Institute of Water Research
Annual Technical Report
FY 2017

Introduction

The Institute of Water Research (IWR) at Michigan State University (MSU) continuously provides timely information for addressing contemporary land and water resource issues through coordinated multidisciplinary efforts using advanced information and networking systems. The IWR endeavors to strengthen MSU's efforts in nontraditional education, outreach, and interdisciplinary studies utilizing available advanced technology, and partnerships with local, state, regional, and federal organizations and individuals. Activities include coordinating education and training programs on surface and ground water protection, land use and watershed management, and many others. We also encourage accessing our web site which offers a more comprehensive resource on IWR activities, goals, and accomplishments: http://www.iwr.msu.edu

The IWR has increasingly recognized the acute need and effort for multi-disciplinary research to achieve better water management and improved water quality. This effort involves the integration of research, data, and knowledge with the application of models and geographic information systems (GIS) to produce spatial decision support systems (SDSS). These geospatial decision support systems provide an analytical framework and research data via the web to assist individuals and local and state government agencies make wise resource decisions. The IWR has also increasingly become a catalyst for region wide decision-making support in partnership with other states in EPA Region 5 using state-of-the-art decision support systems.

The IWR works with MSUs AgBio Research and closely with the Cooperative Extension Service to conduct outreach and education. Outreach activities are detailed in the Information Dissemination section of this report. USGS support of this Institute as well as others in the region enhances the IWR credibility and facilitates partnerships with other federal agencies, universities, and local and state government agencies. The IWR also provides important support to MSU-WATER, a major university initiative dealing with urban storm water issues with funding from the university Vice President for Finance. A member of the IWR's staff works half-time in facilitating MSU-WATER activities so the IWR enjoys a close linkage with this project. The following provides a more detailed explanation of the IWR's general philosophy and approach in defining its program areas and responsibilities.

General Statement To deal successfully with the emergence of water resource issues unique to the 21st century, transformation of our knowledge and understanding of water for the protection, conservation, and management of water resources is imperative. Radically innovative approaches involving our best scientific knowledge, extensive spatial databases, and "intelligent" tools that visualize wise resource management and conservation in a single holistic system are likewise imperative. Finally, holistic system analysis and understanding requires a strong and integrated multi-disciplinary framework.

Research Program Introduction

The management of water resources, appropriate policies, and data acquisition and modeling continue to be at the forefront of the State, Regional, and National Legislatures agenda and numerous environmental and agricultural organizations. Our contribution to informing the debate involved numerous meetings, personal discussions, and most importantly, the enhancement of web-based information to aid in the informed decision-making process.

Unique Capabilities: Decision Support Systems as the Nexus IWR, with its “extended research family,” is exceptionally well-positioned to integrate research conducted within each of the three principal water research domains: hydrologic sciences, water policy, and aquatic ecosystems. Integrated decision support both reflects and forms the nexus of these three research domains. Expanding web accessibility to the decision support system nexus (formed by the intersection of the three research domains) will facilitate broad distribution of science-based research produced in these domains. A special emphasis is being placed on facilitation of science-based natural resource state and national policy evolution. Fundamentally we are addressing the Coupled Human and Natural System (CHANS).

The IWR’s extensive experience in regional and national networking provides exceptional opportunities for assembling multi-agency funding to support interdisciplinary water research projects and multi-university partnerships.

Using a multi-disciplinary framework facilitates dynamic applications of information to create geospatial, place-based strategies, including watershed management tools, to optimize economic benefits and assure long-term sustainability of valuable water resources. New information technologies including GIS and computational analysis, enhanced human/machine interfaces that drive better information distribution, and access to extensive real-time environmental datasets make a new “intelligent reality” possible. This is our way of addressing the "CHANS."

Effective watershed management requires integration of theory, data, simulation models, and expert judgment to solve practical problems. Geospatial decision support systems meet these requirements with the capacity to assess and present information geographically, or spatially, through an interface with a geographic information system (GIS). Through the integration of databases, simulation models, and user interfaces, these systems are designed to assist decision makers in evaluating the economic and environmental impacts of various watershed management alternatives.

The ultimate goal of these new imperatives is to guide sustainable water use plus secure and protect the future of water quality and supplies in the Great Lakes Basin, across the country and the world—with management strategies based on an understanding of the uniqueness of each watershed.

IWR Advisory Team The Water Resources Research Act supports the development of an Advisory Committee that has broad representation for each of the 54 Water Institutes located at Land-Grant Universities.

The IWR at Michigan State University (MSU) has assembled an Advisory Team consisting of five key individuals each with major responsibilities in different realms of water research, management and outreach education assuring a wide diversity of perspectives. The characteristics of the team incorporate a vision of future needs, technologies, and approaches that the IWR should consider including into our present and future planning and strategies.

Specific responsibilities include: (1) provide informative and broad guidance/direction for the director and personnel of IWR for the present and future; (2) provide guidance for IWR operations; (3) advise on diffusion and linkages of research, information technologies, and their use in operationalizing IWR activities; (4) serve as an important interface with AgBio Research, MSU Extension, and the University.

The Advisory Team meets two times per year. However, IWR contacts board members on an as needed basis for their guidance and insight. On an ongoing basis, key IWR activities and planning will be provided to the Advisory Team and they will assist the IWR in its mission to assure a continued high level of productivity, creativity, and impact.

Mr. Jon Allan, Director, Office of the Great Lakes Michigan Department of Environmental Quality; Mr. Scott Piggott, Chief Operating Officer Michigan Farm Bureau; Dr. Pat Doran, Associate State Director/Conservation Director for Michigan The Nature Conservancy, Michigan; Ms. Lisa Brush, Executive Director Stewardship Network, Michigan; Dr. Michael Jones, Assistant Director of Natural Resources Programs AgBio Research, and Professor, Department of Fisheries & Wildlife Michigan State University; Dr. Ron Bates, Director Agriculture and Agribusiness Institute - MSU; Dr. Dave Ivan, Director Greening Michigan Institute - MSU; Melissa Damaschke, Agriculture Program Director Erb Family Foundation; Dr. James Kells, Chair of Plant Soils and Microbial Sciences - MSU.

