2013 Monitoring Report
Alliance of Downriver Watersheds

September 2014

Prepared by
Huron River Watershed Council
with Wayne County Department of Public Services
Water Quality Management Division

This report was produced as a monitoring and progress evaluation report for the member governments within ***the Alliance of Downriver Watersheds****. Funding for the project and monitoring was provided directly by the Alliance of Downriver Watersheds (ADW) – a legal umbrella governing body established to carry out stormwater policy and management across the Ecorse Creek, Combined Downriver and Lower Huron River watersheds. The ADW is comprised of the following member governments:*

Allen Park
Belleville
Brownstown Township
Dearborn Heights
Ecorse
Flat Rock
Gibraltar
Grosse Ile Township
Huron Township
Lincoln Park
Melvindale
Riverview
Rockwood
Romulus
Southgate
South Rockwood
Sumpter Township
Taylor
Van Buren Township
Wayne County
Westland
Woodhaven
Woodhaven-Brownstown
School District
Wyandotte

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1 Introduction

Monitoring Program Purpose and Goals

The monitoring program is consistent with the watershed management plans developed for the Alliance of Downriver Watersheds (ADW) by Huron River Watershed Council (HRWC), Wayne County, local communities, citizens, and other stakeholders. The program was designed with the purpose of establishing the environmental status of the watersheds and evaluating progress toward environmental goals. The program is designed to evaluate the following goals and objectives from the watershed plans:

Goals	Objectives
• Reduce Stream Flow Variability • Increase Public Education, Understanding, and Participation Regarding Watershed Issues • Improve Water Quality • Protect, Enhance, and Restore Riparian Habitat	• Reduce runoff volume/rate • Create partnerships with institutions, schools, and the private sector • Foster relationships with the County and neighboring communities • Protect, expand and restore the riparian corridor • Improve erosion and sedimentation controls

Evaluation Purpose

Environmental progress evaluation is recognized as a critical element of watershed planning and is critical to determining ultimate effectiveness of management strategies. To this end, a combination of staff, consultant resources and project partners were utilized to develop and implement the monitoring strategy and a Quality Assurance Project Plan (QAPP). A combination of desk top analysis, field physical measurements, photo documentation and biological indicator monitoring is ultimately used in the monitoring program.

Evaluation Approach

The current five-year monitoring strategy is presented in Table 1.

Five Year Monitoring Plan Summary (2013-2017)
Ecorse Creek, Combined Downriver, and Lower Huron River Watersheds

Monitoring Activity	Proposed Responsible Party	Sites/Frequency/Season	Year Performed				
			2013	2014	2015	2016	2017
Planning & Reporting							
ADW develops/refines monitoring plan	ADW Facilitator	Not applicable	X	X	X	X	X
Data Handling, Data Management & Analysis	WQD/HRWC	Not applicable	X	X	X	X	X
Prepare Monitoring Report/Brochure/Press Release	ADW	Not applicable				X	
Physical Monitoring							
Precipitation	Communities	April - Oct at 5 sites	X	X	X	X	X
Flow	HRWC/WQD/USGS	April - Oct at 7 sites				X	
Temperature	HRWC/WQD	April - Oct at 6 sites				X	
Geomorphology/stream classification	HRWC/Stream Team/WQD	28 sites, 5-year returns	?	?	?	?	?
Biological Monitoring							
Macroinvertebrates	HRWC/Stream Team/WQD	3x per year at 28 sites	X	X	X	X	X
Green Infrastructure Monitoring	WQD	Across ADW			X		X
Fish, Macroinvertebrates, Habitat	MDEQ	As selected by MDEQ/DNR	?	?	?	X	X
Water Quality							
Dissolved Oxygen (DO)	ADW	April - September at 10 sites 2x per month	X	X	X	?	?
E. Coli	ADW	April - September at 10 sites 2x per month; wet event sampling	X	X	X	?	?
Total Phosphorus (TP)	ADW	April - September at 10 sites 2x per month; wet event sampling	X	X	X	?	?
Total Suspended Solids (TSS)	ADW	April - September at 10 sites 2x per month; wet event sampling	X	X	X	?	?
Public Education/Involvement							
Public Survey	SEMCOG	Not applicable	?	?			
Summary of Volunteer Restoration Efforts	HRWC/Stream Team/WQD	Not applicable	X	X	X	X	X
Pollution Prevention							
Illicit Discharges Identified & Eliminated	WQD/Communities	Not applicable	X	X	X	X	X

HRWC = Huron River Watershed Council
WQD = Wayne County Department of Public Works, Water Quality Division
USGS = United States Geological Survey
MDEQ = Michigan Department of Environmental Quality
DNR = Michigan Department of Natural Resources
SEMCOG = Southeast Michigan Council of Governments

For monitoring in 2013, three different evaluation techniques are reported. The watersheds were evaluated through the use of benthic macroinvertebrate surveys, water quality sampling, and flow monitoring. Staff and qualified volunteer partners conducted this work. Each method is described in the QAPP. These methods provided quantitative and qualitative evaluation of the success of ADW efforts to improve stormwater management.

Benthic macroinvertebrate sampling events took place in the spring and fall. Sampling was conducted as a team activity. Each team consisted of 1-2 experienced team leaders and 1-3 inexperienced staff or volunteers. Each team visited and sampled 2 - 3 sites on sampling days.

Water Quality sampling was conducted twice per month during the growing season: April through September. Volunteers or staff, in teams of two or three, visited pairs of fixed, long-term sampling locations during a sampling event to collect measurements and samples. Samples were analyzed by the Ypsilanti Community Utilities Authority (YCUA) laboratory as an in-kind contribution to support the monitoring effort.

Stream discharge or flow monitoring was conducted to provide data that can be used to evaluate the flow dynamics of target streams within the ADW system. It involved the collection of continuous water level data at a fixed point using a pressure sensor, accompanied by regular discharge measurement across a range of flow conditions to calibrate water level to stream discharge. Discharge was measured during the growing season (roughly April through October) at eight sites over four years. Statistics are computed to determine the stream's flashiness, peak and base flows over that period. These statistics will be used to assess trends over time with the goal being to realize decreases in the streams' flashiness and peak flows and increased baseflows to make them more comparable to natural streams draining similar-sized watersheds.

2 Benthic Macroinvertebrates

Evaluation Approach

Monitoring the diversity of benthic macroinvertebrates is a staple of the ADW monitoring program. Monitoring changes in macroinvertebrates over time also provides a basic measure of stream habitat and water quality. The ADW has been monitoring macroinvertebrate diversity at many sites across the ADW. Most sites have three or more years of data.

Macroinvertebrate diversity is measured twice a year (augmented by winter stonefly collections in January). Multiple diversity measures provide a reasonable estimate of stream conditions. Stream habitat is also evaluated directly every 3-5 years. Changes in site quality measures may indicate habitat improvements. Two metrics have been evaluated for this report. First, the Stream Quality Index (SQI) is a composite biotic integrity score developed for the Michigan Clean Water Corps (MiCorps).[1] The SQI is based on order-level identification, however, and does not take advantage of family-level identification performed by ADW programs. The second metric is total taxa diversity (TD), which counts the number of different families of aquatic macroinvertebrates found at each site. This measure utilizes the higher resolution of family identification, but does not account for the sensitivities of different families. Taken in tandem, these two metrics provide a good measure of aquatic biotic integrity over time.

Aquatic Diversity and Habitat Quality

Over 30 sites across the ADW have been monitored for benthic macroinvertebrates. Many of the sites have been monitored since 2004, though a number of sites were added over the past few years. Figure 1 shows the location of these sites along with the macroinvertebrate status as of Spring 2013. The map shows the location of the monitoring sites along with their most recent 3-year sample mean of the MiCorps Stream Quality Index (SQI), for spring samples. The color indicates the site's current 3-year status rating, while those sites with arrows indicate the trend (up indicating improving trend, and down indicating declining trend). Only sites with statistically significant trends[2] are indicated with arrows.

[1] Jo Latimore, Huron River Watershed Council. *MiCorps Volunteer Stream Monitoring Procedures.* August 2006. Available at http://micorps.net/streamresources.html.

[2] Statistical significance is determined using analysis of variance from linear regression. A threshold probability (α) of 0.10 was used to determine significance.

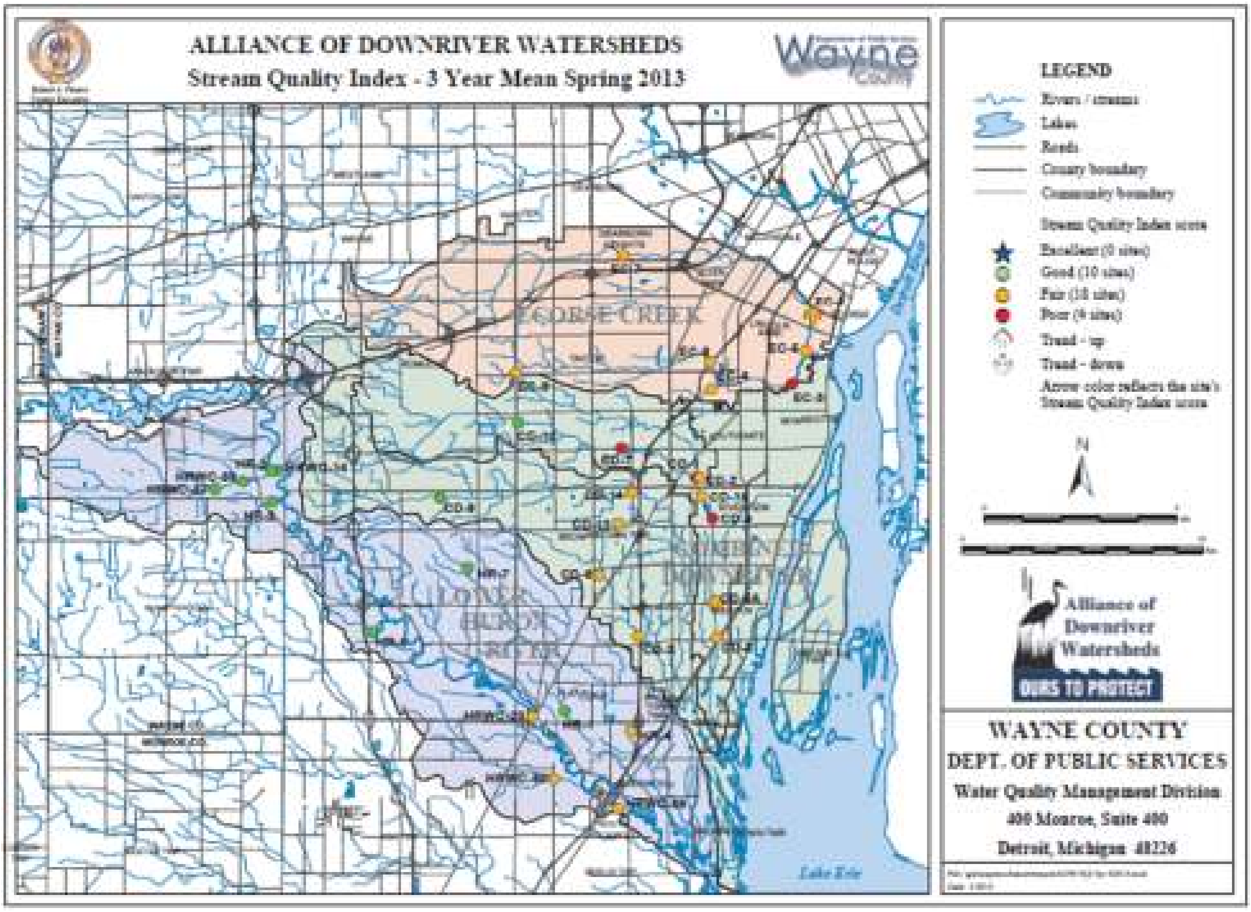


Figure 1. Three-sample spring sample mean Stream Quality Index ratings for ADW macroinvertebrate sites through 2013.

Across all sites, spring SQI ratings were higher than fall ratings(see Figure 2), so it would be inappropriate to combine fall and spring samples. Similar 3-year sample means for fall SQI ratings are depicted in Figure 2.

The geographic pattern of these results suggests that upstream sites have higher SQI ratings than downstream sites across each of the three watersheds. This pattern could reflect a difference in land use or impervious cover. This pattern should be assessed further in future analysis.

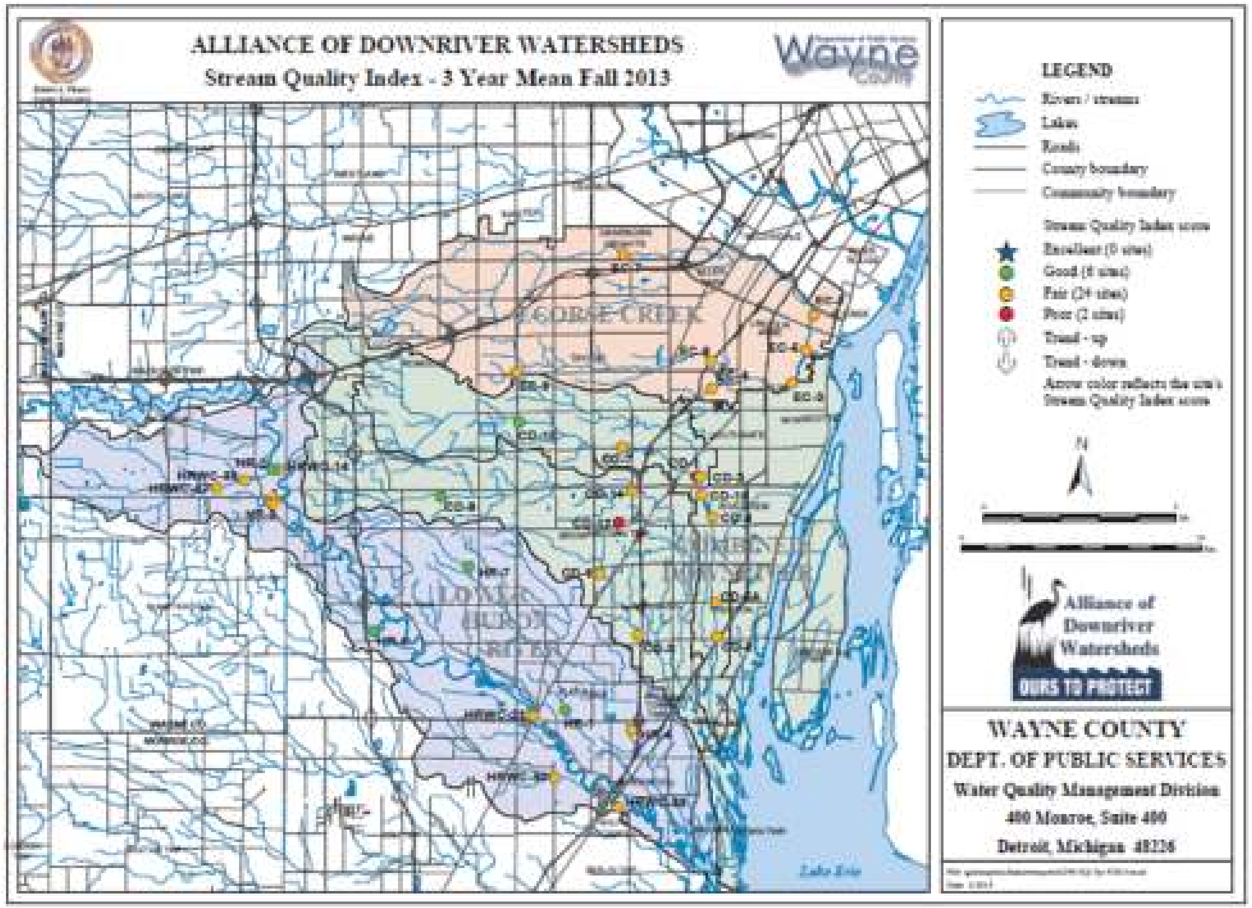


Figure 2. Three-sample fall sample mean Stream Quality Index ratings for ADW macroinvertebrate sites through 2013.

These maps also illustrate the range of ratings across sites in the ADW. Most of the sites (69% in Spring; 81% in Fall) are impacted (with ratings of fair or poor) according to the SQI. It is also important to note that ratings are generally higher on the whole for spring samples, and that results for sites with fewer than 3 samples for each season are considered preliminary. Results from each of the three watersheds varied. On average, sites in the Lower Huron had higher SQI ratings (Spring=36, Fall=30) than Combined Downriver (Spring=26, Fall=28) and Ecorse Creek (Spring=21, Fall=27). The differences between the watersheds correlate with the different land use patterns in the watersheds. The Lower Huron generally has a lower amount of impervious cover, has a greater amount of green infrastructure or natural cover and has a greater amount of natural cover in the riparian zone than the other two watersheds. The Lower Huron is also less urbanized and has a greater amount of protected riparian area.

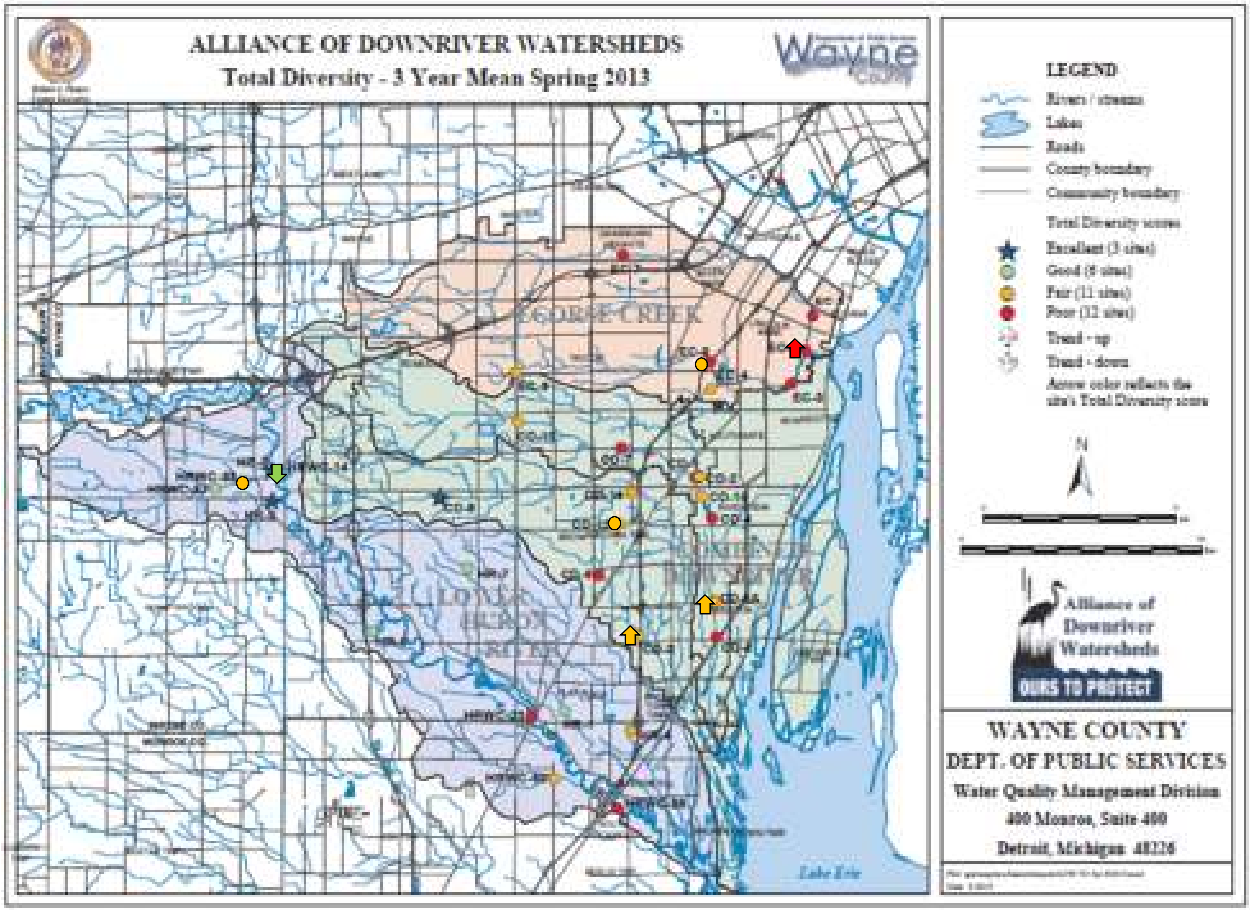


Figure 3. Three-sample spring sample mean Total Diversity ratings for ADW macroinvertebrate sites through 2013. Ratings are based on relative distribution of TD scores.

