Application to the Long-Term Agro-ecosystem Research (LTAR) Network

Eastern Corn-Belt LTAR Node Covering the Ohio River Basin and Great Lakes Region

"Producing the best science to improve agricultural productivity, environmental sustainability and ecological diversity for the Eastern Corn Belt"

Executive Summary

This LTAR proposal is a joint effort among the USDA-ARS Soil Drainage Research Unit, the USDA-ARS National Soil Erosion Research Laboratory, and the National Center for Water Quality Research (NCWQR) at Heidelberg University that share the common mission to address the impacts of agricultural production systems on the environment. The proposed LTAR Node represents the Eastern Corn Belt (ECB), specifically the Ohio River Basin and the Great Lakes Region. Intensive agricultural production in this region has caused excessive nutrient and pesticide loads to the streams and lakes. Besides agricultural chemical issues, how to properly manage water on poorly drained lake plain soils and to reduce erosion and sedimentation from fields and in channels and streams are major challenges in this region. The proposed LTAR network addresses nationally known water quality and ecological issues in the Western Lake Erie Basin, Grand Lake St. Marys, and the Gulf of Mexico (from the Ohio River). All three team members have long histories of working on agricultural and environmental issues in the region. Their combined personnel include 20 research scientists and more than 26 skilled support personnel with expertise covering areas such as soil water dynamics, erosion processes, fate and transport of sediments, nutrients and pesticides, soil quality, drainage water management, cumulative impacts, watershed scale analyses, trend analyses, ecology and environmental statistics and modeling. All three team members participated in the Conservation Effects Assessment Project (CEAP). The team members maintain an extensive network of long-term research sites and monitoring stations, ranging from plot and edge-of-field sites and small watersheds to large watersheds draining into Lake Erie or the Ohio River. To complement the field and watershed research, laboratory facilities include state-of-the-art instrumentation for analysis of nutrients, trace metals, pesticides, volatile organic compounds (VOCs), and greenhouse gases, as well as flumes and rainfall simulators for process-level understanding of sediment and pollutant transport. The geographic coverage, the combined scientific expertise, the extensive background data, and collaborations with faculty members at two major land grant universities and personnel of many federal, state and local agencies and stakeholder and customer groups would make this a unique entry in the nationwide LTAR network.

Introduction: The Corn Belt is one of the most agriculturally productive regions in the US but also has one of the most fragile ecosystems. The combination of glacially derived, low permeability soils and the cool humid climate make for a very productive but highly susceptible ecosystem. This unique combination of climate and soils increases the risk for soil erosion and requires the use of artificial subsurface drainage for crop production and economic viability. The primary resource concerns in the Eastern Corn Belt node are soil erosion and nutrient transport. Specifically, the impact of nutrients to hypoxia in the Gulf of Mexico and Lake Erie has been well documented. Nitrogen losses from Midwestern agriculture have been linked to Gulf of Mexico hypoxia. While it was long thought that the amount of total phosphorus loading to Lake Erie was the primary cause of eutrophication, recent data demonstrate that the soluble phosphorus component is now driving the Harmful Algal Blooms in the Lake. In both cases, subsurface drainage has been shown to be an integral pathway for the movement of nitrogen and phosphorus. The Port of Toledo on Lake Erie is the second busiest port in the great lakes. The US Army Corps of Engineers spends roughly $5 million annually to dredge the 12 mile long channel to ensure the ports viability. Thus, not only is minimizing nutrient loading to Lake Erie a vital concern, but so is minimizing erosion in the basin and the sedimentation in Lake Erie. The formation of a Long-term Agro-ecosystems Research (LTAR) network is intended to address agricultural, ecological and environmental issues in a national scale using a systematic and unified approach such that optimal strategies for individual regions or ecosystems can be obtained.

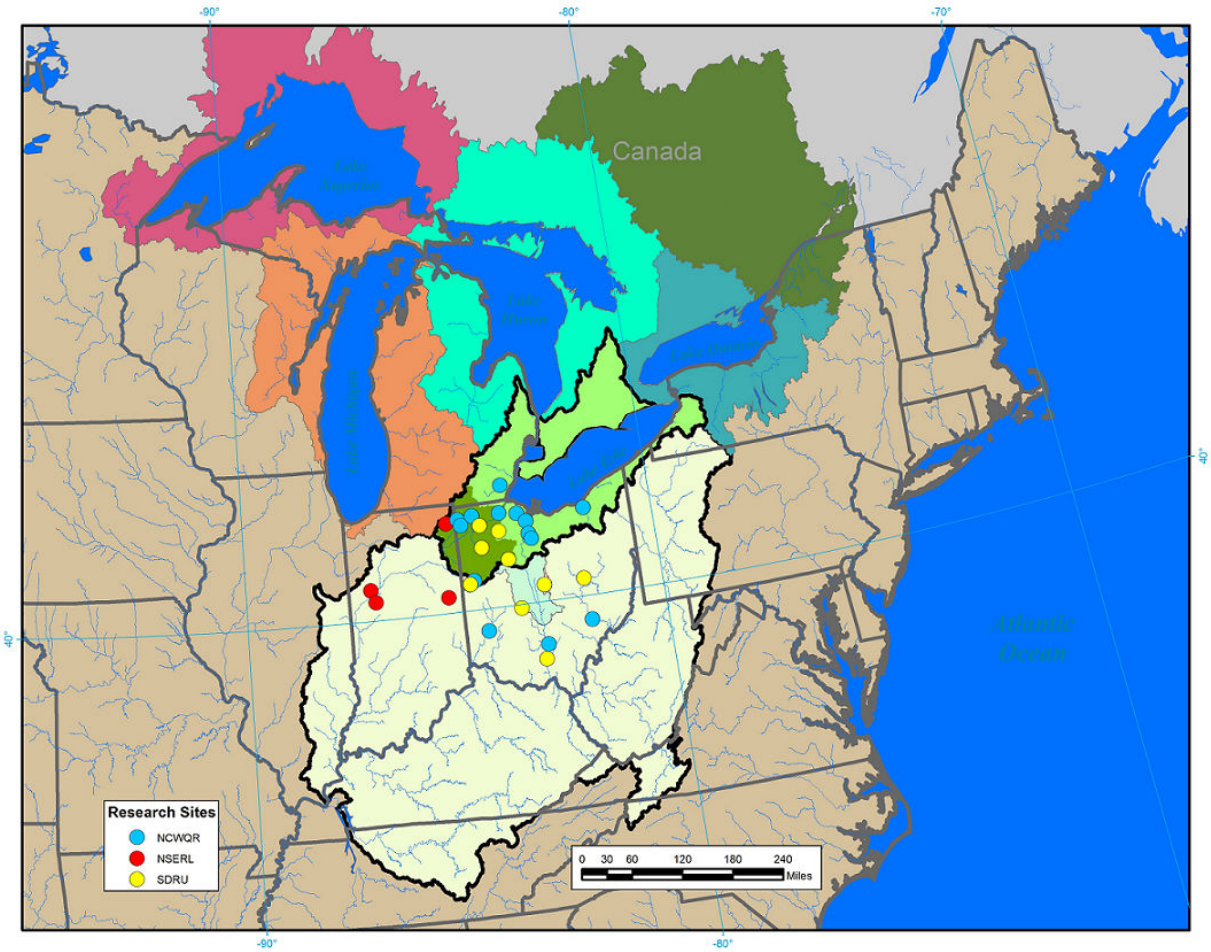

Figure 1. Map showing locations where research is active for the ECB LTAR Node.

The current LTAR network of 10 nodes has a void in the Eastern Corn Belt, hence this proposal is developed to fill the gap from west of the Appalachians to eastern Illinois, encompassing the Great Lakes Basin and the Ohio River Region. The proposed new LTAR node for the Eastern Corn Belt is a collaboration of three specialized research teams that all have a long-history of conducting process-level research in the region (Figure 1). The ARS National Soil Erosion Research Laboratory (NSERL) at West Lafayette, IN has been the national focal center for soil erosion and sediment transport technology and prediction model development. The ARS Soil Drainage Research Unit (SDRU) at Columbus, OH has been the national leader in developing agricultural drainage management systems for improved crop production and water quality. The Heidelberg University National Center for Water Quality Research (NCWQR) was created to address erosion and water quality issues within the Lake Erie Basin since the early 70s. Starting in 2002, both NSERL and SDRU began an effort for Source Water Protection Initiative that later turned into the Conservation Effective Assessment Project (CEAP) and established an extensive network of water quality monitoring and ecologic assessment in IN and OH. Combined with the long-term hydrologic and water quality data collected at the tributaries of the Lake Erie and Ohio River

Basins by the Heidelberg team, the LTAR team has the scientific diversity in several disciplines, the geographic coverage of research sites, the breadth of data collection, and a wide spectrum of partners. This proposed new Eastern Corn Belt node fills the gap and adds to the viability to the LTAR network.

1) **Productivity** – *the track record of the current research team and the level of existing process-based understanding (this information will be used to assess the overall strength of the research team and its leadership)*.

The team members are highly innovative and productive with remarkable impacts on the scientific knowledge and technology available for reducing soil erosion and managing water quantity and quality related to agricultural production systems and turf grasses.