Developing and Enhancing Sustainable Water Use of Natural and Agricultural Systems

Basic Information

Title:	Developing and Enhancing Sustainable Water Use of Natural and Agricultural Systems
Project Number:	2017MI241B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Categories:	Water Quality, Water Quantity, Models
Descriptors:	None
Principal Investigators:	Darrell W Donahue

Publications

1. Young, Laura, Jason Piwarski, and James Duncan. 2018. Groundwater Management Guidebook for Ottawa County, Michigan. 35 pp.
2. Lusch, Dave, Prasanna Sampath, Shu-Guang Li, Zachary Curtis, Hua-Sheng Liao, Jason Piwarski, and Laura Young. 2018. Groundwater Sustainability Analysis of Southern Lower Michigan and Statewide Action Plan. Prepared for the Michigan Department of Agriculture and Rural Development. 136 pp.
3. Young, Laura and Glenn O'Neil. 2017. Great Lakes Watershed Management System Tutorials for the Saginaw Bay Regional Conservation Partnership Program. 5 pp.
4. Piwarski, J., S. Burlew, K. Cronk. 2017. "Overview of runoff risk forecasting tools under development in the Great Lakes Basin". Conference on Great Lakes Research. International Association for Great Lakes Research. Detroit, Michigan, USA.
5. Piwarski, J. 2017. "Precision Agriculture and Water Resources". Annual Fall Convention. Michigan Association of Conservation Districts. Bellaire, Michigan, USA.
6. Piwarski, J. 2018. "Runoff Risk Decision Support Tools: The Regional Runoff Risk Advisory System". MABA 2018 Winter Conference. Michigan Agribusiness Association. Lansing, Michigan, USA.
7. Piwarski, J. 2018. "Michigan EnviroImpact – A Focus on Technical Aspects". Nutrient Runoff Risk Reduction: A Workshop to Explore Decision Support Tools. Minnesota Sea Grant. Tuscaloosa, Alabama, USA.
8. Piwarski, J. 2017. "Michigan EnviroImpact". URL: https://enviroimpact.iwr.msu.edu/
9. Asher, Jeremiah. 2017. "Great Lakes Watershed Management System - Nutrient Reductions", Great Lakes Sedimentation Workshop. Chicago, IL.
10. Wu, Huiyun, Amira Oun, Ruth Kline-Robach and Irene Xagoraraki. 2018. Microbial pollution characterization at a TMDL site in Michigan: effect of hydrological conditions on pollution loading. Journal of Great Lakes Research. In preparation.
11. Wu, Huiyun, Amira Oun, Ruth Kline-Robach and Irene Xagoraraki. 2018. Microbial pollution characterization at a TMDL site in Michigan: Source identification. Journal of Great Lakes Research. In preparation.

12. Muenich, R. L., Kalcic, M. M., Winsten, J., Fisher, K., Day, M., O'Neil, G., Wang, Y., Scavia, D. (2017). Pay-for-Performance Conservation Using SWAT Highlights Need for Field-Level Agricultural Conservation. Transactions of the ASABE, 60(6), 1925–1937. https://doi.org/10.13031/trans.12379

Problem Statement

Water is replacing oil as one of the single most important resources upon which policy and, in fact, human existence in many portions of the globe will depend. Political power, economics, and civilization's development will be critically impacted by our ability to sustainably manage and optimally utilize the planet's water resources. Because of the United States' relative advantage from a water resource standpoint, this country's role will be increasingly significant in food production and industrial production requiring significant quantities of quality water, and in developing sustainable approaches to maintain waters' ecological services. Specifically, the Great Lakes region will have tremendous opportunities to capitalize in numerous ways on the potential of its vast water resources. But water resources management always occurs in a social context involving multiple stakeholders. Stakeholders can have radically different perceptions of the problems and potential trade-offs associated with finding solutions because of dynamic social, economic, and political factors as well as biophysical complexities of water resources issues. This complex nature of water resource management and other related issues, such as global climate change and health care, is often referred to in the scientific community as "wicked." Research on wicked-type problems suggests that a comprehensive knowledge system sustained by a boundary organization is essential. Boundary organizations act as intermediaries between science and policy because they fulfill or possess 1) specialized roles within the organization for managing the boundary; 2) clear lines of responsibility and accountability to distinct social arenas on opposite sides of the boundary; and 3) a forum in which information can be co-created by research and interested parties. IWR has effectively worked with a variety of organizations and audiences. This has allowed IWR to build a diverse network of partners. As a complicated and wicked problem, effective water resource management requires solutions from the broad economic sectors it affects. With partners from the university, government, nongovernment, and private sectors, IWR will receive the input needed as a boundary organization, bridging the gaps between each of the sectors.

Research Objectives

The operational research approach/objectives include:
(1) Investigate holistic assessment approaches which examine a watershed's agricultural and urban ecological and social systems to inform underpinnings of future modeling work.
(2) Using the holistic assessment described above, develop a modeling framework that includes physical, biological, climate, economic and policy components.
(3) Incorporate the modeling framework into existing or new decision support tools to guide specific water quantity and quality activities.
(4) Facilitate and study the adoption of improved or newly created decision support tools within a watershed, local/state government, regionally and with some connections internationally.
(5) In the long-term, evaluate the use and impacts of decision support tools to more successfully meet agricultural production, industrial and urban environmental sustainability goals, and support informed policy development and implementation.

Methodology

Research Methods/Experimental Procedures

(1) Investigate holistic assessment approaches which examine a watershed's agricultural, ecological and social systems to inform underpinnings of future modeling work.