Total Diversity measures (see Figure 3 and Figure 4) show a similar spread across ADW sites. Most of the sites that had high SQI ratings also have high taxa counts. Mean TD measures were more widely spread for Spring sampling than for Fall sampling, which was also true for SQI ratings. In Spring, the diversity of the best site was just over four times greater than that for the worst site. As with the SQI, Lower Huron sites had greater diversity in spring (Spring=15, Fall=13), on average, than Combined Downriver (Spring=11, Fall=14) and Ecorse Creek (Spring=10, Fall=13).

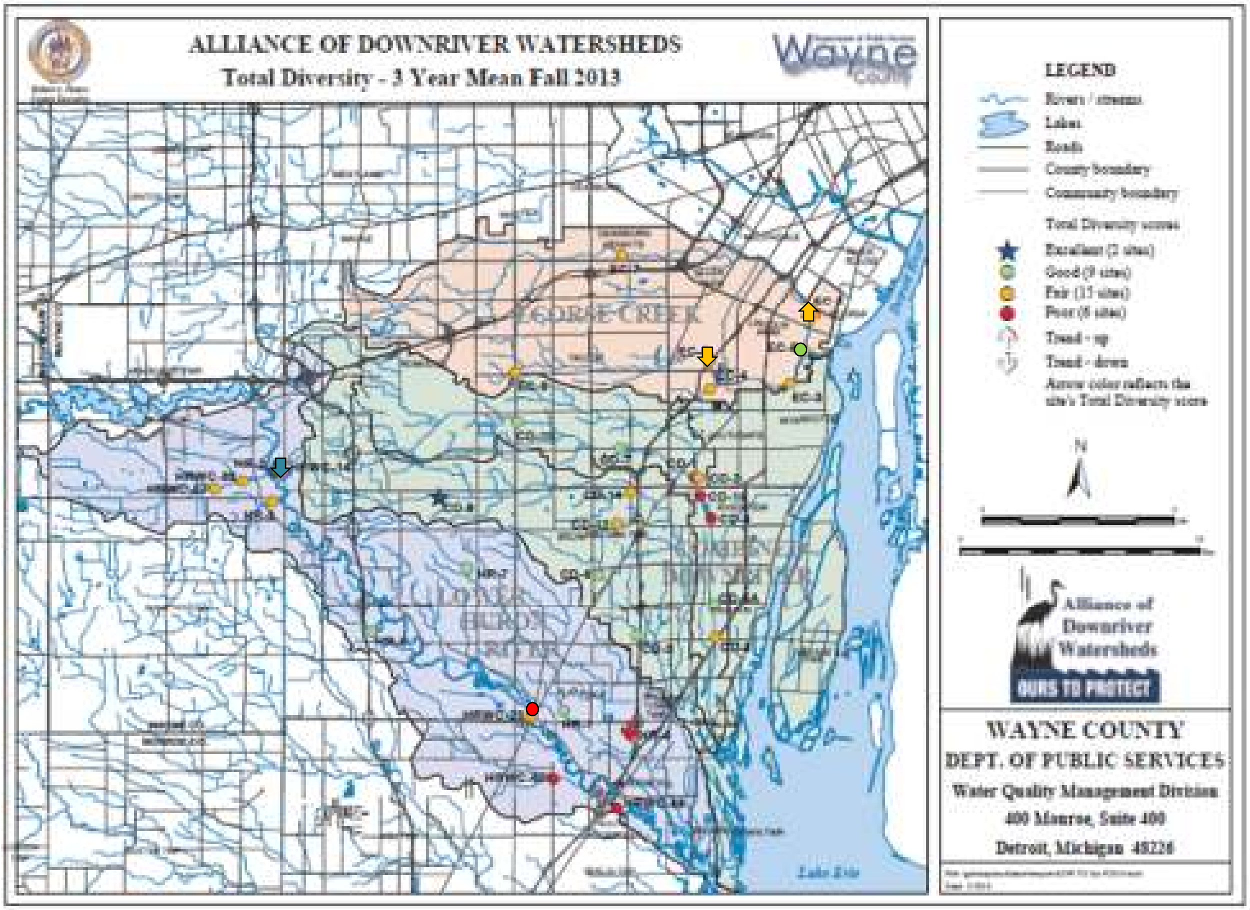
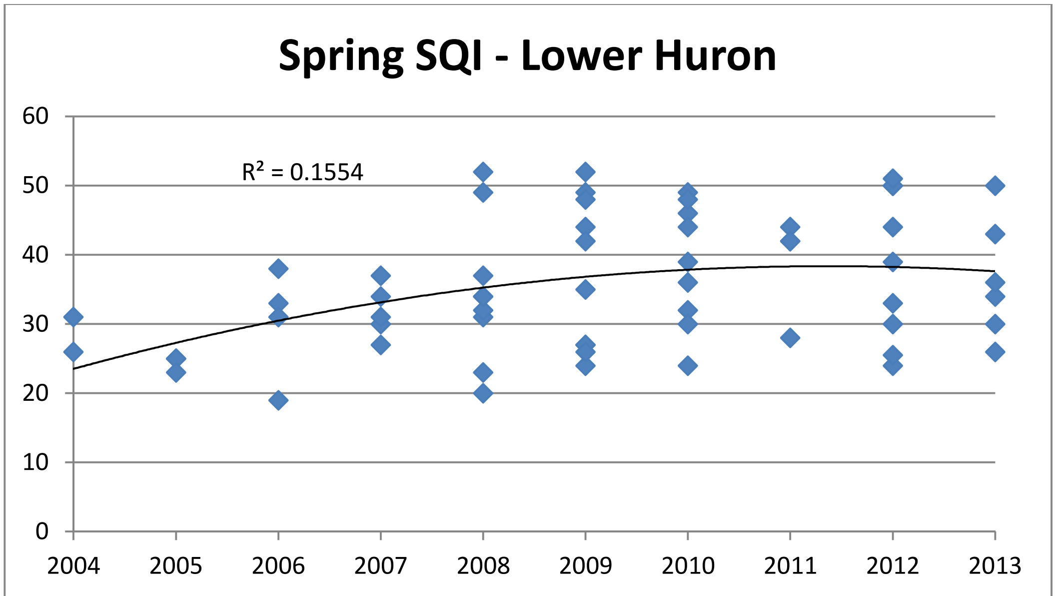


Figure 4. Three-sample fall sample mean Total Diversity ratings for ADW macroinvertebrate sites through 2013. Ratings are based on relative distribution of TD scores.

Trends in Aquatic Quality and Diversity

The macroinvertebrate data was assessed for trends over time by simple regression of Spring and Fall data for each site, and collectively for sites across each watershed. Overall, the mean SQI rating across all sites sampled for each event has increased over time. However, this positive trend has diminished over the past two years. It should be noted that mean ratings can differ each year based on the specific sites sampled, so each point is not truly independent. Also note the difference between Spring and Fall ratings. Still, these results suggest generally improving or stabilizing conditions overall.



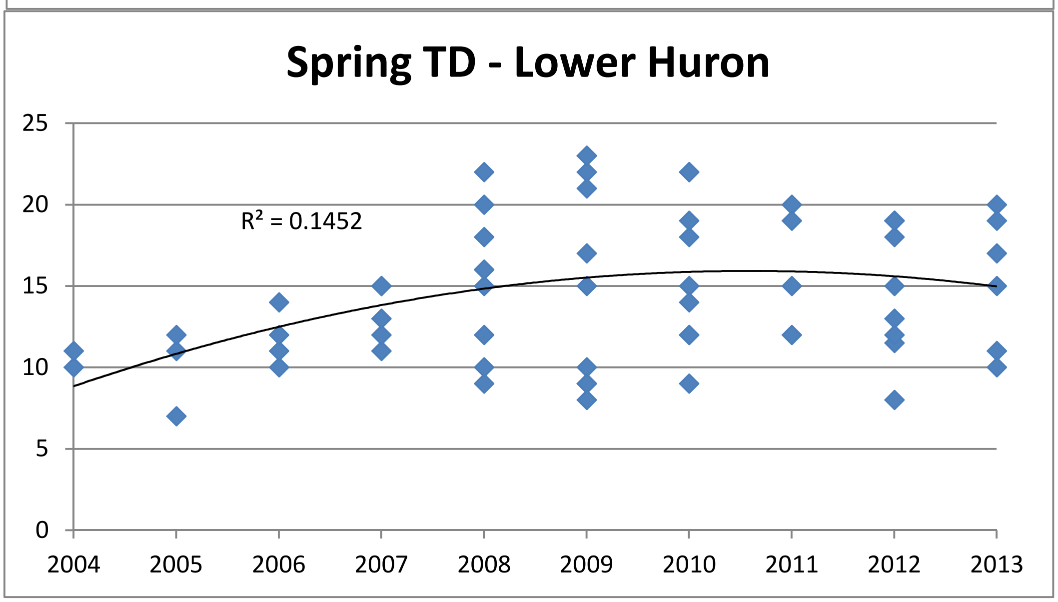


Figure 5. SQI and TD ratings for all Lower Huron sites for spring sampling events with best fit trend line included.

Sites in the Lower Huron River watershed show a strong upward trend in spring monitoring for both SQI and TD (Figure 5). The trend for both measures is statistically significant.[3] This is an encouraging result that indicates improvement in macroinvertebrate colonization and suggests improvements or stabilization of habitat over time. However, as more sites have been sampled over time, the spread of scores has increased.

The fall trend for both measures across Lower Huron sites is decidedly different (Figure 6). The trend is declining. The trend for both measures is statistically significant. The spread of data across sites appears to be much greater in the fall versus spring sampling. Also, variability year-

[3] As before, statistical significance was determined using regression analysis.

to-year is greater, suggesting environmental events (such as heavy rain or other climatic events) on the date of sampling are affecting scores for all sites.

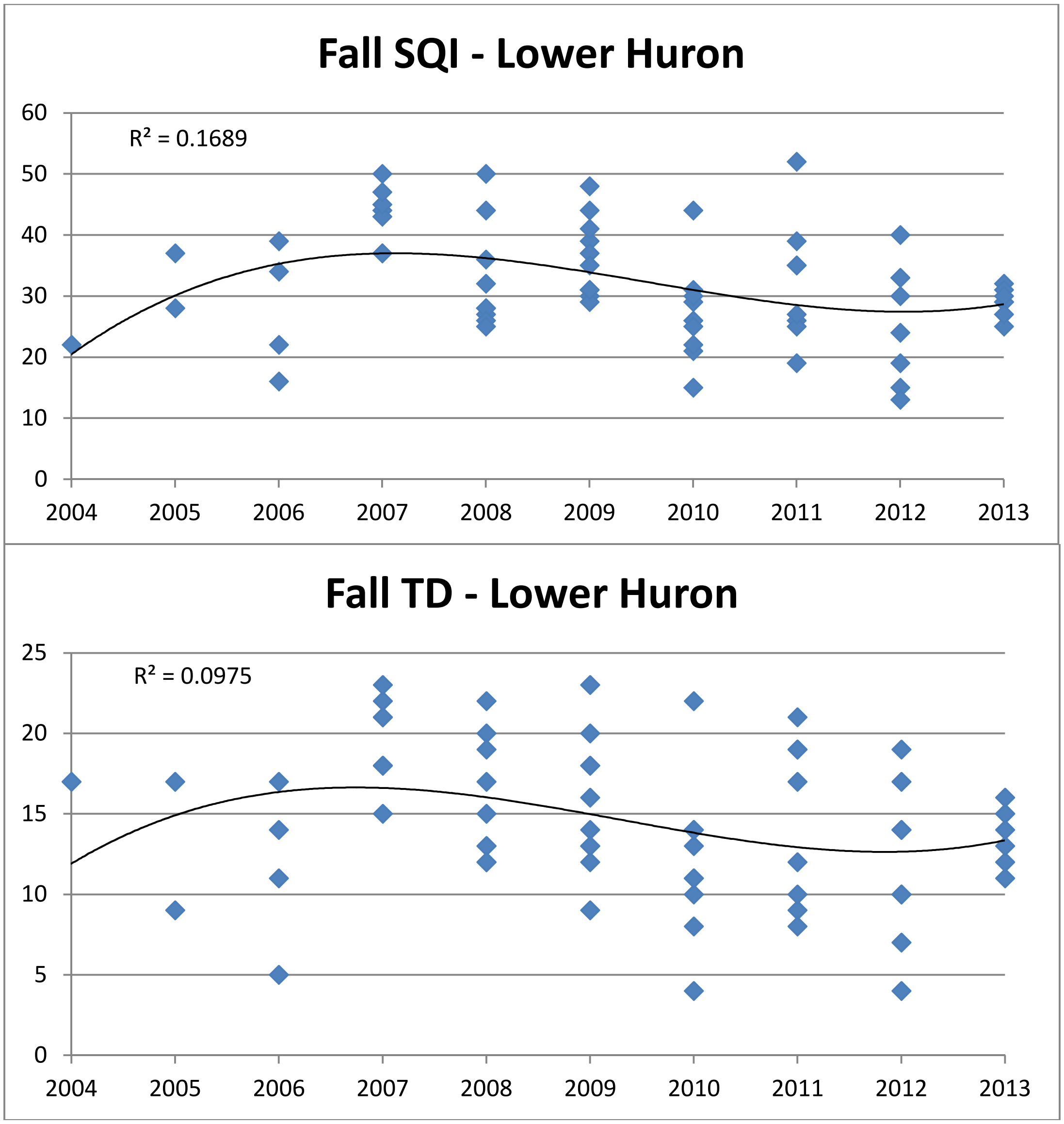
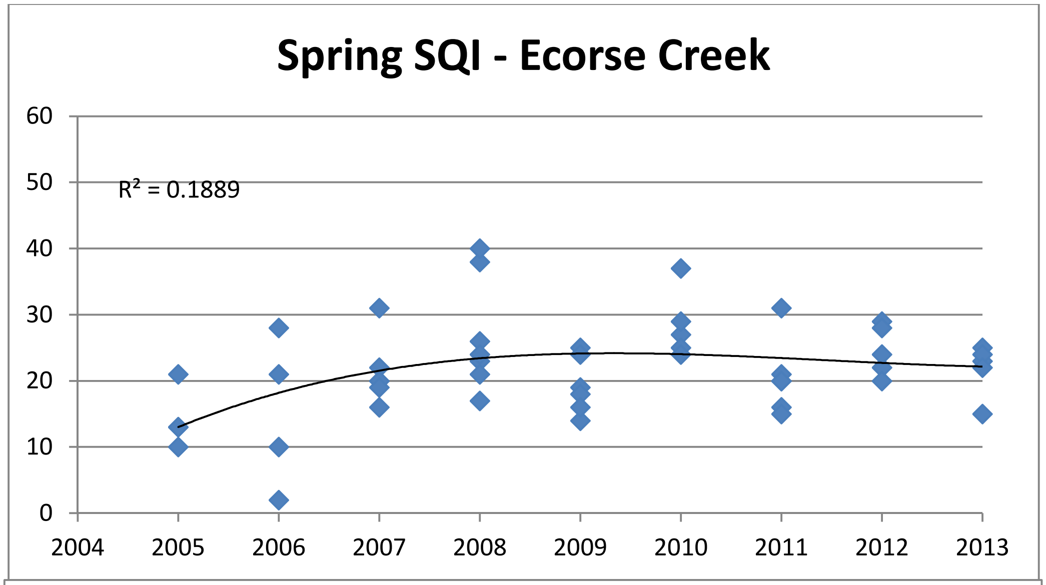


Figure 6. SQI and TD ratings for all Lower Huron sites for fall sampling events with best fit trend line included.

For Ecorse Creek watershed sites, the spring trend is strongly positive, similar to that for Lower Huron sites (Figure 7). The trend is significant for both spring SQI and TD, indicating that macroinvertebrate taxa are colonizing stream sites in greater numbers. However, the total diversity trend is not significant. Also, scores appear to be leveling out or even decreasing in recent years, though the trend is not significant.



