NERRS Science Collaborative Progress Report

Reporting Period: September, 2013 – February 28, 2014
Project Title: Implementing Credits and Incentives for Innovative Stormwater Management

Principal Investigator(s): Amy H. Brennan
Project start date: March 1, 2014
Report compiled by: Amy H. Brennan
Contributing team members and their role in the project:

- *Project Coordination and Fiscal Agent:* Amy H. Brennan; Chagrin River Watershed Partners, Inc.
- *Collaboration Lead:* Heather Elmer; Old Woman Creek National Estuarine Research Reserve with Ona Ferguson; Consensus Building Institute providing Collaboration Technical Assistance
- *Applied Science Investigator:* Jay D. Dorsey; ODNR, Division of Soil and Water Conservation
- *Additional project team members:*
    - Breann M. Hohman and Crystal Dymond; Erie Soil and Water Conservation District
    - Frank Lopez and Cheryl Wolfe-Cragin; Old Woman Creek National Estuarine Research Reserve
    - Keely Davidson-Bennett, Chagrin River Watershed Partners, Inc.
    - Ryan Winston, North Carolina State University

A. Progress overview:

The goal of this project is to promote the implementation of Low Impact Development (LID) and other innovative stormwater systems in the Ohio Lake Erie Basin by addressing barriers to implementation, gathering data on local best management practices (BMPs), building capacity of local stormwater professionals, and developing tools to effectively guide communities and consultants toward more sustainable stormwater management. This project will also highlight the role of LID in adapting to changes in rainfall volumes and intensities due to climate change. The project team includes the Chagrin River Watershed Partners (CRWP), Old Woman Creek National Estuarine Research Reserve (OWC NERR), Ohio Department of Natural Resources Division of Soil and Water Resources (ODNR-DSWR), Erie Soil and Water Conservation District (Erie SWCD), North Carolina State University (NCSU), and the Consensus Building Institute (CBI).

We have received positive feedback from the project team and the Collaborative Learning group (CLG) participants. 71% of the CLG participants noted that they are already applying information from our project in their work. In addition both CRWP and Erie SWCD are working with numerous communities that are interested in pursuing projects to construct additional LID stormwater control measures. Construction and equipment installation is complete at four of our project sites. The remaining two sites have completed the design phase and are slated for a spring 2014 construction. All of these sites will be monitored through 2014. The modeling components are moving forward with development of site scale models in using both SWMM and DRAINMOD models. As monitoring data is collected for each of these sites, the data will be used to calibrate and validate these models. Numerous presentations about our projects of related components occurred this project period including a roll out of new design specifications for bioretention and presentation and site tour at the National Nonpoint Source Conference. This project will be highlighted in several presentations at the Ohio Stormwater Conference in June 2014.

B. Working with Intended Users:

CLG meetings held during this reporting period on September 18, 2013 included site visits to the Willoughby Hills Community Center to view stormwater BMPs and monitoring equipment and a guest presentation on design and performance of innovative stormwater practices by Dr. Bill Hunt of North Carolina State University. The meeting included discussions on construction and monitoring progress for all sites and updates on the stormwater modeling effort. The project team and TIDES intern Will Brown gathered CLG member input to shape development of site-based case studies. More detail, including full presentations and meeting summaries are posted online at http://www.crwp.org/index.php/projects/research-projects/nerrs-science-collaborative.

Attendance at CLG meetings continues to be strong with over 25 participants at the September session and NCSU research seminar. Of CLG, project team members, and others responding to a semi-annual project evaluation survey in September 2013:

- 100% said participating in the project is a good use of their time.
- 100% said participating has increased their knowledge of BMP performance 'a lot' or 'a great deal'
- 92% have learned something new that they intend to apply in their future work or decisions.
- 71% are already applying the information in site planning, design of stormwater practices and development of state specifications for LID design
- 92% have shared project information with others including co-workers, communities, and college hydrology students, and counties/communities in Northwest Ohio.

Respondents indicated that it is beneficial to hear different points of view regarding LID design and performance and that they value cross-disciplinary dialogue on stormwater issues.

