfall. *Journal of Hydrology* 313:195-207.

Chu, X. 2005. Pesticide occurrence and distribution in relation to use. In: Water Encyclopedia: Surface and Agricultural Water, J.H. Lehr, J. Keeley, and J. Lehr (eds). John Wiley & Sons, Inc., New York 3:655-657.

Chu, X. and M.A. Marino. In Press. Improved compartmental modeling and application to three-phase contaminant transport in unsaturated porous media. *ASCE Journal of Environmental Engineering*.

Luttenton, M. and R. Lowe. In Press. Response of a lentic periphyton community to nutrient enrichment at low N:P ratios. *Journal of Phycology*.

Luttenton, M. and C. Baisden. In Press. The relationships among disturbance, substratum size and periphyton community structure. *Hydrobiologia*.

Students work with microscopes in the Education Classroom at AWRI.

Madenjian, C.P., D.V. O'Connor, S.M. Chernyak, **R.R. Rediske**, and **J.P. O'Keefe**. 2004. Evaluation of a chinook salmon (*Oncorhynchus tshawytscha*) bioenergetics model. *Canadian Journal of Fisheries and Aquatic Sciences* 61:627-635.

Madenjian, C.P., D.V. O'Connor., S.A. Pothoven, P.J. Schneeberger, **R.R. Rediske**, **J.P. O'Keefe**, R.A. Bergstedt, R.L. Argyle, and S.B. Brandt. In Press. Evaluation of a Lake Whitefish Bioenergetics Model. *Transactions of the American Fisheries Society.*

Breen, M.J., and **C.R. Ruetz III**. In Press. Gear bias in fyke nets: evaluating soak time, fish density, and predators. *North American Journal of Fisheries Management.*

Ruetz, C.R., J.C. Trexler, F. Jordan, W.F. Loftus, and S.A. Perry. 2005. Population dynamics of wetland fishes: spatio-temporal patterns synchronized by hydrological disturbance? *Journal of Animal Ecology* 74:322-332.

Steinman, A.D., **R. Rediske**, and K.R. Reddy. 2004. The importance of internal phosphorus loading in Spring Lake, Michigan. *Journal of Environmental Quality* 33:2040-2048.

Steinman, A.D. and **R. Denning**. In Press. The role of spatial heterogeneity in the management of freshwater resources. In: Ecosystem Function in Heterogeneous Landscapes. G. Lovett, M. Turner, C. Jones, and R. Weathers (eds). Springer Verlag.

Steinman, A.D., G.A. Lamberti, and P. Leavitt. In Press. Biomass and pigments of benthic algae. R. Hauer and G. Lamberti (eds). Methods in Stream Ecology. Academic Press, NY.

Steinman, A.D. and P. J. Mulholland. In Press. Phosphorus limitation, uptake, and turnover in stream algae. R. Hauer and G. Lamberti (eds). Methods in Stream Ecology. Academic Press, NY.

Steinman, A.D. 2005. Book review of: The Lakes Handbook. 2003. Volume 1. P.E. O'Sullivan and C.S. Reynolds (eds). Blackwell Publishing. *Journal of the North American Benthological Society* 24: 441-442.

Uzarski, D.G., T.M. Burton, **M.J. Cooper**, J. Ingram, and S. Timmermans. In Press. Fish habitat use within and across wetland classes in coastal wetlands of the five Great Lakes: Development of a fish based index of biotic integrity. *Journal of Great Lakes Research.*

Uzarski, D.G., T.M. Burton, and J.A. Genet. 2004. Validation and performance of an invertebrate index of biotic integrity for Lakes Huron and Michigan fringing wetlands during a period of lake level decline. *Aquatic Ecosystem Health & Management* 7:269-288.

Burton, T.M., **D.G. Uzarski**, and J.A. Genet. 2004. Invertebrate habitat use in relation to fetch and plant zonation in northern Lake Huron coastal wetlands. *Aquatic Ecosystem Health & Management* 7:249-267.

Jude, D.J., D. Albert, **D.G. Uzarski**, and J.C. Brazner. 2005. Lake Michigan's coastal wetlands: distribution, biological components with emphasis on fish and threats. In: The State of Lake Michigan: Ecology, Health and Management, M. Munawar and T. Edsall (eds). Ecovision World Monograph Series, Aquatic Ecosystem Health and Management Society pp. 439-477.

Graduate student Royce Hughes analyzes water samples for heavy metals using an atomic absorption spectrometer.

Technical Reports and Manuals

Chu, X. 2005. Integrated pesticide transport model for a coupled canopy soil system, IPTM-CS Version 1.10, User's Manual pp. 139.

Chu, X. 2005. Integrated pesticide transport model for soils, IPTM-S Version 1.10, User's Manual pp. 130.

Chu, X. 2005. Modified green-ampt infiltration-runoff model in layered soils, hydrol-inf, Version 1.04, User's Manual pp. 62.

Denning, R. 2005. Wetland potential map, Whitehall Township, Muskegon County. MR-2005-4.

Denning, R. et al. Natural connections – A vision of regional green infrastructure in west Michigan, published by the Land Conservancy of West Michigan. MR-2005-5.

Denning, R. and **B. Hanson**. 2005. Potential natural areas ranking map – Rogue River Watershed. MR-2005-6.

Denning, R. and **M. VanPortfliet**. 2005. Pierce Cedar Creek Institute Resource Atlas. MR-2005-2.

Hanson, B. and **N. De Mol**. 2005. Best management practices photo documentation report, Rogue River Watershed Clean Michigan Initiative. MR-2005-7.