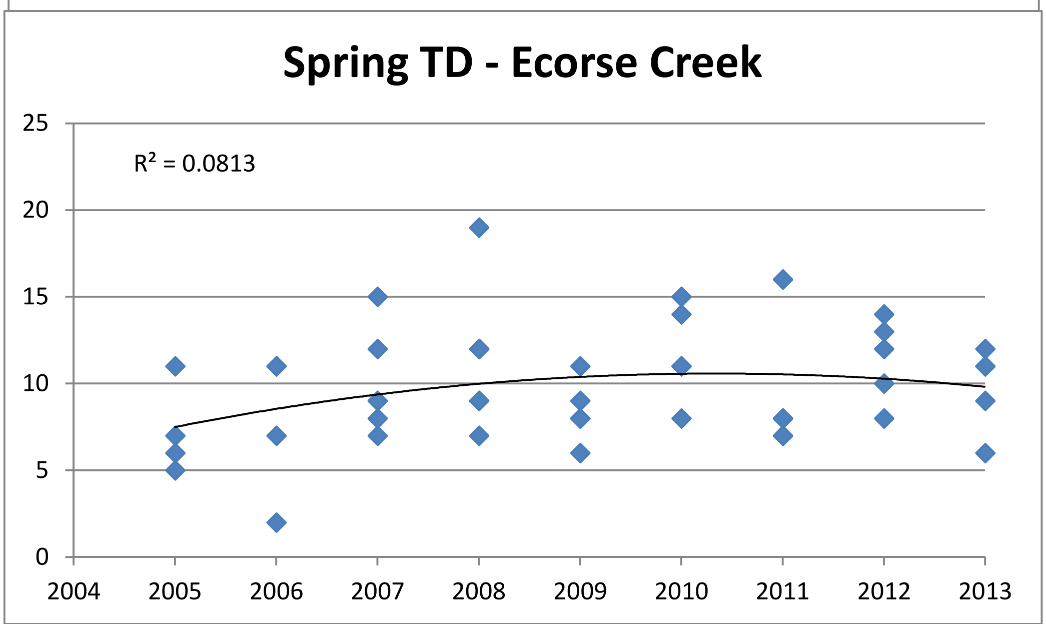
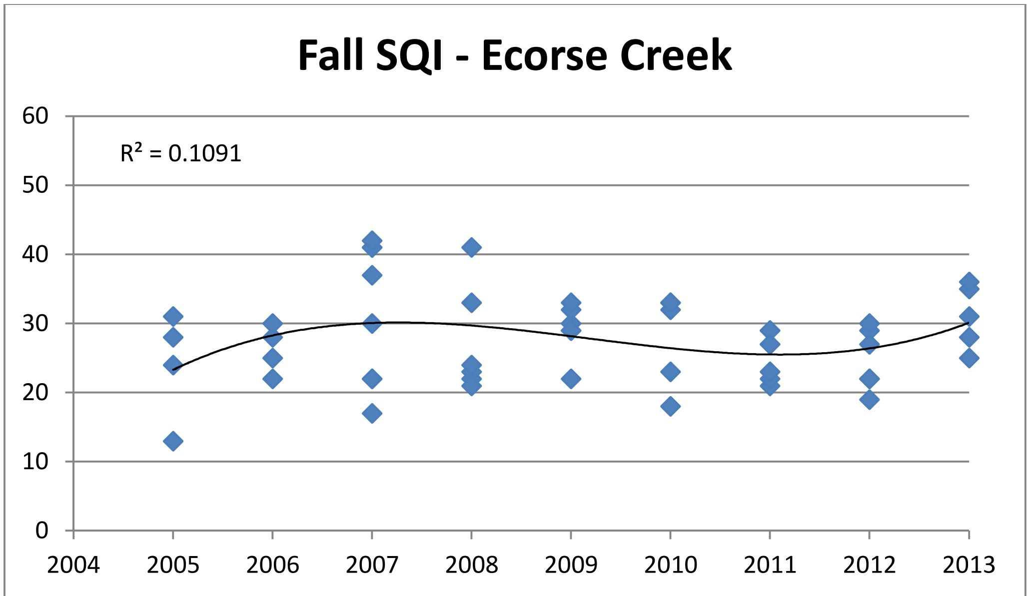


Figure 7. SQI and TD ratings for all Ecorse Creek sites for spring sampling events with best fit trend line included.

The trends for fall SQI and TD scores in Ecorse Creek sites are not significant (Figure 8). However, 2013 marks initial upward improvements, compared to the previous year, in diversity. The differences in fall measures from the previous year to this year could be accounted for in environmental conditions at the time of sampling.



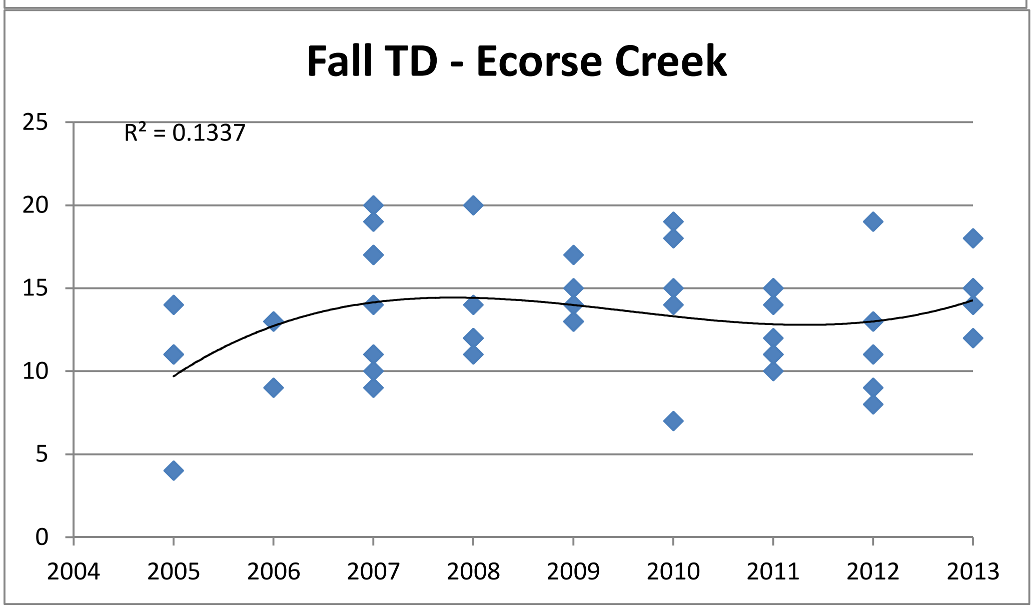
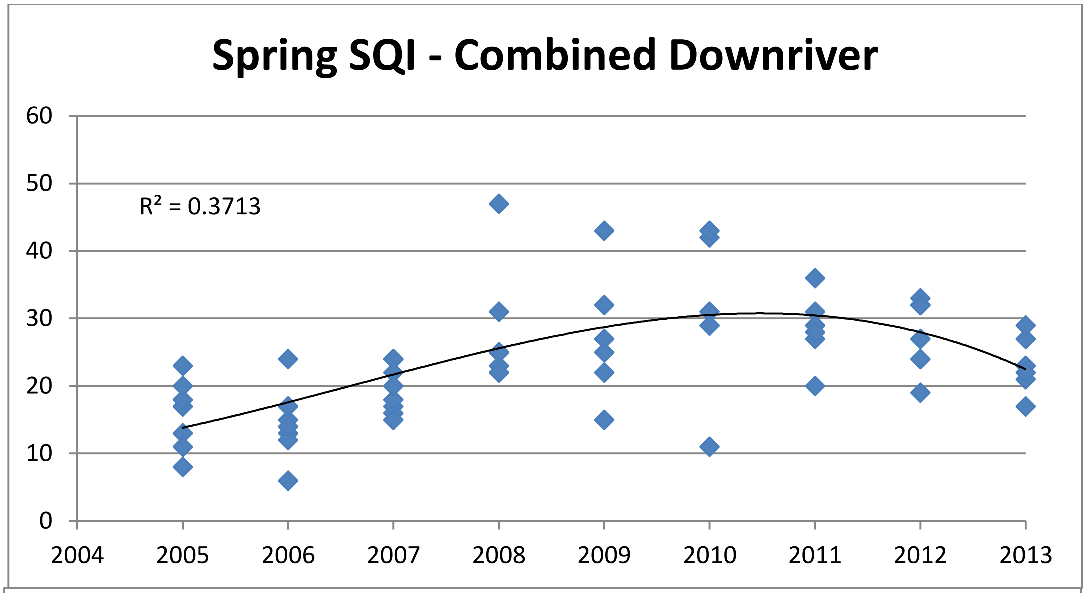


Figure 8. SQI and TD ratings for all Lower Huron sites for spring sampling events with best fit trend line included.

Trends for Combined Downriver watershed sites are similar to the other two watersheds (Figure 9). The trend over time historically has been strongly upward until 2010 or 2011, illustrating stabilization in the number and diversity of benthic biota. The trend for Combined Downriver sites is more highly significant and explains a greater amount of the variance (as measured by R^2) than with the other two watersheds. This suggests that the trend is more indicative of reaching a state of true equilibrium or stabilization of aquatic habitat.



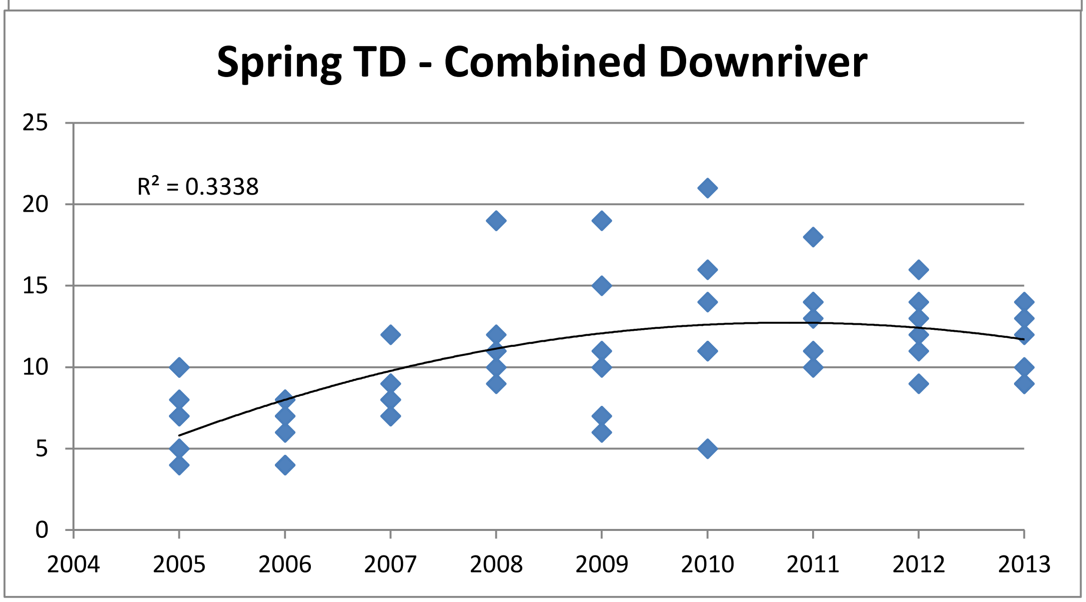
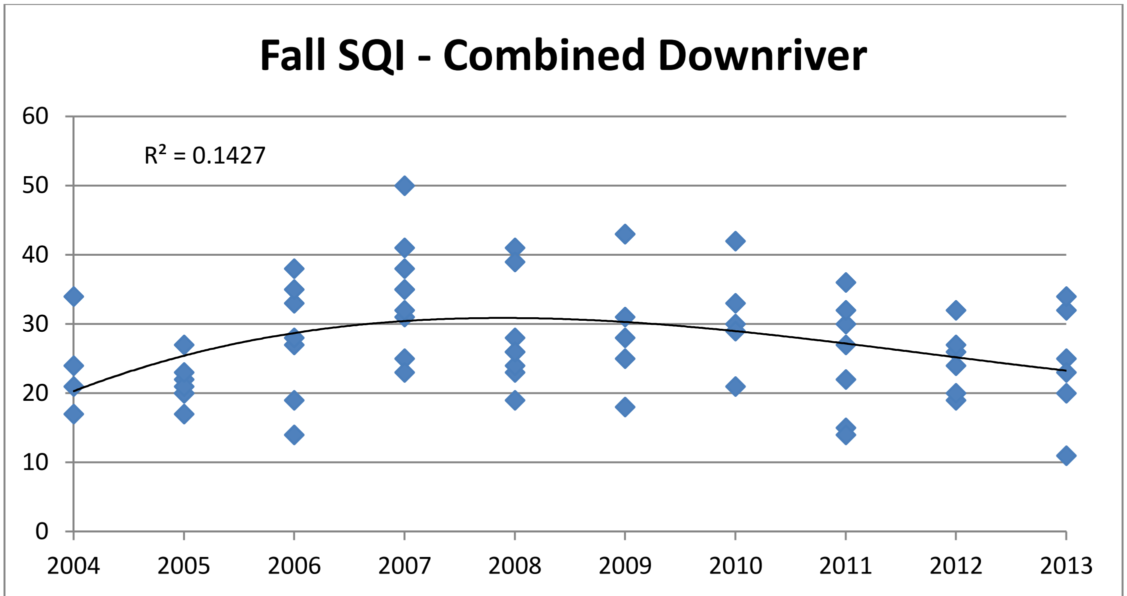


Figure 9. SQI and TD ratings for all Combined Downriver sites for spring sampling events with best fit trend line included.

Fall trends for Combined Downriver sites are similarly less emphatic (Figure 10), and not statistically significant. Again, Combined Downriver sites appear to have recovered to a point, but now may be reaching a state of equilibrium. Alternatively, population numbers may be varying around an average diversity rating.



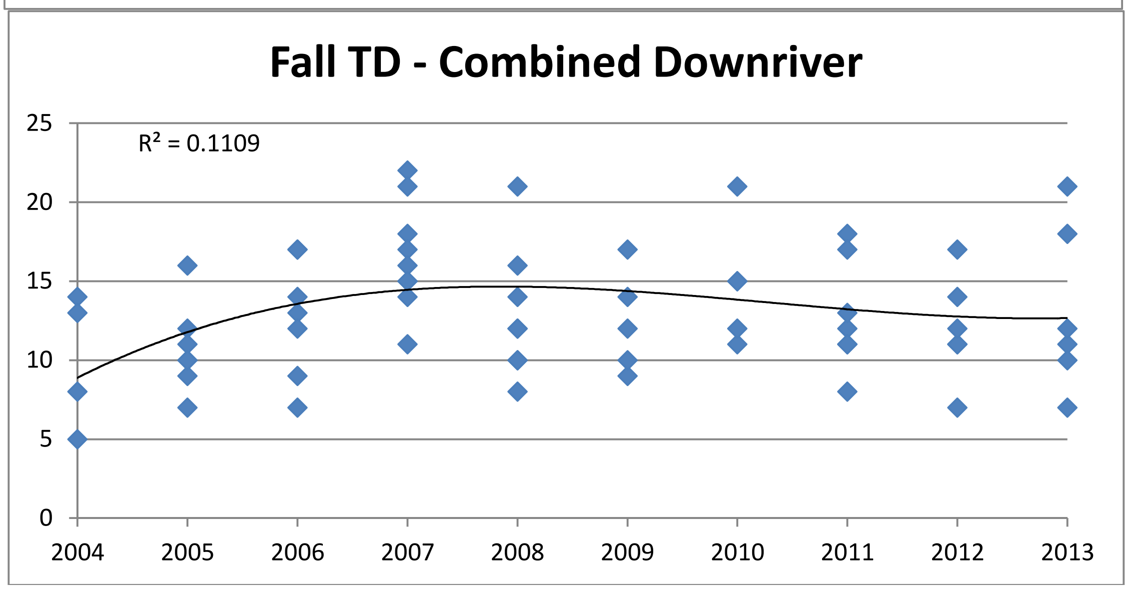


Figure 10. SQI and TD ratings for all Combined Downriver sites for spring sampling events with best fit trend line included. Data points in the SQI chart are color coded by individual site.

Conclusions

Overall, many stream segments across the ADW appear to be impacted such that the stream habitat is not able to sustain populations of a very diverse range of aquatic macroinvertebrates. Many of the sites in the ADW are designated county drains and, as such, the stream channels and habitat have been highly modified. Sites within watersheds with a greater proportion of imperviousness (i.e. less green infrastructure) are more highly degraded than those with less imperviousness (i.e. more green infrastructure). Thus, site habitat conditions are more likely to be directly (i.e. negatively) affected by stormwater discharges. This conclusion is also consistent with findings from other regional published studies and reports.

On the positive side, conditions appear to be slightly improving in many of the sites being monitored. Both stream quality and macroinvertebrate diversity show improving trends over time across all sites in the ADW, at least with Spring measures. This may suggest that stream habitats are recovering somewhat. Future analysis should investigate regional trends more thoroughly.

3 Water Quality

Evaluation Approach

This program was designed to complement monitoring conducted by the Michigan Department of Environmental Quality (MDEQ) and other ADW monitoring programs, and was modeled after successful programs in Washtenaw and Livingston Counties. Data was collected twice monthly from April to September from eight stream locations that were established over the past 4 years in the ADW to investigate flow dynamics, geomorphology and benthic macroinvertebrates. Water quality data from these locations facilitate the establishment of relationships between land cover and ecological stream health, capturing the range of subwatershed and upstream conditions.

Water samples, water quality parameters and stream flow data were collected during each site visit. Efforts were made to collect water samples and make stream flow measurements during wet and dry weather for comparison. Level sensors were deployed at two lower Huron River sites for collection of continuous stream flow data and one northern site is an established United States Geological Survey (USGS) site (N. Branch, Ecorse Creek). Water level gages, or staff gages, were installed at 5 sites. Water samples were analyzed for Total Phosphorus (TP), Total Suspended Solids (TSS) and bacteria Escherichia coli (*E.coli*). Water chemistry was assessed through the measurements of conductivity, dissolved oxygen and temperature.

Stream Monitoring Field Teams and Training

With any new field program that has limited staff resources, engaging the public is extremely important to the success and continuation of the program. Launching the ADW monitoring program was no different. We continue to have very successful recruiting efforts, with some experienced volunteers returning for the 2013 monitoring season. In total, twelve volunteers supported the 2013 ADW program.

HRWC typically provides two types of training for our water quality stream monitoring programs: 1) a classroom-style session to give volunteers an overview of the program and a demonstration of equipment that they would be using in the field and 2) hands-on field training during season-opening site visits. The overview session was held 3 weeks prior to the start of the field season, after which the monitoring teams were introduced to their sites and taken through field training.

Volunteers were given a pre-determined baseline monitoring schedule, with field visits usually scheduled on Mondays – Thursdays on alternating weeks from April through September. This schedule was set up in advance with the Ypsilanti Community Utilities Authority (YCUA) Lab to ensure they could accommodate our water sample load.

Stream Monitoring Protocol

Stream monitoring was conducted monthly from April through September at the designated long-term monitoring sites described in the introduction and depicted on the following figures showing results. Volunteers collect environmental information about each site and record it on the field datasheet. Water sampling information and instantaneous water quality measurement results are also recorded.

Stream flow is measured separately during the field visit. Upon completion of the fieldwork, the monitoring team delivered water samples to the YCUA laboratory for analysis.

Below are descriptions of the water quality sampling and stream flow methods, and the water quality parameters measured. All field equipment was used as recommended by the equipment manufacturers.

Water Sampling

For all samples, the team member followed the same "grab" sampling protocol in accordance with the method prescribed in the 1994 MDEQ field procedures manual for wadeable streams. Baseline samples were collected to measure 1) Total Phosphorus (TP) and 2) Total Suspended Solids (TSS). If TP samples could not be analyzed within the method-specified holding period after delivery to the lab, they were treated with preservative. A separate water sample was collected in a sterile Whirlpak® to analyze for the bacteria *E.coli*. The same sampling method was employed as for collecting baseline water samples.

Water Quality Testing

Three water quality parameters were measured as part of the monitoring program. Water quality measurements for dissolved oxygen, temperature, and conductivity were made using hand held meters. For all measurements, the instrument was placed in the water at the appropriate submerged level at arm's length distance and upstream from the team member. The results were read from the digital displays and recorded on the field data sheet. Separate dissolved oxygen and conductivity meters were used for most sampling events.

