INNOVATIVE APPROACHES TO DEVELOPING AN NPDES STORM WATER PROGRAM – PUBLIC INVOLVEMENT AT THE WATERSHED SCALE THROUGH STREAM MONITORING

AN ANALYSIS OF 2010-2011 MONITORING EFFORTS ASSOCIATED WITH THE GREAT MIAMI RIVER CITIZENS' WATER QUALITY MONITORING PROGRAM & AULT PARK STREAM RESTORATION/CSO REDUCTION PROJECT


Lower Great Miami River – Colerain Township, Hamilton County, Ohio

A PUBLICATION OF THE HAMILTON COUNTY SOIL AND WATER CONSERVATION DISTRICT (CINCINNATI, OHIO)

HAMILTON COUNTY
soil and water
CONSERVATION
DISTRICT

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February 2013

INTRODUCTION

In February 2003, the Hamilton County Board of County Commissioners (southwest Ohio) established the Hamilton County Storm Water District (HCSWD) to address the United States Environmental Protection Agency (USEPA) and Ohio Environmental Protection Agency (OEPA) National Pollutant Discharge Elimination System (NPDES) Phase II Storm Water Program requirements. The USEPA and OEPA requirements fall into 6 categories: public education and outreach, public involvement/participation, illicit discharge, construction site runoff control, post-construction storm water management and pollution prevention/good housekeeping. Under HCSWD guidance, Hamilton County Soil & Water Conservation District (HCSWCD) administers several NPDES Phase II program areas, including public involvement/participation.

Since 2003, HCSWD and HCSWCD have employed innovative approaches to building public involvement/participation programs, leveraging resources and meeting NPDES Storm Water permitting requirements within 42 jurisdictions. These include development of partnerships and funding support for nonprofit and watershed organizations; installation of 400+ watershed/stream crossing signs; storm drain labeling events (3,000+ storm drains labeled, 7,000+ door hangers distributed and 500+ participants); community presentations; personal land owner consultations; multimedia approaches such as billboards and local news programs (156 news stories) through a Southwest Ohio-Northern Kentucky Collaborative; installation of storm water best management practices (BMPs) such as rain gardens, bioswales and pervious pavement; soil bioengineering, tree planting, water quality monitoring, stream assessment and soil fertility testing programs; and waterway clean-ups.

From 2010-2012, a few of the most unique and watershed focused public participation programs are 1.) monitoring of water chemistry through the Great Miami River Citizens' Water Quality Monitoring Program and 2.) conducting biological surveys as part of the Ault Park stream restoration/combined sewer overflow (CSO) reduction project. Both of these programs are unique public involvement initiatives from the standpoint that they involve public participation as a key component to stream and watershed analyses. Additionally, the Ault Park project incorporates public participation in addressing challenges associated with the construction of stream restoration projects. This paper discusses the benefits and nature of public involvement in each of these projects, approaches to data collection as well as sampling and data assessment methodologies.

GREAT MIAMI RIVER CITIZENS' WATER QUALITY MONITORING PROGRAM

Program Background

The Great Miami River Citizens' Water Quality Monitoring Program utilizes citizen volunteers to collect stream samples once a month (March – November) within the Lower Great Miami River watershed. The Great Miami River flows from west-central Ohio 170 miles southwest, draining into the Ohio River. The total drainage area of the basin is 5,702 square miles[1]. The majority of the sampling efforts take place in the Lower Great Miami River watershed south of Hamilton, Ohio in Hamilton and Butler County, Ohio (refer to **Figure 1**).

In 2009, Dr. Michael Miller, Professor Emeritus with the University of Cincinnati informed HCSWCD that the university had recently acquired facilities in western Hamilton County on Hamilton County Park District property (see **Figure 2** - Miami Whitewater Forest). Under Dr. Miller's guidance, a collaboration of partners working on various watershed issues agreed that the facility would be ideal for a citizens' "river lab". The establishment of the Great Miami River Citizens' Water Quality Monitoring Program in 2010 was initiated as a partnership between HCSWCD, the University of Cincinnati and two nonprofit watershed groups, "Friends of the Great Miami" and "Rivers Unlimited", to enable volunteer monitoring throughout the Lower Great Miami and Whitewater River basins. The Whitewater River is one of the longest tributaries to the Lower Great Miami River, flowing 90 miles from eastern Indiana southeast into the Great Miami River. It has a watershed size of 1,765 square miles[1].

During 2010, volunteers used clean and sterile water bottles to collect water samples for delivery to the University of Cincinnati Center for Biological Studies site (UCCBS – see **Figure 3**). The UCCBS includes both an indoor and outdoor covered facility where samples were analyzed. Once delivered, samples were organized for chemical analyses. These analyses were performed on 15-20 year old equipment from the university and included pH, conductivity, turbidity, nitrate, total phosphorus and *E. coli*. Dissolved oxygen measurements were taken in the field at selected sites. By the end of 2010, it became apparent that the lab would not be able to continue long-term operation without an outside source of funding, new lab equipment and reagents. Therefore, in early 2011, HCSWD and HCSWCD committed to provide $10,000 in funding toward the purchase of updated lab equipment/supplies and $10,000 in administrative support to Friends of the Great Miami and Rivers Unlimited.

The administrative support duties consisted of generating new volunteers, publicizing the program to school groups, mapping of sample sites, brochure and logo development and data entry. Working under contract through Friends of the Great Miami, Lisa Link developed the brochure for the Great Miami River Citizens' Water Quality Monitoring Program, which can be viewed at http://riversunlimited.org/documents/gmrwqm2011.pdf and a unique logo for the Great Miami River Citizens' Water Quality Monitoring Program (see **Figure 4**). Based on consultation with partners and citizen samplers, she also developed a map of existing and potential sample sites in Hamilton County (see **Figure 5**).

In addition to the HCSWCD funding, Rivers Unlimited secured grants from CSX Corporation and the Seasongood Foundation to help maintain monitoring efforts. Another local nonprofit organization, Oxbow Inc. has provided $2,000 in funding toward the purchase of sampling supplies. Oxbow Inc. owns and preserves 2,500 acres of wetlands and floodplains at the confluence of the Great Miami River and Ohio River[2]. The organization has a strong interest in the water quality monitoring in order to protect the quality of their land holdings and unique wildlife.

