The mission of the Robert B. Annis Water Resources Institute (AWRI) at Grand Valley State University is to integrate education, outreach, and research to enhance and preserve freshwater resources.

Located in Muskegon, Michigan, the Institute’s work centers around three main focal areas:

- **Research** into major questions about aquatic ecology, chemistry and toxicology, fisheries ecology, hydrology, microbial ecology, aquatic molecular ecology, ecosystem restoration, and ecological modeling.

- **Information Services** use state-of-the-art geospatial technology to collect and analyze data, and condense them into useful information for those who make critical decisions about natural resources management.

- **Education & Outreach** to graduate and undergraduate students, K-12 students, policymakers, educators, and the general public.
Dr. Alan Steinman, The Allen and Helen Hunting Director

The Robert B. Annis Water Resources Institute, as evidenced by its very name, owes a disproportionate amount of its growth and success to the incredible generosity of its donors. This philanthropy dates from our earliest days, including Bob Annis’ gifts and our first major grant—$1,000,000 from the Grand Rapids Community Foundation to study the Grand River—both of which allowed the Institute to establish itself and build a foundation, to the late 1990s as shown by the generosity of the Muskegon community, including Bill Jackson, Chuck and Pat Johnson, Bill Schroeder, and Roger Andersen, who donated and raised the funds for our second research vessel and our new home on Muskegon Lake.

That ethos of giving permeates west Michigan, and especially the lakeshore, where people are connected to the water in a very intimate way. Our mission at AWRI, to integrate research, education, and outreach to preserve and enhance our freshwater resources, resonates with our broader community, and we take that charge very seriously. While we rely heavily on competitive grants from state and local government for funding, philanthropy plays an absolutely essential role in helping us achieve our mission.

That is one reason why we are so delighted to recognize the recent gift from Allen and Helen Hunting, establishing the Hunting Research and Innovation Fund, as described on page 2. While we are thrilled to receive this gift, it is equally rewarding to recognize the Huntings, whose passion, sense of humor, and generosity help keep us motivated to continue protecting and preserving our precious water resources.

Writing on behalf of the faculty, staff, and students at AWRI, we thank you, and all our donors, for their incredible generosity; we are indeed blessed to live in this region. We are committed to do our absolute best to provide our west Michigan community with a return on your investment that will make you proud.

Alan Steinman, The Allen and Helen Hunting Director, AWRI
**PROJECT WET USA COMES TO MICHIGAN**

Dr. Janet Vail served as chairperson for the annual Project WET (Water Education for Teachers) USA Coordinators Conference held in Traverse City, which drew coordinators from as far away as Alaska and Hawaii. Conference highlights included the keynote address by Mark Breederland from Michigan Sea Grant, a field trip to Sleeping Bear Dunes, and a workshop on the new Project WET early childhood curriculum. As the Michigan Project WET state coordinator, Dr. Vail will be presenting workshops on the new curriculum.

**AWRI HOSTS A PLANKTON-ALGAE COURSE**

After a year of planning by a committee consisting of personnel from water treatment plants, academia, and the Michigan Department of Environmental Quality, AWRI hosted a three-day Plankton-Algae course sponsored by the Michigan Section of the American Water Works Association. Participants in the course were staff from water treatment plants throughout Michigan. In this team effort, Dr. Rick Rediske was the lead instructor with assistance from Dr. Bopi Biddanda, his students, and Dr. Charlyn Partridge. Dr. Janet Vail coordinated the course and its materials.

**ARRON PARKER: DISTINGUISHED ALUMNUS-IN-RESIDENCE**

The College of Liberal Arts and Sciences’ Distinguished Alumni-in-Residence Program provides a venue for departments to invite outstanding alumni back to campus to share their post-graduation experiences. AWRI honored Aaron Parker as its 2017 distinguished alum. Aaron earned his M.S. in biology at AWRI in 2007 studying the ecology and evolution of yellow perch. He is an aquatic biologist for the Michigan Department of Environmental Quality where he studies harmful algal blooms.

Over the years, Lake Michigan populations have seen dramatic shifts among both dominant and less abundant taxa caused by invasive species such as quagga mussels, which are known to have arrived via ballast water dumping. Less known, however, is the impact of “hitchhikers” on invasive species – microbial invaders naked to the human eye – like viruses. In their studies, the Strychar lab has been investigating viruses that have been preserved (i.e. dead) and living in the sediments to those associated with invasive species. Studies show that while some viruses are not well described and may even be newly described, many are “recycled” between species, water column, and benthic substrate systems.