Water Flow Measurements

The measurement of water velocity at the monitoring sites, when combined with water samples that are analyzed for nutrient concentration, allows for calculating the "load" of a particular nutrient for a specific moment in time. A "load" is a measure of the amount of a substance entering a water body over a given time period, such as a day or year. Concentration, when coupled with stream discharge, can be used to estimate the export rates of phosphorus (or other nutrients) for the watershed, and to estimate the loading rates of phosphorus in receiving waters.

Water velocity was measured directly in the stream after water samples were collected and water quality testing was completed. Flow velocity was measured at each site by team members across a range of measured water levels. Where stream discharge instrumentation or a water level gage was in place, discharge measurements can be charted against water level to establish a "rating curve." Once established, the rating curves were used to estimate discharge from water level readings. Figure 11 depicts the rating curve for Smith Creek. A USGS water-level gage station is located on N. Ecorse Creek near the intersection of Beech-Daly Rd and Van Born Rd. Water-level sensors maintained by HRWC were located at 1 site in the Lower Huron near Flat Rock (ADW09-Smith Creek) for the duration of this season. Data from this sites is reported in the Flow Monitoring section along with past results for other sites.

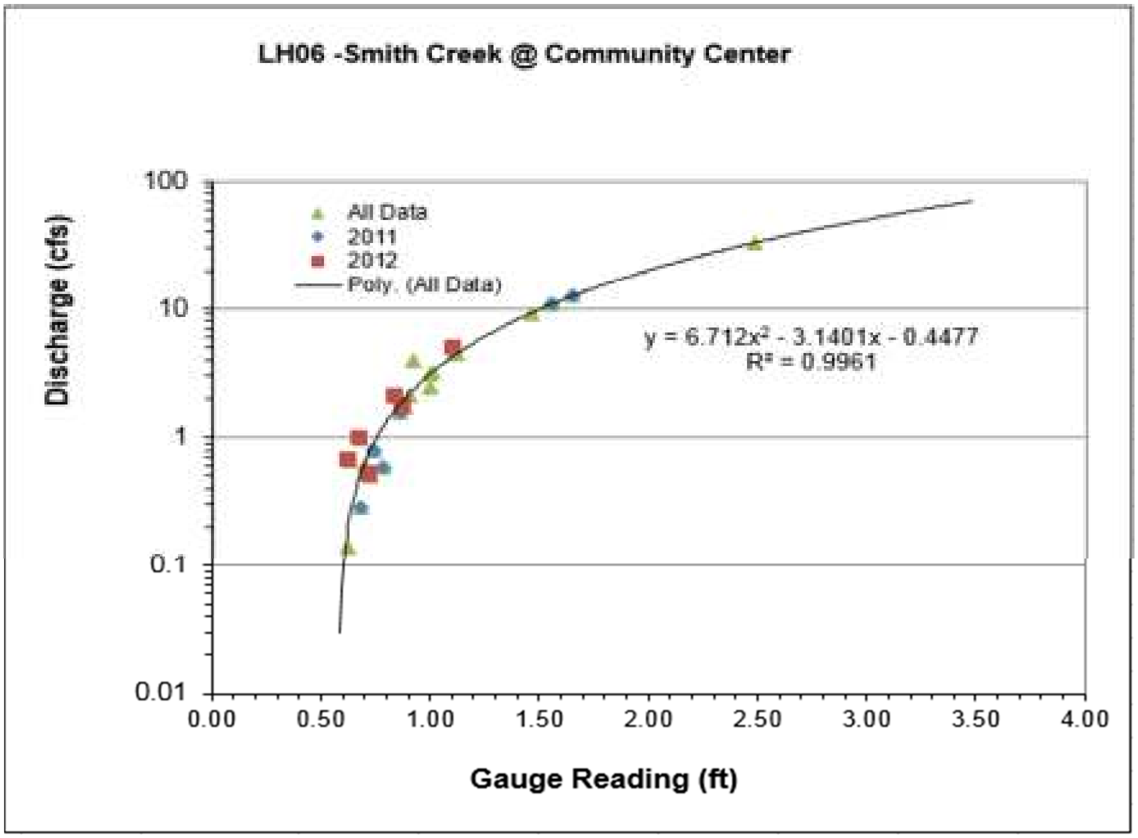


Figure 11. A "stage-discharge" curve used to estimate stream flow from water level at Smith Creek.

Monitoring Results and Discussion

Following is a summary discussion of the most important findings regarding the status at each of the monitoring locations, as well as general findings across the ADW. A compendium of graphic results for each tributary is included in Appendix A.

Total Phosphorus (TP)

One of the most important aspects of this monitoring effort was the analysis of Total Phosphorus (TP) data. Phosphorus is an essential nutrient for all aquatic plants. It is needed for plant growth and many metabolic reactions in plants and animals. In southern Michigan, phosphorus is typically the growth-limiting factor in fresh water systems. Total Phosphorus (TP) is a measure of all forms of phosphorus present in a water sample. The typical background level of TP for a Michigan river is 0.03 mg/L or ppm. (milligrams/liter and parts per million respectively)A level of 0.05 mg/L is used as a healthy ecosystem threshold in some lake systems in SE Michigan. This level of 0.05 mg/L is used as a target for ADW streams.

Phosphorus is the main parameter of concern in eutrophic lake and stream systems for its role in producing blue-green algae. Excessive concentrations of this element can quickly cause extensive growth of aquatic plants and algae. Abundant algae and plant growth can lead to depletion of dissolved oxygen in the water, and, in turn, adversely affect aquatic animal populations and cause fish kills. This nuisance algal and plant growth interferes with recreation and aesthetic enjoyment by reducing water clarity, tangling boats, and creating unpleasant swimming conditions, foul odors, and blooms of toxic and nontoxic organisms.

Figure 12 below shows the TP concentration ranges for each of the long-term monitoring sites. Because the water quality monitoring program is still in its infancy, there has not been enough data collected to run meaningful quantitative trend analyses. However, there are some site results worth highlighting.

Mean TP concentration values were much higher than the 'target' of 0.05 mg/L at all monitoring sites. The sites had a mean value of 0.089 mg/L in 2013, which is a 0.015 mg/L decline from the first season mean of 0.1 mg/L. TP means for all but two sites declined from 2012. Woods Creek and Silver Creek both have TP means greater than or equal to those of the previous year. However, Woods Creek still represents the site with the lowest mean TP per year, and Silver Creek also still represents the site with the highest mean TP per year.

Overall, the 2013 TP mean concentrations were lower than 2012 mean concentrations (Figure 12). When the 2013 monitoring season began in April, TP levels were fairly low when the outdoor temperatures were still cool. This brought the annual average down. As the air temperature began to rise in May, so did the TP concentrations with levels peaking during the hottest period, late June to August. The drought that this region experienced in 2012 (with little or no precipitation to dilute the pollutants in the streams) may be the primary explanation for the differences in mean concentrations between the years. More rain throughout 2013 may have contributed to lower means from the previous year. However, the TP concentrations during storms were the highest TP concentrations for 2013. Those occurred during the hottest period, late June to August. In late September, phosphorus concentrations were lower at 0.06 mg/L or less at all but one (Brownstown) of the sites.

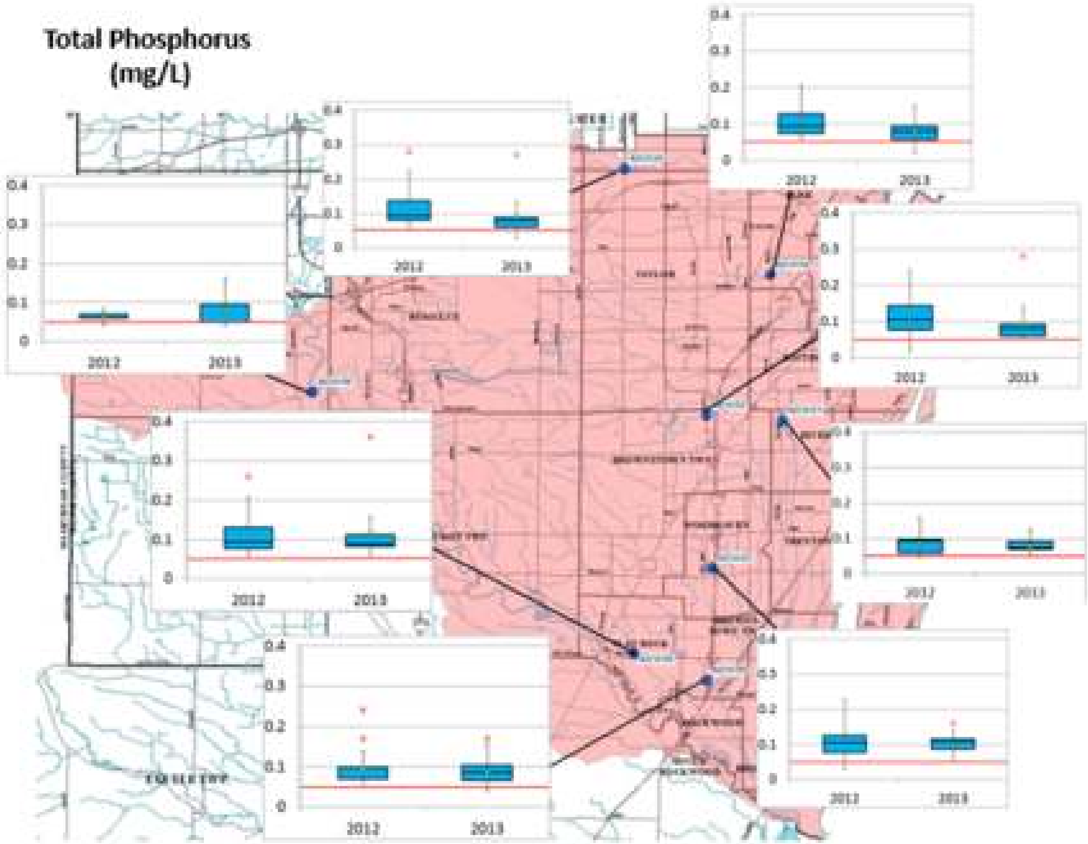


Figure 12. Total Phosphorus concentrations over time at all ADW monitoring sites. The red line indicates the 0.05 mg/L threshold for healthy streams.

<u>Total Suspended Solids (TSS)</u>

Total suspended solids include all particles suspended in water which will not pass through a filter. As levels of TSS increase in water, water temperature increases while levels of dissolved oxygen decrease. Fish and aquatic insect species are very sensitive to these changes which can lead to a loss of diversity of aquatic life. While Michigan's Water Quality Standards do not contain numerical limits for TSS, a narrative standard requires that waters not have any of these physical properties: turbidity; unnatural color; oil films; floating solids; foam; settleable solids; suspended solids; and deposits. Water with a TSS concentration <20 mg/L (ppm) is considered clear. Water with levels between 40 and 80 mg/L tends to appear cloudy, and water with concentrations over 150 mg/L usually appears muddy. In streams that have shown impairments to aquatic life due to sedimentation, TSS is used as a surrogate measure for Total Maximum Daily Load (TMDL) regulation, since large amounts of sediment can bury potential habitat for aquatic macroinvertebrates. Suspended solids may originate from point sources such as sanitary wastewater and industrial wastewater, but most tends to originate from nonpoint sources such as soil erosion from construction sites, urban/suburban sites, agriculture and exposed stream or river banks. Michigan DEQ uses the following high-flow TSS levels to evaluate the sedimentation impact on a stream's biota:

- Optimum = ≤ 25 mg/l
- Good to Moderate = >25 to 80 mg/l
- Less than moderate = >80 to 400 mg/l
- Poor = >400 mg/l

TSS concentrations for each of the monitoring sites are shown below in Figure 13. In general, the mean TSS concentrations are in the “optimum” range at all monitoring sites for the 2013 season. This is an improvement from 2012 where the mean TSS concentration for S Ecorse Creek was slightly higher than the optimal upper limit. In 2013, Woods Creek and S Ecorse Creek were the only two sites where mean TSS concentration declined from the previous year. The mean TSS concentrations for the remaining six monitoring sites all increased. Silver Creek experienced the greatest increase in mean TSS concentration, rising 11.8 mg/L from 2012, which is almost four times more than the increase experienced at any of the other sites. While mean concentrations are still well below the impairment standard, the range of TSS levels at Silver Creek may indicate that the creek is still undergoing streambank and bottom erosion during storm events. Woods Creek, on the other hand continues to have the lowest mean TSS concentration of all the monitoring sites.

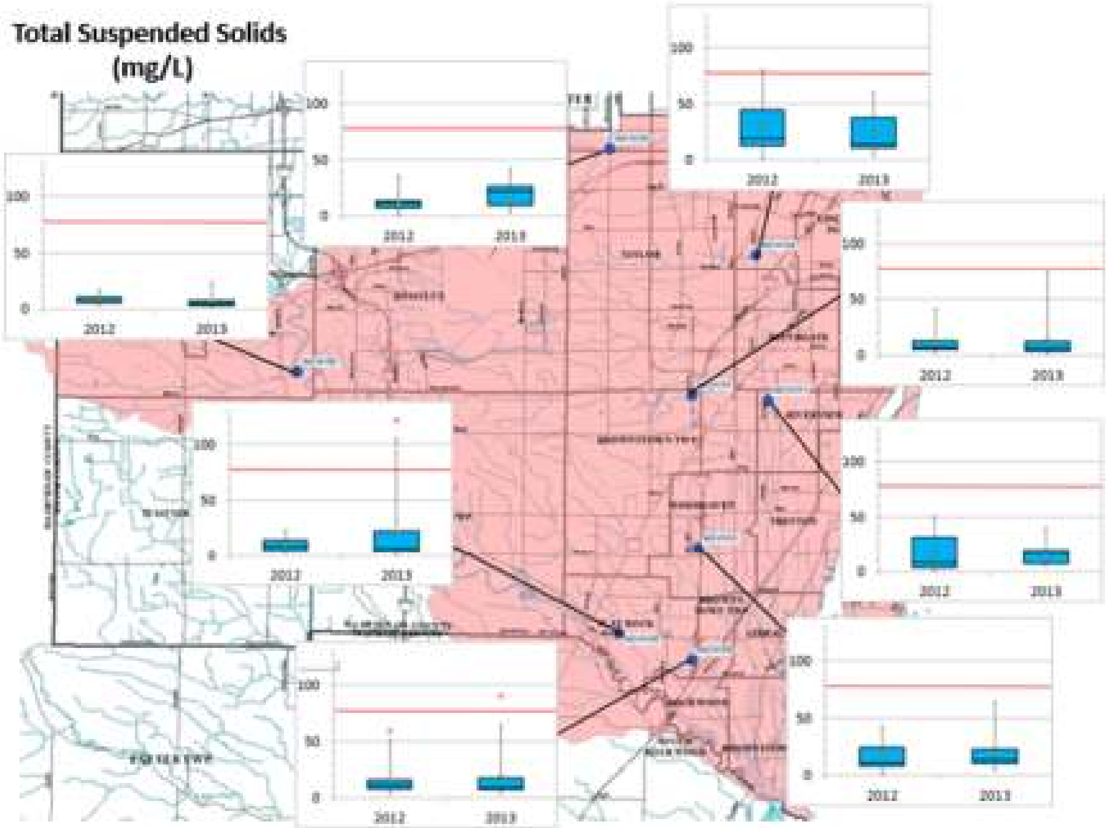


Figure 13. Total Suspended Solids over time at all monitoring sites. The red line indicates the upper limit, <80 mg/L, for streams considered "good to moderate".

Sediment-phosphorus relationship

Since phosphorus binds to soil particles, it is important to try and understand whether phosphorus in streams is coming along with sediment or not. To do this, one can examine TP concentrations with corresponding TSS concentrations. If they are well correlated, then there is some evidence that phosphorus is moving through the stream with sediments, and coming from erosion sources. If not, some amount of phosphorus may be moving through the system in dissolved form, unbound to sediment particles. Sources in this case, are likely from stormwater runoff.

All of the sampling sites showed some relationship between phosphorus and sediments, but the degree of correlation was highly variable between sites and differed significantly from the 2012 data. Correlations between TP and TSS ranged from 0.0085 on the low end (Brownstown Creek, ADW03) in 2012 to 0.412 in 2013. The high correlation of 0.85 at Smith Creek (ADW09) in 2012, decreased to 0.734 in 2013. Overall, the correlations in 2013 ranged from the lowest, 0.0020 (S Ecorse Creek, ADW04) to the highest, 0.96 (Blakely Creek, ADW02). This suggests that erosion (sediment-bound TP) may be more of a contributing factor to elevated TP levels in this tributary than at S Ecorse Creek. Figure 14 below illustrates the variability of the TP/TSS relationship across all the ADW sites in Wayne County.

One interesting observation to note is the difference in correlation coefficients between TP and TSS from N Ecorse Creek, to the downstream S Ecorse Creek location. In 2012 the correlation values were 0.00936 (N Ecorse Creek, ADW05) and 0.597 (S Ecorse Creek, ADW04). In 2013, the inverse relationship was observed. The correlation values in 2013 were 0.579 (N Ecorse Creek, ADW05) and 0.002 (S Ecorse Creek, ADW04). This suggests there may have been greater stormwater runoff, in 2013, in the south branch Ecorse Creek contributing to a greater proportion of unbound phosphorus dissolved in the system.

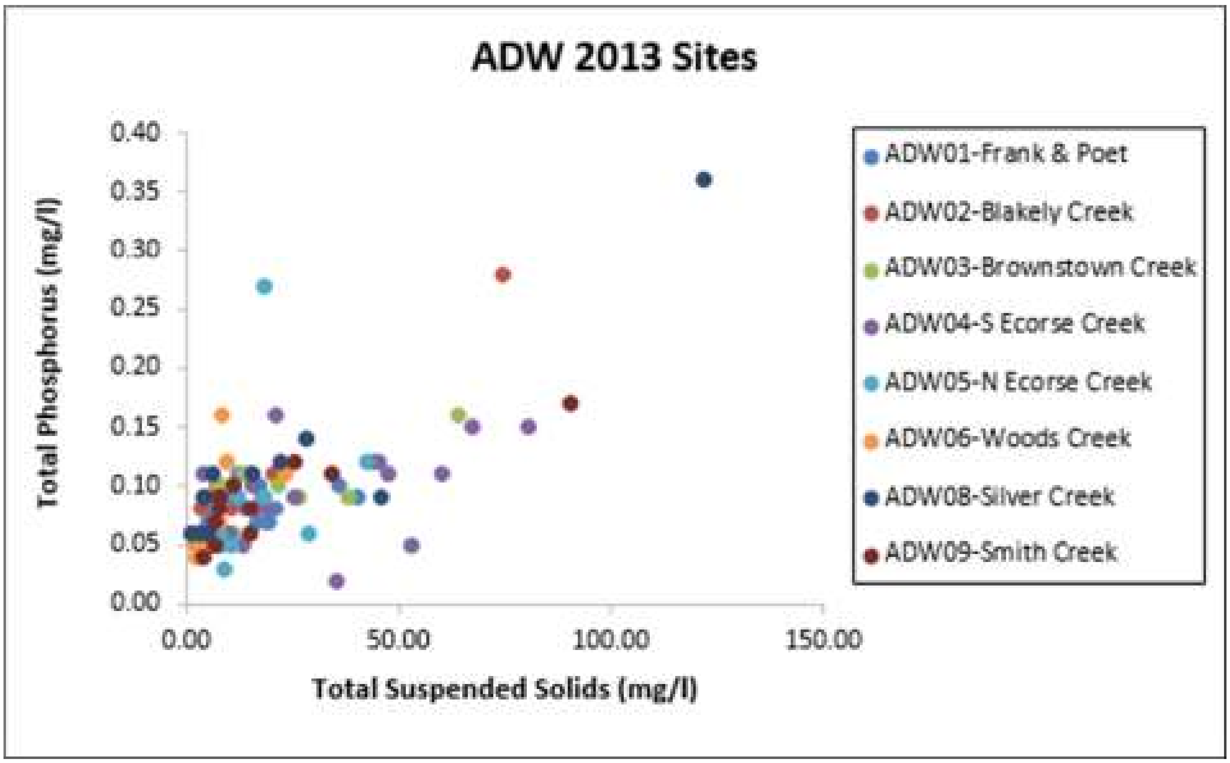


Figure 14. Combined TP vs. TSS concentrations over the 2013 season for all ADW monitoring sites.