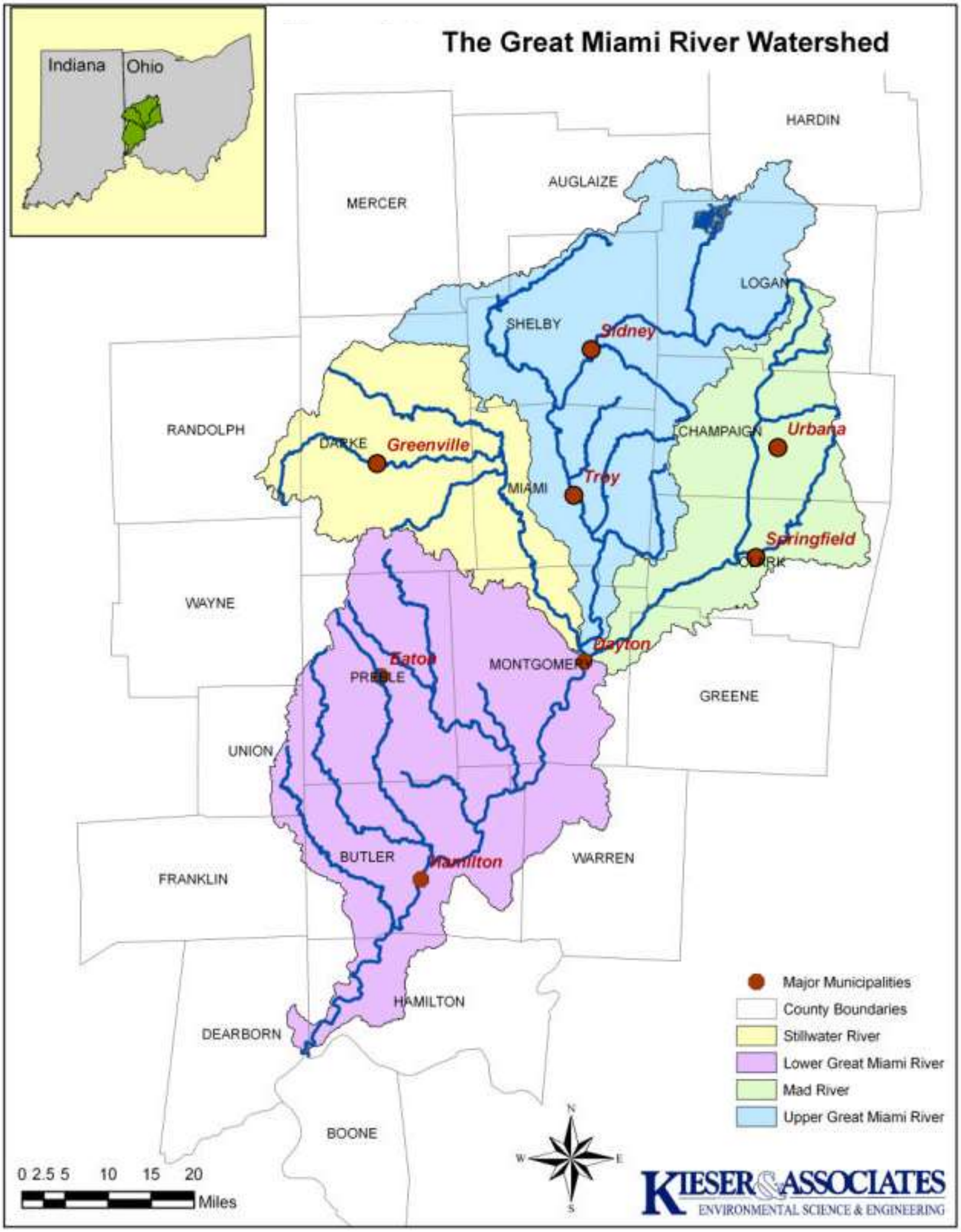

Figure 1: Great Miami River drainage basin[3]

Figure 2: University of Cincinnati Center for Field Studies, 10053 Oxford Rd., New Haven, OH.

Figure 3: University of Cincinnati Center for Field Studies

Figure 4: Great Miami River Citizens' Water Quality Monitoring Program logo

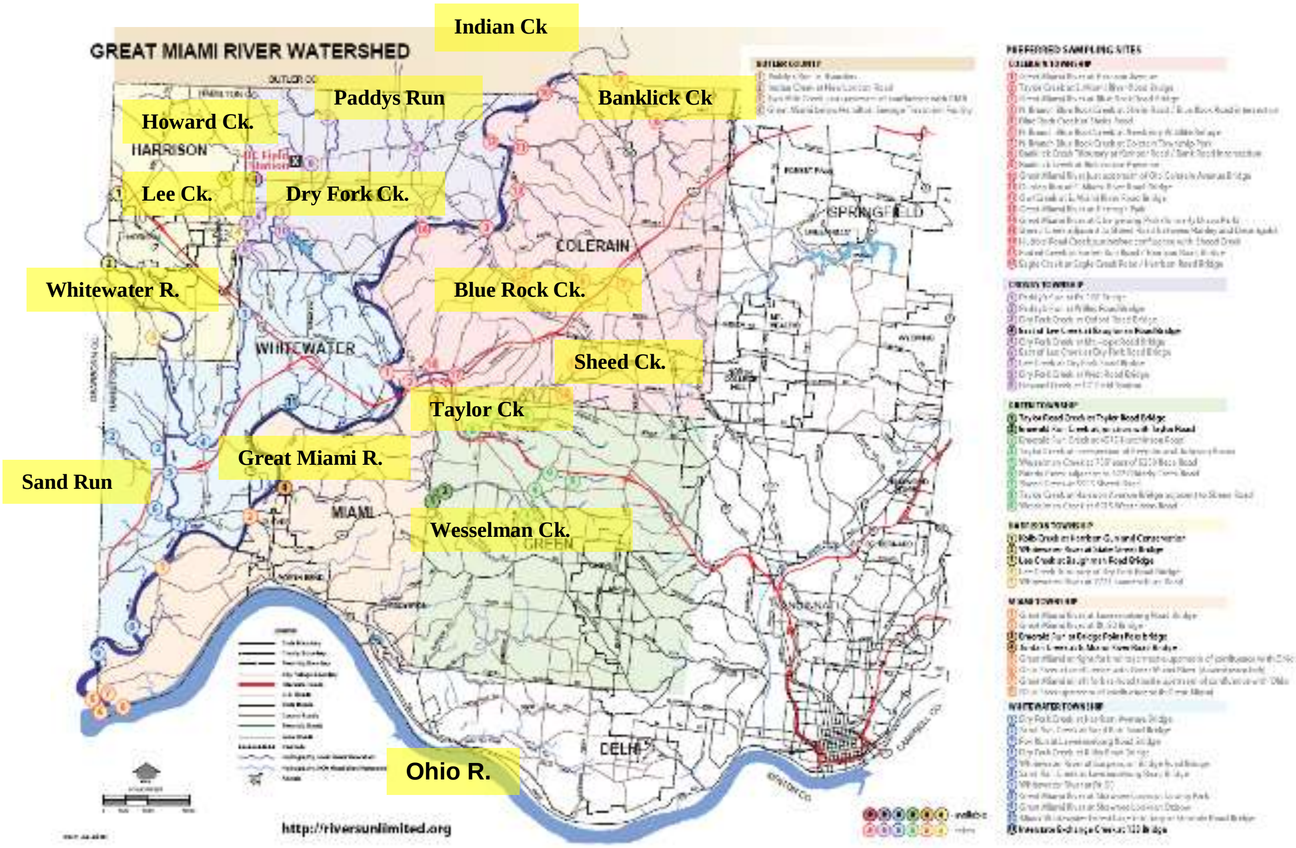

Figure 5: Great Miami River Watershed Citizens' Water Quality Monitoring Program sample locations

Water Quality Sampling and Data Analysis Parameters

Prior to the onset of yearly sampling efforts in March, volunteers are trained regarding standard sampling techniques. The training provides details of these techniques in order to increase the quality of the results[4]. For instance;

- Sample as far from the stream bank as possible. Use a sampling wand if you have it.
- If entering the stream, enter downstream of where you plan to sample. This prevents disturbance of substrates, potentially skewing the sample composition.
- Sample at a point within the regular monitoring reach where the stream is flowing, well mixed and at least 6 inches deep.
- Triple rinse the bottle prior to gathering sample.
- Do not set the cap of the bottle down to avoid contamination.
- Sample midway between the bottom and water surface.
- Leave air space in the bottle as spills and contamination can occur at the lab.
- If available, place sample bottle on ice.
- Obtain samples within 8 hours of analysis to meet OEPA *E. coli* holding time requirements.