- Conduct literature reviews:

  - Enhance understanding of agricultural and hydrologic modeling approaches
  - Explore improved methods for involving stakeholders and potential end users in the decision support tool development process
- Conduct focus groups with stakeholders and interviews with key informants to assess needs, understand key work functions that could be improved with modeling and decision support tools, and identify additional data needed to generate models
- Establish an advisory group with a diverse set of stakeholders (*e.g.*, agricultural commodity groups, conservation organizations, watershed groups, government agencies, academia) to provide feedback on project components and connect results back to members' respective organizations
- Identify areas within the Great Lakes Basin where water quality and quantity models (*e.g.*, Soil and Water Assessment Tool-SWAT, High Impact Targeting-HIT and others) could aid in agricultural land management. Focus on areas where the demand for food production is stressing water resources and/or where irrigation is prevalent.

(2) Using the holistic assessment described above, develop a modeling framework that includes physical, biological, climate, and economic components.

- Explore updating Water Withdrawal Assessment Tool (WWAT) models with more detailed model results (*e.g.*, from Process-based Adaptive Watershed Simulator -PAWS or MODFLOW) that simulate the potential impacts of increased water use and climate change on aquifer sustainability.
- Generate model outputs for selected areas under various agro-environmental climate change model ensembles, for example, groundwater recharge rates under various climate change scenarios.
- Investigate a set of approaches to incorporate tile drainage into hydrologic models that also examine groundwater recharge
- Enhance existing hydrologic models for use in incentive-based conservation programs (*e.g.*, Pay for Performance)
  - Calibrate water quality models in pilot areas for nutrients and sediment.
  - Simulate land cover change and management scenarios on the calibrated models to evaluate the potential impacts on model outputs.

(3) Incorporate the modeling framework into existing or new decision support tools to guide specific water quantity and quality activities.

- Improve and expand geographic coverage of existing systems (*e.g.*, Great Lakes Watershed Management System-GLWMS) with modeling efforts described above
- Utilize enhanced techniques for programming decision support tools
  - Re-program the GLWMS with a more modular design, which could allow for inclusion of more real-time modeling results from other models, such as STEP-L, MODFLOW, and SWAT.
  - Incorporate findings from the literature to improve system usability and user-friendliness (*e.g.*, refine the GLWMS to work seamlessly on mobile devices, particularly smart phones) (McIntosh et al., p. 1400).
- Work with stakeholders in the development or refinement of decision support tools

(4) Facilitate and study the adoption of improved or newly created decision support tools within a watershed, local/state government, regionally and with some connections internationally.

- Coordinate with conservation groups like The Nature Conservancy to utilize decision support tools to prioritize and implement land management practices
- Develop and conduct user evaluations of decision support tools
- Test technology transfer approaches for disseminating decision support tools

(5) In the long-term, evaluate the use and impacts of decision support tools to more successfully meet agricultural production, environmental sustainability goals, and support informed policy development and implementation.

- Assess impact of using decision support tools and other modeling information to increase an optimized selection of agricultural best management practices on high risk areas for nutrient and sediment loading
  - Work with agencies such as the USDA, NRCS to evaluate historical implementation of best management practices
  - Review geospatial data saved by users as they implement best management practices and compare with historical BMP implementation
  - Conduct focus groups or interviews with landowners and conservation professionals to assess influence of using a decision support tool on decision-making

(6) Facilitate establishing a communication process and network for government officials and policy makers regarding research findings. In the long term, continue ongoing discussions to inform policy development and evaluate policy outcomes.

Principal Findings

IWR developed several new decision support systems and enhanced several others to target sensitive agricultural areas, evaluate sediment and nutrient reduction by changing farm practices, and incorporating weather to help farmers determine when it is safer to apply manure.

The Great Lakes Watershed Management System (GLWMS) online tool was used by multiple user groups, agricultural producers, conservation districts and MSU Extension to evaluate non-point source (NPS) pollution estimates at watershed and field scales. Users conducted on-the-fly field scale scenario evaluations of land cover changes or best management practices for run-off volumes, sediment loading and other pollutant loads. By linking other models, including the High Impact Targeting (HIT) model from the MSU IWR with the Long Term Hydrologic Impact Assessment (L-THIA) model from Purdue University's Department of Agricultural and Biological Engineering, the system was used to:

- Estimate nonpoint source pollutant loadings at the field and watershed scales
- Determine potential reduction in nonpoint source pollutants based on implemented best management practices (BMPs)
- Assess potential increases in groundwater recharge based on implemented BMPs
- Adjust input parameters for select analysis modules
- Generate PDF reports containing field-scale analysis results and detailed maps
- Track watershed improvements over time

The GLWMS is currently available in the four U.S. EPA GLRI Priority Watersheds – Fox River Basin (WI); Genesse River Basin (NY); Maumee River Basin (OH); Saginaw River Basin (MI) as well as the River Raisin Watershed in southeastern Michigan. Future expansion beyond these watersheds is a continuing goal.

The Michigan Sensitive Areas Identification System (SAIS) was developed as an online mapping and reporting tool to improve water quality by connecting producers with NRCS and conservation organizations to address sensitive areas through conservation treatments and available assistance programs. It identifies and maps sensitive areas on farm fields. Producers used the tool to assist in identifying ecologically sensitive areas that may be prone to soil erosion by wind or water, leaching of nutrients, or other risk factors. Results were based upon the field's physical characteristics, such as soils and slope, and the answers that the users provided in a series of questions asked. The generated report provided users with information on phosphorus risks and manure risks. For example, a report might indicate that the risk of phosphorus leaving the field is high, and that there is a "high" potential risk of offsite phosphorus movement, and no manure or fertilizer phosphorus should be applied to the field. Recommended practices to address risks were also provided. Users also had the option of completing a brief questionnaire and generating a printable report with a summary of results and information to follow-up with the Natural Resourced Conservation Service.