Recent accomplishments have significantly influenced USEPA rule making regarding the use of the fungicide chlorothalonil and NRCS planning regarding a national strategy to promote adoption of their National Engineering Practice 554, Drainage Water Management. Members of the research team were instrumental in the development of the NRCS practice standards for edge-of-field water quality monitoring. Research on the use of blind inlets for drainage in surface depressions in prairie pot-hole topography has led to the Indiana NRCS to provide cost sharing for their installation. The team members advised the Chief of NRCS on water quality issues in the Western Lake Erie Basin (WLEB) and Grand Lake St. Marys (GLSM) watersheds and consequently played a significant role in NRCS' decision to provide additional funding to these watersheds where soluble phosphorus is causing unprecedented levels of harmful algal blooms.

The research team and expertise:

At Soil Drainage Research Unit, Columbus, Ohio:

Dr. Barry Allred, is a Research Agricultural Engineer with the U.S. Department of Agriculture - Agricultural Research Service - Soil Drainage Research Unit in Columbus, Ohio. He is also an Adjunct Assistant Professor in the Food, Agricultural, and Biological Engineering Department at Ohio State University. Dr. Allred's research interests involve application of near-surface geophysical methods to agriculture; aspects of agricultural drainage water management; and laboratory or field hydraulic/mechanical property, solute transport, and environmental remediation studies. He is the lead author or co-author on over 70 journal article, technical report, conference proceedings, and book chapter publications.

Dr. Norman Fausey, Supervisory Research Soil Scientist and Research Leader, expertise in soil physics and drainage water management. Dr. Fausey is an ARS Distinguished Senior Research Scientist, and has 45 years of experience in field evaluation and modeling of drainage, subirrigation, drainage water recycling, and drainage water management. He has authored more than 85 peer-reviewed manuscripts, and his research findings have resulted in NRCS promotion and cost-share of drainage water management practices nationwide.

Dr. Kevin King, Agricultural Engineer and Hydrologist, expertise in surface and subsurface hydrologic processes, edge-of-field monitoring, tile drainage water quality, and conservation practice assessment. Dr. King's research program integrates research across three national research initiatives: Conservation Effects Assessment Project (CEAP), Mississippi River Basin Initiative (MRBI), and Ag. Drainage Mgt. Systems (ADMS). Dr. King has authored 140 publications, with more than 50 peer-reviewed. Results from Dr. King's research have been used to influence USEPA rule making for the fungicide chlorothalonil and state phosphorus task force guidelines on tile drainage phosphorus.

Dr. Peter C. Smiley Jr. (Rocky), Research Ecologist with the USDA-ARS Soil Drainage Research Unit, is currently leading a multi-faceted ecology research program focused on providing the quantitative information required for developing restoration plans that will benefit the biota and improve the physical and chemical quality within degraded agricultural streams. This research program involves individual and collaborative cross-location research projects in Ohio and Indiana. Dr. Smiley has authored or coauthored 29 peer-reviewed manuscripts, 2 book chapters, and 23 technical articles. Additionally, he has given 18 invited presentations and 56 other presentations at regional, national, and international scientific and professional meetings.

At National Soil Erosion Research Lab, West Lafayette, Indiana:
Dr. Dennis Flanagan, USDA-ARS Research Agricultural Engineer, has over 20 years of experience in research related to soil erosion mechanics, erosion control, erosion prediction, and water quality. He is a Lead Scientist at the NSERL and also the leader of the process-based Water Erosion Prediction Project (WEPP) modeling efforts since 1999. Dr. Flanagan has more than 60 peer-reviewed publications and over 100 other publications. WEPP is used by many state and federal entities, including the USDA-Forest Service (FS), particularly for burned area emergency response assessments. The model has helped the FS in targeting over $25,000,000 in federal funds for forest remediation after wildfires. NRCS has recently (3/2013) conveyed plans to implement WEPP into their programs, especially for CEAP assessments.

Dr. Javier Gonzalez, USDA-ARS Research Soil Scientist, joined the NSERL in 2012 and has expertise in biogeochemical processes affecting soil organic transformations, nutrient cycling, pesticides, and water chemistry. Dr. Gonzalez's previous research included interactions between soils and organic compounds and how these interactions affect soil health and water quality and fate and behavior of pesticides in soils. Dr. Gonzalez has more than 25 peer-reviewed publications.

Dr. Chi-hua Huang, USDA-ARS Research Soil Scientist, has expertise in soil erosion mechanics and chemical transport processes. Dr. Huang's research is focused on relating surface boundary condition to soil erodibility and chemical transport and includes: rill and interrill erosion processes, sediment detachment and transport, seepage effects on sediment detachment and chemical transport, surface microtopography effects on runoff initiation, sediment production and chemical loading. He was instrumental in developing two generations of laser scanners for measuring soil surface microtopography in mm scales with sub-mm resolution. His current research involves 1) development of a simplified digital photogrammetry technique for monitoring ephemeral gully development; 2) using fluidized bed techniques to quantify soil cohesion and soil erodibility; 3) quantification of chemical transport processes under different surface and subsurface hydrologic conditions; and 4) quantification of sediment deposition processes. Dr. Huang has more than 70 refereed journal publications.

Dr. Gary Heathman, is a USDA-ARS Research Soil Scientist/Hydrologist with 30+ years of service involving the integration of field, laboratory, remote sensing, and modeling research. He has authored or co-authored 39 peer-reviewed publications, two book chapters, 34 additional publications, and 90+ presentations. As part of the USDA CEAP, Dr. Heathman led research on calibrating and validating the Soil Water Assessment Tool (SWAT) model in the St. Joseph River Watershed, one of 14 benchmark watersheds involved with the national Watershed Assessment Study. He was the first to conduct large-scale watershed analysis of the SWAT and Annualized Agricultural Nonpoint Source Pollution (AnnAGNPS) models for estimating stream flow and atrazine loss, a major objective of CEAP. His consistent effort in developing new conceptual geospatial approaches and experimental field methods for characterizing soil moisture spatiotemporal behavior has been crucial in advancing applications of remotely sensed soil moisture and data assimilation techniques.

Dr. Douglas Smith, USDA-ARS Research Soil Scientist, expertise in nutrient fate, transport and management. Dr. Smith has led the St. Joseph River CEAP Watershed Assessment Study (WAS) for the NSERL since 2007. Dr. Smith has studied many of the processes of nutrient fate and transport, including runoff and leaching losses, greenhouse gas emissions, and in-stream nutrient attenuation. Dr. Smith has published more than 50 peer-reviewed publications. Results from his work have led to the adoption of blind inlets as a practice to replace tile risers in closed depressions, as a practice which NRCS will cost-share for through EQIP.

Dr. Diane Stott, USDA-ARS Research Soil Scientist (Biogeochemistry), with expertise in soil quality assessment, soil carbon cycle, and soil metabolic activity. Dr. Stott has been the co-leader of the National CEAP Soil Quality Assessment for ARS. Dr. Stott's studies have concentrated on soil quality assessments of cropland watersheds east of the Mississippi River, environmental and biofuel feedstock harvest impacts on soil microbiological properties, enzyme activities and carbon cycle, and greenhouse gas emission. Dr. Stott as published almost 50 refereed publications, 1 computer model (RESMAN), and components of 4 other natural resource models (RUSLE, WEPP, WEPS, SMAF), as well as edited one book.

At National Center for Water Quality Research, Heidelberg University, Tiffin, Ohio:
Dr. David Baker, Director Emeritus of the NCWQR, has more than 40 years of experience analyzing, interpreting, and presenting data from the lab's long-term studies of nutrient, sediment, and pesticide transport in area rivers. He is experienced in organizing interdisciplinary research programs linking pollutant transport from fields, through stream networks and bays and into Lake Erie. He currently directs two major grants: an EPA Targeted Watershed Grant supporting targeted BMP adoption to reduce dissolved phosphorus and nitrate export from the Honey Creek watershed; and a Great Lakes Protection Fund Grant to assess the extent, causes, and significance of phosphorus stratification in area soils.

Dr. Remegio Confesor, a Research Scientist at the NCWQR, Heidelberg University, has 18 years of research experience in watershed modeling and parameter estimation, runoff and sediment transport processes, nitrogen and phosphorus movement, and soil-water-plant relationships. As NCWQR's watershed modeler, he verified and helped improve the Soil and Water Assessment Tool's (SWAT) simulation of soluble reactive phosphorus (SRP) and currently implements sub-award grants from the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) and the Great Lakes Protection Fund (GLPF) through the Integrated Pest Management (IPM) Institute of North America. He is actively involved as a steering committee member of the Sandusky River Watershed Coalition, a grassroots group dedicated to the protection and enhancement of water resources in the Sandusky watershed (Ohio).

Dr. Laura Johnson, Research Scientist at the NCWQR, has expertise in stream biogeochemistry and watershed nutrient and sediment transport. Prior to joining the NCWQR in January 2013, Dr. Johnson had worked on a variety of topics including coupled biogeochemical cycling in streams, the influence of microbial diversity on ecosystem functioning, greenhouse gas emissions from agricultural watersheds, and the fate of nitrate in headwaters streams. This research has thus far culminated in 16 publications. Dr. Johnson was a part of the Lotic Intersite Nitrogen eXperiment II (LINX II), a collaboration among 18 PI's across 17 different institutions that successfully conducted highly technical stable isotope tracer additions in 72 streams in North America. Since joining the NCWQR, Dr. Johnson has participated in the Lake Erie Ecosystem Priority workshop by the International Joint Commission, presented at the Ohio Water Resources Council workgroup meeting, presented at a Farmer's Meeting in Michigan on agricultural P and Lake Erie, and will give presentations at 3 scientific conferences this summer.