Along with preliminary stream sampling training, volunteer analysts are trained by more experienced analysts from the river lab coordination team (refer to **Figures 6-9**). The volunteers were also supplied an explanation of safety procedures, sampling attire along with chemical and biological analysis parameters, their sources and effects. The goal is to increase their understanding in the importance of the measured parameters and quality testing. Analysis parameters, sources and effects are indicated as follows:

- Nitrates
  - Sources: Agricultural and urban fertilizers, manure, septic tanks and vehicle exhaust.
  - Effects: Excessive algal growth, eutrophication (low oxygen conditions), Blue Baby syndrome and brown blood disease in fish.
- Total Phosphorous
  - Sources: Excess from waste water treatment plant (WWTP), agricultural and urban fertilizers, manure, septic tanks and soil erosion.
  - Effects: Excessive algal growth and eutrophication (low oxygen conditions).
- pH (acidity or basicity)
  - Sources: Natural stream bed minerals ($CaCO_3$, $MgCO_3$), WWTP discharge and soils (NH_3 will elevate pH); elevated by algal photosynthesis.
  - Effects: Low pH allows toxic compounds to become more available to aquatic organisms. High pH is associated with warm waters.
- Conductivity (dissolved ions)
  - Sources: Elevated by WWTP discharge, septic systems, agricultural discharge, road salt and warm water.
  - Effects: Toxic to aquatic organisms at elevated levels. Nature of toxicity dependent upon ionic presence.
- Turbidity (cloudiness of water)
  - Sources: Elevated by runoff erosion from row crops, pastures, stream bank erosion, construction sites and high algal content.
  - Effects: Inhibits growth of submerged aquatic plants and food supply of aquatic organisms and affects the ability of fish gills to absorb oxygen.
- *E. coli* (bacteria)
  - Sources: Elevated by human and animal feces from WWTPs, septic systems and storm water runoff.
  - Effects: Gastroenteritis, ear infections and Hepatitis A in humans. Low oxygen due to decomposition.
- Dissolved oxygen (DO - % saturation and concentration)
  - Sources: Elevated in cooler temperatures, but can be extremely high with excessive algal growth and photosynthesis due to nutrients. Low dissolved oxygen associated with algal die-off and elevated bacterial concentrations.
  - Effects: Over 100% is supersaturated or more oxygen than the maximum amount that the water column can hold at a given temperature and pressure. Above 100%, there will be small gas bubbles. Values between 80%-120% are optimal. Species such as trout and salmon can’t tolerate much above 105% for an extended period. Most fish species can’t survive DO concentrations below 3 mg/L for extended periods.

Each of the prior listed parameters requires unique instrumentation and methods to conduct the analyses. Through the purchase of new equipment in February 2011, HCSWCD evaluated the effectiveness of monitoring equipment and/or supplies for assessment of total phosphorus, pH, conductivity, turbidity and *E. coli*. Specifications, instrumentation and methods used to conduct analyses for the 6 parameters immediately follow this discussion. University of Cincinnati equipment is used for the assessment of nitrate, incubation of total coliform and *E. coli* samples and back-up instrumentation as needed. Prior to each Saturday sample analysis, all instruments are calibrated using the appropriate standards and buffers for a given test. Total phosphorus and nitrate runs include analysis of distilled water blanks and standards appropriate for the sample range. Total phosphorus, pH, conductivity and turbidity analyses include laboratory duplicate runs on 10% of the samples as a quality control check and total coliform/*E. coli* filtration procedures consist of 1 mL and 10 mL dilutions for each sample. These dilutions are multiplied by 100 and 10 respectively to determine colonies per 100 mL. Then, the two values per 100 mL are averaged to compute colonies per 100 mL at a given site. Field duplicates are occasionally taken and analyzed to assess the variability of samples among samplers. All Quality Assurance/Quality Control (QA/QC) data are stored in a spreadsheet for each month that data are collected.

- Nitrates
  - Instrumentation: Portable Spectrophotometer
  - Method: Cadmium Reduction Method – Hach 8171
- Total Phosphorous
  - Instrumentation: DR 2800 Portable Spectrophotometer
  - Method: Acid Persulfate Digestion – Hach 8190
- pH (acidity or basicity)
  - Instrumentation: Oakton 650 pH Meter
  - Range: 0-14
  - Accuracy (0.002), Precision (0.001-0.1)
- Conductivity (dissolved ions)
  - Instrumentation: Hach sensION5 Conductivity Meter
  - Range: 0-19,999 uS/cm
  - Accuracy (0.5%), Precision (1 uS)
- Turbidity (cloudiness of water)
  - Instrumentation: Hach 2100Q Turbidity Meter
  - Method: U.S. EPA method 180.1
  - Accuracy (2%), Precision (0.01 NTU)
- *E. coli* (bacteria)
  - Instrumentation: Total coliform and *E. coli* screening with membrane filtration equipment
  - Method: Membrane Filtration - Hach 10029, U.S.EPA 1603
- Dissolved oxygen
  - Instrumentation: YSI 556 multi-probe meter
  - Range: 0-50 mg/L, 0-500% air saturation
  - Accuracy: (2% or 0.2 mg/L;), Precision (0.01 mg/L, 0.1% saturation)

Figure 6: Lisa Link checks in samples and associated sample forms from volunteers.

Figure 7: Dr. Michael Miller (blue jacket) and Bernie Moller (red jacket) provide training on *E. coli* analysis for volunteers. Also pictured are experienced analysts George Sutthoff (blue hat) and Bruce Koehler (brown jacket).

Figure 8: Emily Heintzelman and Nate Holscher, Rivers Unlimited Program Director, perform turbidity analyses.

Figure 9: Brian Bohl (HCSWCD) shows a young volunteer how to pour a sample.

Public Involvement and Sampling Accomplishments: 2010-2011

When determining the success of the Great Miami River Citizens' Water Quality Monitoring Program, there is definitely more than one barometer. A few of the program evaluation measures include the following:

- Volunteer contribution/participation and ability to leverage resources: Important for NPDES Phase II programs and organizations involved in fundraising.
- Stream miles or number of sites sampled. Number of waterways sampled.
- Ability to educate volunteers, share the data and reach out to other groups or organizations through presentations or events (a key component in NPDES Phase II program reporting).
- Use of the data: Does the data collection process create positive change within watersheds?