Another newly developed tool was designed to provide users with regularly updated forecasts for surface manure runoff risk. The tool allows users to create email and text message alerts that notify them of significant predicted runoff risk events. Additionally, the tool provides a seven-day forecast for runoff risk at any location in Michigan. EnviroImpact is a collaborative effort between the National Ocean and Atmospheric Administration National Weather Service (NWS), the Michigan Department of Agriculture and Rural Development, the Michigan Agriculture Environmental Assurance Program, the IWR, Michigan Sea Grant and MSU Extension. The tool is part of the larger Regional Runoff Risk Advisory System being developed by the NWS. One Extension coordinator said of the tool, "This online, mobile-friendly tool helps farmers assess their risk of possible runoff as they develop their manure spreading schedules. Farmers have the ability to adjust their management plans if a rainfall event on particular fields is imminent—enabling them to make better management decisions and improve their ability to protect Michigan's water quality."

IWR tool development and enhancement has led to the leveraging of USGS funding to obtain larger grants. Through a grant from the Great Lakes Restoration Initiative, IWR has been able to work with producers and a variety of conservation partners to improve water quality in Lake Erie by reducing nutrient runoff and sediment loss from farm fields. This ongoing two year program offers online tools to farmers and conservation technicians to optimize soil health and retain sediment and nutrients in the field. Participating farmers are then eligible to receive reimbursement for conservation practices. The IWR tools and computer models help track the cumulative benefits that farmers' activities are making toward improving water quality in the Western Lake Erie Basin. The program is working with a farmer-led watershed conservation group, local conservation districts, MSU Extension and others.

Inline Wetland Treatment Effectiveness for Treating Nutrients from Tile Drains

Basic Information

Title:	Inline Wetland Treatment Effectiveness for Treating Nutrients from Tile Drains
Project Number:	2017MI243B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Categories:	Agriculture, Water Quality, Wetlands
Descriptors:	None
Principal Investigators:	Jeremiah A Asher, Dawn Reinhold

Publication

1. Asher, Jeremiah, 2017, In-Ditch Wetlands to Treat Phosphorus Through Tile Drains, Michigan Agribusiness Association Winter Conference, Lansing, MI.

Problem

Dissolved reactive phosphorus leaving agricultural fields through tile drains are impacting water quality in the Great Lakes particularly in the western Lake Erie Basin. Growths of harmful algal blooms in western Lake Erie are linked to increases in dissolved reactive phosphorus by providing excess nutrients. There have been in increase in the density and number of tile drain systems installed the basin increasing the paths of dissolved reactive phosphorus entering western Lake Erie.

Research Objectives

Research of the activities will start in the spring and sampling will occur throughout the summer at weekly intervals. The objective is to quantify the impacts of wetland treatment of phosphorus leaving tile drains.

Methods

Samples will be collected by Adrian College students weekly and taken back to MSU Soil and Plant lab or at testing facilities at Adrian College to test for dissolved reactive phosphorus, ph, TSS, and nitrates.

Principal Findings and Significance

This project was closely aligned with other water quality sampling work in the River Raisin. Samples were collected from multiple tile drain sites in the River Raisin watershed and analyzed at Adrian College.

Of the 7 fields sampled, 3 fields had phosphorus levels over the 1ppm discharge limit for permitted discharges in Michigan. Two other fields had nitrate levels leaving the tile drains that were above thresholds indicating too much fertilizer was applied during the growing season based on recommendations from Purdue University.

This information was used to help site potential wetland sites that could be used to treat phosphorus leaving the tile drains. During the year, multiple visits were made to assess different sites. These sites will be built in a related project funded by the Army Corp of Engineers. The following describes the investigation of three sites for installing a inline treatment wetland. The first site that was evaluated and surveyed did not have sufficient elevation drop to allow the wetland to work properly. During the following season we investigated another site which had sufficient gradient but was too far away from the road for students to be able to easily take water quality samples. The third site reviewed required a wetland permit from DEQ, we are currently in the process of applying for that permit. Construction of the wetland and instrumentation is anticipated to start in July of 2018.

Nutrient Monitoring of the River Raisin Watershed to Inform Farmers and Optimize Decision Making for BMP Implementation

Basic Information

Title:	Nutrient Monitoring of the River Raisin Watershed to Inform Farmers and Optimize Decision Making for BMP Implementation
Project Number:	2017MI244B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Categories:	Management and Planning, Water Quality, Education
Descriptors:	None
Principal Investigators:	James B Martin

Publication

1. Nunn, Alaina. 2018. Exploring the Use of Subsurface Water Quality Data as a Feedback Mechanism for Improving Conservation: A Case Study in the River Raisin Watershed. MS Dissertation. Department of Community Sustainability. Michigan State University. East Lansing, MI. 70 pages.

Problem

Statement of Regional or State Water Problem

The Great Lakes Restoration Initiative has been assisting the Stewardship Network and its partners with building relationships with Michigan farmers in the River Raisin watershed who have exhibited low BMP adoption rates since 2014. However, no current funding exists to perform water quality analysis in this area for the purpose of keeping farmers informed of where areas of concern are located.

Research Objectives

Nature and Scope

Recent investments in restoring the River Raisin watershed have been allocated towards building better relationships with farmers, while providing them the outreach and technical support needed to increase BMP adoption rates.

Objectives

We hope to assist in increasing BMP adoption by making water quality data accessible to farmers. This will be done using a phased approach. *P hase I (Objective A)* includes sampling bi-weekly from farmer tile drains, as well as different stream locations throughout the south branch of the River Raisin watershed. *Phase II (Objective B)* involves organizing the data into charts that are easily understood by farmers, and *P hase III (Objective C)* includes presenting the data to farmers during a field day, which will be held in September of 2017.

Methods

Samples will be taken bi-weekly with all testing to be done within 24 hours in the lab facilities at Adrian College. Data will be input into an Excel spreadsheet and sent to the MSU IWR bi-weekly for interpretation of results. Data will also be sent to the IWR from the RRWC after completion of their adopt-a-stream sessions. After six months of water sampling data collection, data will be compiled into charts which express trends and demonstrate areas of concern. Data will be presented to farmers and we will discuss what it suggests.