<u>Streamflow, Storms and Pollutant Loads</u>

Ultimately, pollutant concentrations can vary widely due to many environmental variables. One important variable is the amount of total discharge of water or flow moving through a measurement site. Storms result in increased flow and can also wash material including soil and pollutants into the stream channels. Further, it is the total load of a pollutant entering the system that water resource managers are ultimately concerned with. Pollutant load is a calculated value based on the concentration and water flow at a given point in time, and it is expressed as pounds or tons per year, taken over an entire year or a season. Measuring the phosphorus load, for example, gives an idea of how much phosphorus is being transported downstream from tributaries to the Detroit River and ultimately Lake Erie over the growing season or entire year. Gaining an understanding of load dynamics can help to target management practices and measure their collective impact.

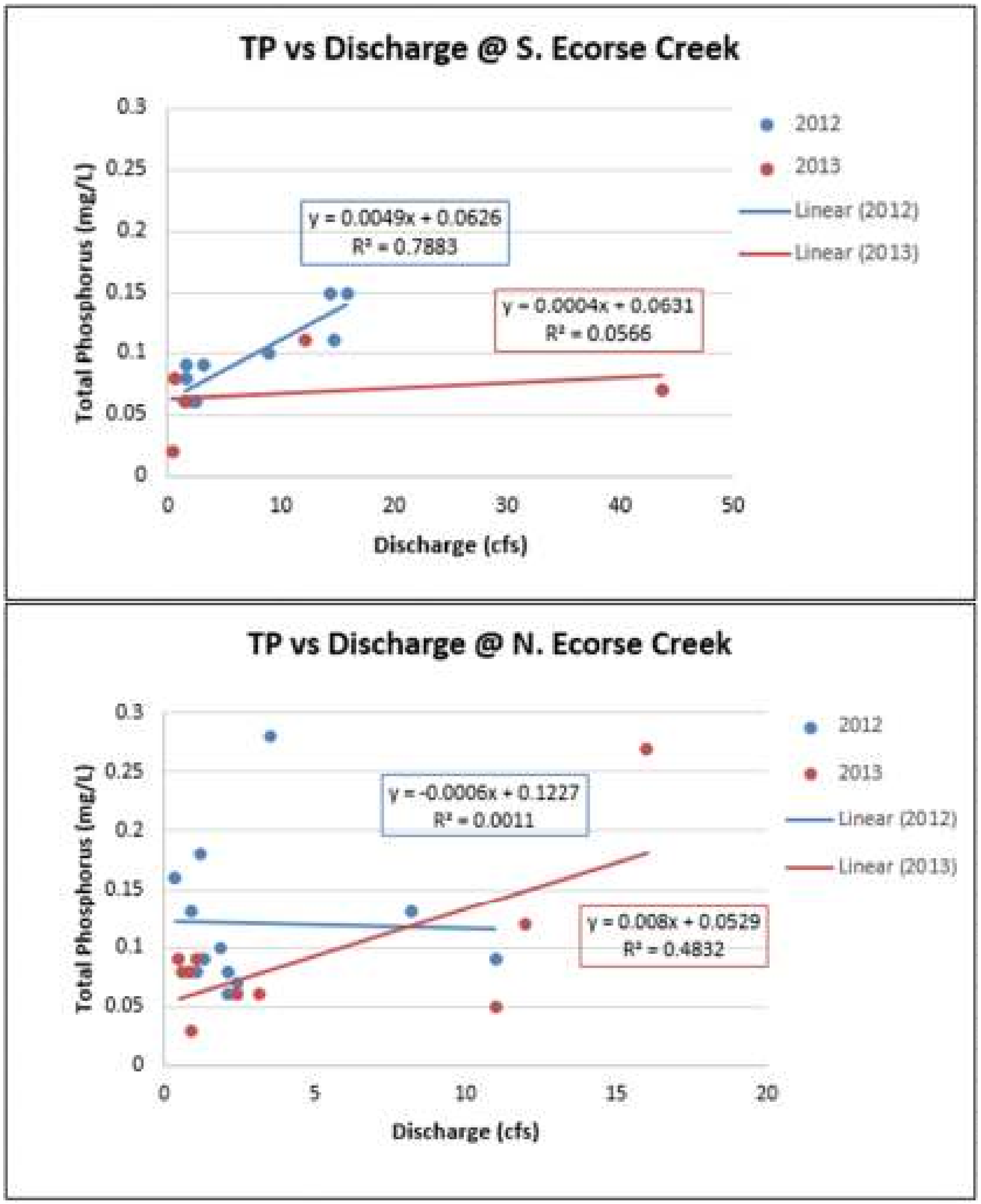


Figure 15. Examples of the year-to-year variability in the TP-Discharge relationship on the two branches of Ecorse Creek.

Similar to the TP-TSS relationship, the relationships between TP and discharge are highly variable at the monitoring sites throughout the ADW. Figure 15 illustrates this year-to-year variability. However, it is difficult to draw conclusions at this point since the data represents only two field seasons and we were unable to collect wet weather samples to give a more complete picture of the conditions impacting each of the streams.

Ultimately, TP concentrations can vary widely due to many environmental variables. TP load is a calculated value based on the phosphorus concentration and water flow at a given point in time, and it is expressed as pounds per day. TP loads were estimated for each sampling event. These instantaneous loads can be seen in Figure 16. TP concentration and TP-TSS relationship graphs for all tributaries are included in Appendix A. Additional years of sampling are needed to accurately estimate mean annual loads for phosphorus, sediment or other constituents.

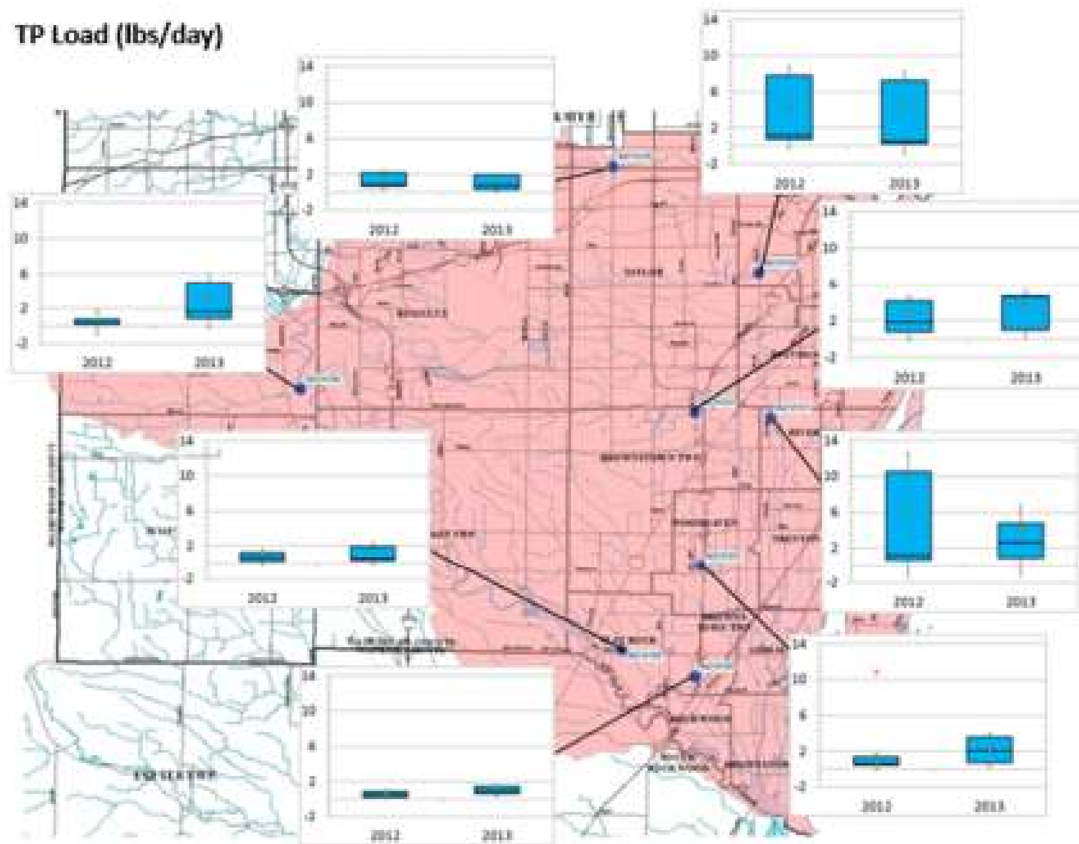


Figure 16. Instantaneous total phosphorus load measurements for monitoring sites in the ADW.

<u>Bacteria</u>

Escherichia coli (*E. coli*) counts are measured from water samples as an indicator of the presence of pathogens found in the digestive tracts of warm-blooded animals. Their presence may indicate the presence of sewage or wastewater, but high counts can also result from other animal sources. These generalized bacterial counts are not specific enough to be directly indicative of health risks. However, consistently high levels serve as a warning of potential health risks and warrant further investigation to determine the source of bacterial outbreaks. The State of Michigan water quality standard for total body contact is a monthly geometric mean of 130 individual colonies per 100 ml of water, while a single sampling event for waters protected for total body contact should be below 300 *E. coli* counts per 100 ml of water. The partial contact standard is a monthly geometric mean of 1,000 colonies per 100 ml.

Figure 17 below represents the *E.coli* results for each of the monitoring sites. The majority of the measures significantly exceeded the water quality standards for both partial- and full-body contact, and in some cases by multiple orders of magnitude. The median values were greater than the partial body contact standard at several sites, but often lower than the standard for full body contact. A bright spot is Woods Creek, which consistently had lower levels of *E.coli*, meeting the full body contact standard for all but two sampling events.

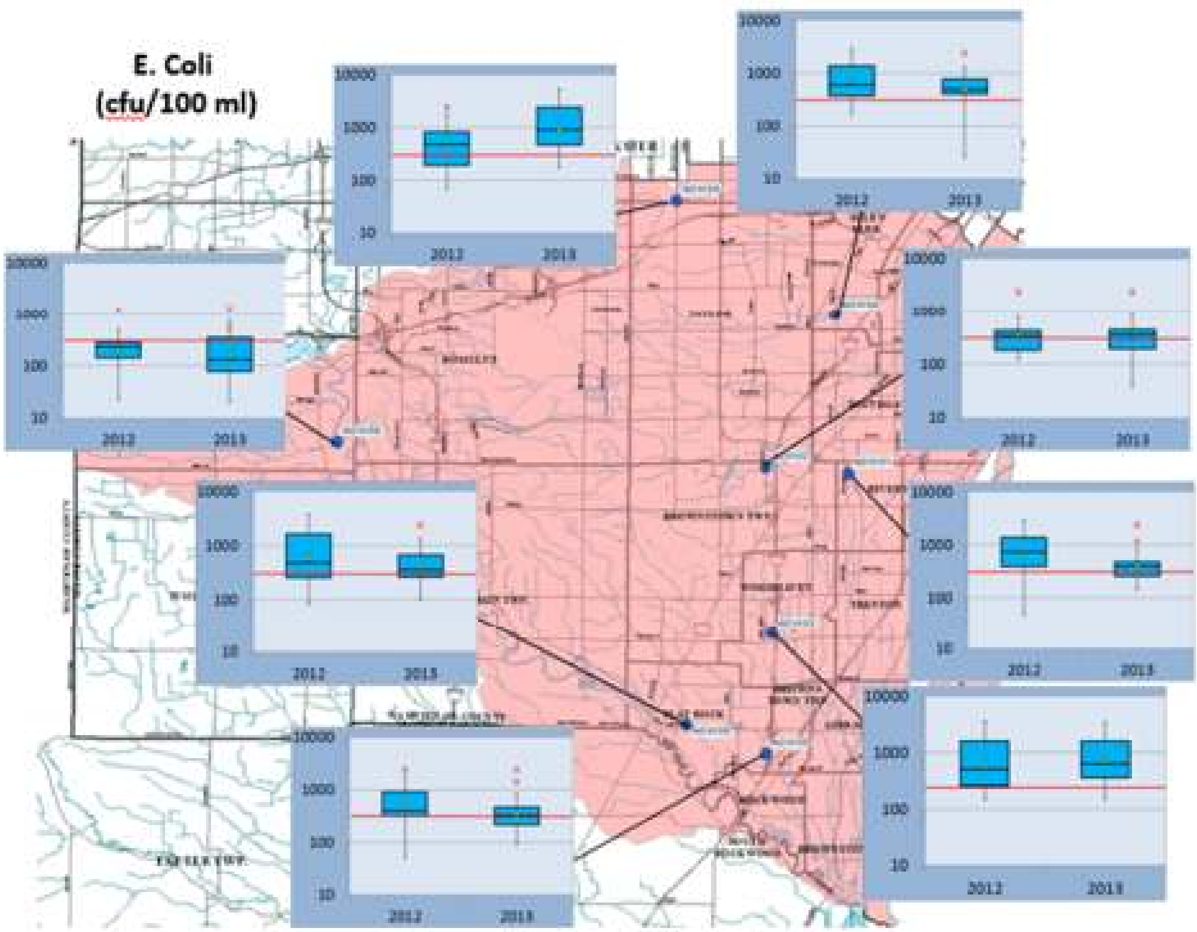


Figure 17. Range of *E. coli* counts at monitoring sites. Red lines indicate single-sample total body contact standard.

Other Important Measures – dissolved oxygen, conductivity and temperature

Volunteers in the Water Quality Monitoring Program also directly measure three other water quality parameters: dissolved oxygen (DO), conductivity, and temperature. HRWC uses these parameters to identify potential short-term impairments that may suggest local problems upstream. Out of all the monitoring sites we investigated, only Woods Creek exhibited DO *and* conductivity levels within state water quality standards throughout both the 2012 and 2013 field seasons. Many of the other sites had periods of low DO at various times during the summer and every other site had high conductivity ranges, greatly exceeding the state guidelines for healthy streams. These results warrant further investigation, as low DO and high conductivity are both broad indicators of poor water quality. For DO, low levels could indicate a problem with stagnation due to obstructed water flow or climate conditions, and high conductivity could suggest the presence of excessive amounts of salts, metals, other contaminants or even naturally-occurring minerals.

Dissolved Oxygen (DO)

Most aquatic plants and animals require a certain level of oxygen dissolved in the water for survival. Trout and stoneflies thrive in waters with high dissolved oxygen levels, whereas carp and bloodworms can out-compete other species in waters with low DO. DO levels drop to very low levels in warm, stagnant water, whereas fast-flowing, cooler water generally has high concentrations of DO. Some forms of pollution can also provide conditions that impact DO levels. For example, excess nutrients such as phosphorus and nitrogen can lead to algae outbreaks, resulting in reductions in DO levels, which can be detrimental to certain species of aquatic insects.

Normal DO values in Michigan waters range between 5 to 15 mg/L. The statewide minimum water quality standard is 5 mg/L. However, concentrations change throughout the day and night due to air and water temperature changes, photosynthesis, respiration and decomposition.

The graph below (Figure 18) depicts the DO levels measured over the 2012 and 2013 monitoring seasons. Compared to only three sites in 2012, six of the eight sites in 2013 consistently had DO levels above the state minimum standard for healthy waters. DO levels at the remaining two sites (Brownstown and Silver Creeks) had periods where the DO levels dropped below the standard, but showed improvements from the drier 2012 season. Mean DO values for Brownstown Creek increased from 4.71 mg/L to 5.52 mg/L and at Silver Creek from 5.30 mg/L to 5.72 mg/L, placing both sites at the minimum threshold to sustain healthy aquatic life.

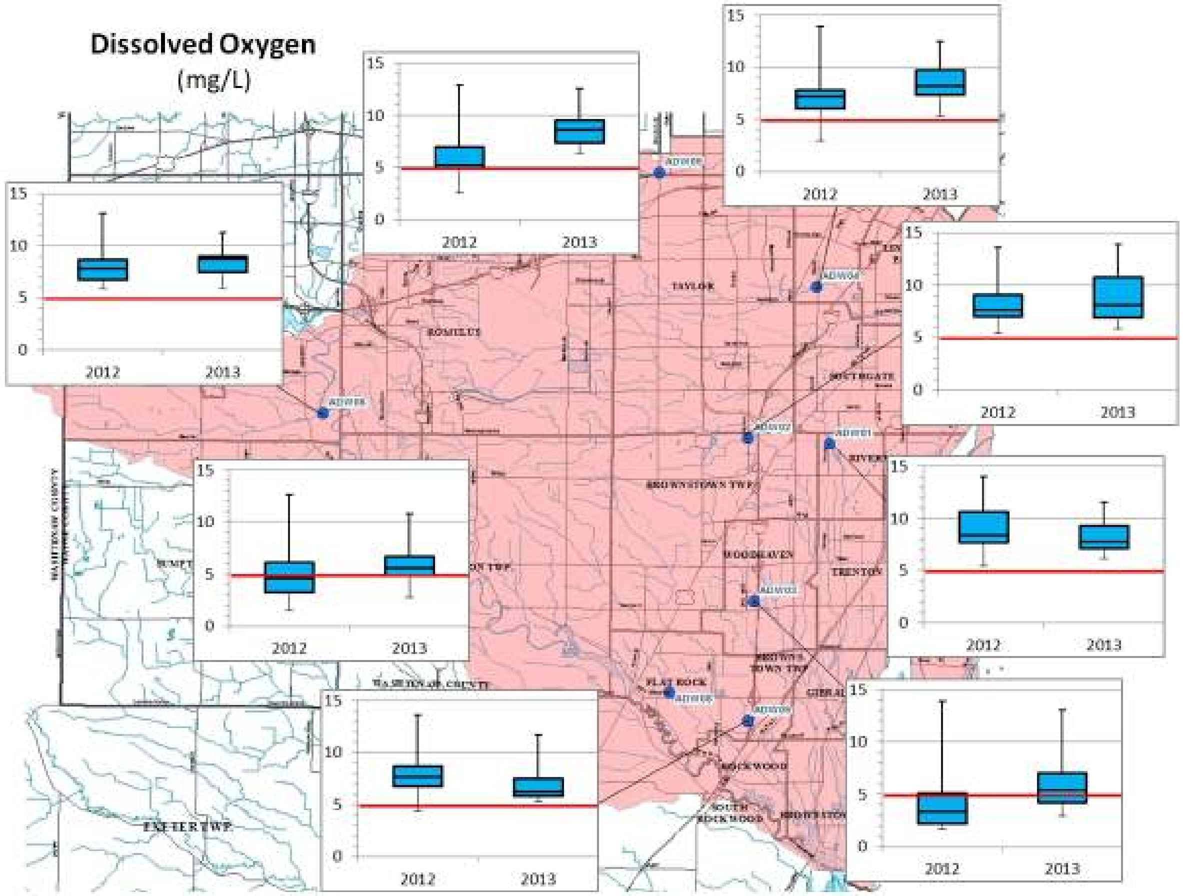


Figure 18. Range of dissolved oxygen measures for all long-term ADW sites, with minimum water quality standard indicated by the red lines.