**INVASIVE QUAGGA MUSSELS AND THEIR VIRAL “HITCHHIKERS”**

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AWRI Researchers Use Laser Instrumentation to Measure Stream Bank Erosion

Graduate student Molly Lane preparing beach samples for qPCR analysis.

A small floral adornment with a cute name is wreaking havoc throughout the coastal sand dunes in northwest Michigan. Baby’s breath (scientifically known as Gypsophila paniculata) is an aggressive invasive species that outcompetes native vegetation, such as the federally threatened Pitcher’s thistle. It is especially problematic around Sleeping Bear Dunes National Lakeshore and managers have been working tirelessly to get the species under control. A collaborative project between Charlyn Partridge’s lab, The Nature Conservancy, and The National Park Service is looking into more effective ways to manage and contain the spread of baby’s breath. Graduate students Emma Rice and Hailee Leimbach-Maus spent the summer working with The Nature Conservancy to examine the efficiency of two common treatment methods, manual removal and herbicide application. They are also looking to see how the plant is spreading through the region. This project is funded by an EPA – Great Lakes Restoration Initiative grant.

AWRI Expands qPCR Beach Monitoring to Include Inland Lakes

AWRI completed its third year of polymerase chain reaction (qPCR) testing of Muskegon County beaches for pathogens. qPCR is the quantitative amplification of DNA conducted in real time. For the 2017 program, AWRI collected and analyzed samples from 13 Lake Michigan and 15 inland lake beaches for E. coli using both traditional culture-based techniques and the qPCR method. Because qPCR detects DNA from both live and dead cells, inland lakes present more of a challenge due to local septic systems, smaller lake volume, and wildlife sources. AWRI research assistant Brian Scull and graduate student Molly Lane (left) presented their comparisons of qPCR and culture-based methods at the Great Lakes Beach Conference in Green Bay, WI. Molly is conducting her thesis research on the influence of landscape variables on the comparison of the two methods in inland lakes. AWRI has worked in partnership with Public Health Muskegon County on beach monitoring programs since 2001.

Tracking Invasive Baby’s Breath Throughout Northwest Michigan

Hailee Leimbach-Maus standing among clumps of baby’s breath (lighter colored vegetation) in Sleeping Bear Dunes National Lakeshore.

2017 marked the third and final year of AWRI’s Research Experiences for Undergraduates (REU) summer program, operated with funding obtained from the National Science Foundation by AWRI scientists Drs. Jim McNair and Kevin Strychar. The 2017 class of 10 students hailed from California, Louisiana, Maryland, Michigan, Minnesota, New Hampshire, North Carolina, and Pennsylvania. Further information about AWRI’s REU program is available on its website (www.gvsu.edu/wri/mcnair/reuquest).
RESEARCH SUPPORTS ARCTIC GRAYLING RESTORATION

The Arctic grayling was extirpated from Michigan in the early 1900s due to logging activities, overharvest, and introduction of non-native trout. Recent conservation efforts elsewhere have focused on reestablishing native fish using incubators to hatch eggs in streams targeted for reintroduction. The in-stream incubators are small, flow-through units that allow eggs to rear at the site of reintroduction, allowing fry to acclimate and imprint on local conditions.

Carl Ruetz’s laboratory, in collaboration with the Little River Band of Ottawa Indians (LRBOI), is testing egg incubators in tributaries of the Manistee River. In a “pilot” study, rainbow trout eggs were used as surrogates for Arctic grayling eggs, which are not yet available in Michigan. The preliminary results were promising, suggesting the egg incubators can be effective in Michigan streams. This research supports a broader effort by the Michigan Department of Natural Resources and the LRBOI to reintroduce Arctic grayling to Michigan.

IMPROVING MANAGEMENT OF INVASIVE BABY’S BREATH BY KNOWING WHEN ITS SEEDS MATURE

Baby’s breath (Gypsophila paniculata), that lovely plant of wedding bouquet fame, is an aggressive invader of coastal dune habitats in Michigan’s northwestern Lower Peninsula, outcompeting rare and threatened plants such as fascicled broomrape (Orobanche fasciculata) and Pitcher’s thistle (Circium pitcheri). Baby’s breath reproduces mainly by seed, so reducing the production of mature seeds is an important part of managing this invader. To do this, plants must be removed or sprayed with herbicide before their seeds mature. But when do they mature? AWRI graduate student Jay Zuidema, in collaboration with his advisor Dr. Jim McNair, is assessing different methods for making these inferences and how the estimated rates depend on properties such as the amount of shade and abundance of aquatic plants in a stream reach. His results to date show pronounced differences among rate estimates obtained in different reaches along a stream. He currently is considering how to account for these differences when extrapolating reach-scale estimates to an entire stream.