Procedures

All chemical testing will be done according to EPA standard methods, those also used by the MDEQ. Data will be made available to all stake holders within the River Raisin watershed in order to assist in making informed, science-based decisions regarding implementation of BMPs, as well as increasing adoption rates among farmers.

Principal Findings and Significance

The results of this study demonstrate the potential of two key approaches to assisting farmers in better meeting on-farm subsurface water quality goals: 1) partnering with local colleges to implement a cost-effective water monitoring program and 2) providing farmers with annual field-specific water quality reports as a form of environmental feedback.

More often than not, farmers have little to no understanding of phosphorus or nitrate levels coming from their tile drains due to the expense associated with water monitoring; however, the monitoring model used in this study was able to keep expenses low. Through the recruitment of undergraduate students at Adrian College, high labor costs were avoided by hiring students to complete field collections and lab analysis in exchange for university research credits, or through providing free campus housing during the summer months.

The benefits to collaborating with a small or large university in this way was clearly demonstrated through the responses from participating farmers during in-depth interviews, as well as through feedback provided from non-participating farmers through a survey administered at a farmer-led watershed meeting. Using the subsurface water quality data as a source of environmental feedback proved to be very enlightening and useful to the farmers who received a summarized water quality report at the end of this study.

Results indicated that before these farmers had access to field specific water quality data they had very little to no awareness of how much nutrient loss was occurring on their fields. In general, all participants were anticipating some nutrient loss to be occurring, but this was attributed to a mix of factors, including their own farm management decisions, mother nature, and physical land characteristics. As a response to these concerns for nutrient loss, each farmer already had a number of different BMP's in place. Two farmers admitted, however, that they had no idea whether those conservation practices were leading to positive water quality results, but all three participants remained optimistic that they were. Therefore, each farmer felt content with their farm management styles, with the exception of additional BMP's they said they'd be interested in implementing if they felt it was necessary to do so.

Upon farmer review of their water quality reports, though, each participant became increasingly more aware of how much nutrient loss was actually occurring on their fields. This inevitably led to a more in-depth review of which farming practices were used the previous growing year(s) in an effort to pinpoint what was contributing to what the farmers interpreted as "good" or "bad" water quality results. Each farmer discussed things they could have or wished they had done differently, and as a result of the information provided to them, they felt more in control of what they could do during the next growing season to lower nutrient loss from their fields.

In conclusion, these interviews revealed something very important to consider moving forward, and that is that farmers in this study did not feel it was necessary to adjust land management or implement additional BMP's unless they had information that suggested otherwise. All participants were content with their current management styles and were optimistic that the BMP's they had in place were keeping nutrient losses low. Water quality results from each tile drain, however, showed that three of the five fields studied had DRP concentrations above 0.03ppm greater than 90 percent of the time; and all fields studied had DRP concentrations above 0.03ppm greater than 50 percent of the time.

Additionally, it is important to recognize that each farmer came up with a very different strategy, specific to their farm's needs, in an effort to lower nutrient losses. As Pete Nowak mentions in *The Conservation Journey*, each farm is very diverse both in its physical characteristics and its management, and uniform conservation programs cannot be expected to reduce nutrient losses in the most efficient way. Therefore, the results of this study suggest that in order to meet watershed water quality goals, and achieve a 40 percent reduction in phosphorus loading to Lake Erie, farmers will need field-specific water quality data to better assist them in implementing conservation practices that will be most effective, and for tracking improvements along the way.

It is also anticipated that farmers will be open to using water quality data for this purpose because results from the farmer-led watershed group survey demonstrated significant interest in having access to it, as well as a high likelihood that they would use the information to reach environmental goals through

changing practices. This will be important information moving forward as we decide whether or not farmers would want to use this data, and how it would potentially impact on-farm conservation decisions.

Students Trained

During the project period five students were trained and provided summer internship credits at Adrian College.

Phosphorus Optimized Wetland Treatment and Placement Screening

Basic Information

Title:	Phosphorus Optimized Wetland Treatment and Placement Screening
Project Number:	2017MI249S
USGS Grant Number:	
Sponsoring Agency:	Army Corps of Engineers
Start Date:	12/1/2017
End Date:	9/30/2018
Funding Source:	104S
Congressional District:	
Research Category:	Water Quality
Focus Categories:	Wetlands, Agriculture, Nutrients
Descriptors:	None
Principal Investigators:	Jeremiah A Asher

Publications

There are no publications.

Problem

Dissolved reactive phosphorus leaving agricultural fields through tile drains are impacting water quality in the Great Lakes particularly in the western Lake Erie Basin. Growths of harmful algal blooms in western Lake Erie are linked to increases in dissolved reactive phosphorus by providing excess nutrients.

Research Objectives

Research of the activities will start in the spring and sampling will occur throughout the summer at weekly intervals. The objective is to quantify the impacts of wetland treatment of phosphorus leaving tile drains.

Methods

Samples will be collected by Adrian College students weekly and taken back to MSU Soil and Plant lab or at testing facilities at Adrian College to test for dissolved reactive phosphorus, ph, TSS, and nitrates.

Principal Findings and Significance

The wetland treatment site for phosphorus removal from tile drains has been extended due to complications in the field for selecting an appropriate site. The first site that was evaluated and surveyed did not have sufficient elevation drop to allow the wetland to work properly. During the following season we investigated another site which had sufficient gradient but was too far away from the road for students to be able to easily take water quality samples. The third site reviewed required a wetland permit from DEQ, we are currently in the process of applying for that permit. Construction of the wetland and instrumentation is anticipated to start in July of 2018.