Table 1 provides a synopsis of these suggested program evaluation measures. Volunteer hours are computed based on the Average Wage Method as described in the *Investigator*, a publication of the Lyndon B. Johnson School of Public Affairs at the University of Texas[5]. Average hourly earnings have been reported by the Bureau of Labor Statistics in March 2010 as $22.47 (when volunteers start sampling) and March 2011 as $22.87[6]. Adding 12% to these values in order to account for fringe benefits, as suggested in the Average Wage Method, yields a volunteer labor value of $25.16 per hour in 2010 and $25.61 in 2011. In 2011, 255 total volunteers helped out at the river lab, with an average of 28 volunteers during each monthly sampling event. This compares to an average of 15 volunteers per month during 2010.

Year	Volunteer Hours and Value	# Sample Sites, Analyses and Samples	Collaborative Data Presentations and Events
2010	Hours: 750 Value: $18,870	• Total sites: 71 • Monthly range: 15-45 sites • Analyses: 1,644 • Samples: 274 - 30/mo. ave.	• Data sharing presentation to volunteer samplers in February 2011 on 2010 data.
2011	Hours: 1,066 Value: $27,300	• Total sites: 73 • Monthly range: 38-64 • Analyses: 2,994 • Samples: 499 - 55/mo. ave.	• Local TV segment (Channel 5 Project Earth) • Ohio EPA • Greater Cincinnati MSD • Hamilton County Environmental Action Commission • Land Lab for Price Hill Middle School students • Oxbow Inc. • Green Umbrella • University of Cincinnati Planning Students • Data sharing presentation to volunteer samplers in February 2012 on 2011 data.

Table 1: 2010-2011 Evaluation measures for the Great Miami River Citizens' Water Quality Monitoring Program.

The success of the Great Miami River Citizens' Water Quality Monitoring Program is evident through the increasing public participation represented in **Table 1** through the estimated $46,170 volunteer contribution as well as the sampling at 73 sites throughout the Lower Great Miami River basin. During the year of the HCSWD and HCSWCD contribution, the value of volunteer labor increased by $8,430, an average of 25 additional samples were processed per month, 1,350 additional analyses were performed and 7 additional programs were provided to public, private and nonprofit organizations. Furthermore, new connections were made and brochures were distributed at 10 high schools, 5 parks/preserves, 8 businesses and 10 nonprofit organizations and 2 colleges. Finally, 10 local and/or regional media outlets were contacted and provided with program updates. This led to a local television station segment (Channel 5 Project Earth) on the Great Miami River Citizens' Water Quality Monitoring Program in March 2011 (refer to http://www.wlwt.com/weather/27283100/detail.html).

Table 1 does not by itself answer the question "Does the data collection process create positive change within watersheds?" However, it takes time for the data processing to create positive change within watersheds. The Great Miami River Citizens' Water Quality Monitoring Program has been successful in the first stage of the process through generating exceptional public participation and media coverage.

Presentations, meetings and discussions with entities such as OEPA, MSD, Hamilton County Health Dept., Hamilton County Park District, Hamilton County Environmental Action Commission, Ohio-Kentucky-Indiana Regional Council of Governments (OKI), Natural Resources Conservation Service (NRCS), Miami Conservancy District and Butler County Storm Water District have established a greater understanding of the role that volunteer data can play in filling in data gaps associated with watershed monitoring. While it can take years to diagnose and reverse problem areas within watersheds, knowing where to sample and how to interpret the data in a meaningful manner for the public are valuable initial steps to a successful citizens' water quality monitoring program. As the examples in the next subsection on "data analysis and observations" illustrate, the sheer number of samples volunteers are able to collect and analyze, combined with the quality control built-in to the program, produced meaningful results about the sources of water quality issues that might otherwise not be discovered. Furthermore, some data are currently being collected to be used as part of OKI's regional water quality plan.

Data Presentations: Analyses and Observations

In February 2011 and 2012, following 9 months of prior year data collection efforts, presentations were provided to citizen volunteers to give insight as to what the data means. While **Table 1** provides some valuable components associated with OEPA NPDES Phase II reporting, dedicated volunteers involved in a monitoring program ultimately want to hear about the data they have worked so hard to collect and/or analyze. Even local and regional businesses show interest in the data. Therefore, data parameters were synthesized, evaluated and presented based on the following criteria.

- Comparison of data between large rivers, feeder tributaries and floodplain wetlands (Oxbow Inc. property) (refer to **Table 2**).
- Yearly average and maximum values for each waterway sampled (Dr. Michael Miller).
- Pollutant loading and chemical parameters associated with seasonal discharge (Dr. Michael Miller).
- Data parameters by river mile along the Great Miami River (Dr. Michael Miller).
- Pollutant loading trends in recent years (Dr. Michael Miller).
- Water quality in close proximity to NPDES or industrial dischargers. Example sample sites downstream of 3 Whitewater River dischargers provided in **Figure 10**.
- Water quality downstream of agricultural best management practices and stream bank stabilization efforts (Lee Creek, tributary to the Dry Fork Whitewater River and Paddys Run, tributary to the Great Miami River).
- Water quality upstream and downstream of septic system hotspots (as defined by Hamilton County Health Department).
- Comparison of urban/rural watersheds (Blue Rock Creek/Paddys Run, respectively (**Figure 11**)).
- Water quality in a stream restoration project area (Dry Fork Whitewater River – see **Figure 12**).
- Upstream/downstream correlations (Dry Fork Whitewater River – refer to **Figure 12**).
- Seasonal correlations – change in parameters by season (Dry Fork Whitewater River – refer to **Figure 12**).

Figure 10: Strategic monitoring on the Whitewater River.

Figure 11: Case study comparison of an urban and rural watershed (Blue Rock Creek and Paddys Run, respectively).

Figure 12: Monitoring sites in the Dry Fork Whitewater River watershed (identified by black dots).

One of the ways that data have been presented through the Great Miami River Citizens' Water Quality Monitoring Program include an evaluation of water chemistry by the type of waterway (see **Table 2**). Using 2011 data, types of waterways evaluated include large rivers (117 sample points), small tributaries (329 sample points) and Oxbow ponds (18 sample points). River analyses targeted Ohio River, Great Miami River and Whitewater River samples. All of the other feeder streams fell into the small tributaries category. Oxbow ponds included wetland and floodplain samples along the Great Miami River near the confluence of the Ohio River. Great Miami River and Whitewater River seasonal averages are provided in **Figures 13 and 14,** respectively, and **Figure 15** reveals a record of 2010-2011 Great Miami River discharge.

	Turbidity (NTU) (< 20)	pH (6.5 < pH < 8.5)	Conductivity (uS/cm) (< 550)	Nitrate (mg NO3/L) (< 1.0)	Total Phosphorus (mg/L) (< 0.1-0.3)	*E. coli* (geometric mean - # colonies/100 mL) (< 126 - 30 day ave., < 284 – 7 day ave.)
2011 Oxbow Ponds Average Values	47.3	8.25	679	2.74	0.27	90
2011 River Average Values	39	8.22	606	2.73	0.21	123
2011 Tributary Average Values	19.7	8.07	751	1.28	0.23	247

Table 2: 2011 evaluation of water chemistry by type of waterway (values in parentheses represent ranges consistent with Ohio aquatic life use goals. *E. coli* range represents guidelines and goals for human health).