GENETIC STOCK STRUCTURE OF YELLOW PERCH IN EASTERN LAKE MICHIGAN

Greg Chorak, a graduate student working with Dr. Carl Ruetz, examined the genetic structure of yellow perch populations in eastern Lake Michigan, focusing on populations in drowned river mouth (DRM) lakes (e.g., Muskegon Lake). Greg found that Lake Michigan yellow perch are genetically distinct from DRM lake populations even though they use those habitats during particular times of the year. Fisheries managers should consider yellow perch population structure and movement patterns when setting fishing regulations.

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1. Dr. Bopi Biddanda (left), graduate student Katie Knapp (center), and technician Tony Weisie (right) pose with the Muskegon Lake Observatory buoy before its 2017 deployment.

2. Graduate student Travis Ellens holds a northern map turtle caught during fish sampling.

3. Graduate student Jay Zuidema calibrates a YSI water quality sonde.

4. Graduate student Hailee Leimbach-Maus collects baby's breath samples for genetic analysis.

5. Science instructor Shirley McIntire displays a water sample onboard the W.G. Jackson in Hammond, IN.

6. Graduate student Suse LaGory displays a brown trout.

7. Graduate student Molly Lane downloads temperature data from a field logger.

8. Graduate student Emma Rice collects baby's breath samples for genetic analysis.

9. Visiting Ph.D. candidate Xiaomei Su (front) and research assistant Maggie Oudsema (back) celebrate the successful completion of fieldwork in Spring Lake.

10. Summer interns Noah Cleghorn (left) and Matt Allen (right) collect GPS coordinates in Indian Mill Creek.

11. Graduate student Kim Oldenborg deploys a buoy in Bear Creek.
The labs of Rick Rediske, Kevin Strychar, and Charlyn Partridge evaluated rapid assessment methods for cyanobacteria in Muskegon Lake and Bear Lake. *Microcystis* is a cyanobacterium that is responsible for harmful algal blooms (HABs). The organism can produce a toxin called microcystin, which is harmful to human health. Open water and beach samples were collected during the summer and quantitative polymerase chain reaction (qPCR) and imaging flow cytometry (IFC) methods were used to study *Microcystis* populations and toxin production. qPCR techniques were employed to determine the presence of toxin-producing genes and their activity. IFC methods were used as confirmation of toxin production. When paired with water chemistry and toxin measurements, these rapid assessment methods can aid in forecasting HABs by tracking genetic changes and environmental triggers that influence toxin production. This project is funded by a grant through the Michigan Department of Environmental Quality.

### AWRI Implements Rapid Assessment Procedures for Cyanobacteria

Graduate student Andrew Pyman preparing samples for qPCR analysis of cyanobacteria populations.

Three students, Greg Chorak, Emma Rice, and Hailee Leimbach-Maus, presented their research at the annual Ecological Society of America meeting this year in Portland, OR.

AWRI Uses L-Thia Model to Estimate Pollutant Loading in Indian Mill Creek

The Long-Term Hydrological Impact Analysis (L-Thia) model has been in use for decades as a tool to estimate water quality impacts. The model is available in three formats, including a new internet version. AWRI researchers were eager to try the web-based version on the Indian Mill Creek (IMC) watershed in Kent County.

Associate research scientist John Koches and 2017 AWRI summer intern Noah Cleghorn decided to supplement their temperature and rainfall data collection in IMC by using L-Thia to prioritize the seven subcatchments within IMC, with respect to their potential as sources of water quality pollutants. The online version of L-Thia proved very capable. Preliminary results point to the upstream, more agricultural subcatchment areas of the watershed as a potential source of sediments and nutrients, while the urban downstream areas are a more likely source of excess runoff.

### Gabrielle Thelen

**Where Is She Now?**

Former AWRI Intern Gabrielle Thelen assisted with the design and construction of AWRI’s first Autonomous Surface Vessel (ASV) during the summer of 2015. As the recipient of a Michigan Space Grant Consortium Award, Gabrielle worked on the initial testing of AWRI’s “BoatBot” during the fall of 2016. Gabrielle submitted a final report of her work with AWRI to the Michigan Space Grant Consortium in April 2017. She now looks forward to graduating from GVSU’s School of Engineering, having completed her co-op involving the industrial application of robotic technologies.

### Welcome, Lidiaa!

Dr. Lidiia Iavorivska joined AWRI this year as a postdoctoral research associate in Dr. Al Steinman’s lab, where she’ll be using a Soil and Water Assessment Tool (SWAT) computer model to help inform land management decisions and water pollution control in local watersheds. By combining modeling tools with water quality data collected by AWRI, modelers will evaluate how land-use decisions (such as different agricultural management practices or stream and wetland restoration projects) can influence water quality and identify which practices are most effective in solving water quality problems.