Dr. Kenneth Krieger, Director of the Heidelberg University NCWQR and Professor of Biology, has been PI on numerous federal and state funded grants on the impacts of agricultural practices on habitat quality and the biological (macroinvertebrate) integrity of headwater streams and ditches of tributaries of both Lake Erie and the Ohio River. He also was PI on a study of the water, sediment and nutrient budgets and nutrient transformation processes in a Lake Erie coastal wetland. He has published 23 peer-reviewed articles and numerous technical reports and has presented to both technical and lay audiences on water quality issues in Lake Erie as well as its coastal wetlands and tributaries.

Dr. R. Peter Richards, Senior Research Scientist at NCWQR, has 35 years of experience in detailed monitoring of rivers draining agricultural watersheds in Ohio and Michigan. Specific areas of expertise include application of statistics to environmental data, temporal trend analysis, and pollutant load estimation. Dr. Richards has more than 30 papers in peer-reviewed journals (>20 as first author), including papers in Nature and PNAS (accepted). In the last decade, he has been associated with two major multidisciplinary projects centered at U. Michigan and funded by NOAA and NSF, examining process-based relationships among agricultural land use, tributary loading, and ecological health in Lake Erie.

The level of process-based understanding is documented by several examples in which the knowledge and understanding of processes has enabled the team to realize broader impacts. First, the NSERL research unit was formed to develop the tools to help minimize erosion. The first step in this process was the development of the Universal Soil Loss Equation (USLE), followed by the Revised USLE (RUSLE) which is applied to fields throughout the US as a part of NRCS conservation programs through field offices. The NSERL has further improved erosion prediction technology through the development of a process-based erosion model – the Water Erosion Prediction Project (WEPP), which is widely used throughout the US and the world. Process-based understanding has led to the development of conservation practices and their adoption by NRCS for cost share practices by scientists at the SDRU and NSERL. The SDRU has conducted some of the primary research used by NRCS to develop practice standards for the use of controlled drainage in fields, so that fields are allowed to free drain only during times of the year when traffic on the field is required. The remainder of the time, drainage water can be inhibited, thereby reducing the flow of water from fields and allowing more water to be stored in the soil for use by the crop. The research team has also conducted the first research on quantifying the watershed scale impacts of tile drainage. Tile drainage has been shown to be a significant component of basin scale hydrology and nutrient transport. The team has also developed technology that has been developed as a conservation practice standard to improve water quality from closed depressional areas that are traditionally drained with tile risers. In this example, the tile risers as a source of contamination to surface waters was observed, and a practice developed that requires the surface water to be drained through filter media to remove sediment and other contaminants. In a final example, long-term water quality monitoring data from the NCWQR led to the observation that adoption of conservation tillage practices resulted in decreases in total phosphorus loadings to Lake Erie; however since the mid 1990's increases in soluble phosphorus loadings to the lake have been observed. This is most likely due to mismanagement of phosphorus fertilizers in current agricultural production. In addition, this long-term dataset has facilitated the development of the R-B flashiness index that quantifies the frequency and rapidity of short-term changes in stream flow during runoff events (see Appendix).

2) **Infrastructure Capacity** – *The presence of an instrumented watershed or other long-term research facility (e.g. experimental range) of sufficient size to capture landscape-scale processes and heterogeneity; to integrate across small plot, watershed and landscape scales; the availability of land to support crop and/or livestock production; and the availability of critical infrastructure (e.g. field and analytical laboratory facilities; storage capacity; IT support; housing for visiting researchers).*

The ECB LTAR Node research team operates watershed, field and plot research throughout the region. Below is a brief description of the research sites and facilities.

<u>Watershed and landscape scale research</u>: All three partners bring into the ECB LTAR Node a wealth of watershed and landscape scale research infrastructure and experience. The NCWQR currently operates and maintains 15 water quality monitoring sites with periods of record as long as 38 years (Figure 2). Three of these (Great Miami River, Scioto River and Muskingum River) drain to the Ohio River. The remainder of these represent small watersheds (e.g., Lost Creek, and Coldwater Creek) or large river basins (e.g., Maumee River) that drain to Lake Erie. Most of the sites are located at U.S. Geological

Survey stream gaging stations, and are equipped with a refrigerated water quality sampler that collects three samples per day. Samples are analyzed for sediment, nutrients, major ions, and seasonally for pesticides.

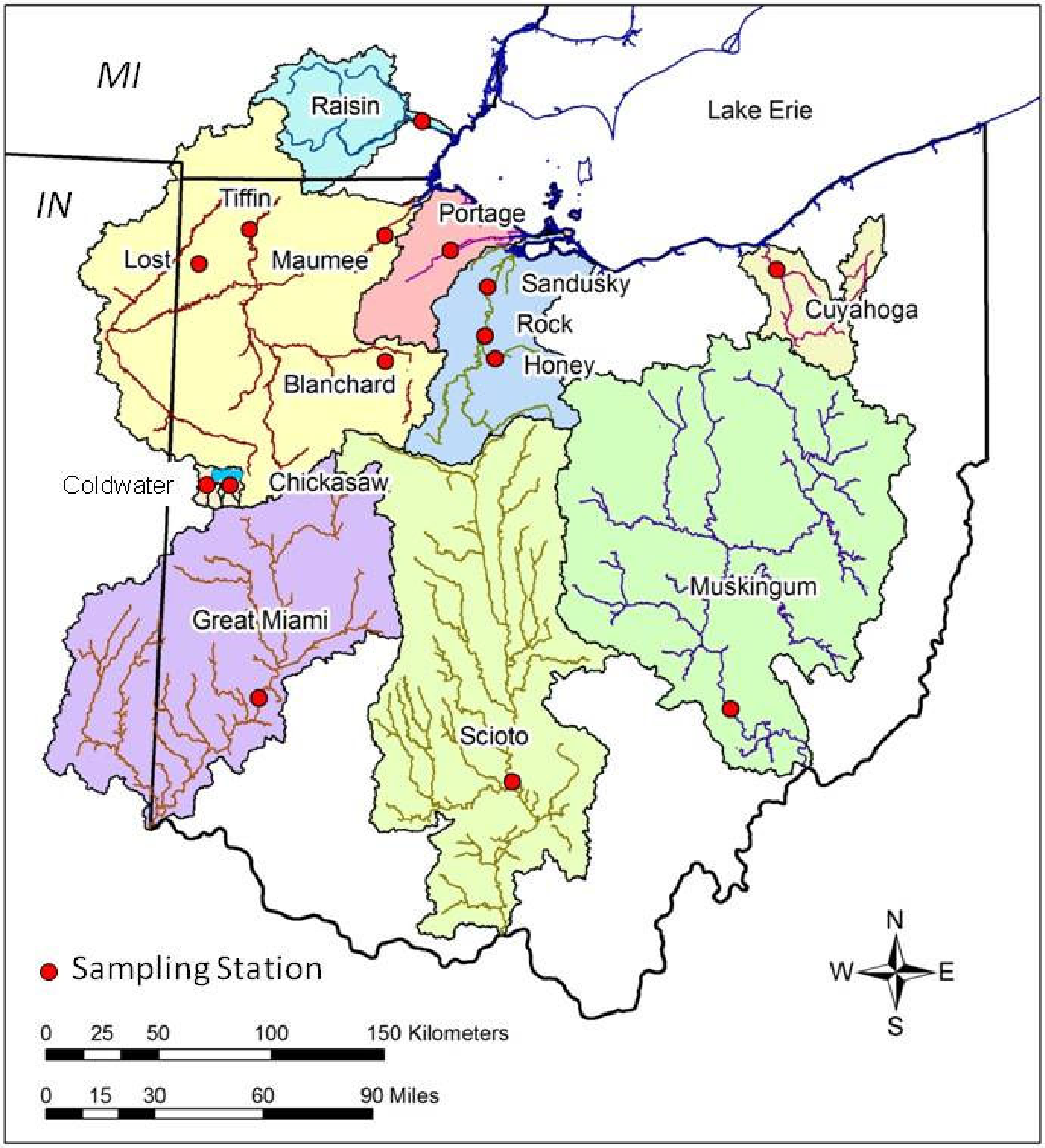

Figure 2. Watershed monitored by the NCWQR at Heidelberg University. These sites cover both the Ohio River Basin and the Lake Erie Basin.

The ARS SDRU operates the Upper Big Walnut Creek CEAP Project (figure 3). Monitoring occurs at greater than 50 sites along streams and ditches in the Upper Big Walnut Creek watershed, including hydrology, water quality, and aquatic ecology. These sites range from edge of field to HUC 12 in scale. This landscape is dominated by subsurface tile drainage serving as a dominant flow path to the first order streams monitored by the SDRU. Upper Big Walnut Creek drains to the Scioto River, which is in the Ohio River Basin. Additionally, SDRU recently initiated 23 surface and subsurface edge-of-field research sites in the UBWC watershed and Grand Lake St. Mary watershed as part of the Mississippi River Basin Initiative. A similar approach is underway in the WLEB where an additional 10 sites have already been installed.