Information Transfer Program Introduction

The state of Michigan has an abundant and widespread supply of water due in large part to its geographical location within the Upper Great Lakes Region. The state's many rivers, lakes, and wetlands as well as the Great Lakes support critical habitat, a world class fisheries, and high quality waters. Citizens within the state and region utilize these resources for drinking water, recreation, industrial processes, irrigation, and numerous other activities. As these uses continue to grow, these waters become more susceptible to degradation, ecosystem changes, and may result in conflicts among water users. Problems associated with phosphorus and nitrogen runoff, storm water, invasive species, habitat degradation, climate change, and wetland loss are just a few of the many challenges that Michigan residents and decision makers face. Additionally, water withdrawals from both surface water and groundwater for irrigation or other water uses can result in decreased stream flow or reduced lake levels and lead to ecological and human-related problems. Conflicts between irrigators and domestic users may also increase as withdrawals affect well water. These issues are exceedingly complex and sometimes contentious. They require people working together and having access to reliable data, human resources, and good science-based knowledge of the situations.

Technology Transfer Training, Dissemination and Program Development

Basic Information

Title:	Technology Transfer Training, Dissemination and Program Development
Project Number:	2017MI242B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Categories:	Surface Water, Education, Water Quantity
Descriptors:	None
Principal Investigators:	Lois Wolfson, Darrell W Donahue

Publications

1. Koundinya, Vikram, Anne Baird, Jenna Klink, Lois Wolfson, Jane Frankenberger, Joseph Bonnell, and Rebecca Power. 2018. Core Competencies for Successful Watershed Management Work. Research In Brief, Journal of Extension. Volume 56(1).
2. Elgin, Erick, Lois Wolfson, Angela DePalma Dow and Elizabeth Throckmorton. 2017. Study of Water Quality and Aquatic Plant Assessment. Lake Shore Breeze, Spring 2017. pp 2-3.
3. Kline-Robach, Ruth, Lois Wolfson, Susan Masten, Darren Bagley, Terry Gibb and Bindu Bhakta. 2017. A Guide to Home Water Treatment. Michigan State University Extension Bulletin E3342. 8pp.
4. Asher, Jeremiah, Laura Young, Lois Wolfson, and Jason Piwarski. 2017. Great Lakes Clean Communities Network Final Report, Project No. 966. Great Lakes Protection Fund. 15 p.
5. Bhakta, Bindu and Lois Wolfson. 2017. Celebrate Lake Appreciation Month. MSU Extension News, East Lansing, MI
6. Kline-Robach, Ruth and Lois Wolfson. 2017. Successes and Challenges in Training Adult Professionals through Distance Learning – June 13-15. 2017 UCOWR/NIWR Conference. Water in a Changing Environment, Colorado State University - Fort Collins, Colorado.
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Problem Statement

The demand for water for agriculture, industry, recreation, and drinking continues to increase with expansion of operations, facilities, and population growth. While Michigan has an abundant water supply from both surface water and groundwater sources, the huge demand and multiple uses of water by individuals, municipalities, cities, and numerous other groups can lead to both water quality and quantity challenges. Issues such as degradation of water resources, water use conflicts, ecosystem perturbations, and invasion of nonnative species can lead to serious risks for the State's water resources and its economy. Other issues such as water withdrawals can result in decreased streamflow or reduced lake levels. The end results produce ecological and economic related problems, such as lower temperatures or oxygen levels in impacted streams, stress or death to aquatic organisms or reduced irrigation in intensive water use areas, respectively. These issues are extremely complex and require knowledge from multiple disciplines, ways to analyze small and large data sets and interpret results to assess the problems. Further, mechanisms to successfully transferring timely, accurate, unbiased and current research based information to diverse audiences is critical for helping people understand the complexity of these issues, enable them to make more informed and better decisions concerning water resources and provide alternative solutions to real world problems.

Objective

The objectives of the technology transfer and information dissemination program are to: 1) develop and present educational programs designed to increase the public's awareness, knowledge and stewardship of the water quality and quantity problems in Michigan and present alternatives in practices or behavior that lead to improvement of the resource; 2) incorporate new information on water into existing programs and coordinate and link IWR programs with knowledge generation in order to more effectively address and solve complex water issues; 3) provide hands-on tools and models to address environmental and economic complexities required to solve real world water related problems; 4) address high priority and emerging issues; 5) evaluate the projects disseminated and incorporate lessons learned into new programs; 6) develop programs in a variety of formats that suit the needs of individuals and user groups; 7) work cooperatively with user groups to give them more ownership in the development and use of the programs and to help ensure sustainability for the project; 8) coordinate and develop multidisciplinary projects with Michigan State University Extension and its Institutes, faculty on campus, state and local agencies, environmental organizations, and other Universities, and 8) transfer science based water-related information and data for educational purposes, more informed decision making, and improved management of water resources.

Methods

Programs proposed for this fiscal year are developed with IWR staff members, but also include other University personnel, Extension Educators, NGOs, agency personnel and others with expertise in the area being discussed. This interaction helps contribute to the technical accuracy of the programs. The use of advanced technology, such as decision support systems, on-line calculators, models or GIS-based applications helps provide users with planning tools and options for management. The use of a co-creative process involving partners and clientele increases participation and sustainability of the program. The methods employed include: (1) creating teams of experts in developing technical and non-technical conferences and workshops; (2) delivering lectures, demonstrations and power point presentations using science-based research; (3) developing training sessions and hands-on workshops with partner organizations, Extension and other researchers and specialists; (4) working with technical teams to develop web-based interactive programs to assess and address potential problems and provide a means to visualize areas within watersheds; (5) supporting the work of and interacting with MSU Extension to make water related information relevant at the local level and available through the county extension offices; (6) partnering with state agencies and other Universities on critical issues; and (7) coordinating and developing multidisciplinary and complex projects in a co-creative process with both clientele and associates to make water-related information readily available to a vast clientele across the state. The

facilities and equipment used to help implement these programs include large servers and other computer equipment for data storage, web sites and large databases. Two LCD projectors are routinely utilized to present power point presentations, host video-conferencing events; and support demonstrations. In addition, the Institute also maintains scanners, a laser color printer, inkjet color printers, digital camera, iPAD, and software for promoting activities and developing materials. For field demonstrations and research related opportunities, the IWR employs meters, water sampling devices, and chemical testing kits for teaching workshops and for measuring parameters in lakes, and has primary access to a campus outdoor lake facility, the Inland Lakes Research and Education Area, that can function as a hands-on outdoor laboratory.