Dr. Lidiia Iavorivska collecting a water sample from the north branch of the Macatawa River.
After four years of study, the Great Lakes fungal collaboration funded by the National Institutes of Health (NIH) has collected nearly 200 sediment samples in Great Lakes waters from as deep as 900 feet and produced over 6,000 fungal isolates. Most of the nearly 465 identified taxa are previously unreported from the Great Lakes, and many are new species. In addition, over 127 fungal extracts exhibit significant anti-pediatric cancer properties. This is the most comprehensive fungal study ever conducted on the Great Lakes.

**Graduate student Justin Wegner checking a deepwater sample in a Van Dorn bottle aboard the W.G. Jackson.**

**GREAT LAKES FUNGAL STUDY DRAWS TO A CLOSE**

The onset of summer warms the surface waters that float over cooler and denser waters, creating “thermal stratification” or “layer effect” in temperate lakes. We can now track the formation of this layering effect in Muskegon Lake and study its ecosystem consequences – such as surface water productivity and bottom water hypoxia – over intervals of hours to years using the power of time-series weather and water quality data from the Muskegon Lake Observatory: www.gvsu.edu/buoy

**Summer undergraduate research student Tom Claffey utilized the time-series data obtained by the Muskegon Lake Observatory (left, in background) to model the changing thermal structure of the lake over the seasons.**

**LAYERVER LAKE: WHAT HAPPENS WHEN MIXED?**

Time, water, and geology have converged to create low-oxygen, high-sulfur ecosystems characterized by filamentous microbial mats that thrive in submerged sinkholes in Lake Huron. A microscopic study revealed that these benthic (bottom) microbial mats are composed of not only the dominant photosynthetic purple-pigmented cyanobacteria (that appear green under stress), but also photosynthetic diatoms and chemosynthetic (energy obtained from chemicals, not sunlight) sulfur-oxidizing bacteria. In addition to being capable of different and complementary pathways of carbon and sulfur metabolism, these organisms can actively form aggregations that optimize sunlight capture for oxygenic and anoxygenic photosynthesis and carbon burial – processes that are likely to have played a key role in the evolution of Earth’s early biosphere. The Biddanda lab and collaborators are trying to figure out if these ancient cousins of modern-day microbial mats could have oxygenated the Earth during life’s turbulent childhood.

**Microscopic images of photosynthetic cyanobacterial filaments (purple and green), diatoms (golden brown; bottom right) and chemosynthetic bacteria (black and clear filaments) that comprise the benthic mats in Lake Huron’s sinkholes (photo dimensions are ~100 µm × 60 µm). Photo credit: Tony Weinke and Rachel Ratliff.**

**DYNAMIC INSIGHTS FROM INSTRUMENTING A GREAT LAKES ESTUARY**

Water draining from Michigan’s 2nd largest watershed pauses temporarily in Muskegon Lake before entering Lake Michigan. Knowledge of Muskegon Lake’s water circulation and residence time is vital to understanding issues including river loading, nutrient and pollutant retention, primary productivity, food web function, surface water algal blooms, bottom water hypoxia, and more. To quantify lake-wide water movement, the Biddanda lab and NOAA’s Great Lakes Environmental Research Laboratory placed instruments throughout this lake ecosystem. In addition to AWRI’s Muskegon Lake Observatory (buoy), an array of moorings that included temperature and water quality sensors, tilt meters, and acoustic Doppler current profilers were deployed during the 2016-2017 season. With the additional sensors, researchers will be able to better understand the spatial and temporal dynamics of this system. So far, time-series measurements and hydrodynamic models have shown intriguing intrusions of cold water from Lake Michigan well into Muskegon Lake, providing new insights into the lake’s behavior.

**AWRI technician Tony Weinke (left), graduate student Katie Knapp (center) and post-doctoral research associate Qianqian Liu (right) prepare mooring ropes for deploying instruments on Muskegon Lake.**
AWRI FACULTY AND STAFF

THE ALLEN AND HELEN HUNTING DIRECTOR:
Alan Steinman, Professor

STAFF/ADMINISTRATIVE:
Tonya Brown, AWRI Assistant
Roxana Taylor, Secretary
Paula Wicklund, Office Coordinator