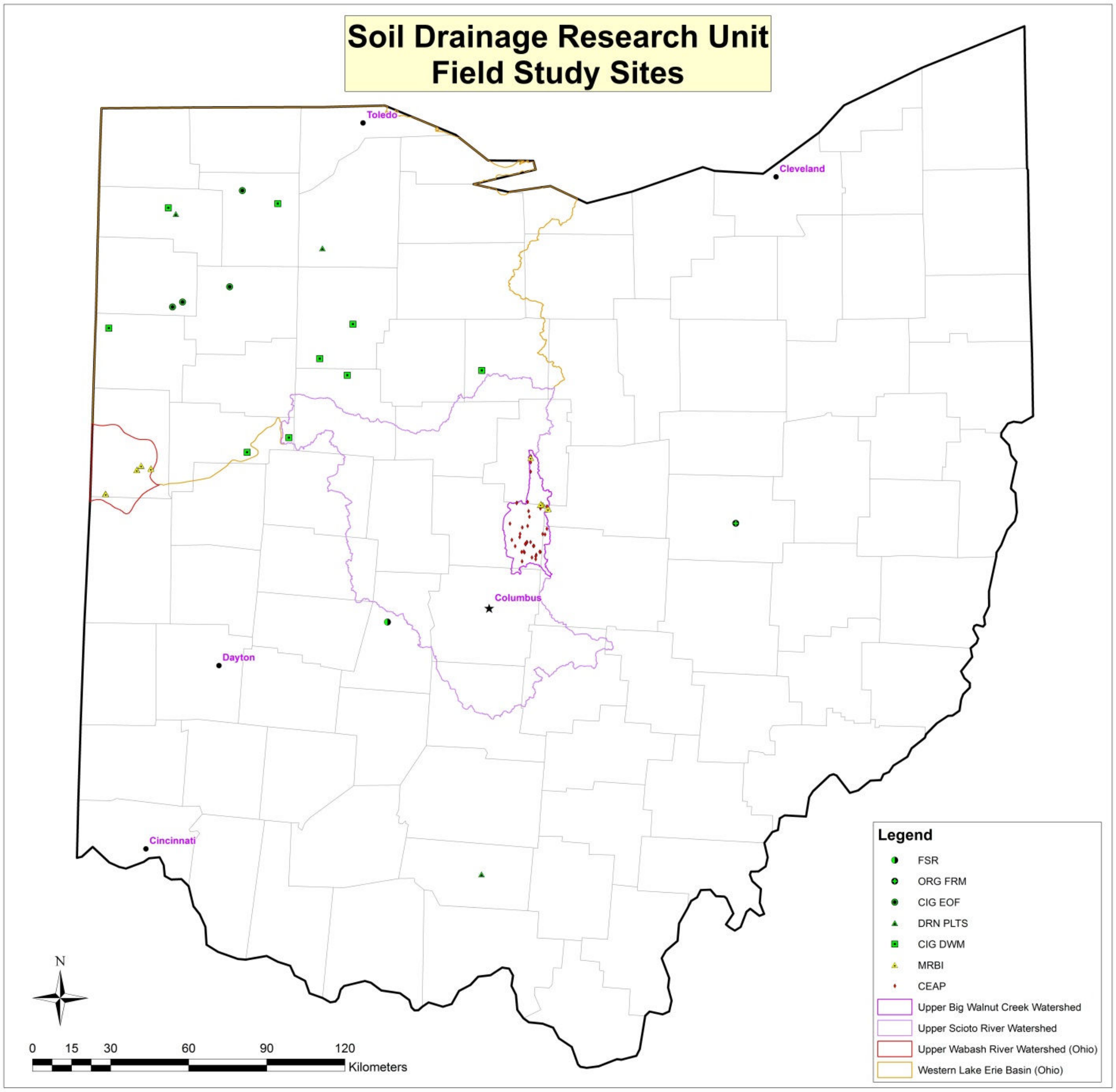

Figure 3. Location of watershed monitoring sites operated by the ARS SDRU. The Upper Big Walnut Creek is an ARS CEAP WAS benchmark watershed.

The ARS NSERL operates and maintains the St. Joseph River Watershed CEAP WAS, an ARS benchmark watershed project (figure 4). The St. Joseph River drains to Lake Erie through the Maumee River (monitored by the NCWQR). Eight sites on ditches and streams monitored by NSERL range from 3 to 190 km^2, and are nested and paired, with three agricultural ditches being monitored and the stream that receives water from two of these agricultural drainage ditches. Aquatic ecology at these eight sites is being studied by a collaborator from Indiana University /Purdue University - Ft. Wayne in close collaboration with and utilizing the same protocols as the aquatic ecology monitoring in ditches and streams in Upper Big Walnut Creek.

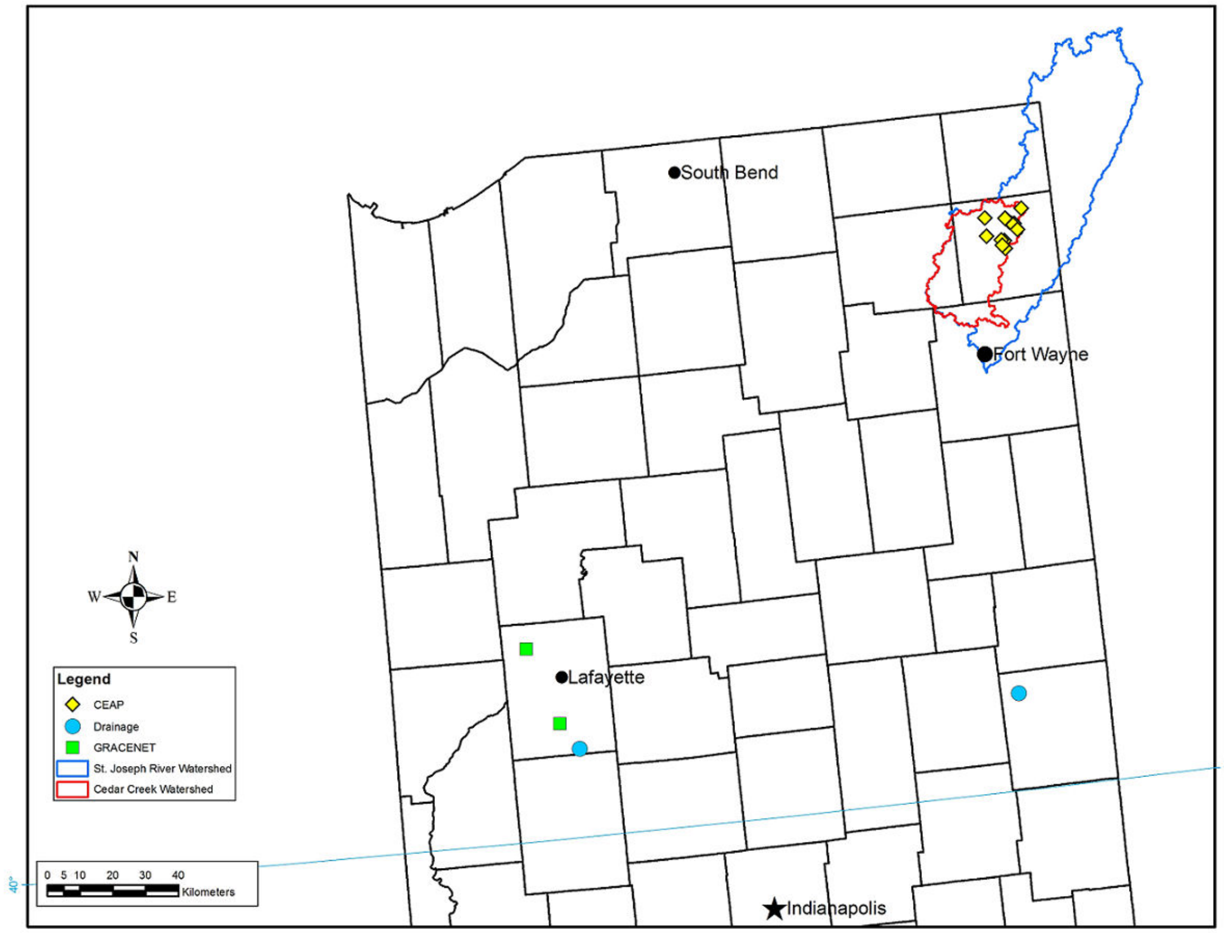

Figure 4. Map showing locations and watersheds monitored by the NSERL for the St. Joseph River CEAP WAS project as well as other locations where GRACEnet or drainage research is occurring.

NSERL has constructed a 300 sqft wet laboratory for the initial processing of water quality samples in the monitoring area. Thus samples can be processed within hours of collection from the autosamplers in preparation for return to the laboratory for analysis.

<u>Field scale research</u>: Scientists from the SDRU are currently monitoring 30 field sites that are paired. In each pair, surface drainage and/or tile drainage are being monitored for hydrology and water quality. Each pair represents a set of management, and one field from each pair will have a conservation practice placed in its drainage boundary to evaluate the impact of specific conservation practices on water quality using the before-after-control-impacted (BACI) research design. Fields range from 1 to 20 ha in size.

The NSERL is currently monitoring surface runoff and tile discharge from four fields ranging from 2.2 to 4 ha. These fields represent important landscape level flow paths in the upper Midwestern US. Two of the monitored fields represent a mature landscape with dendritic flow paths away from the field, while the other pair represents the younger portions of the Wisconsin age glacial till landscape, where closed depressions (also known as potholes) are common. In closed depressions, surface runoff water collects at the low-point and this runoff water, in farmed fields, is often removed through a tile riser that is a direct conduit between this surface runoff water and the subsurface tile water. Over the last 10 years, conservation practices have been placed in these fields, and are being tested using the BACI research design.