Principal Results/Findings and Significance

Conferences

Great Lakes: This fiscal year marked the 27th year for this year's conference, *The Great Lakes: Moving Michigan Forward*. This theme incorporated the ideas generated by Michigan State University's year-long focus on Water Moves, a university-wide initiative fostering scientific innovation and cultural and artistic expression inspired by water. Overall, 175 people attended the conference and 93% ranked the conference as excellent or very good. Participants also commented on what they felt was most valuable about the conference. Comments included the ability to network with peers and discuss new topics, connecting research with students, the diversity of talks, new water management advances in the state, hearing creative solutions to big problems, and learning about global water issues, harmful algal blooms, rip currents, and other Great Lakes topics. One participant said, "It is amazing to see what we are doing to clean the water and protect it." Most participants indicated they learned a lot, and indicated that they had plans to use the information in the future in such venues as in their classrooms, in environmental education events, in developing an app, using drones (one of the talks) for storm water management, and sharing. This conference continues as a partnership with the IWR, Michigan Sea Grant Extension, MSU Department of Fisheries and Wildlife and the Michigan Department of Environmental Quality Office of the Great Lakes (now part of the Michigan Department of Natural Resources)

Shoreline and Shallows: The biennial Michigan Shoreline and Shallows Conference: Increasing Habitat, Reducing Threats featured the newly established Michigan Shoreland Stewards program that provides recognition to lakefront property owners who protect their lakes through best management practices. Other talks focused on healthy lakes initiatives and BMPs; invasive plant species and nuisance animal species management and control options; fish habitat and accessing information about lakes; and new products for bioengineering structures. Overall, 106 people attended. Of those completing evaluations, 90.7% rated the conference as excellent or very good, and nearly 90% indicated an increased confidence in understanding relationships between invasive species and shoreline restoration projects, two topics covered during the event. The conference is jointly sponsored by IWR, the Michigan Department of Environmental Quality and led by the Michigan Natural Shoreline Partnership. Several other NGOs contributed to the conference.

Workshops and Training Sessions

Lake and Stream Leaders Institute: The biennial Lake and Stream Leaders Institute (LSLI) consisted of five sessions of intensive on-site training on process skills such as conflict resolution, communicating with the public, and leadership; and science-based skills such as lake and stream sampling and analysis, wetlands identification, watershed planning and management, and invasive species. Participants took part in classroom and field-based sessions designed that helped them better understand local water resource management planning and program implementation. They also completed an independent applied project, based on what they learned during the Institute sessions. IWR played a significant role in the development, implementation, and instruction of the program and was involved in the coordination, development and running of it. The participants included resource managers, waterfront property owners,

non-profit organization representatives and decision makers. Although the number of participants was relatively low at 18, the program brought together people with diverse perspectives but common goals; they were introduced to experts from MSU, state agencies, and other organizations, and gained multiple perspectives on leadership and science-based learning. Evaluations were very good to excellent. One question asked participants about their interactions with others in the class. Responses included: "Outstanding. I feel very comfortable contacting any of the instructors for help in the future; can't be better. I met very committed people with a wealth of knowledge and experience; amazing people; fellow students, instructors, guest speakers all incredible resources in a variety of ways; Informal discussions about our own interests/issues during down times were incredibly useful; This was a very collegial group; Instructors were very approachable and their enthusiasm was contagious; and It brought a sense of being passionate about topics." A presentation was given at a national conference focusing on the lessons learned from the program, and a paper on core-competencies for watershed leaders was published.

Water School: Essential Resources for Local Officials*:* This two-day workshop consisted of a series of lectures and interactive sessions with an afternoon field trip. Topics included water basics, water quantity, water quality, economics, and policy issues. As a first time program, there were many observations made by instructors, observers and participants on the program, and how it can be improved. Participants indicated that they found the program useful and that most presentations flowed well. One observer noted that the program was light on defining and informing people about the major water quality issues that communities and the state are facing and that they were missing a driving force. However, the observer noted that the participants walked away with valuable information. Another issue concerned targeting the right group of people and keeping their involvement strong so that they come back the next day. Overall, about 33 participants began the course, but less than 20 finished it. For this program, IWR staff helped to develop components of the program and lead some of the sessions. However, the program was conceived by MSU Extension and Michigan Sea Grant Extension. Future programs have been scheduled, and changes are being made to reformat portions of the course

On-Site Lake Programs: The Higgins Lake Foundation worked with educators at MSU, including IWR to hold a regional one day workshop on "Life on the Lake" focusing on inland lakes ecology and management. Topics included natural shorelines; low impact shoreline practices; groundwater; septic system maintenance; and aquatic invasive species. Approximately 30 people attended the session. One township official attending the workshop wrote of the session, "I can't think of a better way to spend a Saturday morning."

The annual Oakland county "Investigating Lake Ecology" program was also held. About 24 participants learned about lakes, common aquatic vegetation and their role in keeping lakes healthy, aquatic invasive species that threaten lakes, the effects of seasonal changes on lakes, as well as the physical, chemical and biological properties of the water. Participants received hands on experience in lake sampling, chemical analyses and species identification. IWR staff co-taught the workshop in coordination with MSU Extension personnel and Oakland County Parks and Recreation. Evaluations for the workshop were extremely positive. One of the top two ratings were marked by over 90% of participants for statements concerning usefulness of materials, the instructor's teaching; the participant's engagement; and the ease of getting actively involved in the workshop.