2011 GMR Seasonal Averages

- **Turbidity – 42.4 NTU**
- **pH – 8.33**
- **Conductivity – 690 uS/cm**
- **Nitrate – 3.11 mg/L**
- **Total Phosphorus – 0.26**
- ***E. coli* – 122 colonies/100mL**

Figure 13: 2011 Great Miami River Seasonal Averages

2011 WWR Seasonal Averages

- **Turbidity – 36 NTU**
- **pH – 8.11**
- **Conductivity – 508 uS/cm**
- **Nitrate – 2.23 mg/L**
- **Total Phosphorus – 0.14**
- ***E. coli* – 90 colonies/100mL**

Figure 14: 2011 Whitewater River Seasonal Averages

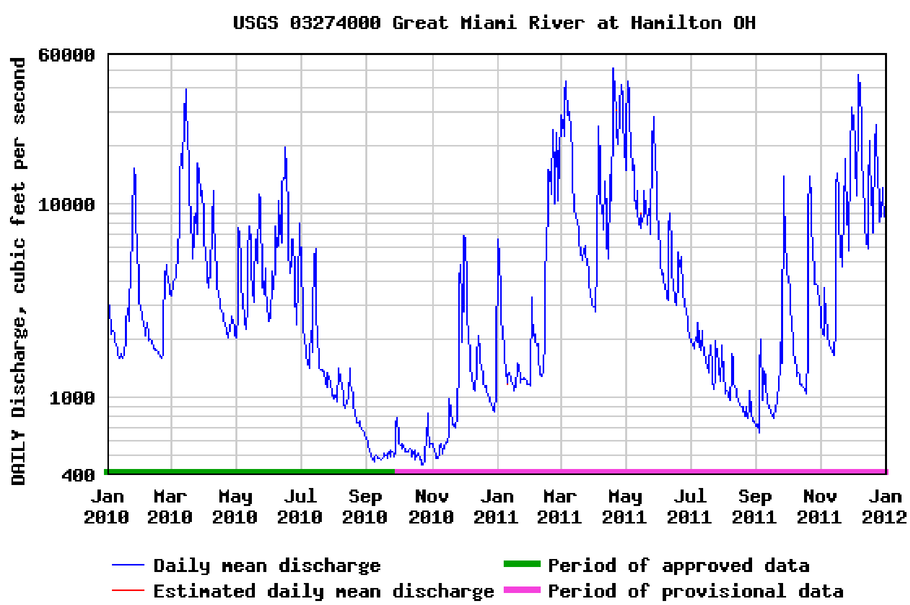

Figure 15: 2010-2011 Great Miami River discharge at Hamilton, Ohio (Source: United States Geological Survey – Real Time Stream Data)

Following is a general summary of observations associated with **Table 2** and **Figures 13-15.**

- The yearly averages of all chemical parameters at the Oxbow ponds are higher than both large rivers and tributaries.

- The highest yearly turbidity values for the large rivers and tributaries tend to be associated with elevated spring discharge events and sediment movement. The higher average turbidity value in the Oxbow ponds is likely due to sediment re-suspension after rain events and high algal content in the open, stagnant waters during periods of low flow.

- Great Miami River high total phosphorus (TP) values of 0.89 and 0.8 mg/L and a pH value of 8.57 during low flow on September 17, 2011 tend to favor the link between nutrients, algal photosynthesis and increased turbidity values.

- Based on pH values, it appears that there is greater photosynthetic activity on larger waterways compared to the tributaries. Furthermore, the wider Great Miami River has a higher average pH than the Whitewater River, which has a well vegetated riparian corridor and shading that limits photosynthesis.

- High conductivity and *E. coli* readings in the tributaries compared to the rivers are likely to due numerous locations with failing septic systems. The conductivity data seem to reinforce Hamilton County Health Department findings. However, it is beneficial to examine both data sets as the Health Department generally conducts end of pipe sampling while river lab volunteers sample upstream and downstream of septic inputs. Elevated phosphorus concentrations during low flow also points to septic discharge as a primary source of nutrients.

- Since *E. coli* counts tend to increase with high flow events, additional sources of contamination appear to be entering the waterways during these times. Potential sources from storm water runoff include animal waste, manure and sewer overflows. Re-suspension of *E. coli* also appears to be a contributing factor.

- Lower nitrate during low flow events suggest transport of fertilizers and/or animal waste with storm water runoff.

- Urban/rural tributary watershed comparison (Blue Rock Creek – urban, Paddys Run – rural) reveals elevated conductivity, phosphorus and pH in the urban as compared to the rural watershed (see **Figure 11**). Septic discharge and fertilizer runoff into North Branch Blue Rock Creek is likely contributing to the increase in nutrients and periphyton/algae. However, *E. coli* bacterial counts are still more pronounced in Paddys Run. The Paddys Run sampling locations are downstream of a 1,050 acre Fernald Preserve, 7 acres of grass waterways and upstream/downstream of 2 NPDES dischargers.

Case Study: Dry Fork Whitewater River Data

During recent data presentations in 2012, case studies involving sampling points in **Figure 12** have been discussed. The original sampling strategy was to obtain multiple upstream-downstream samples on rivers and some large tributaries, and at tributary confluence areas just upstream of the river systems. However, 2010-2011 sampling has revealed where there is a need to sample higher in the watersheds. A case study on the Dry Fork Whitewater River and its tributaries has proven to be an effective tool toward this end as well as educating the public regarding upstream-downstream correlations, seasonal and even daily fluctuations. Since sampling began in March 2010, samples from 7 sites have been taken on the Dry Fork of the Whitewater River and 6 sites from tributary areas.

Consistently sampled Dry Fork Whitewater River upstream to downstream sampling sites are as follows: Oxford Rd., West Rd., Harrison Avenue and Kilby Rd. (near confluence with Whitewater River.) Incoming tributaries from upstream to downstream include Howard Creek, Miami Whitewater Lake inflow and outflow, unnamed tributary to the Dry Fork northeast of Lee Creek, Lee Creek and southwest tributary to Lee Creek. The following bullet points highlight findings of upstream-downstream and seasonal analysis of samples taken within the Dry Fork Whitewater River watershed.

- Excessive high flow spring peaks in *E. coli* (6,400 colonies/mL) and total phosphorus (TP > 0.8 mg/L) along the Dry Fork at West Rd. bridge. The NPDES dischargers between the Oxford Rd. sampling point and West Rd., Howard Creek septic systems and runoff laden with animal waste are likely increasing *E. coli* and TP at West Rd.

- Elevated spring TP levels at the West Rd. bridge and both TP and nitrate (6 mg/L) levels upstream at Oxford Rd. Extremely high turbidity levels (978 NTU) in April 2011. Increased turbidity is due to elevated discharge and in-stream erosion, while elevated nutrient levels follow the same reasoning as *E. coli.* There appears to be heavy pollutant loading in the upper Dry Fork watershed. Additional sample points to the north could pinpoint sources of nutrients and bacteria.