Thompson, K. 2005. Procedure for creating a new road/stream crossing GIS (update) file using ESRI ArcView 3.3 GIS and Microsoft Excel software applications. TM-2005-6.

Rediske, R.R., **M. Buth**, **G. Smythe**, **J. O'Keefe**, and G. Peaslee. 2005. Preliminary investigation of the extent of sediment contamination in Lake Macatawa. MR-2005-3.

Steinman, A.D., **R.R. Rediske**, and **L. Nemeth**. 2004. Internal phosphorus loading in Spring Lake: Year 2. MR-2004-5.

Steinman, A.D., **K. Thompson**, **R.R. Rediske**, **X. Chu**, **B. Biddanda**, **J. Koches**, and **J. Vail**. 2005. Environmental analysis of well water in Mecosta County: A comprehensive and integrated approach (Year 2). MR-2005-1.

2005 AWRI Staff

Director:
Alan Steinman

Staff/Administrative:
Tonya Crossen, AWRI Assistant
Heidi Feldpausch, Office Coordinator
Roxana Taylor, Secretary

Information Services Center:
John Koches, Associate Professor (Land Use Change; Watershed Management)
Jean Conzelmann, Research Assistant
Nichol De Mol, Research Assistant
Rod Denning, Research Associate
Betty Gajewski, Technical Call-in
Brian Hanson, Adjunct Research Assistant
Eric Nemeth, Technical Call-in
Kurt Thompson, Research Associate

Outreach & Education:
Janet Vail, Associate Professor (Outreach and Education)
Paula Capizzi, Science Instructor
Bonnie Cowles, Science Instructor
Leslie De Vries, Science Instructor
Candi Goldman, Science Instructor
John Gort, Science Instructor
James Muller, Science Instructor
Roger Tharp, Science Instructor
Chuck Vanderlaan, Science Instructor

GVSU Vessels/Field Station Operations:
Anthony Fiore, Jr., Fleet Captain
Ronald Brown, Captain
Robert Burns, Captain
William Frost, Deckhand
Roger Hillstead, Maintenance
Eric Nemeth, Deckhand
Brad Nieboer, Marine Electrician
Robert Pennell, Deckhand
Marc Porter, Deckhand
Jim Winks, Captain and Deckhand

Ecological Research, Environmental Chemistry:
Richard Rediske, Professor (Environmental Toxicology & Chemistry)
Ying Hong, Adjunct Research Assistant
Jim O'Keefe, Research Associate
Kate Rieger, Technical Call-in
Brian Scull, Technical Call-in
Gail Smythe, Adjunct Research Assistant

Ecological Research, Environmental Biology:
Bopaiah Biddanda, Assistant Professor (Microbial Ecology)
Xuefeng (Michael) Chu, Assistant Professor (Hydrologic & Environmental Modeling)
Mark Luttenton, Associate Professor of Biology (Aquatic Ecology)
Carl Ruetz III, Assistant Professor (Fisheries Ecology & Management)
Alan Steinman, Professor (Aquatic Ecology)
Don Uzarski, Assistant Professor (Wetland, Stream, & Lake Ecology)
Adam Bosch, Technical Call-in
Matt Cooper, Adjunct Research Assistant
Scott Kendall, Technical Call-in
Lori Nemeth, Research Assistant
Mary Ogdahl, Adjunct Research Assistant
Michael Rediske, Technical Call-in
Kelly Wessell, Post-Doctoral Research Associate

Graduate Students:
Matt Breen, AWRI Assistantship
Jennifer Cymbola, AWRI Assistantship
Keto Gyekis, AWRI Assistantship
Janel Hager, AWRI Assistantship
Kenneth Royce Hughes, AWRI Assistantship
Elaine Isely
Stephanie Januchowski
Jennifer Jones
Aaron Parker, AWRI Assistantship
Michael Shoemaker, AWRI Assistantship
Nancy Taylor
Allison Trumble
Dana VanHaitsma, AWRI Assistantship

Student Assistants:
Macy Al-Shatel
Matt Breen
Renee Briggs
Nick Fiore
Jonathan Ginka
Mary Horan
Michelle Lelli
Elizabeth Maldonado
Michael Rediske
Melissa Reneski
Michael Sanders
Matt VanPortfliet

AWRI Science Advisory Board:
Stephen Brandt, NOAA-GLERL
Carol Johnston, South Dakota State University
Gary Lamberti, University of Notre Dame
Peter Meier, University of Michigan
Claire Schelske, University of Florida

AWRI provides opportunities for students to pursue their interests in our environment. The following students received AWRI internships during 2005.

D. J. Angus-Scientech Educational Foundation Interns:
Michelle Lelli
Chad Meece
Patrick Womble
Michelle Zwagerman

Herbert VanderMey Intern:
Matt Breen

Allen Hunting Intern:
Melissa Reneski

Michigan Space Grant:
Cynthia June

NOAA Intern:
Brad Robinson

MI Space Grant and Air & Waste Management Intern:
Rachel Kent

Pierce Cedar Creek Institute, Undergraduate Research Grants for the Environment:
Matt VanPortfliet

If you would like more information about AWRI's programs, please call us at (616) 331-3749 or (231) 728-3601, fax us at (616) 331-3864, contact us through the internet at http://www.gvsu.edu/wri/, or write us at Annis Water Resources Institute, Lake Michigan Center, 740 W. Shoreline Dr., Muskegon MI 49441.

GRAND VALLEY STATE UNIVERSITY

R.B. Annis Water Resources Institute
Lake Michigan Center
740 West Shoreline Drive
Muskegon MI 49441

ADDRESS SERVICE REQUESTED

Non Profit Org
U.S. Postage
PAID
Grand Valley
State University