On February 11, 2014 the project team had a face to face meeting to finalize a work plan; discuss collaborative process status, needs and plans; development of training, tools, and other end products. The team reviewed and added detail to a work plan to complete project deliverables by August 2015. The team also discussed what is working well and what could be improved with regard to project coordination. Overall, team members felt that they group is working well together and generally on track with deliverables. Several indicated that they find face to face meetings valuable. The team may hold another meeting in summer 2014 to check in on progress and make adjustments. In 2014, the team will strive to improve facilitation and management of bi-weekly project team calls. The team will periodically revisit to do lists and renegotiate deadlines if needed. Small working sessions with a subset of the project team will be held as needed to manage project tasks.

C. Progress on project objectives for this reporting period:

Objective 1: Engage stormwater professionals in a collaborative process to identify and remove regulatory and technical barriers to implementation of LID in Ohio.

1. Completed activities and products:
    a. Held one collaborative learning group (CLG) meeting on September 18, 2013.
    b. Documented lessons learned, conflict, and ideas from CLG meetings in summaries, which are widely shared, and in our private project notes on lessons learned housed on Basecamp.
    c. Conducted survey to gather feedback on the project from CLG members, project team, contractors, and partners.
    d. Gathered initial CLG input on content and format for site-based case studies.
    e. Conducted interviews and document analysis for development of site-based case studies.

Objective 2: Quantify BMP specific and site level hydrology for local soil and climate characteristics.

1. The project team assisted with the design of 2 sites with LID BMPs to track hydrologic performance and to calibrate and validate models.
    a. Ursuline College: Bioretention cell to treat existing parking lot on campus in Pepper Pike.
    b. Old Woman Creek: The design for porous asphalt parking area at Old Woman Creek NERR was redesigned as a pervious paver and rainwater harvesting system.
2. Completed construction at and installed monitoring equipment at:
    a. Willoughby Hills Community Center: Two permeable interlocking concrete pavement retrofits
    b. Orange Village Community Center: permeable interlocking concrete pavement and bioretention
    c. Holden Arboretum (Kirtland): two bioretention cells
3. Continued monitoring at two permeable concrete applications in Perkins Township, Erie County; two permeable interlocking concrete pavement retrofits in Willoughby Hills; permeable interlocking concrete pavement, swale, and bioretention at Orange Village; and two bioretention cells at the Holden Arboretum (Kirtland).
    a. Ten months of data has been collected at Perkins Township and approximately 4 months of data has been collected at the other three sites.

b. All sites have a weather station to monitor climatic parameters, internal water level sensors within each stormwater control measure (SCM), and outlet weir structures to monitor outflow from each device. In all cases, inflow to each SCM is being calculated using measured rainfall and catchment characteristics.
c. Data analysis for all sites is underway. At the Perkins Township site, both stage data within the aggregate and drainage data have been analyzed for the western permeable concrete application.

4. Winter Monitoring Update: The monitoring contractor observed substantial challenges during monitoring in the winter of 2013-2014. In January and February, snow was on the ground constantly, with frequent plowing and salting of parking lots. Other difficulties observed with monitoring under these conditions included:
   - It was often difficult to access loggers in catch basins because they catch basins either had large piles of snow on them or the metal grate was frozen to the catch basin itself, making accessing the equipment difficult or impossible.
   - Downloading the pressure transducers in below freezing temperatures was difficult. The loggers often had to be taken into a heated location in order to make an electrical connection with the USB hub.
   - Monitoring with vented pressure transducers or using water quality samplers with dedicated tubing is complicated further by the use of snow plows. The tubing cannot be run over the surface of the parking lot, but should be fed through the side of the catch basin during construction to avoid destruction of the tubing by the snow plow blade.
   - Monitoring in near-surface weir boxes (i.e. within catch basins) or at surface flow monitoring points becomes problematic during extended periods of below freezing temperatures, since the water behind the weir freezes solid. Since this is where the pressure transducer is also located, monitoring data are often not valid or useful. Because of this difficulty, no water quality samples are currently being collected.
   - Plowing of snow can change the size of the watershed that you are monitoring, since snow can be moved into or out of the watershed and across watershed boundaries. This means that when monitoring in the wintertime, either the plow driver needs to be educated about the ongoing monitoring, or a defined inflow monitoring point needs to be created. This is often difficult to do, however, with SCMs such as permeable pavement, where no elevation drop (needed for a weir or flume) or defined inflow location (i.e. sheet flow) exists at the inlet to the SCM.