NCWQR has a paired field installation near the campus of Heidelberg University that permits monitoring of tile and surface drainage from each field. While currently inactive, it could be re-instrumented as part of this collaboration.

Plot scale research: At the Purdue University Agricultural Research and Education Center (ACRE), NSERL has long-term field plots for GRACEnet and bioenergy feed stock research. At the Throckmorton Purdue Agricultural Center (TPAC), also a GRACEnet site, NSERL is conducting research on nutrient runoff under different nutrient and manure management practices. At the Davis Purdue Agricultural Center (DPAC), field plots have been established to quantify the combined effects of gypsum application and controlled drainage on crop yield and water quality. Also at DPAC, there is on-going research, funded by the United Soybean Board, to assess the benefit and sustainability of including cover crops and gypsum on soybean production.

The SDRU has drainage and water quality research plots at the Northwest Agricultural Research Station at Hoytville, the South Centers at Piketon, and at the North Appalachian Experimental Watershed at Coshocton, OH in conjunction with the Ohio State University and Ohio Agricultural Research and Development Center (OARDC).

Laboratory facilities: The NCWQR on the Heidelberg University campus has fully equipped laboratories to analyze water quality samples for nutrients, trace metals, pesticides and volatile organic compounds. The NCWQR's biological laboratory has modern microscopy and imaging instrumentation to apply its expertise in the identification of benthic macroinvertebrates and zooplankton, and has sampling equipment for qualitative and quantitative sampling of lake and stream macroinvertebrates.

The SDRU is housed at The Ohio State University in the College of Food, Agriculture and Environmental Sciences. The Unit operates its own limited environmental water chemistry laboratory, an aquatic ecology laboratory, and has some soil physical property laboratory equipment. Currently, pesticide samples from Columbus, OH are analyzed at NSERL.

The NSERL is housed in a federal building located on the campus of Purdue University. Analytical instrumentation at the NSERL includes: spectrometers (Konelab and Lachat for nutrient analysis), ICP-OES (some nutrients and metals), GC-MS (pesticides), HPLC (dedicated to Glyphosate analysis), UPLC (pesticides and other organics), and GC (greenhouse gases).

In addition to the dedicated water quantity/quality and meteorological monitoring equipment, the NSERL is equipped to conduct rainfall simulation studies in situ or to collect soils and conduct rainfall simulation studies at the NSERL facility. NSERL also has two fluvaria, specialized equipment to study in-channel contaminant fate and transport processes. The NSERL has 4 walk-in freezers and 2 walk-in coolers for sample storage.

Support personnel: The NSERL has three support scientists: one computer programmer, one chemist who is responsible for instrumentation maintenance and database management, and one soil scientist who oversees all the operations at the St Joseph River Watershed. In addition, NSERL has six skilled technicians to support research needs.

The SDRU has 6 technicians who collect, process, and analyze samples and maintain the field sites. SDRU has one analytical chemist and one IT who supports all research projects through chemical analysis and data base management.

Scientists at both ARS units hold adjunct faculty appointments in various academic departments. There is substantive interaction with university faculty, graduate students and visiting scholars.

3) **Data Richness** – *The number of years, breadth, depth, and overall quality of the existing data record*.

Both ARS Research Units started watershed scale monitoring in 2002. At the St Joseph River watershed, water quantity and meteorological data are collected on a sub-hourly time step. Water quality data are collected using autosampling equipment on a daily time step at the ditch and stream sites from April 1 through mid-November. Samples from the field sites are collected to ensure the entire hydrograph is represented by water quality samples. From mid-November through March 31, weekly grab samples are collected from the ditch and stream sites. Data exist for each site since they were installed and activated. Most of the infrastructure was installed in the 2002-2004 time-frame. The subsurface tile lines in each field site were not instrumented until 2008. However, the data from each sample collected from these sites exist in the database.

The NCWQR maintains the most detailed and long-term sediment, nutrient and pesticide databases for computing loads from major tributaries into Lake Erie. The program operates year-round, collecting three samples per day using autosampling equipment and 1 to 3 samples per day are analyzed, depending on flow conditions. Key stations are represented by more than 15,000 samples each, spanning up to 38 years. Individual data sets are available for around 20 different tributary loading stations for varying periods of record, and the ongoing stations on the Maumee and Sandusky Rivers have the longest periods of record, dating to 1975.

Additional available data include: annual tillage transect survey conducted by local Soil and Water Conservation District personnel; NRCS conservation plans through interagency agreement; NASA and other remote sensing data on land use, land cover and surface soil moisture content through ARS Hydrology Laboratory (Beltsville, MD) and the Purdue University Laboratory of Applied Remote Sensing (LARS).

The ARS in-house ecologist at Columbus also collaborated with an Ecologist at Indiana University-Purdue University-Fort Wayne (IPFW), funded by NSERL, to conduct an annual habitat survey at the monitored sites in both the St Joseph River Watershed and the Upper Big Walnut Creek Watershed. This consistent ecological survey data set enhances the efforts to relate the physical environment attributes to ecological responses.

4) **Data Availability (Accessibility)** – *The state of organization and accessibility of existing data sets (e.g. data in STEWARDS or some other publicly available database)*.

ARS hydrology and water quality data generated through the CEAP WAS projects in the St. Joseph River and Upper Big Walnut Creek are available publicly through the ARS Sustaining the Earth's Watersheds Agricultural Research Data System (STEWARDS) database. STEWARDS is the repository for watershed assessment data collected as part of ARS's CEAP Watersheds activities. Summary data are uploaded regularly and include hydrology (precipitation and discharge) and water chemistry (ammonium, nitrate, total nitrogen, dissolved reactive phosphorus, total phosphorus, atrazine, metolachlor, and simazine).

NSERL also maintains an in-house database that is publically accessible through: http://milford.nserl.purdue.edu/swpi/ind.php.

The long-term hydrology and water quality data set maintained at Heidelberg University for the Lake Erie and Ohio River tributaries is publicly available through a website maintained by the NCWQR at: http://www.heidelberg.edu/academiclife/distinctive/ncwqr/data

5) **Geographic Coverage at Various Scales** – *How does the site fit within the overall network, and/or complement other potential network sites with regards to the 10 major US agro-ecosystems, the 21 HUC2 watersheds within the lower 48 US states, the 20 NEON Domains, etc.? LTAR sites should complement both existing networks and other LTAR sites by filling geographic gaps. Where there is geographic overlap, each site should provide unique data (e.g. long-term datasets) or data collection opportunities not possible at other sites (this information will be used to assess network overlap and/or redundancies now as well as existing gaps to be filled later); LTAR sites should be representative of their region, however defined – i.e. LTAR sites would be focal points for research in that region*.

The ECB LTAR Node is representative of the agricultural landscapes in the 2-digit HUCs 04 and 05. There are currently no LTAR sites within either of these HUCs, and thus the ECB LTAR Node will fill a much needed gap.

The NEON domains represented by the ECB LTAR Node include D5, D6 and D7. While there are currently two LTAR sites in the D6, neither represents D5 nor D7.

The Farm Resource Regions represented by field and watershed scale work being conducted by ECB LTAR Node include Northern Crescent, Heartland and Eastern Uplands. While the Upper Chesapeake Bay LTAR site represents the Northern Crescent, and the Central Mississippi River Basin and Upper Mississippi River Basin LTAR sites represent the Heartland, there is currently no LTAR sites representative of the Eastern Uplands.

6) **Partnerships** – *The strength of existing external partnerships with producers, other stakeholders, local universities, federal agencies, etc., including the potential for education and outreach (responses should include descriptions of the various activities – research; education; outreach – as well as their strengths and weaknesses)*.

The research team has partnered with many federal, state, and local entities. Below is a brief list of those:

NRCS/FSA/USFS – NSERL and SDRU are working with NRCS, FSA and USFS on the Agency Priority Goals Project to identify all the publicly funded conservation practices placed in the St. Joseph River watershed, the Upper Big Walnut Creek watershed, and to provide an estimate of the conservation benefits to these practices. NCWQR has been a team member of the Lake Erie CEAP project. In addition, NRCS has contributed funding as recently as 2011 in support of several stations in the NCWQR tributary loading network as well as funding toward edge-of-field monitoring stations to support SDRU research.

NASA – The research sites at the Upper Cedar Creek in Indiana have been selected as a calibration and validation site for the NASA-Soil Moisture Active Passive (SMAP) mission scheduled to launch in November 2014. These sites provide ground truth for remotely sensed soil moisture observations on space-borne satellites.

USEPA – Both NSERL and SDRU have on-going partnership with USEPA to evaluate the impact of anaerobic manure digesters on nutrient fate and transport from land applied effluent and to quantify the nutrient source and loading at the Grand Lake St. Marys. NCWQR has had several multi-year grants from USEPA Great Lakes National Program Office, Region 3, and Region 5, most aimed at reducing water quality impacts of agricultural practices or understanding the mechanisms of the movement into and distribution within Lake Erie of NPS nutrients and sediments. A 5-year Targeted Watershed grant from Region 5 will end in 2013.

NOAA – NCWQR is part of a grant project centered at the University of Michigan that is using a suite of models to investigate the impacts of land use, invasive species, and climate change on hypoxia in the Central Basin of Lake Erie and the impact on fisheries.

NSF – NCWQR is part of a five-year grant project centered at the University of Michigan that is investigating the impacts of land use, climate change, and possible future demographic shifts on nutrient loading to the WLEB and harmful algal blooms.