Aquatic Invasive Species Working Group: As part of the North Central Region Water Network, several Universities including MSU, University of Wisconsin, Ohio State University, University of Minnesota, Illinois-Indiana Sea Grant, and Dakota Water Watch were awarded a multi-state team grant to create an Aquatic Invasive Species (AIS) Working Group in order to increase connectivity and learning between university professionals and partners across a diversity of water-related disciplines and roles. The group's goals were to build capacity of universities to address multi-state water-related issues and opportunities; and generate measurable impacts for aquatic invasive species prevention and management. Through this

group, members came together at an Invasive Species regional conference to strategize on future programming efforts, developed a webinar on approaches for engaging volunteers in aquatic invasive species detection and monitoring, and shared resources so that duplication of materials would be avoided.

Online Courses

Introduction to Lakes Course*:* In its third offering (January-March 2018), the Introduction to Lakes course had the highest attendance reaching 189 participants in eight states, with the majority from Michigan. The team running the course included the Department of Fisheries and Wildlife, IWR and MSU Extension, with strong support from the Michigan Departments of Environmental Quality and Natural Resources. This year, approximately 86% of participants completed the course. Assessment data demonstrated substantial improvement in understanding of course topics: Lake Ecology, Watersheds, Shorelines, Law, Aquatic Plants, and Promoting Public Involvement. In addition, students who completed the course were eligible to receive credits offered for Pesticide Applicator Recertification (Commercial Core or Category 5 [Aquatics]) (received by 8 participants); Michigan Department of Education for State Continuing Education Clock Hours (received by 2 participants); and MSU Extension Master Citizen Planner (received by1 participant). With the course just recently ending, not all survey results have been analyzed. Already recognized by two previous awards in 2016, the course received the 2017 Leadership and Service Award from the North American Lake Management Society. A presentation on this and other online programs was given during the 2017 UCOWR conference by IWR staff.

Web Based Tools

Decision Support Systems and Tools: As summarized in the overall IWR narrative, many of the IWR programming efforts involve the development of Decision Support Tools for multiple audiences. These tools are used in many outreach programs to assist farmers, local decision makers, state agency personnel, and Extension educators with decisions, accessing data sets, viewing maps, and sharing resources. The outcomes from using these systems often include savings in time and money, increased networking among groups, and over time, changes in practices in the landscape that decrease sediment and nutrient runoff to receiving lakes and streams. IWR staff are continually upgrading the software, incorporating new models, and writing new code. Some of these systems, including the Great Lakes Clean Communities Network, e-Watershed, the Sensitive Areas Identification System, Enviro-impact, and the Great Lakes Watershed Management System, are being used by IWR, agencies, nonprofit organizations, and MSU Extension with their constituents, and by agricultural producers in a "Pay for Performance" program in which IWR is one of the collaborators.

Web Site*:* IWR launched its new website in 2016 and continued to add new online tools, articles, announcements, and IWR activities. The site includes access to all the online tools developed at the IWR, USGS research funded projects, and new opportunities for training. The web site also includes its on-line newsletter, *The Watershed Post*. This electronic newsletter provides current information on Institute activities, upcoming events, links to other pertinent programs or materials, and general interest articles. Contributions are made by faculty, staff, and students.

University sponsored Programs

Exhibits and Demonstrations

On an annual basis, the IWR participates in a variety of University sponsored events, and provide programs that showcase the University's role in science based education. This year, IWR was again invited to participate in the MSU Science Festival, an event that explores multiple aspects of science and how it affects people within the state. Due to its popularity from year one, the IWR program, "Edible Aquifer" was elevated to one of the Festival's Featured Programs. The program focused on illustrating groundwater movement and contamination. The event culminated with participants creating "edible aquifers" as a hands-on learning exercise. Two classes, both filled to capacity, were given. Another event MSU Grandparents' University, was held and featured live macroinvertebrates, pelts, and activities for

youth and their grandparents to learn more about the local river that flows through the campus. Each class was limited to 30 grandparents and one to two grandchildren, and each was filled to capacity. IWR also participated in a youth fishing program over three weekends. Approximately 210 youth and their parents took part to learn how to cast, learn about ethics and conservation in fishing, and shown how to tie a hook and bait their line. Excellent comments were received by both the children and their parents. Another exhibit was displayed during the annual MSU Autumn Fest, where participants were provided information on surface and groundwater in a game-like setting. Approximately 150 people visited the exhibit.

In-house Contributors
The IWR's technology transfer program is under the direction of Principal Investigator Dr. Lois Wolfson, with several IWR personnel contributing to several of the project, including Dr. Darrell Donahue, Ruth Kline-Robach, Jeremiah Asher, Laura Young, Glenn O'Neil, and Jason Piwarski.

Notable Awards/Accomplishments
The Introduction to Lakes online course received the 2017 Leadership and Service Award from the North American Lake Management Society

Dr. Lois Wolfson, Senior Specialist received the MSU Distinguished Academic Specialist Award from the University.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	6	0	0	0	6
Masters	2	0	0	0	2
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	8	0	0	0	8

Notable Awards and Achievements

The U.S. Department of Agriculture (USDA) provided an $890,000 Regional Conservation Partnership Program grant to the IWR and its partners to restore fish habitat and improve water quality through a variety of conservation measures including buffer strips, and drainage management. The Maple Watershed Fish Habitat Improvement project will bring together 13 partners to help implement a novel approach to improve water quality and fish habitat. This innovative new partnership is one of ten projects in Michigan made possible by the 2014 Farm Bill's Regional Conservation Partnership Program, authored by US Senator Debbie Stabenow. These locally-led partnerships leverage private and public dollars to bring together partners to address regional conservation issues. Sen. Stabenow said, "This project is another great example of businesses, non-profits and conservation leaders working alongside farmers at the local level to improve water quality and create new habitats for fishing in the Maple River Watershed. The new partnership will build on the historic investments in land and water conservation that we have already made across the state, which is strengthening local economies and supporting our way of life."

Dr. Lois Wolfson, Senior Specialist received the Michigan State University Distinguished Academic Specialist Award from the University.

The Introduction to Lakes online course received the 2017 Leadership and Service Award from the international North American Lake Management Society.