- In the spring, there seems to be more of a tributary TP contribution from Howard Creek than from Lee Creek and its tributaries. Howard Creek TP spikes are also evident during periods of low flow suggesting a combination of fertilizer or manure issues and septic system discharge. During 2011, Lee Creek TP is lower during the spring and fall discharge than its tributaries, suggesting that there could be more fertilizer or animal waste nonpoint source input from the tributaries. The data provide valuable input regarding a watershed focused HCSWCD soil testing program and indicate that Howard Creek would be a viable initial target watershed.

- Elevated *E. coli*, nitrate and turbidity levels reveal a contaminant source above Miami Whitewater Lake at Strimple Rd. (Aug.-Nov. 2011.) Miami Whitewater Lake is assimilating pollutants.

- Consistently higher dissolved oxygen levels in the Dry Fork at Oxford Rd. (generally above 6.0 mg/L) compared to sites downstream. The OEPA has established areas upstream of Oxford Rd. as Exceptional Warm Water Habitat (EWWH) and downstream areas as Warm Water Habitat (WWH). Dissolved oxygen concentrations are consistent with this designation.

- There are 3 peaks in pH throughout the year. A high spring peak and a late summer/fall increase with a minor mid-summer peak. The farthest downstream site on the Dry Fork (Kilby Rd.) yielded the highest pH values in 2010 and 2011. This indicates that algal photosynthetic activity is increasing downstream as the channel widens and receives more sunlight. The consumption of carbon dioxide (CO_2) during photosynthesis will increase with elevations in primary productivity/biological activity, thereby elevating pH[7]. Peaks in algal matter or periphyton in spring will increase the pH, followed by some algal die-off and a pH spike again in the late summer from a resurge in plant cell growth along with the warmer waters. Daily elevations in pH occur as sunlight and photosynthesis intensifies. As CO_2 consumption slows and respiration continues at night, pH will decline because algal and biological oxygen consumption will return CO_2 to the water[7].

- The highest conductivity concentrations are coming from the Dry Fork tributaries and are reduced at downstream sites (Harrison Ave. and Kilby Rd.). This suggests a contaminant source, such as septic discharge coming from the upstream tributaries.

AULT PARK STREAM RESTORATION/CSO REDUCTION PROJECT

Program Background

In the greater Cincinnati area, roughly 14.1 billion gallons of raw sewage and storm water overflow into local streams and rivers. The Metropolitan Sewer District of Greater Cincinnati (MSD) is required under Federal Consent Decree to capture, treat or remove 85% of all CSOs and eliminate all sanitary sewer overflows (SSOs), roughly 100 million gallons[8]. Hamilton County is among the top 5 locations in the nation for urban CSOs[9]. One of the designated CSO removal areas is in Cincinnati's Ault Park. The project will eliminate about 17 million gallons of sewer overflows a year into Duck Creek, a tributary to the Little Miami River, a National Wild and Scenic River. The proposed solution is to control sewer overflows by reducing the amount of storm water entering the combined sewer, which carries both sanitary sewage and storm water in the same pipe. The upstream storm water, which was routed into a pipe decades ago will be reintroduced to its existing stream channel and removed from the pipe[10].

In the summer of 2010, MSD sought technical support from HCSWCD concerning project monitoring and preliminary plan review. Prior to submittal of comments at the preliminary plan review stage, HCSWCD conducted a stream habitat survey in the proposed stream restoration project section, where significant earthmoving was to occur, and found 14 southern two-lined salamanders (*Eurycea cirrigera*) (see **Figure 16**). In the state of Ohio, evidence of reproduction (larvae, eggs, or a mixture of juvenile and adults) can be used in primary headwater (PHWH) stream classification. Since the larval period of *Eurycea cirrigera* can last 2-3 years and larvae need cool, continuous flowing water, this find is indicative of Class III PHWH. Class III status is the highest quality PHWH stream in Ohio (drainage area roughly 1 square mile or less).[11] Larvae were in fact found upstream of the project area. Consequently, HCSWCD project comments included relocation of stream organisms (salamanders and macroinvertebrates) well upstream to un-impacted reaches. After consultation with the Cincinnati Park Board and with their partnership, it was determined that the public could be involved in the relocation initiative. Through 3 public events and 2 stream walks/sampling efforts with University of Cincinnati and Miami University (OH) students, data collection on this unique stream restoration project has been an opportunity for 68 citizens of all ages to become part of the solution (see **Figure 17 and 18**). Project construction started in February 2012 and is scheduled for completion by mid 2012 (refer to **Figure 19**).

While a unique opportunity, there are inherent risks to bringing the public to a CSO area. A thorough safety review needs to be provided and volunteers should be briefed on appropriate sampling attire. Public events should be rescheduled if heavy rains, which could trigger CSO overflows, occur prior to the event. With strict adherence to safety procedures, the value of public participation and incorporating a stream restoration/CSO reduction project into an NPDES Phase II program includes:

- Partnerships are developed between multiple agencies tasked with addressing challenges associated with storm water volume. This can also serve to maximize public resources.
- Public participation facilitates understanding with respect to the nature of CSO problems and how CSO reduction and stream restoration can serve to eliminate public health concerns within the community.
- Citizens can provide feedback regarding any proposed solution, while on the project site. It is often hard to grasp challenges associated with restoration related solutions from a plan alone.
- There is an elevated level of interest when individuals are given the opportunity to be key players in the solution – in this case “saving key indicator organisms.”
- The outdoor classroom tends to be preferable to an indoor setting. Participants can hold and use the nets, seines and water chemistry equipment.
- Preliminary surveys with the public can help identify key sampling locations for more intensive data collection efforts.

Overall, the HCSWCD role in the project consists of the following components:

- Preliminary stream restoration site plan review and comment.
- Review of a project monitoring proposal for MSD.
- Pre-construction organization of public salamander/macroinvertebrate relocation events in collaboration with the Cincinnati Park Board, MSD and USEPA. Water chemistry is also taught at public events.
- Pre-construction meetings with MSD project inspectors, contractors, project consultants and Cincinnati Park Board personnel.
- Pre-construction monitoring upstream of the project area, midstream and downstream. Monitoring targets include water chemistry, stream habitat, stream stability, macroinvertebrates and salamanders.
- Periodic construction site visits to assess sediment and erosion control as well as stream restoration techniques. Recommendations are provided to appropriate parties as needed.

Figure 16: Ault Park Southern Two-Lined salamander

Figure 17: Joe Milanovich (USEPA) helps young biologists identify salamanders (June 2011).

Data Collection Methods

Data collection methods used for a preliminary site assessment of the Ault Park Project are indicated in **Table 3**. Many techniques were used by HCSWCD during independent studies. Those used by the volunteer public are explicitly indicated as "Public Events" in the table.