Local SWCDs – NSERL has a Specific Cooperative Agreement (SCA) with DeKalb SWCD to handle local logistics of the project. Currently, the SWCD provides local support for maintaining autosamplers, processing of water quality samples, and for collection of field level production data from farmers. DeKalb SWCD has also submitted grants and received funding to place conservation practices on the ground in the watershed. One current project will saturate an area of approximately 100 ha with conservation practices that the NSERL will study. NSERL is working with the Tippecanoe SWCD to provide the APEX assessment for the benefits of conservation practices for these groups' Mississippi River Basin Initiative projects. NCWQR collaborates with the Seneca, Crawford, and Wyandot SWCDs (Ohio) in giving farmers incentives to implement best management practices (BMPs) to reduce DRP through the Honey Creek Targeted Watershed Project funded by EPA (Assistance No. WS-00E39901-0). SDRU has an SCA with the Deleware SWCD to provide support for research in the UBWC watershed, including water quality and field level data collections and GIS support. SWCDs have been instrumental in helping to identify landowners and operators for establishing research.

NGOs - The NSERL and SDRU have been working closely with The Nature Conservancy (TNC) on different projects in the WLEB. NSERL has been collaborating with TNC to locate a site on the study reaches to place a two-stage ditch. This requires coordination with TNC and the DeKalb County Drainage Board. We anticipate installation of a two stage ditch within the next 24 months, which will allow the NSERL a unique opportunity to test this practice on a well-studied stream reach. SDRU has been working with TNC to identify a cooperator and evaluate the impacts of different land management practices on tile discharge and phosphorus. NCWQR is collaborating with the Environmental Defense Fund (EDF) on implementation of innovative practices throughout the Maumee River basin under a grant from the Joyce Foundation. The NSERL is working with EDF on the Demonstration Watersheds Project, designed to utilize the entire landscape to decrease nutrient loads. In this project, 12-digit HUCs (including the 12-digit HUC represented by the A-watershed in the St. Joseph River watershed) have been selected and traditional and innovative upland practices (cover crops, nutrient management plans, conservation tillage, and adaptive management) will be coupled with traditional and innovative lowland and stream practices (two-stage ditches, vegetative ditches, and wetland restoration). The NSERL has worked with the SJRWI early in the CEAP WAS project to provide local logistics in previous years. More recently, the partnership with the SJRWI has been related to providing opportunities for ARS scientists to conduct outreach with producers at the Tri-State Tillage Expo. Held in the winter each year, this event hosts producers both within and outside the 19,000 ha study area.

Commodity organizations – SDRU is working closely with OSA on a project to revise the Ohio P index by monitoring surface runoff and tile discharge from paired fields throughout Ohio. NSERL has partnered with ISA to provide adaptive management and technical assistance in the watershed. ISA is working with individual farmers to assess the efficacy of nitrogen applications on a field by field basis in the watershed. NSERL and SDRU are working with USB to evaluate how soybean crops are impacted by controlled drainage.

Universities - Dr. Gillespie with the Biology Department at Indiana University/Purdue University at Ft. Wayne has been working to assess the in-stream aquatic ecology at the 7-ditch and 1-stream sites at Upper Cedar Creek, IN. Dr. Gillespie is coordinating the in-stream assessments with Dr. Smiley from ARS-SDRU to ensure comparable datasets and analysis. Dr. John Lehman is working on adaptive management to reduce phosphorus loading to drinking water sources at the southeastern Michigan. This project is very similar to CEAP and an excellent partnership with the Research Team. The extent of NCWQR experience and datasets provides frequent opportunities for collaboration and comparative studies with many outstanding scientists, including Andrew Sharpley of the University of Arkansas, Helen Jarvie and colleagues at the Center for Ecology and Hydrology, Wallingsford, England, and Robert Hirsch of the U.S. Geological Survey.

Local land owners – The Research Team considers the local land owners and farmers to be critical partners in this project. All land in the watershed that ARS works on is private land. The agreements between ARS and the local land owners are key to the success of the project. NCWQR also has extensive collaborations with local land owners, both directly and through the activities of the Sandusky River Watershed Coalition and the WLEB Partnership.

7) **Institutional Commitment** – *Is there a multi-decadal institutional commitment to support the continued operation of the site (a letter of support from the appropriate ARS Area Office or institutional leadership is strongly recommended)? How well-integrated are the existing projects and/or research groups currently at the site? Are scientists and support staff committed to this effort?*

The NCWQR has been monitoring water quality for nearly 40 years, and the two ARS units have been participating in CEAP for more than a decade. With a combined base funding of more than $5.5 million dollars, scientists at both ARS Research Units and Heidelberg NCWQR are dedicated to address issues related to agricultural productivity, environmental sustainability and ecological diversity. All these research efforts, from lab, field, and watershed scales to modeling, contribute to the long-terms needs and objectives of a successful LTAR network.

Support letter from Dr. Robert Matteri, Director, Midwest Area, USDA-ARS is attached.

Appendix 1. Letter of Support.

USDA United States Department of Agriculture

Research, Education, and Economics
Agricultural Research Service

March 28, 2013

SUBJECT: Letter of Support for the LTAR proposal – Great Lakes and Ohio River Region

TO: Long-term Agro-Ecosystem Research (LTAR) Network Steering Committee

FROM: Robert Matteri, Director, Midwest Area

The ARS-National Soil Erosion Research Laboratory, ARS-Soil Drainage Research Unit and Heidelberg University National Center for Water Quality Research are proposing to become a member of the Long-term Agro-Ecosystem Research (LTAR) network for the eastern Corn Belt, specifically the Great Lakes and the Ohio River Region. The Director's Office of the Midwest Area supports this application.

This LTAR proposal formalizes and strengthens an existing collaboration of two ARS Conservation Effects Assessment Project (CEAP) watersheds and the Heidelberg University long-term water quality monitoring network to address issues related to agricultural productivity, environmental sustainability and ecological diversity of the eastern Corn Belt. The geographic coverage, the combined scientific expertise and the availability of very detailed long-term hydrologic and water quality data make this proposal a unique entry in the LTAR network. Another noted strength of the research team is the expertise in ecology, from ARS and Heidelberg University. The breadth of the research team members is well suited to tackle the diverse issues in agricultural sustainability, environmental protection and services, and ecological system health associated with changing climatic inputs.

Based on the well-recognized history of these research laboratories and the quality and impact of the science produced, I believe the inclusion of the Great Lakes and Ohio River Region in LTAR is beneficial to meet the objectives of the network.

Office of the Director, Midwest Area
1815 North University St.
Peoria, IL 61604
USDA is an Equal Opportunity Employer

Appendix 2. Selected Publications and Accomplishments.

1996

Solomon, K.R., Baker, D.B., Richards, R.P., Dixon, K.R., Klaine, S.J., LaPoint, T.W., Kendall, R.J., Weisskopf, C.P., Giddings, J.M., Giesy, J.P., Hall, L.W. Jr., and Williams, W.M. (1996). Ecological risk assessment of atrazine in North American surface waters. *Environmental Toxicology and Chemistry* 15:31-76.

2002

Baker, D.B., and Richards, R.P. (2002). Phosphorus budgets and riverine phosphorus export in northwestern Ohio watersheds. *Journal of Environmental Quality* 31:96-108.

Calhoun, F.G., Baker, D.B., and Slater, B.K. (2002). Soils, water quality, and watershed size: interactions in the Maumee and Sandusky River basins of northwestern Ohio. *Journal of Environmental Quality* 31:47-53.

Richards, R.P., and Baker, D.B. (2002). Trends in water quality in LEASEQ rivers and streams, 1975-1995. *Journal of Environmental Quality* 31:90-96.

Richards, R.P., Baker, D.B., and Eckert, D.J. (2002). Trends in agriculture in the LEASEQ watersheds, 1975-1995. *Journal of Environmental Quality* 31:17-24.

2003

Krieger, K.A. (2003). Effectiveness of a coastal wetland in reducing pollution of a Laurentian Great Lake: hydrology, sediment, and nutrients. *Wetlands* 23:778-791.

Richards, R.P. and Grabow, G. L. (2003). Detecting reductions in sediment loads associated with Ohio's Conservation Reserve Enhancement Program. *Journal of the American Water Resources Association* 39(5):1261-1268.

2004

Baker, D.B., Richards, R.P., Loftus, T.T., and Kramer, J.K. (2004). A new flashiness index: Characteristics and Applications to Midwestern Rivers and Streams. *Journal of the American Water Resources Association* 40(2): 503-522.

Richards, R.P. (2004). Improving Total Maximum Daily Loads with lessons learned from long-term detailed monitoring. *Journal of Environmental Engineering* 130:657-663.

2005

Fausey, N.R. (2005). Drainage management for humid regions. *International Agricultural Engineering Journal*. 14(4):209-214.

Lant, C.L., Kraft, S.E., Beaulieu, J., Bennett, D., Loftus, T., and Nicklow, J. (2005). Using GIS-based ecological-economic modeling to evaluate policies affecting agricultural watersheds. *Ecological Economics* 55:467-484.

2006

Cruse, R. M., Flanagan, D. C., Frankenberger, J. R., Gelder, B. K., Herzmann, D., James, D., Krajewski, W., Kraszewski, M., Laflen, J. M., and Todey, D. (2006). Daily estimates of rainfall, water runoff, and soil erosion in Iowa. *Journal of Soil and Water Conservation*. 61 (4):191-199.