<u>Conductivity</u>

Conductivity is a measure of the ability of water to pass an electrical current, and is a general measure of water quality. Conductivity is affected by temperature: the warmer the water, the higher the conductivity. As such, conductivity is reported as conductivity at 25ºC. Conductivity in surface waters is affected primarily by the geology of the area through which the water flows. In Michigan, values for a healthy river or stream habitat range between 100 and 800 microSiemens/centimeter (µS/cm). Low values are characteristic of oligotrophic (low nutrient) lake waters, while values above 800 µS/cm are characteristic of eutrophic (high nutrient) lake waters where plants are in abundance. High values are also indicative of high mineral concentrations. There are a number of potential sources of minerals and some natural variation, but consistent results above 800 µS would be unexpected from natural sources. Anthropogenic sources can include winter road salts, fertilizers, and drinking water softeners.

The conductivity results are presented for all sites over the monitoring season in a similar fashion as was done for dissolved oxygen (see Figure 19). The mean values for conductivity exceeded the upper limit for healthy waters (800 µS) for all but one of the monitoring sites. Woods Creek, which, as noted earlier, runs through the Lower Huron Metro Park, had a mean value of 573 µS, which is an increase from the previous year mean of 504 µS. The mean increase from 2012 to 2013 can be attributed to an increase in values above the upper limit in May and June of 2013. Similar to Woods Creek, the remaining sites sampled all experienced higher than average conductivity levels in late May and throughout June in 2013. This spike in mean value could be attributed to increased anthropogenic inputs, such as fertilizers or water softeners, during the time period, or movement of salts (from winter road treatment) through groundwater. High levels early in the season would be consistent with melt-water groundwater flow.

With the exception of Silver and Smith Creeks that both showed decreases in conductivity values, the remaining five sites all increased slightly from 2012 to 2013. The north and south branches of Ecorse Creek both had mean values in excess of 1100 µS, as did Frank & Poet and Blakely Creeks. Woods and Smith Creeks are the only monitoring sites that are not located near heavily traveled roads, connecting urban and suburban areas or are commercial routes between major highways. It was surprising that Smith Creek had such highly elevated conductivity measures, as the location of the monitoring site is downstream of a long stretch of the tributary that runs through wooded land with good riparian buffers.

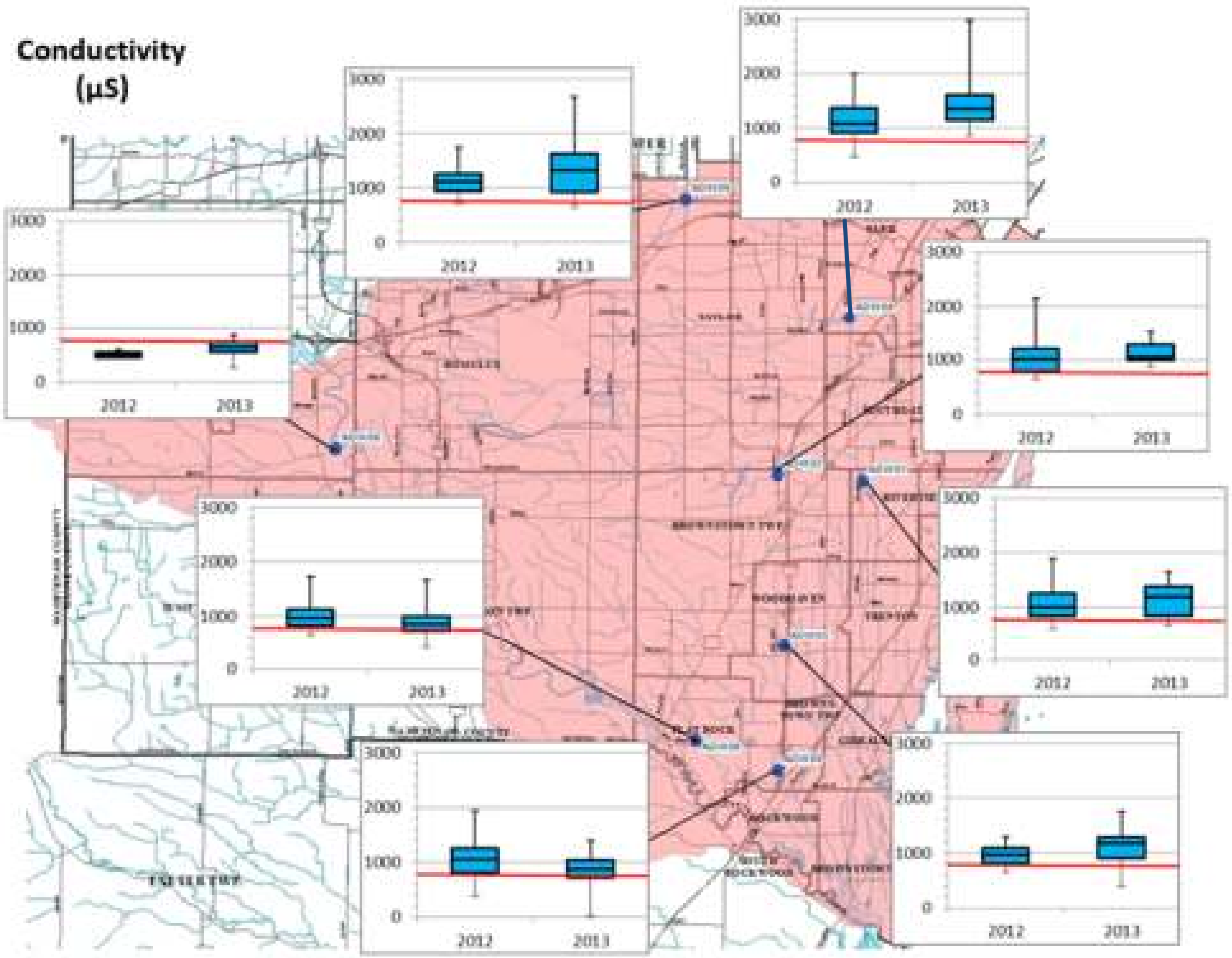


Figure 19. Conductivity levels recorded at long-term monitoring sites, with a biological impact threshold indicated by red lines.

<u>Temperature</u>

Figure 20 presents the temperature data gathered for each monitoring site for the 2012 and 2013 sampling seasons. The data is not analyzed for impact on biota, but is measured and presented for context. However, most fish species show signs of stress when temperatures exceed 25°C.

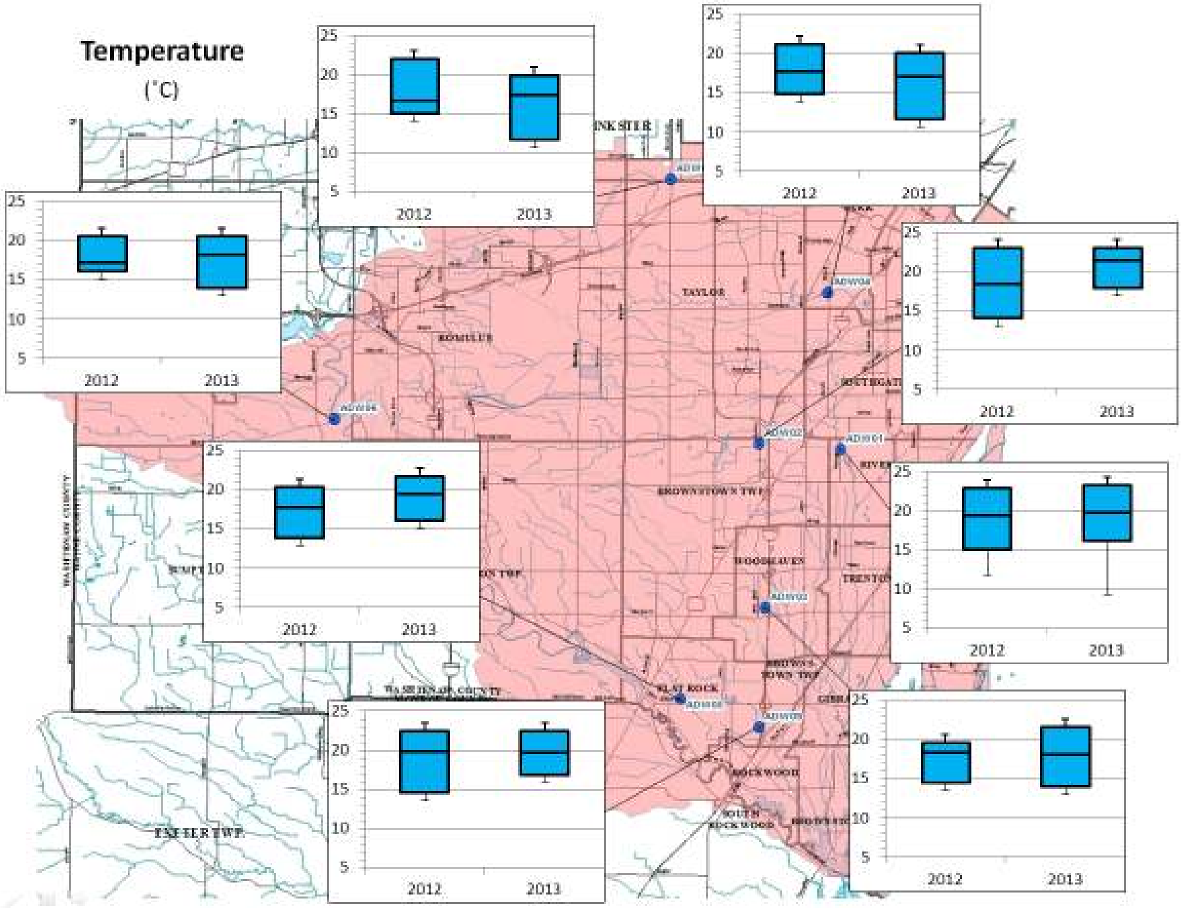


Figure 20. Temperature data for ADW monitoring sites.

Investigative Sites

For the 2013 monitoring season, four sites (Table 2) were chosen to investigate sources of high nutrient and bacteria results observed in the 2012 season. Figure 21 shows the 2013 investigative sites in relation to the long-term monitoring sites. Two of these four sites, ADW10 and ADW11, were used to investigate upstream of the long-term locations, ADW04-S. Ecorse Creek and ADW01-Frank and Poet Drain. The two remaining locations, ADW12 and ADW13 were selected to investigate additional tributaries for potential sources upstream.

Table 2: Investigative site list for 2013 ADW monitoring season.

Creek	Site #	Monitoring Location
Sexton and Kilfoil Drain	ADW10	S. Beech Daly Rd, north of Goddard
Frank and Poet Drain	ADW11	Racho Blvd at Eureka Rd
Marsh Creek	ADW12	Van Horn Rd, east of Allen Rd
Vandecar Drain	ADW13	Huron River Drive, west of Middlebelt

Figure 21. Geographic location of long-term ADW monitoring sites (red), and 2013 Investigative sites (yellow).

Sampling at investigative sites was similar to long-term sites, except that in-stream flow was not collected. Grab samples collected were submitted to the lab to test for: 1) Total Phosphorus (TP), 2) Total Suspended Solids (TSS), and 3) *E. coli*. The results from these investigative sites were compared to their long-term, downstream, counterparts. Several interesting results were observed, and will play an important role in the selection of investigative sites for the 2014 season. First, all four the investigative sites were above eutrophic levels for TP, with ADW12 having the highest mean season TP value of 0.12 mg/L, which is 0.03 mg/L greater than the other three sites TP (Table 3) and well above averages for other long-term sites.

Table 3: Total phosphorus results from the four ADW investigative sites in 2013.

Creek	Investigative site ID	Mean TP (mg/l)	Mean Difference from downstream (mg/l)	Percent Difference	n (# samples)
Sexton and Kilfoil Drain	ADW10	0.08	0.00	4.35%	6
Racho Blvd at Eureka	ADW11	0.08	-0.01	-13.22%	6
E. of Brownstown	ADW12	0.12	N/A	N/A	8
Vandecar Drain	ADW13	0.09	N/A	N/A	7

Second, all of the sites exceeded the full body contact limit of 300 cfu/100 mL for bacteria, with one site also exceeding the partial body contact limit of 1000 cfu/100 mL. ADW11 had the most drastic difference observed from upstream investigative site, to downstream long-term location at ADW01-Frank and Poet Drain. Mean *E. Coli* results at this location were almost twice as high as the downstream location, with a 2013 season mean of 1006.57 cfu/100mL (Table 4). This is the only site that exceeded the partial body contact limit, and could be attributed to the high density urban setting, with minimal areas for infiltration. However, additional investigation is needed to examine the source of the high *E. Coli* levels.

Table 4: E. Coli results from the four ADW investigative sites in 2013.

Creek	Investigative site ID	Mean *E. Coli* (cfu/100 ml)	Mean Difference from downstream (cfu/100 ml)	Percent Difference	n (# samples)
Sexton and Kilfoil Drain	ADW10	605.40	52.87	9.57%	6
Racho Blvd at Eureka	ADW11	1,006.57	503.26	99.99%	6
E. of Brownstown	ADW12	694.81	N/A	N/A	7
Vandecar Drain	ADW13	639.37	N/A	N/A	6

Lastly, mean TSS results are in the "optimum", <25 mg/L, range at three of the four investigative sites for the 2013 season (Table 5). ADW12-Marsh Creek was the only investigative site that fell in the "good to moderate" range, with a mean TSS concentration of 26.05 mg/L.

Table 5: Investigative site list for 2013 ADW monitoring season from April through September.

Creek	Investigative site ID	Mean TSS (mg/l)	Mean Difference from downstream (mg/l)	Percent Difference	n (# samples)
Sexton and Kilfoil Drain	ADW10	22.07	-6.53	-22.84%	6
Racho Blvd at Eureka	ADW11	23.73	9.83	70.68%	6
E. of Brownstown	ADW12	26.05	N/A	N/A	8

Vandecar Drain	ADW13	22.17	N/A	N/A	7

CONCLUSIONS

There are several findings worth noting about the water quality status of ADW streams. First, Woods Creek continues to be in good condition chemically. Across all water quality parameters, it showed the best results and usually was within state standards. This creek should therefore be used as a reference stream for what could be achieved throughout the ADW if effective management practices were put in place. It should be noted that the Woods Creek catchment is the least developed, has the lowest amount of impervious cover and the best riparian vegetative cover of all the creeks in the ADW, so management practices would need to mimic these conditions.

Other streams in the ADW have much poorer water quality. All exceeded quality standards on multiple occasions for more than one of the parameters measured. There are significant issues with phosphorus, bacteria, and conductivity across all these sites. Dissolved oxygen is a concern at several sites. It will be difficult to achieve a healthy aquatic ecosystem in these streams until these conditions are improved. On the other hand, erosion and sedimentation does not appear to be a significant issue. ADW streams appear to have generally reached equilibrium and therefore may have the habitat conditions to sustain healthy aquatic biology if water quality is improved.

In the streams that showed higher degrees of impaired water quality, the investigative sites proved to be helpful in beginning to locate the potential sources leading to high nutrient and bacteria results seen in 2012. ADW11 and ADW12 were the two sites that had the highest degrees of impairment for *E. Coli* and TP. Further investigation is needed, upstream of these investigative sites, to help determine where the "hot spots" are that contribute greater amounts of pollutants.

Finally, wet weather data would help verify the status of ADW streams. While data results through 2013 represent a variety of conditions, it is difficult to know if the true variability during active storm runoff has been captured. Sampling through several storm events would help determine the behavior of ADW streams across a full range of weather and runoff conditions and is critical for determining stormwater contributions. Still, the results represent a good baseline with which to compare future years.

4 Stream Discharge (Flow)

Evaluation Approach

Pressure sensors and staff gages were deployed at two monitoring locations in each watershed (see Figure 22) to monitor stream water levels over the course of 3-4 running seasons each. The pressure sensors recorded water levels every ten minutes. In order to translate pressure (water level) data to stream discharge, staff and volunteers measured discharge during a range of flow levels. Rating curves (see Figure 11) were developed for both staff gages and pressure sensors to estimate discharge from water level.