Monitoring Target	Method	Instrumentation	Approach
Steam Habitat	OEPA Headwater Habitat Evaluation Index (HHEI) for assessment of PHWH streams[12]. Conducted Wolman pebble count for substrate analysis[13].	Clipboard, HHEI form, pencil, measuring tape to assess bankfull width, yard stick for pool depth and a ruler for substrate measurements.	Assessed 300 foot reference reaches upstream, midstream and downstream of project area. Site revisited multiple times during the dry months and minimum pool depths used in HHEI scoring.
Stream Stability	Pfankuch stream reach inventory (1975) [14]. Conducted Wolman pebble count for substrate analysis.	Same tools as used with HHEI.	Assessed the same reference reaches as HHEI sections. Walked entire upstream, midstream and downstream reach to determine if any additional stability features exist.
Macroinvertebrates/ Aquatic Insects	Sampling method: Macroinvertebrate Aggregated Index for Streams (MAIS) [15]. Scoring method: OEPA Headwater Macroinvertebrate Field Evaluation Index (HMFEI)[12].	Specific habitats sampled with a seine and D-net. Forceps, microscope, magnifying glass, 5 gallon buckets, small containers, 70% ethyl alcohol, hip waders, sorting tray and sorting plastic also used.	Followed MAIS sampling methodology and OEPA HMFEI scoring methodology. ***Public events***: Used a much less intensive version of the MAIS.
Salamanders	Identified salamanders while conducting HHEI and MAIS assessments.	Same tools as used with macroinvertebrates.	Looked under boulders and large cobbles when using MAIS protocol. ***Public events***: Salamander traps were constructed by rolling organic matter into a 1 meter square mesh netting. Traps were set prior to events and retrieved and sorted by volunteers.
Water Chemistry	HCSWCD - Assessed instream pH, conductivity, total dissolved solids, salinity, temperature, turbidity and dissolved oxygen. MSD – Assessed same parameters as HCSWCD, as well as total phosphorus, nitrate, *E. coli* and numerous metals.	HCSWCD - YSI-556 multi-probe instrument . MSD – Hydrolab multi-probe instrument.	Bi-monthly monitoring during June-Sept. 2011 (MSD). Sporadic monitoring in the summer and fall of 2010. ***Public events***: Interested volunteers were trained how to read the YSI-556 and educated on the meaning of various chemical parameters.

Table 3: Ault Park project data collection methods

Public Involvement/Sampling Accomplishments and Data Collection Results: 2010-2011

The overall project could be summarized in a table such **Table 1**. However, even more important than such a table are the results discussed in the following paragraph. These illustrate that public involvement in monitoring projects can have an immediate impact in maintaining the biological integrity of a watershed through capturing and relocating stream organisms. This occurred despite the inherent challenges and technical complexities of a CSO site. Furthermore, the process of providing on-site training to public volunteers served to focus the efforts of field professionals in the selection of sample sites and in performing biological identifications.

During the 5 public participation efforts from November 2010 through July 2011, university and Norwood High School students along with consultants, children and families helped to relocate about 50 adult southern two-lined salamanders and 15 larvae to un-impacted reaches at least 300 feet upstream of the project area. Sampling for relocation took place both in the project section and downstream. One hundred and seventeen crayfish were moved along with the following macroinvertebrates: 255 scuds (mini shrimp-like organisms), 10 riffle beetles, 4 midge larvae, 213 sowbugs, 9 cranefly larvae, 4 water pennies, 14 caddisfly larvae, 8 pouch snails, 2 planaria and numerous aquatic earthworms. Public event data tracking was conducted by Stacie Martin of the Cincinnati Park Board.

Table 4 provides scoring results of HCSWCD independent stream habitat, stability and macroinvertebrate surveys. **Table 5** reveals trends or unique macroinvertebrate taxa and species observed in the project areas. Given the positive participant survey responses, these data will be used as educational tools in follow-up public involvement opportunities at the project site. To this point, water chemistry data reveal spikes in conductivity at all project sections. Upstream and tributary septic system discharge will continue to impact the project area once CSOs are reduced. However, under current conditions, upstream and downstream sections of the project area indicate a higher level of habitat, and increased diversity in macroinvertebrate taxa compared to the project section. A tributary feeding the headwater channel downstream of the project area allows for additional flow downstream of the project area. The stream restoration project should serve to improve habitat, macroinvertebrate and salamander populations to meet upper Class II to Class III PHWH status[12].

Figure 18: Seining for salamander/macroinvertebrate larvae with a Norwood High School student (April 2011).

Figure 19: A restored section in the Ault Park project area (April 2012).

	Ault Park - Upstream Observatory Ave.	Ault Park Stream Restoration Area	Ault Park Downstream Restoration Project
Pre-Restoration Project Indices			
Stream Habitat Metrics			
HHEI Score	**67**	**45**	**59**
HHEI Category	**Class III**	**Class II**	**Class III**
HMFEI Score	**18**	**13**	**19**
HMFEI Category	**Class II-III**	**Class II**	**Class II-III**
Macroinvertebrate taxa	**9**	**8**	**12**
EPT taxa	**2**	**1**	**4**
Salamander larvae (Eurycea cirrigera)	**4**	**3**	**14**
Salamander adults (Eurycea cirrigera)	**3**	**15**	**1**
Pfankuch Stream Stability Metrics			
Stream Channel Type 1	**A4**	**A6**	**C4**
Stream Stability Index 1	**87**	**98**	**93**
Stream Stability Rating 1	**Good**	**Fair**	**Fair**
Dominant Substrate	Gravel	Silt	Gravel
Channel Slope	4.37%	4.00%	1.90%
Channel Slope Description	High	Moderate to High	Low to Moderate
Channel Entrenchment Ratio	5.17	3.765	26.29
Entrenchment Description	Slightly Entrenched	Slightly Entrenched	Slightly Entrenched
Channel Width/Depth Ratio	6.76	10.51	14.45
Channel Width/Depth Description	Low	Low	Moderate
Channel Sinuosity	1.07	1.1	1.36
Channel Sinuosity Description	Low	Low	Moderate

Table 4: Ault Park Project - Results of stream habitat, macroinvertebrate and stream stability scoring

Ault Park - Upstream Observatory Ave.	Ault Park Stream Restoration Area	Ault Park Downstream Restoration Project
Sowbugs *(Isopoda, Asellidae)* and scuds *(Amphipoda)* very common.	Sowbugs *(Isopoda, Asellidae)* very common and scuds *(Amphipoda*) common.	Sowbugs *(Isopoda, Asellidae, Lirceus, sp. & Isopoda, Asellidae, Caeidotea, sp.)* and scuds *(Amphipoda*) very common.
Water pennies *(Coleoptera, Psephenidae)* abundant.	Other beetles *(Coleoptera)* common.	Other beetles *(Coleoptera)* common.
Midges *(Diptera, Chironomidae, Tanypodinae)* common.	Snails *(Gastropoda, Pulmonata, Planorbidae*) common.	Midges *(Diptera, Chironomidae, Tanypodinae)* common.
Caddisflies-net spinners *(Trichoptera, Hydropsychidae, Diplectrona, Modesta).*	Caddisflies-net spinners *(Trichoptera, Hydropsychidae, Diplectrona, Modesta)* common.	Water pennies *(Coleoptera, Psephenidae)* abundant.
Caddisflies-Fingernet *(Trichoptera, Philopotamida, Chimarra, sp*.) present.		Native Crayfish *(Decopoda, Cambaridae, Cambarus, sp.)* common.
Native Crayfish *(Decopoda, Cambaridae, Cambarus, sp*.) common.	Native Crayfish *(Decopoda, Cambaridae, Cambarus, sp.)* common.	Caddisflies-net spinners *(Trichoptera, Hydropsychidae, Diplectrona, Modesta).*
		Caddisflies-case makers *(Trichoptera, Uenoidae, Neophlax, sp.)* abundant.
		Caddisflies-trumpet/tube-makes *(Trichoptera, Polycentropodidae, Polycentropus, sp.)* rare.
		Stoneflies *(Plecoptera, Leuctridae, Leuctra, sp.)* rare.