   At two monitoring sites (Perkins Township and Holden Arboretum), drawdown data within bioretention cells or permeable pavement applications have been compared against pre-construction infiltration tests completed by Jay Dorsey (ODNR). For the south and north bioretention cells, respectively, at Holden Arboretum, drawdown rates of 0.046 in/hr and 0.062 in/hr have been measured over 4 months of data collection. This compares quite well to the pre-construction rate of 0.05 and 0.02 in/hr measured using a single ring, falling head test at the south and north cell, respectively. At Perkins Township, the west cell drawdown rate over the first six months of data was 0.016 in/hr, which compared well against the 0.01 in/hr measurements made pre-construction. These data appear to confirm that the pre-construction infiltration testing predicts quite well the expected exfiltration or drawdown rate from the constructed infiltration practice. We will continue to analyze these data for the other practices and monitoring sites across the Chagrin and Pipe Creek watersheds.

Objective 3: Simultaneously model treatment of water quality and quantity volumes to meet local and state requirements.

During this semi-annual period CRWP and ODNR worked closely with modeling subcontractor Cardno/JFNew and scoped out contracts to engage NCSU as an additional modeling subcontractor. Cardno/JFNew is completing modeling work using USEPA Storm Water Management Model (SWMM). NCSU will complete DRAINMOD BMP model development for bioretention and permeable pavement practices to complement SWMM modeling performed by Cardno/JFNew. DRAINMOD is an agricultural drainage model which will be used to model permeable pavement performance. In addition, NCSU will coordinate with University of Tennessee Civil Engineering Department (UTCED) and the Oak Ridge Laboratory on development of projected climate change scenarios for the two Lake Erie subwatersheds of interest.

1. Historic Climate Characterization: An analysis of the historic climate record (NOAA Atlas 14 and NCDC Cleveland Hopkins Airport station data) provided the model precipitation input data that drove BMP performance comparison as well as the sensitivity analyses.
    - Cardno/JFNew developed a design event series of precipitation depths based on Atlas 14 depth, duration, and frequency from 0.25" depth to a 100-year event. Individual storm data then were used to characterize BMP performance in response to increasing storm depth.
    - Cardno/JFNew processed and analyzed the historic climate data record from Cleveland Hopkins Airport historical data to identify years in which rainfall data were "average", "wet" and "dry" in terms of total rainfall depth and distribution across the year. The "average" year data were used to develop an annual time series precipitation input file for the SWMM modeling to characterize BMP performance in response to the various hydrologic conditions encountered through a "typical" weather year.
2. Individual BMP Hydrologic Models - As reported in earlier summaries, the following nine BMPs were identified as potential components of a LID stormwater management strategy.
    - Bioretention Cells
    - Permeable Pavements
    - Green Roofs
    - Dry Detention Basins
    - Grass Swales
    - Soil Renovation
    - Grass Filter Strips
    - Underground Detention
    - Infiltration Trenches – eliminated after contractor and ODNR agreed that SWMM could not accurately represent hydrologic processes.