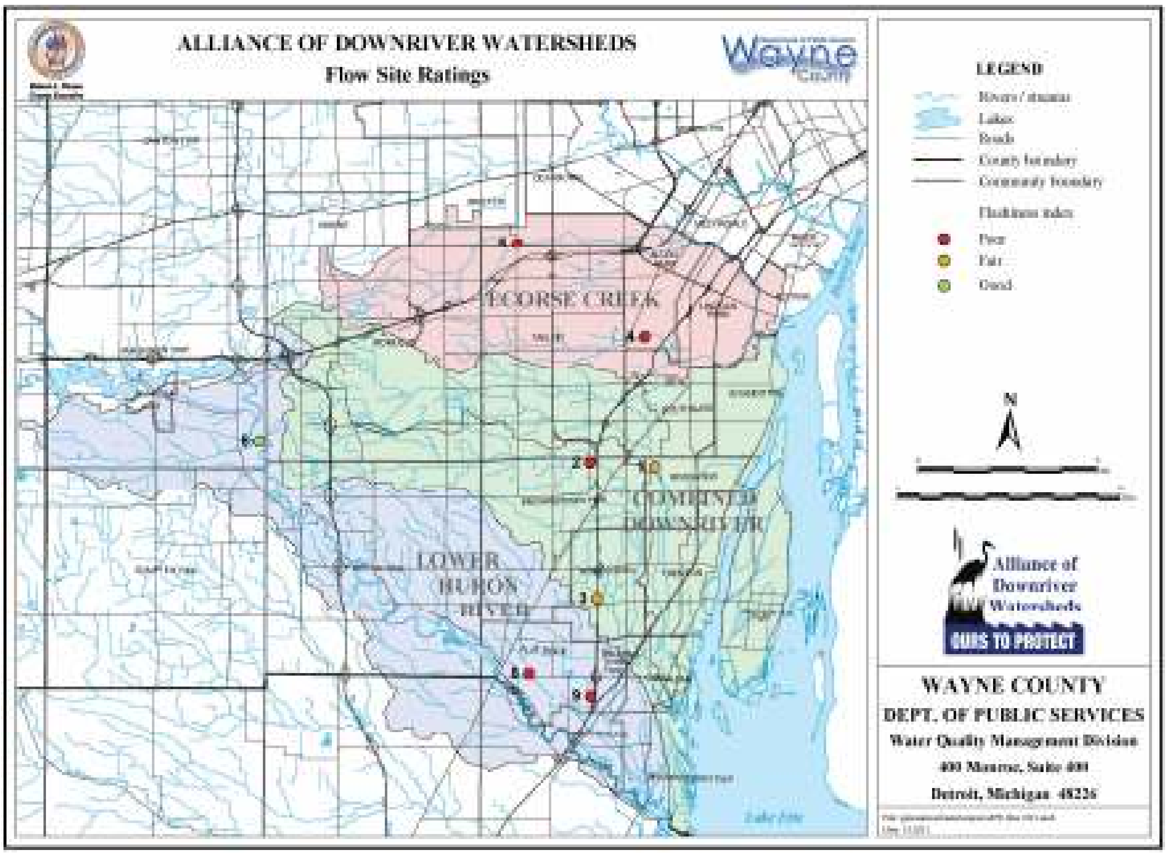


Figure 22. Map showing flow monitoring locations and ratings in the ADW. Ratings are based on the Richards-Baker Flashiness Index.

Stream discharge over time is averaged to generate mean daily discharge. A Richards-Baker Flashiness Index was computed for each year's set of daily mean discharges, based on the method from the Michigan Department of Environmental Quality (MDEQ) study.[4] An increase in flashiness, due to higher peak flows and lower base flows, will likely result in measurable changes to the channel shape – width, depth, sinuosity, and slope. Seasonal average, peak and

[4] Fonger, D., Manning, K., Rathbun, J., *Application of the Richards-Baker Flashiness Index to Gaged Michigan Rivers and Steams*, Michigan Department of Environmental Quality, Lansing, MI, August 3, 2007.

base flow estimates were determined utilizing the Indicators of Hydrologic Alteration (IHA) software.[5]

Six of the eight sites had 3-year records developed by 2011. In 2012 and 2013, two remaining sites were monitored for continuous flow: sites at Silver Creek and Smith Creek in the Lower Huron River watershed. Comprehensive data from the full monitoring record is reported in this report.

Ultimately, a before and after approach will be used to evaluate changes in stream flow dynamics. Comparisons of the above measures before and after management actions are taken should yield a measure of their impact on stream flow dynamics. However, as with most efforts, it will take years to show such an effect.

Stream Discharge (Flow) Results

Table 6 below presents some important measures of stream flow characteristics for the flow monitoring sites evaluated by the monitoring program.

Table 6. Daily Discharge statistics for Grow Zone monitoring sites.

Site	Period Monitored†	Drainage Area (sq. mi.)	Median Flow (cfs)	Peak Flow* (cfs) (Event Precip. (in))	Minimum flow* (cfs)	Flashiness (Quartile)
1. Frank & Poet	2008-11	27	4.33	754 (3.07)	0	0.56 (4)
2. Blakely	2008-11	32	4.05	252 (2.36)	0	0.53 (4)
3. Brownstown	2008-11	27	3.03	214 (3.07)	0	0.45 (3)
4. SB Ecorse	2008-11	12	3.65	290 (0.49)	0.33	0.58 (4)
5. NB Ecorse	2008-11	18	1.7	408 (2.59)	0.16	0.88 (4)
5. NB Ecorse (full record)	2002-11 (all months)	18	2.3	446^	0.08	0.83 (4)
6. Woods	2008-10	21	2.12	68.9 (2.6)	0	0.31 (2)
8. Silver	2009-12	7.9	1.54	334 (1.0)	0	0.73 (4)
9. Smith	2011-13	9.0	2.19	163 (2.36)	0	0.67 (4)

† *For all but NB Ecorse Creek (a USGS station), flow was measured from late spring into early fall, roughly May through October.*

* *Peak flow and minimum flow are extracted from the complete, sub-daily flow record, whereas the other statistics are based on mean daily discharge.*

^ *Peak flow occurred in 2004, prior to precipitation records obtained by the author.*

[5] *Indicators of Hydrologic Alteration*. Version 7.1. The Nature Conservancy. ©1996-2009. http://conserveonline.org/workspaces/iha.

Eight stations on different stream branches in the ADW have now been monitored for at least three seasons (six covering four seasons), with Smith Creek now monitored for three seasons. The flow statistics and variation measured over this time should provide an excellent picture of baseline flow conditions.

Taken on the whole, most streams in the ADW have substantially altered stream flow, when compared to other streams of similar size across the state and Midwest region. This is not entirely surprising, as some of the waterways, such as Ecorse Creek and Frank & Poet Drain, are highly altered, engineered, urban drains. One major exception is Woods Creek in the Lower Huron Metropark in Van Buren Township, which has shown a flashiness index that is near the statewide median with little inter-annual variability. Woods Creek may perhaps be the closest stream to a natural reference site in the ADW. The 2011 ADW Monitoring Report provides more detail on the trends between sites, when examining the different statistics in Table 6.

We examined individual creek flows for the one site monitored in 2013, and a discussion is included below.

<u>Smith Creek</u>

A flow site was established in 2010 in Smith Creek. The site accumulates flow from a 9 square mile drainage area. It produces a median flow of 2.2 cfs. It maintains a low base flow, and finally ran stagnant during the drought in 2012. Responses to storm events are rapid, and flashiness has declined by 0.002 since monitoring occurred in 2012. The highest peak flow measured was 163 cfs, which is a third the size of Silver Creek's peak. Smith Creek has a high flashiness index of 0.67. This index value places the Smith Creek site among the most flashy of sites with similar catchment size in Michigan.

Conclusions

This flow data represents a baseline measure of flow conditions in ADW streams. The results generally show ADW streams to be quite flashy, characterized by rapid increases to extremely high peak flows following storms and a rapid decline to little or no base flow. Such streams are typical of highly urbanized areas and present a challenge for living organisms trying to establish a home.

There has not been enough time or data collected to determine if stormwater/watershed restoration activities have had an effect on stream hydrology. The ADW currently plans to return to monitoring sites on a five-year rotational basis to determine if flow statistics have changed. A positive change in stream flow would be exhibited by lower peak flows for a given storm, higher base flow and a lower flashiness index. A reference target for conditions that could be achieved in the ADW would be Woods Creek. It's characteristics are more natural and consistent with those of other streams across the state. In general, discharge measures show ADW sites to have highly altered flow, characterized by high peak flows and low to no base flow.

5 Summary of Evaluation Results

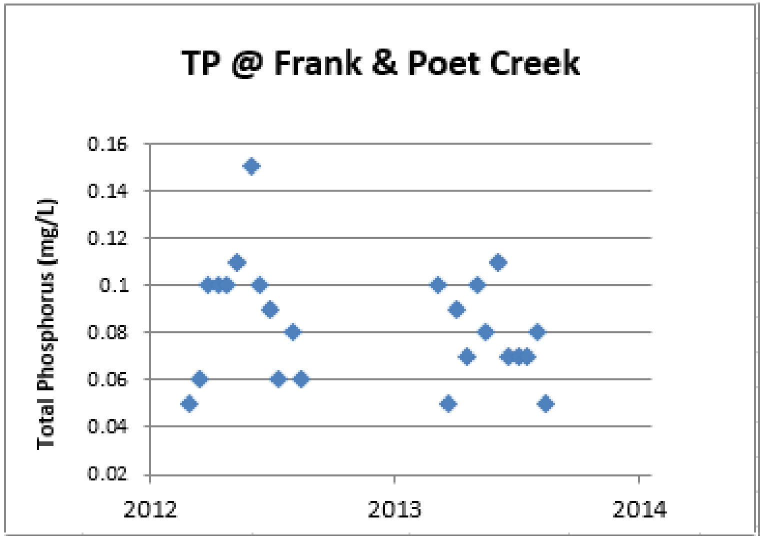
Three methods are reported on here to evaluate environmental progress in the Alliance of Downriver Watersheds. These methods have provided a solid baseline of information on the stream conditions at target sites across the watersheds. The results, which were discussed in the preceding sections indicate that some stream segments are highly impacted by previous urbanization, with imperviousness exceeding 30 and 40% in Ecorse Creek and Combined Downriver watersheds respectively (see 2009 monitoring report). Creek sites within the more highly urbanized areas show evidence of degradation of several functions. Stream sites like those on the Blakely and Frank & Poet Drains suffer from flashy flows – high peak flows followed by low or no base flow – and have unstable stream beds. Their banks and beds are susceptible to erosion. Not surprisingly, those sites also exhibit some of the lowest stream quality ratings and have the lowest macroinvertebrate diversity in the ADW. Sites across the ADW watersheds also exhibit impaired water quality. Phosphorus, the nutrient that can lead to algae blooms if overabundant, is consistently high, and bacteria counts are above state standards at all but one site.

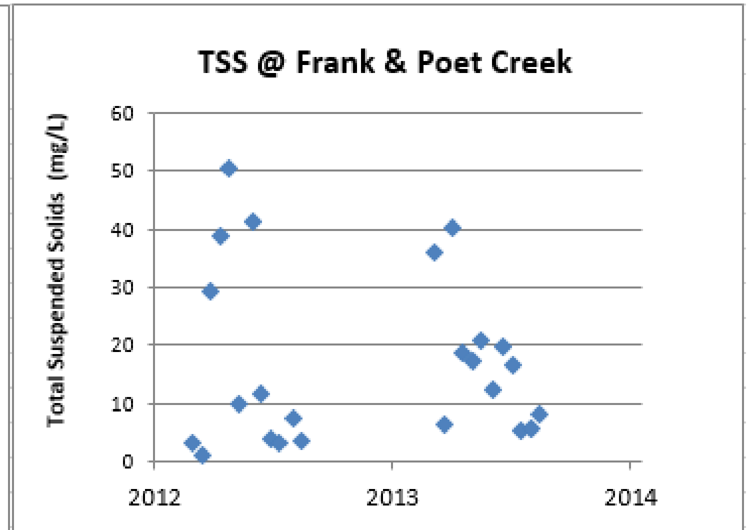
The evaluation also illustrated some streams that are faring well in the ADW. Sites in Woods Creek and the South Branch of Ecorse Creek have relatively natural flow dynamics along with relatively stable stream beds. It follows that those sites also exhibit higher stream quality ratings and have a diverse array of aquatic macroinvertebrates living within them. Woods Creek also has higher water quality, meeting state standards most of the time. These sites could serve as reference sites for future restoration of other sites across the ADW.

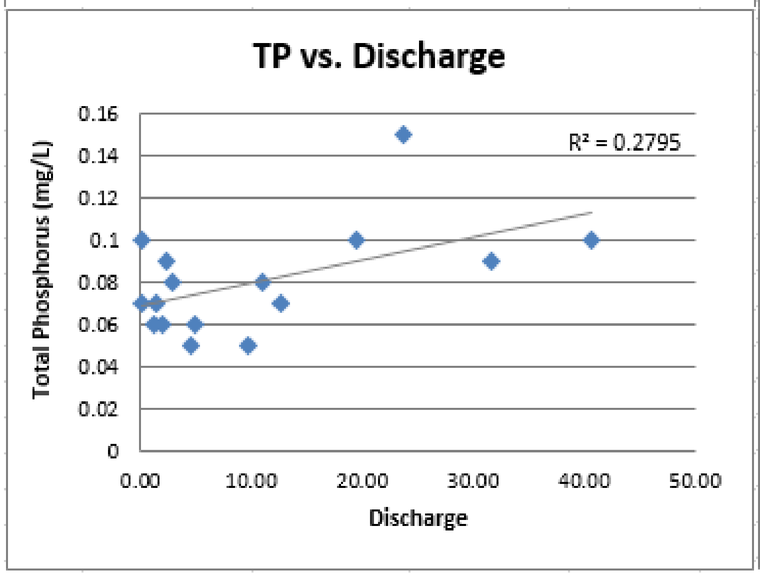
Also, the early results suggest that most of the stream sites monitored for macroinvertebrates are showing some signs of improving diversity and habitat quality. Further, suspended sediments are low, which suggests that erosion has stabilized. As the ADW continues to implement stormwater controls and engage in green infrastructure improvements like Grow Zones, tree planting and broader initiatives, it will be important to return to these evaluation metrics to determine if conditions continue to improve. It is too early in the monitoring process to determine any trends in methods other than macroinvertebrate sampling. However, the current results provide an excellent basis for future comparison to determine progress in stormwater and non-point source management.

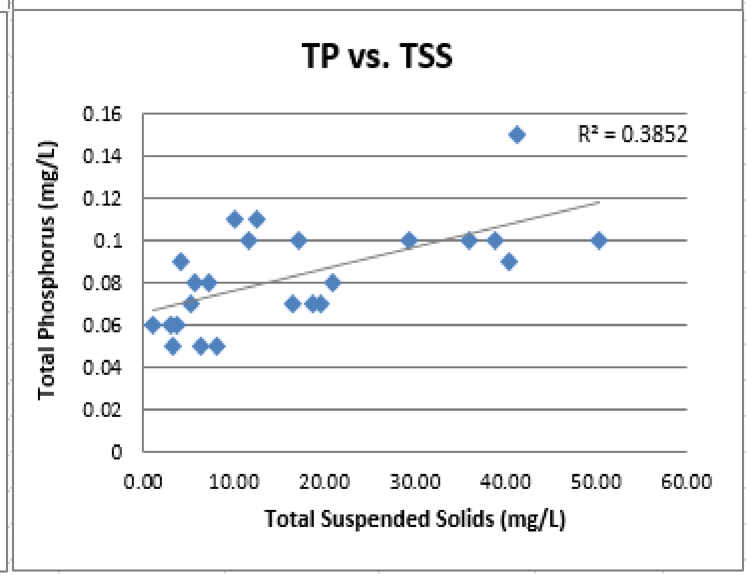
Appendix A.