FACILITIES/Maintenance:
Len Wittlieff, Maintenance

INFORMATION SERVICES CENTER:
John Koches, Associate Research Scientist

OUTREACH & EDUCATION:
Janet Vail, Research Scientist
Paula Capizzi, Lead Instructor DJA
Sherry Claslin, Science Instructor
Cheri Gerhart, Science Instructor
Ann Hesselsteet, Science Instructor
Tom Jackson, Science Instructor
Shirley McIntire, Science Instructor
Maggie Pennell, Science Instructor
Penny Reid, Science Instructor
Michele Smith, Science Instructor
Diane Venevlasen, Science Instructor

ECOLOGICAL RESEARCH, ENVIRONMENTAL CHEMISTRY:
Richard Rediske, Professor
Brian Scull, Research Assistant

ECOLOGICAL RESEARCH, ENVIRONMENTAL BIOLOGY:
Bopash Biddanda, Professor
Scott Kendall, Technical Call-in
Qianqian Liu, Postdoctoral Researcher
Zaky O’Brien, Undergraduate Student Assistant
Rachel Ratliff, Technical Call-in
Anthony Weinke, Technical Call-in
Mark Luttenton, Professor of Biology
Jim McNair, Associate Professor

GVSU VESSELS/FIELD STATION OPERATIONS:
Anthony Flore, Jr., Fleet Captain
Terry Boersen, Deckhand WGJ
John Bontrager, Captain WGJ
Julia Carter, Relief Captain WGJ
Dave Fisher, Marine Engineer WGJ
Allan Grinvin, Deckhand WGJ
Roger Haynor, Captain DJA
Pete Hewett, Deckhand DJA
Tim Lucas, Relief Captain DJA
Emily Morris, Deckhand
Brad Nieboer, Marine Electrician
Jim Rahe, Maintenance WGJ
Peter Stoeckle, Deckhand DJA

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GRADUATE STUDENTS:
Biddanda, major advisor
Katie Knapp, R.B. Annis Educational Foundation Assistantship
Luttenton, major advisor
Barney Bayer, AWRI Assistantship
Justin Wegner, AWRI Assistantship
McNair, major advisor
Meagan McPherson
Emma Rice, AWRI Assistantship
Jay Zuidema, AWRI Assistantship

Partridge, major advisor
Ben Giffin, GVSU Graduate School Special Assistantship
Sarah Lamar, AWRI Assistantship
Halliee (Rowell) Leimbach-Mae, AWRI Assistantship
Andrew Pyman, AWRI Assistantship
Rediske, major advisor
Victoria Harris, AWRI Assistantship
Molly Lane, AWRI Assistantship
Daniel Myers, AWRI Assistantship
Rajesh Sidgeli, AWRI Assistantship
Ruetz, major advisor
Greg Chorak, AWRI Assistantship
Travis Ellens, AWRI Assistantship
Kaitlyn Emelander, AWRI Assistantship
Susanna LaBory, AWRI Assistantship
Jason Lorenz
Alan Mock, GVSU Graduate School Special Assistantship
Steinman, major advisor
Emily Kindervater, AWRI Assistantship
Paige Kleindl, AWRI Assistantship
Kimberly Oldenborg, R.B. Annis Educational Foundation Assistantship
Xiaomei Su, University of Chinese Academy of Sciences Assistantship
Strychar, major advisor
Nick Gezon, AWRI Assistantship

AWRI SCIENCE ADVISORY BOARD
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Dr. Carol Johnston, South Dakota State University
Dr. Gary Lamberti, University of Notre Dame, Chair
Dr. Don Scavia, University of Michigan

INTERNSHIPS & SCHOLARSHIPS:
AWRI provides opportunities for students to pursue their interests in our environment. The following students received internships during 2017.

NSF-REU QUEST STUDENTS
Rebekah Bryant
Thomas Clashey
Bethany Dennis
Meesha Ghedi
Ellen James
Jennifer Kovach
Brady Nahkala
Brooke Ridenour
Brittany Schulz
Marisa Yang

SCIENTECH CLUB FOUNDATION INTERN
Emily Dusicska

HERBERT VANDERMEY INTERN
Evan Hausig

ROBERT B. ANNIS FOUNDATION INTERNS
Matthew Allen
Noah Cleghorn
Mano Scarborough

BILL AND DIANA WIPPERFURTH SCHOLARSHIP
Evan Hausig

RON WARN SCHOLARSHIP
Michael Castleman
Noah Kiser
Madison Mitchell

Photo Credit: Maggie Oudsema


Help Us Save a Tree.

In the future, if you would like to receive our Year in Review and newsletters electronically, please join our email list at:

www.gvsu.edu/wri/review

Giving opportunities to support the operations of the Annis Water Resources Institute are available at the Community Foundation for Muskegon County, www.cffmc.org or at the GVSU Office of Development, www.gvsu.edu/giving.

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