    For each of these BMPs, a preliminary design was developed based on capture and treatment of runoff from the WQv (P = 0.75") event or treatment of the water quality flow from the 0.75" event from a 1 acre watershed with 50% impervious area. Existing design guidance to meet this criteria were available in the Rainwater and Land Development manual for bioretention, permeable pavement, dry detention basins and infiltration trenches. Alternative references were used to develop preliminary designs for the other five practices.
3. Initial runs were performed for each modeled BMP in which the only variables were BMP area to drainage area ratio (A-BMP/DA), hydrologic soil group (HSG) and storm size (0.25" to 3.5"). This allowed CJFN and ODNR to review runoff volumes and peak discharges, look for non-intuitive results, and address issues with model designs/inputs.
4. A sensitivity analysis was performed by varying appropriate design parameters to identify which design enhancements could significantly improve hydrologic performance. Design parameter modifications included surface ponding depths, sump depths (or drain heights), soil media depth, and flow path length and roughness. A thorough review allowed us to evaluate parameter sensitivity and to identify and eliminate insensitive parameters from further consideration. We continue to work on strategies to collate results in a way they can be efficiently used in developing or updating design guidance and communicate the results to other stormwater professionals. The initial sensitivity analysis results will be presented this spring at both the May 2014 CLG meeting and at the Ohio Stormwater conference in June 2014.
5. Monitoring data collected in 2014 for four bioretention practices and five permeable pavement installations will allow us to calibrate our models using measured data. Subsets of the measured data will be used to test or validate the calibrated models.
6. Site Level Hydrologic Models - Site level hydrologic models under development include:
    a. A template site model based on an Rainwater and Land Development Manual design example that will allow comparison of BMPs and suites of BMPs, and an internal "User's Guide" document for applying LID controls within this template.
    b. Cardno/JF New has the site characteristic data for the Perkins Township Administration permeable pavement installation to build a SWMM model.
    c. NCSU is building a DRAINMOD model for the Perkins Township site. Initial results show that the first nine months of data have produced good agreement between modeled and observed water table data

within the aggregate. In the next few weeks, comparisons between modeled drainage and observed drainage (i.e. underdrain flow) will be made.

d. Site models for each monitoring site from which "good" data are collected.
    i. Calibrate models with early 2014 (April - June) data
    ii. Validate models with late 2014 (July - Oct) data

7. Our hydrologic performance database may be expanded with additional bioretention or permeable pavement models developed using solicited data sets from other researchers including:
    a. NCSU Rob Brown DRAINMOD bioretention sites
    b. USGS Ohio monitoring sites

Objective 4: Adapt models to include rainfall runoff scenarios anticipated as a result of climate change and characterize climate change adaptation functions of LID BMPs.

Modeling subcontractor NCSU has established a relationship with UTCED professors Dr. Joshua Fu and Dr. Jon Hathaway through which UTCED will provide dynamically downscaled climate data projections for mid-century (2050s). UTCED will provide continuous precipitation data sets for both moderate and intensive climate change scenarios. This data will be reformatted as necessary allowing us to re-run DRAINMOD and SWMM models of bioretention and permeable pavement to quantify climate change adaptation functions or benefits, if any, of those BMPs. Climate change data sets will be delivered to the NERRS project team by end of 2014, and modeling with projected data will be completed once the permeable pavement and bioretention models have been calibrated with monitored data.

Objective 5: Develop and provide training and technical assistance materials to build capacity of stormwater professionals and communities to implement LID approaches.

1. Provide informal training to the CLG:
    a. The September 18, CLG meeting included a presentation on design and performance of innovative stormwater practices by Dr. Bill Hunt of North Carolina State University. Dr. Hunt highlighted NCSU's research on rainwater harvesting systems, street retrofit projects, downspout disconnection, and large scale underground detention and infiltration.
2. Provide formal training and technical assistance to stormwater professionals: Project team members participated in planning and presenting three training sessions sponsored by the Northeast Ohio Stormwater Training Council, CRWP, Old Woman Creek and others.
    a. Commercial BMP Maintenance training for landscapers at Cleveland Metroparks West Creek Stewardship Center to be held October 1st.
    b. OWC NERR workshop focused on Preparing Stormwater Systems for Climate Change in Monroe, MI in collaboration with Michigan Sea Grant and the Great Lakes Adaptation Assessment for Cities.
    c. Project Team Members presented the project and hosted a tour of monitoring sites at the 21st Annual Nonpoint Source Monitoring Conference in Cleveland in October 2013.
    d. ODNR hosted workshops in February 2014 rolling out the new design standards for bioretention.
3. Model regulations that remove regulatory barriers to LID:
    a. In this reporting period, CRWP revised our model parking code to allow stormwater BMPs and minimizing parking lot size.
    b. CRWP is working with Cleveland State University and Lake County Planning and Community Development to update our model Conservation Development code.
    c. Once the municipal separate storm sewer system (MS4) permit is issued (comments on draft were due January 29, 2014), CRWP will work to update our model codes for erosion and sediment control and stormwater management. This permit may include the following requirements to:
        - Update to Stormwater and Erosion and Sediment Control codes to current Construction General Permit standards within 2 years.
        - Update Storm Water Management Program within 2 years.
        - Use of TMDL recommendations in BMP selection