Luckeydoo, L., Fausey, N., Davis, C., Regnier, E., and Brown, L. (2006). Passive establishment of vegetation in constructed wetlands in agricultural settings: A case study. *Ohio Journal of Science*. 106(4):164-168.

Smith, D.R., Warnemuende, E.A., Haggard, B.E., and Huang, C. (2006). Dredging of drainage ditches increases short-term transport of soluble phosphorus. *Journal of Environmental Quality*. 35:611-616.

Vazquez-Amabile, G., Engel, B. A., and Flanagan, D.C. (2006). Modeling and risk analysis of nonpoint-source pollution caused by atrazine using SWAT. *Trans. ASABE*. 49 (3):667-678.

2007

Flanagan, D. C., Gilley, J. E. and Franti, T. G. (2007) Water Erosion Prediction Project (WEPP): development history, model capabilities, and future enhancements. *Trans. ASABE*. 50 (5):1603-1612.

Fouss, J.L., Fausey, N.R. (2007). Research and development of laser-beam automatic grade control system on high-speed subsurface drainage equipment. *Trans. ASABE*. 50(5): 1663-1667.

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Larose, M., Heathman, G.C., Norton, D.L., and Engel, B. (2007). Hydrologic and atrazine simulation of the Cedar Creek watershed using the SWAT model. *J. of Environ. Qual.* 36:521-531.

Madramootoo, C.C., Johnston, W.R., Ayars, J.E., Evans, R.O., and Fausey, N.R. (2007). Drainage water quality issues in North America. *Journal of Irrigation and Drainage Engineering*. 56:535-545.

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Pappas, E.A., and Smith, D.R.(2007). Effect of dredging an agricultural drainage ditch on water column herbicide concentration, as predicted by fluvarium techniques. *Journal of Soil and Water Conservation*. 62:262-268.

Smith, D.R. and Pappas, E.A. (2007). Effect of ditch dredging on the fate of nutrients in the deep drainage ditches of the Midwestern United States. *Journal of Soil and Water Conservation*. 62:252-261.

Smith, D.R., Warnemuende, E.A., Huang, C., and Heathman. G.C. (2007). How does the first year tilling a long-term no-tillage field impact soluble nutrient losses in runoff? *Soil and Tillage Research.* 95:11-18.

Warnemuende, E.A., Patterson, J.P., Smith, D.R., and Huang. C. (2007). Effects of tilling no-till soil on losses of atrazine and glyphosate to runoff water under variable intensity simulated rainfall. *Soil and Tillage Research*. 95:19-26.

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Selected accomplishments from these watersheds are highlighted below:
Demonstration that reduced SS and PP loads are due to erosion control measures: The success of agricultural practices to control erosion is often reflected in trends toward reduced concentrations and loads of sediment and attached pollutants such as particulate phosphorus. One issue is having enough data over a long enough time to reveal statistically significant trends. Another issue is proving a causal link between the trends and and the practices, i.e. demonstrating that the practice changes caused the trends. With its extensive datasets for Lake Erie tributaries, NCWQR was able to show statistically significant decreases in sediment and particulate phosphorus. Using a novel application of analysis of covariance, they were able to demonstrate that the relationship between flow and concentration was shifting over time, such that as time went on, a given level of flow was accompanied by a reduced level of pollutants. This documents the success of erosion control programs in these major watersheds, something that has rarely been accomplished elsewhere.

Environmental Quality Incentive Program (EQIP) successfully reduced atrazine in drinking water reservoirs. Atrazine is a cost-effective and proven herbicide for corn production in the US, and atrazine concentrations in surface water frequently exceed drinking water standards. The USDA sponsored Environmental Quality Incentive Program provides incentives to farmers to adopt conservation practices that reduce the delivery of agrichemicals to streams. However, quantitative information on the effectiveness of these practices is often limited. One such practice is the pesticide management practice. ARS scientists at Columbus, OH, quantified the effectiveness of the pesticide management practice, when applied at a watershed scale, to reduce the delivery of atrazine to a drinking water supply reservoir. Significant differences in reservoir atrazine concentrations were measured between three distinct time periods: before there were any restrictions on the amount of atrazine that could be applied (pre-label); after atrazine label restrictions were implemented; and during a subsequent EQIP atrazine pesticide management practice implementation. The primary benefit of the practice, reduced water treatment cost, greatly outweighed the incentive payment costs for implementing the practice. This result indicates that the watershed scale implementation of a conservation practice can be a cost effective approach for addressing nonpoint source pollution (King et al., 2009; King et al., 2012)

Controlled drainage improved crop yield and water quality: Drainage waters from agricultural lands, especially those coming from subsurface tile drains, carry nutrients that degrade the quality of downstream waters. Managing drainage system outlets during the non-growing season to reduce water and nutrient exports can both improve water quality and increase yields. In cooperation with Ohio State University researchers, ARS scientists at Columbus, OH, found that over a three year period, corn yields increased in 66 % of the fields where drainage water management (DWM) was practiced. Increased yields should encourage producers to adopt DWM to reduce water and nutrient delivery to aquatic systems. Doing so will help improve water quality in the Gulf of Mexico, Chesapeake Bay, and Lake Erie, as well as in numerous municipal water supply reservoirs. The Natural Resource Conservation Service (NRCS) is currently using this information to develop a strategy to promote the adoption of DWM by farmers in these priority watersheds (Doi:10.2489/jswc.67.6.465 Ghane, et al. 2012).

Blind inlets effectively reduced nutrient runoff: In recent years, a resurgence of algal blooms has occurred in western Lake Erie, due in part to high loadings of phosphorus. Agriculture in the watershed has been identified as a key contributor of phosphorus loadings to Lake Erie. Agricultural Research Service scientists at West Lafayette, IN, have worked with local cooperators in the St. Joseph River watershed in northeast Indiana, to assess the influence of conservation practices on the quality of water conveyed to Lake Erie. Within the monitored watersheds, tile-risers have been identified as conveying very high loads of sediment and contaminants to stream water. In cooperation with the Indiana NRCS, a set of blind inlet construction criteria was developed and implemented at both the field and small watershed scales. At the field scale, installation of blind inlets was followed by observed decreases in sediment, phosphorus, and nitrogen. When this technology was used to replace all tile risers in a 700 acre watershed, there was a clear reduction in P transported to the stream following rainfall events. Within individual fields, blind inlets reduced phosphorus loadings by as much as an additional 86%. This research documents the effectiveness of specific NRCS conservation practices, and quantifies their benefits to water quality (Smith et al., 2008; Smith and Livingston, 2012).

Gypsum benefited plant growth during flooding: Periodic flooding of soil causes substantial decreases in agricultural production in Midwestern U.S., but how short-term flooding affects the biogeochemistry of the root zone and subsequent plant growth has not been quantified. ARS scientists at West Lafayette, IN, performed a greenhouse study comparing corn grown with free drainage to that with a perched water table. Gypsum was applied with both reduction conditions. In the perched water table pots, corn roots died at or near the zone of low redox potential caused by the perched water table. This was alleviated by the addition of gypsum and the roots flourished throughout this zone. In addition, mercury (Hg) accumulations were 10-fold higher in plants grown with a perched water table, independent of gypsum addition. Results indicate that soil drainage is not only important for plant growth, but that applying gypsum to soils can prevent production losses due to flooding, but not the accumulation of Hg in plants (Acuna-Guzman, 2009).

Industrial produces reduced nutrient and pesticide loading: Excess nutrients and pesticides in drainage waters degrade surface water quality. Treatment of these affected waters for public distribution, commercial, and recreational use can be costly. Capturing these contaminants prior to surface water entry is a viable solution to maintain cleaner water downstream. The success of these systems depends on finding inexpensive filter materials capable of effectively and efficiently removing nutrients and/or pesticides. ARS scientists in Columbus, OH, found that some relatively new industrial products have potential as filter materials for agricultural water treatment. Tests show that porous iron composite and sulfur modified iron are sufficiently permeable to water flow to be hydraulically efficient and exhibit potential to remove substantial amounts of nitrate and phosphate from water. Porous iron composite additionally shows promise for water treatment of pesticides such as atrazine. Consequently, porous iron composite and sulfur modified iron may in the future prove valuable for reducing the adverse environmental impacts associated with agricultural subsurface drainage practices. Several commercial entities have expressed interest in this technology (Allred 2010; Agrawal et al., 2011a; 2011b).

Innovative techniques minimized herbicide and nutrient runoff from golf courses: Nitrogen, phosphorus, and herbicides associated with managed turf systems (e.g., golf courses) have been detected in both stormwater runoff and surface waters in urban watersheds. ARS scientists at St. Paul, MN, evaluated the effectiveness of management practices to mitigate the off-site transport of pesticides in runoff from turf managed as a golf course fairway. Relative to other commonly used cultivation methods, cultivation using hollow tine cores (HTCC) reduced the percentage of precipitation that became runoff. Likewise, the percentages of the applied herbicides dicamba, MCPP, and 2,4-D measured in runoff were lower from turf managed with HTCC. In cooperation with a private research organization, ARS scientists at Columbus, OH, quantified surface losses of both soluble and total nutrients from a managed turf system in Duluth, MN. Nutrients in surface runoff exhibited a seasonal trend, were detectable throughout the year, and routinely exceeded levels recommended to minimize algal blooms. This research provides quantitative information to inform decisions on turf management that can maximize chemical retention at the site of application, while minimizing environmental contamination and adverse effects associated with the off-site transport of chemicals in surface waters (Rice et al., 2010; King and Balogh, 2008).