Table 5: 2010-2011 Ault Park macroinvertebrate/aquatic insect larvae findings

The public participation and data collection at the Ault Park events have truly enhanced the Hamilton County NPDES Phase II Storm Water Program as well as the multi-agency and public partnerships. Future events will allow for continued understanding regarding the impact of engaging the public in stream restoration/CSO reduction projects.

CONCLUSION

The Great Miami River Citizens' Water Quality Monitoring Program and Ault Park stream restoration/CSO reduction project have proven to be effective approaches to building public involvement and outreach programs through stream monitoring. Volunteer numbers and sampling sites continue to grow at the citizens' river lab. Furthermore, for both projects, positive feedback has been provided from the public and other agencies. For instance, public survey responses with respect to the Ault Park project include: "Great program for a great cause!", "Kids loved it!" and "Do this more often!"

ACKNOWLEDGEMENTS

Great Miami River Citizens' Water Quality Monitoring Program

- Hamilton County Storm Water District and Soil & Water Conservation District program oversight and funding: Todd Long (HCSWD), Holly Utrata-Halcomb (HCSWCD Administrator) and HCSWCD Board of Supervisors (Denny Benson, Nathan Holscher, Craig Abercrombie, Sam McKinley, Steve Johns, Scott Huber and Pete Mallow.)
- Hamilton County Park District and University of Cincinnati: Use of property and UCCBS facility.
- Dr. Michael Miller - Professor Emeritus with the University of Cincinnati: Facility coordination, lab setup, equipment preparation, data analyses, data entry, data presentations and performing *E. coli* counts.
- Lisa Link - Rivers Unlimited, Friends of the Great Miami: Volunteer recruitment, data entry, sample site mapping, purchasing of supplies, brochure and logo development.
- Bernie Moller - Rivers Unlimited, Friends of the Great Miami: Lab setup and equipment preparation.
- Nathan Holscher - Rivers Unlimited Program Director and HCSWCD Board Member during 2010-2011 sampling: Program administration, funding applications, volunteer recruitment and program overview presentations.
- Bruce Koehler - Ohio-Kentucky-Indiana Regional Council of Governments (OKI), Environmental Planner: Coordination on local and regional water quality studies and data analyses.
- Anne Lyon - Greenacres Foundation: Sharing experience and quality assurance/quality control plans associated with Little Miami River Saturday Stream Snapshot.
- Butler County Stream Team: Sharing experience and quality assurance/quality control plans associated with volunteer monitoring in Butler County.
- Friends of the Great Miami, Rivers Unlimited and citizen samplers and analysts: The program would not be possible without the dedicated, experienced and highly motivated volunteers.
- Hamilton County Public Health (Chris Griffith, Brad Johnson and Kyle Dexter): Collaboration on subwatershed data analysis.

- Kyle Dexter - Hamilton County Public Health, Water Quality Technician II: Provision and analysis of reports related to county septic system hotspot areas.
- Oxbow Inc.: Project funding and access of Oxbow Preserve.
- John Williams - USDA-Natural Resources Conservation Service, District Conservationist: Guidance concerning monitoring locations in agricultural watersheds.
- Matthew Magnuson - United States Environmental Protection Agency, Office of Research and Development, Research Chemist: Extensive review and editing of section pertaining to Great Miami River Citizens' Water Quality Monitoring Program.
- Carrie Gibbons - HCSWCD: Data analysis and chart production.

Ault Park stream restoration/CSO reduction project

- Numerous citizen volunteers deserve recognition for bringing enthusiasm to the project while assisting in salamander and macroinvertebrate capture and relocation efforts.
- Cincinnati Park Board:
    - Stacie Martin - Greenspace Manager: Public event coordination, setting salamander traps, data recording and data entry.
    - Jessica Truman - Civil Engineering Technician: Data recording and setting salamander traps.
    - Dave Gamstetter - Supervisor of Urban Forestry: Project coordination and setting salamander traps.
- MSD Division of Industrial Waste (DIW) water quality sampling team:
    - John Sullivan - Industrial Waste Inspector: Chemical water quality sampling and data recording.
    - Beverly Head and Jim Weist: Coordination on chemical monitoring sites.
    - Wanda Harney: Chemical and biological sample analyses.
- Karen Ball - Hamilton County-MSD, Compliance Coordinator: MSD-HCSWCD preliminary coordination with respect to water quality monitoring.
- MaryLynn Lodor - MSD-Office of the Director, Environmental Program Manager: Project coordination and media coverage.
- Deb Leonard - Environmental Quality Management, Inc.: Public relations and media coverage.
- Joe Milanovich, PhD. - USEPA, NRC Postdoctoral Associate: Salamander trapping/relocation techniques, resources and public education.
- Paul Weaver - The McConnell Group/USEPA, Aquatic and Terrestrial Entomologist: Macroinvertebrate genus-species level identification and resources.
- USEPA Experimental Stream Facility personnel: Use of microscopes and laboratory space for identification of macroinvertebrates.
- Macroinvertebrate, salamander, stream morphology and water chemistry sampling assistance:
    - Norwood High School biology class: Macroinvertebrates and salamanders.
    - Cody Combs – City of Fairfield Public Utilities Department and Miami University (OH): Macroinvertebrates and water chemistry.
    - Sarah Cox - Hamilton to New Baltimore Groundwater Consortium and Miami University (OH): Macroinvertebrates and water chemistry.
    - Niki Marengo - HCSWCD: Macroinvertebrates.
    - Dr. Michael Miller and Jason Mulvaney - University of Cincinnati: Macroinvertebrates.
    - Joanna Castillo - Cincinnati State College: Water chemistry and stream morphology.
    - Paul Worthington: Stream morphology and water chemistry.
    - Robert Lakeberg - OKI: Stream morphology.

- Stream restoration project design and sediment and erosion control:
  - Leslie Schehl - MSD Senior Engineer: Review of project related comments.
  - Stantec & T.C. Dinkins - Stantec EIT: On-site sediment and erosion control inspections and coordination on stream restoration design.
  - Dan DiCarlo, Tim Merk and Water Quality Systems Contractors: Implementation of erosion and sediment control practices as well as channel restoration.
- Matthew Magnuson - United States Environmental Protection Agency, Office of Research and Development, Research Chemist: Extensive review and editing of section pertaining to Ault Park stream restoration/CSO reduction project.

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