CRWP has been working with NOACA and Ohio EPA to developed the below approach to assist communities in updating their local codes and Stormwater Management Plans to include TMDL recommendations.

1. Inventory the number and types of TMDLs.
2. Identify BMPs for inclusion in the update of the Storm Water Management Plan (SWMP).
3. Review and discuss the inventory with other stakeholders and service providers.
4. Identify potential changes in the model codes.
5. Convene a technical review committee to review/discuss identified BMPs and any suggested changes to the SWMP/codes.
6. NOACA/CRWP will work to update the model SWMP and codes.
7. Revise the model drafts and submit to Ohio EPA, interested communities, and Northeast Ohio Storm Water Training Council for review and comment.

4. Provide technical assistance on the adoption and implementation of local codes and project recommendations.
    a. Erie SWCD and CSU provided technical assistance with local code review for 15 communities and agencies in Erie County.
    b. Currently Erie County's Phase II Communities are working with the Erie SWCD to update and revise the County's Stormwater Regulations to include enforcement and regulation language for compliance under the OEPA Small MS4 permit. Erie SWCD staff are are working with the County Prosecutor's office to determine enforcement procedures and have secured a draft that is under review. Once the draft is more substantial it will be presented to the local township trustees and zoning officials for a commenting period to ensure local acceptance and practicality.
    Erie SWCD is also proceeding on securing contracts for a stormwater assessment to be performed in Erie County's Phase II communities in order to evaluate efficiency that is economically feasible in order to secure long term sustainability for our stormwater program and efforts.
    c. Both CRWP and Erie SWCD are seeing increased local acceptance for LID stormwater practices as seen through communities' pursuance of funding thru the Ohio EPA Storm Water Improvement Fund (SWIF) grants.
        i. In Erie County, the City of Sandusky to install pervious concrete at Jackson St. public parking lot, City of Vermilion to install pervious pavers at Showe Park parking lot, and Village of Bay View to install pervious pavement on a walkway along their shoreline for the public. All 3 communities understand the logistics of the pervious LID practice and are willing to include an educational component to further maximum educational outreach within their community.
        ii. 15 CRWP Member communities are considering SWIF grant proposals to incorporate innovative stormwater retrofits at public properties.

5. Support development of Ohio specific guidance on design, construction, cost, operation and maintenance of BMPs:
    a. ODNR revised the bioretention design specifications and sponsored trainings to roll out the standards in February 2014.
    b. ODNR is drafting infiltration testing guidelines for inclusion in the Rainwater and Land Development Manual, which has been informed by our project.

What data did you collect?

- Water quantity monitoring data for Perkins Township, Willoughby Hills, Orange Village, Pepper Pike (discontinued monitoring).
- Interviewed CLG, site owner, and project team member for development of site-based case studies.
- CLG input on tracking BMP design and construction costs.

Has your progress in this period brought about any changes to your methods, the integration of intended users, the intended users involved or the project objectives?

Our original project scope did not anticipate monitoring throughout the winter. We were able to include winter monitoring into our scope and have been collecting data through this winter season thus far. Based on problems encountered with accessing and downloading data, it is unlikely we will monitor in the winter in the future. However, we have learned that the subsurface drainage information has been useful component of winter monitoring. In 2014, the project team and CLG will determine approach for next winter and the lessons learned from this season's winter monitoring will be documented as a part of this project.