Link between increased dissolved P and Lake Erie algal blooms: The NCWQR has documented a substantial increase in dissolved P loading from the Maumee and Sandusky River watersheds since the mid-1990's (Joose and Baker 2011, Baker 2011). The timing of this increase has corresponded to the return of harmful algal blooms (HABs) in the Western Basin. It appears that land management changes (i.e., broadcast fertilizer application on frozen ground or shortly before rain) associated with widespread implementation of no-till agriculture and drastic increases in farm operations are the primary causes of increased dissolved P. This finding from the NCWQR has led to the foundation of and participation in the Ohio P Taskforce, a group aimed to develop a broader consensus on the management actions necessary to decrease algal blooms in the Lake Erie western basin. In collaboration with scientists from NOAA, we recently found that dissolved P loads from the Maumee River during the spring (March-June) was strongly related to the variation in HABs in Lake Erie measured using satellite imagery (Stumpf et al. 2012).This result is already being widely used to help forecast future HABs, predict the influence of climate change on Lake Erie, and to develop target loads to the Western Basin.

Managed wetlands are beneficial to habitats: The ability of created wetlands to reduce nutrient, pesticide, and sediment loadings in agricultural runoff can be optimized by design and management, but addressing these priorities may result in wetlands that are less beneficial as habitats for aquatic vertebrates (e.g., fishes, amphibians, reptiles) that are exhibiting worldwide population declines. ARS scientists in Columbus, OH, documented differences in fishes, amphibians, and reptiles in two wetland types created by the wetland-reservoir-sub-irrigation system (WRSIS), using this information to develop design and management criteria to increase the ecological benefits of these agricultural water-recycling systems. Differences in amphibian abundance and species composition between WRSIS wetlands and reservoirs suggest their potential to provide habitats for different ecological communities, with wetlands favoring amphibian populations and reservoirs favoring fishes. However, this was not the case for 'pond-type' wetlands that, similar to reservoirs, favored fishes. To alleviate this problem, design and management criteria were developed to enable WRSIS wetlands to be managed as amphibian habitat, and reservoirs to be managed as fish habitat. These criteria can be used by federal, state, and private agencies when creating agricultural wetlands, to assist them meeting their conservation and restoration goals (Anderson et al. 2011).

NCWQR demonstrated low levels of contamination in private well water in the corn belt: The NCWQR conducted a broad survey of private wells in the mid-1980s largely funded by the State of Ohio, endorsed by the Ohio Farm Bureau, and sponsored by SWCDs, county health departments, and other agencies. The study later expanded to Indiana, Illinois and other states. Comprehensive atlases of private well water contamination were produced for Ohio and Indiana. The surveys demonstrated that, overall, private wells had very low levels of contamination with nitrate or pesticides, the exceptions usually being associated with well defects, shallowness, or use of pesticides in close proximity to the well. During these surveys the NCWQR discovered the widespread presence in wells of a breakdown product of alachlor.

NCWQR's extensive and detailed data set on atrazine concentrations provided a major role in USEPA's re-registration of atrazine: The NCWQR initiated detailed studies of herbicide concentrations in area rivers in 1981. These studies soon extended to measurements of herbicide concentrations in public water supplies, rainfall, and private well water. The resulting data have been used by governmental agencies and manufacturers for human health risk assessment, ecological risk assessment and evaluation of herbicide removal options at public water supplies. For example, our data was used extensively in the re-registration of atrazine. Since its onset in 1981, the primary support for our pesticide monitoring program has come from pesticide manufacturers. As with our nutrient studies, our pesticide monitoring program is unique in terms of its detail and duration. We are currently evaluating in-situ, solid-phase extraction systems for monitoring herbicide concentrations in flowing waters.

NCWQR improved the dissolved P module of SWAT: NCWQR verified and improved the Soil and Water Assessment Tool's (SWAT) simulation of soluble reactive phosphorus (SRP). The NCWQR found and reported a bug that miscalculates SWAT's SRP output at watershed reaches (Confesor, et al. 2011). This problem was corrected in SWAT version 477 released in April 25, 2011 and later versions.

Ohio's Lake Erie Quality Index incorporated a metric developed by the NCWQR: The nearly complete extirpation in the 1950s of native burrowing mayflies (*Hexagenia*) from Lake Erie, where they comprised a major food source for sport and commercial fisheries, symbolized the severity of the pollution of the lake. Clean-up efforts aimed at municipal and industrial wastes beginning in the 1970s led to improved oxygenation of the western basin to the extent that *Hexagenia* began to recolonize the basin in the 1990s. The NCWQR teamed up with the USGS in Sandusky, OH, and Ann Arbor, MI, to track the extent of the recovery. Based on historic and new data, the NCWQR developed a lake quality metric based on the abundance of burrowing mayflies in the western basin. The metric was adopted by the Ohio Lake Erie Commission as one of its metrics used for scoring the overall quality of Lake Erie.

R-B Flashiness Index: Rivers and streams show varying amounts of short-term (day to day) change in discharge, some changing very rapidly and others only more slowly. This is referred to as flashiness, a useful but rather vague concept. NCWQR researchers developed the R-B Flashiness Index (named after Richards and Baker), which quantifies flashiness as the annual sum of day-to-day changes in mean daily discharge divided by the annual discharge. This index is useful for evaluating trends in flashiness within a watershed and comparing flashiness among various land uses. The index is in wide use throughout the US and in Europe by hydrologists and environmental planners and managers. It is included in the US EPA State of the Lakes Environmental Conference (SOLEC) indicators of health of the Great Lakes watershed.

Remediation strategy for manure spills: After a manure spill has reach surface waters (drainage ditches and streams), the most common method of remediation is to contain the contaminated area using earthen dams, remove the water from the stream using pumping equipment, and to redistribute the recovered waste into an alternative storage system or to land apply the waste in compliance with state regulations. Recent studies have examined the fate of phosphorus (P) during a manure spill and the effectiveness of the current manure spill clean-up method. These studies found that the current remediation of manure spills that reach surface water focuses primary on the contaminated water, while nutrient rich sediments remain in the stream. These sediments have been found to further contaminate the water column for up to 2 months after the spill. This study presents a supplemental clean-up method using aluminum sulfate (alum) as a sediment treatment to prevent the release of P from contaminated sediments to the water following a manure spill. We determined that treating sediments with the highest rates of alum/alum + $CaCO_3$, resulted in a 98-100% reduction in P released to the water following a 24 hour manure spill simulation. Sediments that contained the greatest clay content and extractable Fe and Al content required a greater alum treatment rates to reduce P release. Results from this study have demonstrated that sediment treatment has the potential to reduce P availability to aquatic plants such as algae and downstream transport of soluble P to lakes and reservoirs to prevent contributions to eutrophic conditions. (Armstrong et al., 2012)

Remote sensing facilitated conservation assessment: Recent developments in remote sensing technology provide geospatial data that can be used to assess the effectiveness of conservation practices at watershed and/or landscape scales. To demonstrate this capability, ARS scientists at West Lafayette, IN, used an object-based image analysis approach with Landsat-5 thermal imagery from 2005, and thematic layers of streams, to quantify conservation buffers and grasslands in the Cedar Creek Watershed (CCW) in northeast Indiana. Land cover data were used in the SWAT hydrologic model to assess the impacts of vegetative conservation practices on total P (TP) loads, and the model was calibrated and validated for discharge and TP loads in the CCW. In general, stream flow and TP loads were modeled within acceptable statistical ranges for the total contributing area of two nested catchments within the upper CCW. Compared to no practices, vegetative buffers of 30.5 and 61 m, combined with conservation grasslands generated from the 2005 Landsat imagery, resulted in large reductions in TP loads, but conservation grasslands alone reduced TP loads by less than 2%. These findings demonstrate that the improved representation of vegetative conservation practices in geospatial land cover data sets, combined with hydrologic modeling, enables a more effective assessment of the impacts of conservation buffers and grasslands on water quality (Larose et al., 2011).

Vegetative Buffer Strips (VBS) benefited aquatic ecology: Despite the well- recognized water quality benefits from vegetative buffer strips, their ecological benefits in agricultural streams are less well known. To address this deficiency, ARS scientists in Columbus, OH, assessed the effects of grass buffer strips on physical habitat, water chemistry, and fishes in channelized agricultural headwater streams. Installation of grass filter strips did not influence vegetative structure, vegetative type, channel form, in-stream habitat, water chemistry, or the stream biota. Thus unless used in combination with other conservation practices such as no-till or cover crops, grass filter strips may only provide limited ecological benefits in channelized headwater streams. Federal, state, and private agencies charged with managing agricultural watersheds can use these findings to help plan their conservation and restoration activities (Smiley et al., 2011).

Water quality model validated: ARS scientists at West Lafayette, IN, applied the AnnAGNPS model in the Cedar Creek Watershed (CCW), a main tributary of the St. Joseph River that is the source of drinking water for the city of Fort Wayne, IN. Modeled flow discharge for both the CCW and agricultural drainage ditch sites representing sub-watersheds within the CCW, were well matched with observed values during model calibration and validation. For atrazine concentrations in runoff water, the AnnAGNPS model was satisfactorily calibrated and validated for predictions of atrazine concentrations in the agricultural drainage ditches, but not in the CCW, where only coarsely measured data were available. This work indicates the need to first identify the proper scales at which a water quality model can be calibrated and validated, before an assessment can be made of the effects of conservation practices (Zuercher et al., 2011).