Have there been any unanticipated challenges, opportunities, or lessons learned?

Due to high construction costs associated with the small scale of the project, the porous asphalt parking area at Old Woman Creek NERR was redesigned as a pervious paver and rainwater harvesting system. Construction is anticipated in spring 2014.

Due to problems during construction of the pervious pavement at Pepper Pike, this site is no longer being monitored. The water level monitoring wells were not installed correctly and the data loggers were not collecting any data. In addition the curb between the conventional asphalt and the permeable pavement was not completely level and channeled the stormwater to one area causing the stormwater to flow over the porous pavers in a more concentrated flow. Drift patterns of leaf debris and staining of porous pavers in area of concentrated flow led the project team to believed that some of the stormwater is flowing over the pavers rather than infiltrating. Due to the lack of confidence of the data from this site, we are no longer monitoring this site.

What are your plans for meeting project objectives for the next six months?

Objective 1:

1. Two CLG meetings - May 7 and August 20
2. Produce two project updates to CLG members and others interested in the project at the mid-point between meetings.
3. Finalize project case studies for Perkins, Willoughby Hills, Holden Arboretum, and Orange Village based on feedback from the project team, CLG members and others.
4. Mentor a University New Hampshire TIDES intern that will assist with the collaborative process and develop additional case studies for project sites.
5. Produce Ursuline College and Old Woman Creek NERR case studies with input from CLG members, the project team, and others.
6. Provide informal training on stormwater monitoring equipment, protocols, and data management for CLG members, project partners and others.

Objective 2:

1. Oversee construction and infiltration testing at Old Woman Creek NERR and Ursuline College (May).
2. Install monitoring equipment at Old Woman Creek NERR and Ursuline College (May).
3. Finalize water quality sampling plan and protocols (March).
4. Set up Willoughby Hills for water quality sampling (May).
5. Continue monitoring at all six sites.
6. Analyze monitoring data from all sites.
7. Finalize project construction costs for monitoring sites.
8. Compile economic data and resources on monitored BMPs and share with CLG (May).

Objective 3:

1. Delivery of SWMM climate series data (March).
2. Annual runs of SWMM models and summary documentation (March).
3. Develop DRAINMOD models of Perkins, Orange, Willoughby Hills, OWC NERR, Ursuline, & Holden Arboretum.
4. Develop SWMM models of Perkins, Orange, Willoughby Hills, OWC NERR, Ursuline, & Holden Arboretum.

Objective 4:
1. Obtain Future Climate data for Ohio from University of Tennessee.
2. Format future climate data for use in models.

Objective 5:
1. Provide informal training through CLG meetings.
2. Update CRWP model codes for Conservation Development, Erosion and Sediment Control, Comprehensive Stormwater Management.
3. Provide technical assistance on the adoption and implementation of local codes and project recommendations.
4. Submit an article to a state-wide newsletter for watershed and stormwater professionals.
5. With CLG input, define objectives and target audiences for training on design, construction, performance of bioretention and pervious pavement.
6. Begin developing and pilot testing training content and materials and tools based on project results.
7. Engage CLG members in planning and pilot testing of training and tools associated with the project.
8. Synthesize lessons learned for design and construction into an accessible format for use in training and technical assistance.
9. Presentations about project and project results to Ohio EPA Stormwater Group, County Engineer Association of Ohio, Ohio Stormwater Conference.

D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.

Data from the site characterization and confirmation of the observed infiltration rates with sampling data gives us a high level of confidence in that methodology and ODNR is developing additional guidance to be included in the rainwater and Land Development Manual.

Articles and photographs about the project are available:
- CRWP website at http://www.crwp.org/index.php/projects/research-projects/nerrs-science-collaborative
- SWCD Winter 2014 Newsletter at http://www.eriecounty.oh.gov/departments-and-agencies/environmental-resources/erie-soil-and-water-conservation-district/general-information/newsletters/
- CRWP's 2013 annual report at http://www.crwp.org/files/2013_crwp_annual_report.pdf.

E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.