Frank & Poet Creek – ADW 01

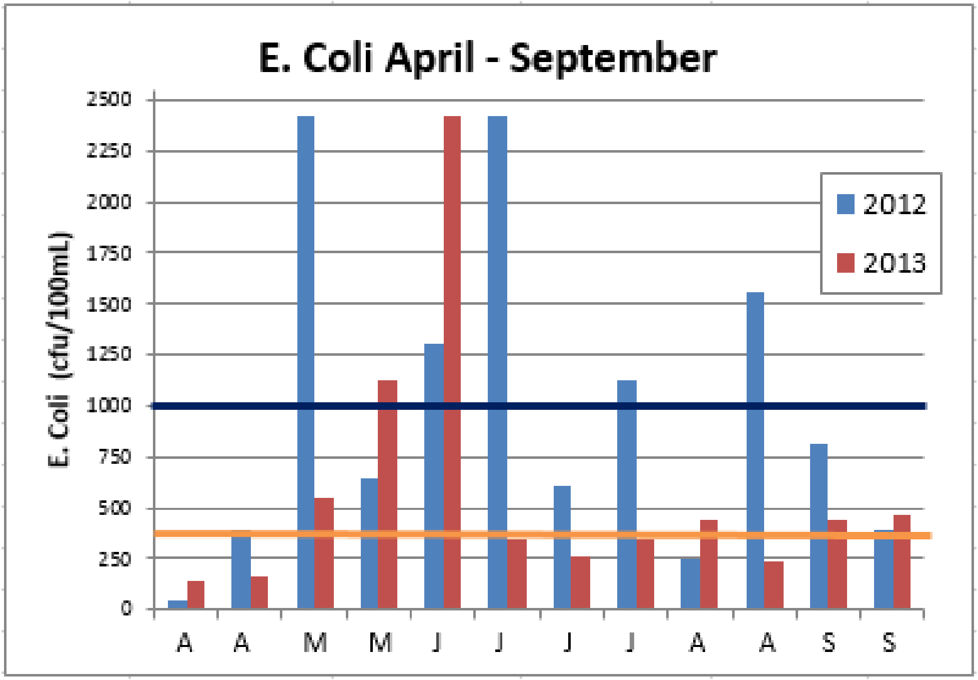




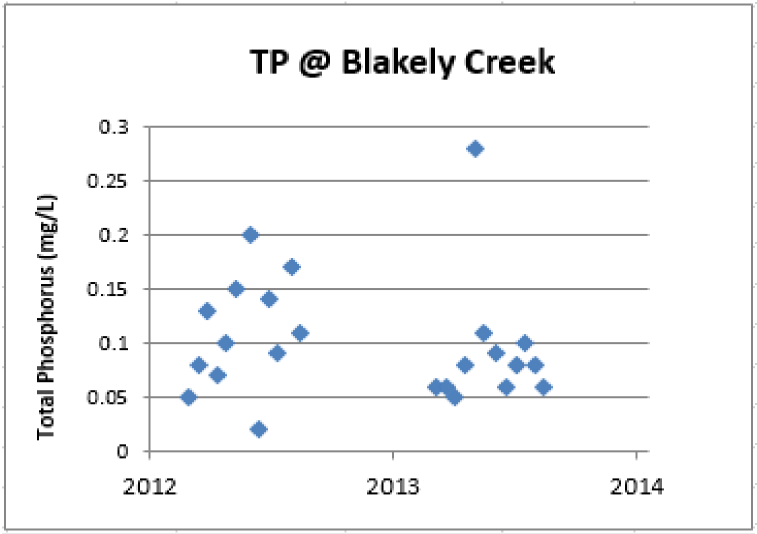


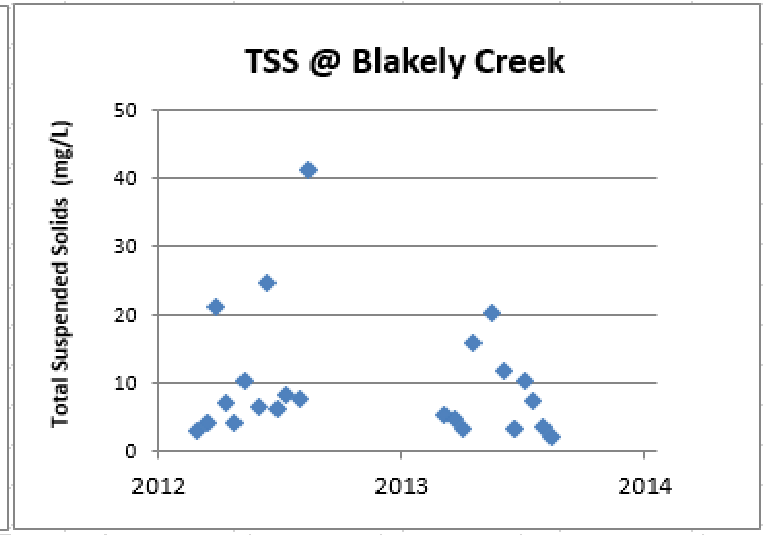


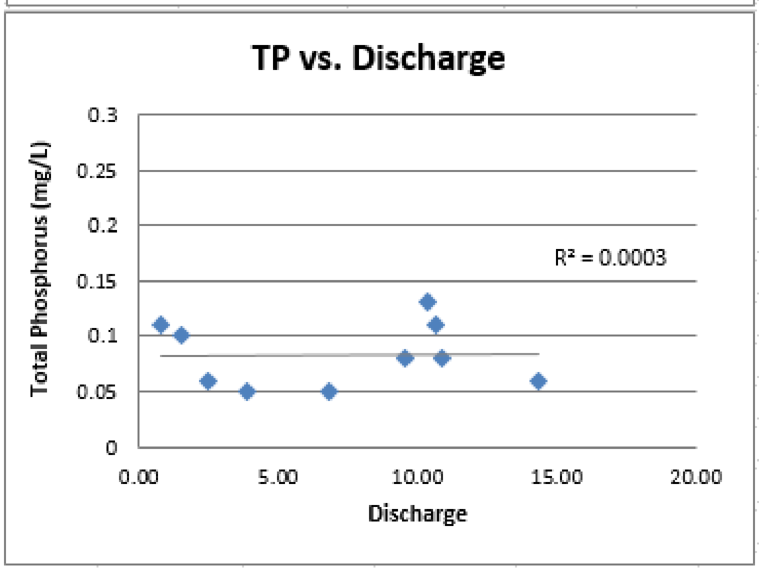
Frank & Poet Creek – ADW 01

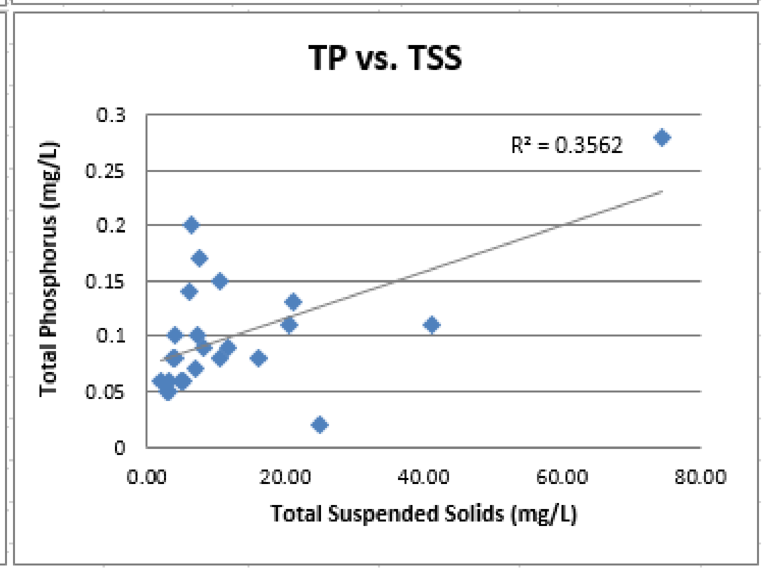


Blakely Creek – ADW 02

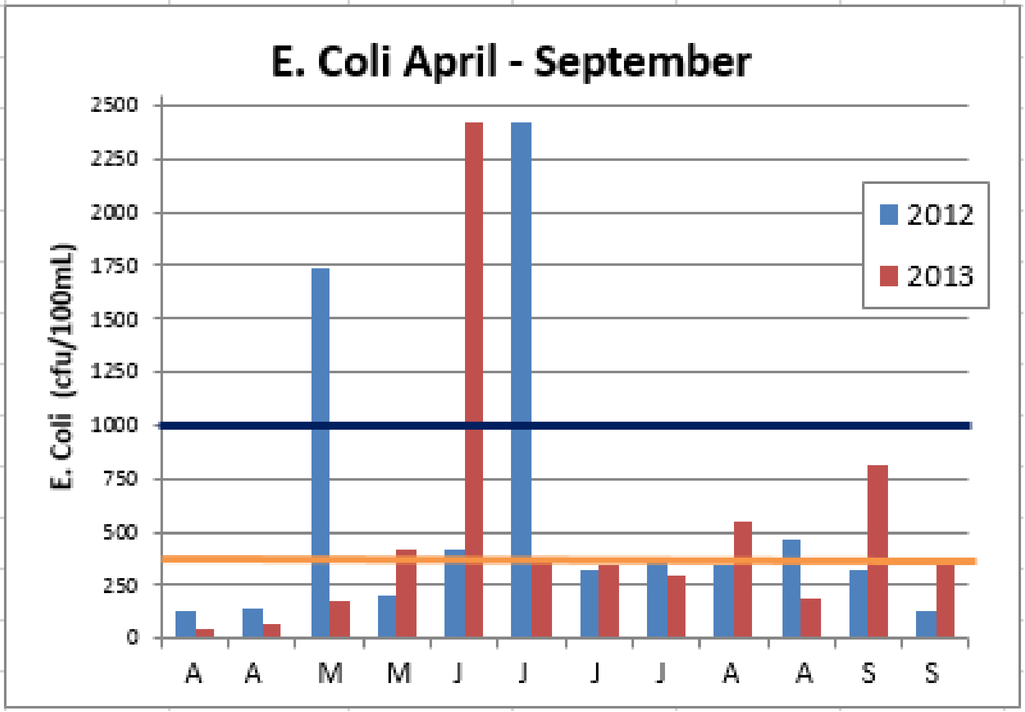




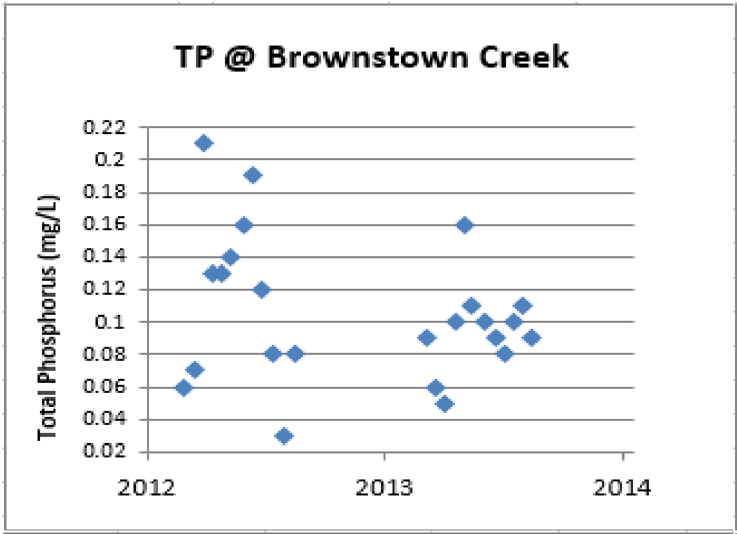


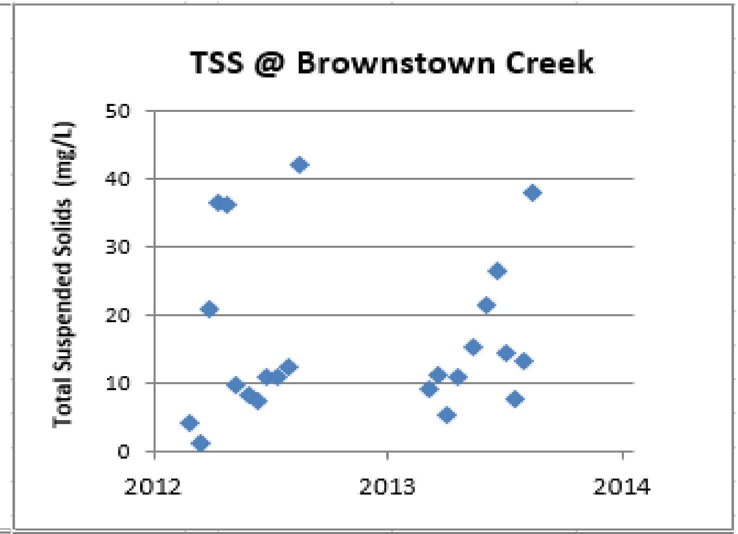


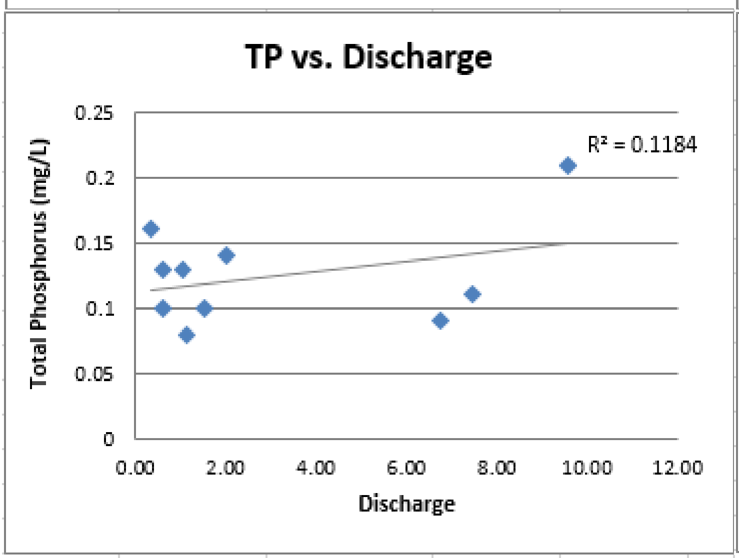
Blakely Creek – ADW 02

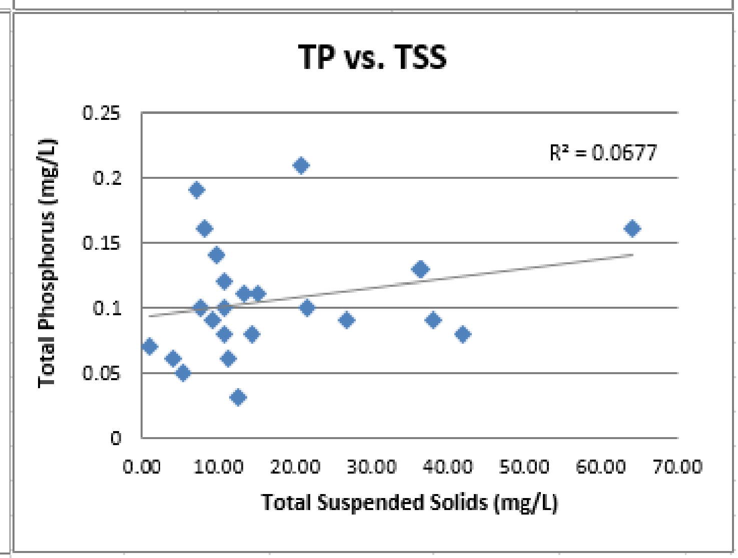


Brownstown Creek – ADW 03

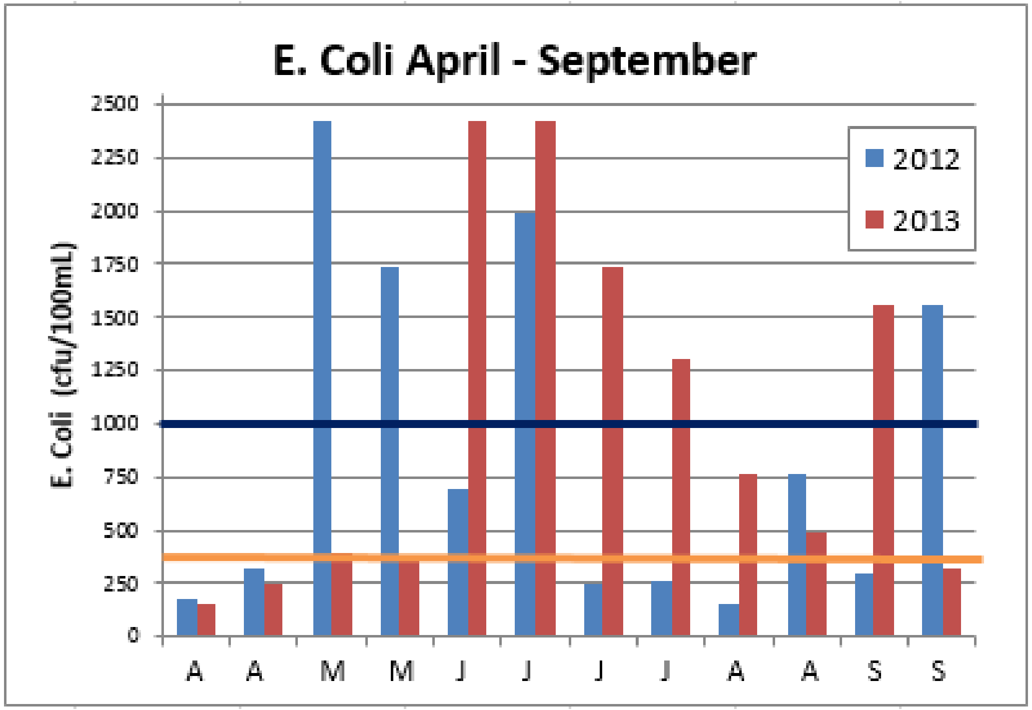




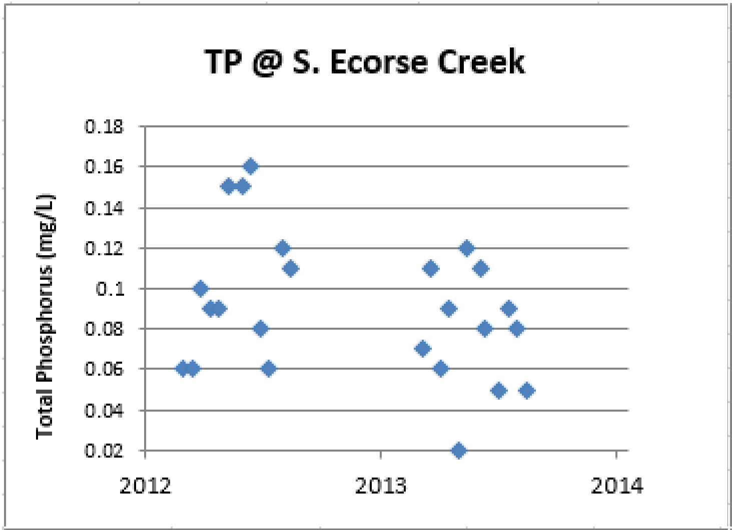


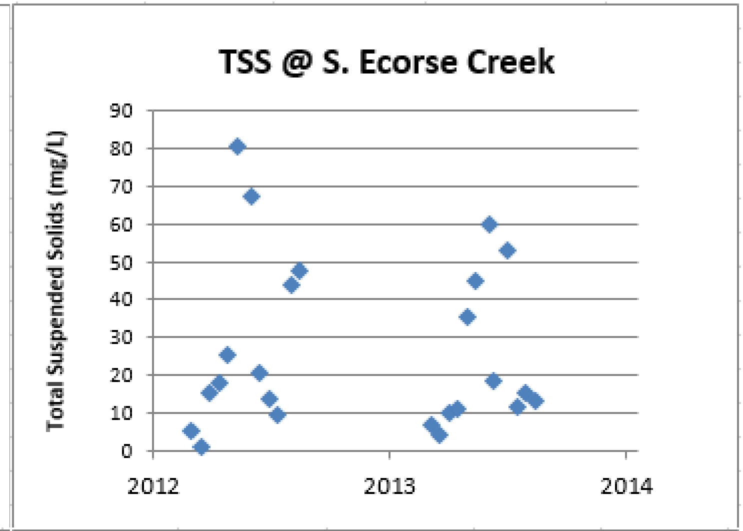


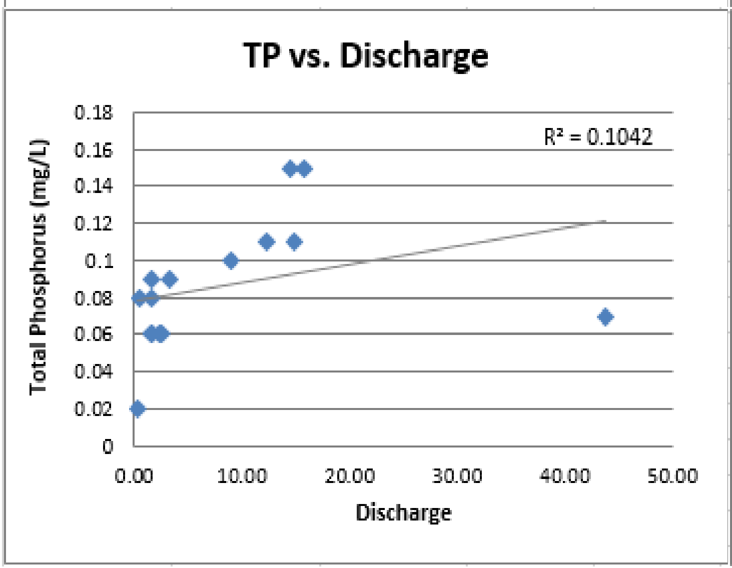
Brownstown Creek – ADW 03

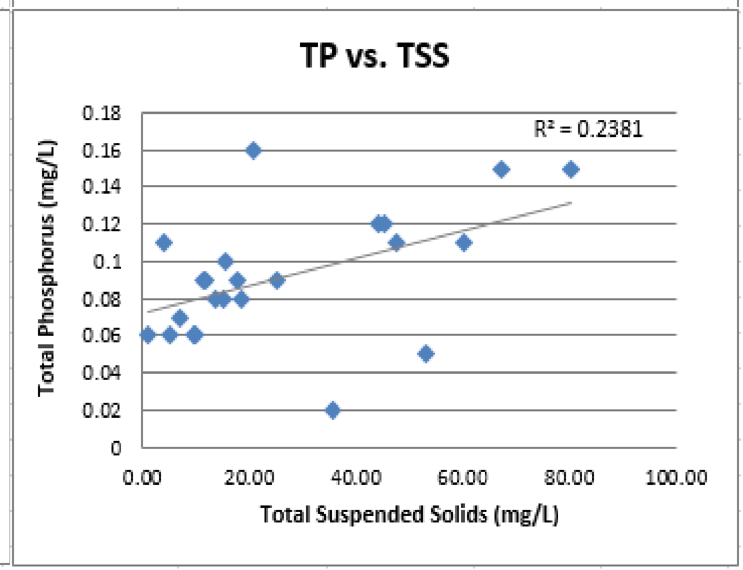


S. Branch, Ecorse Creek – ADW 04

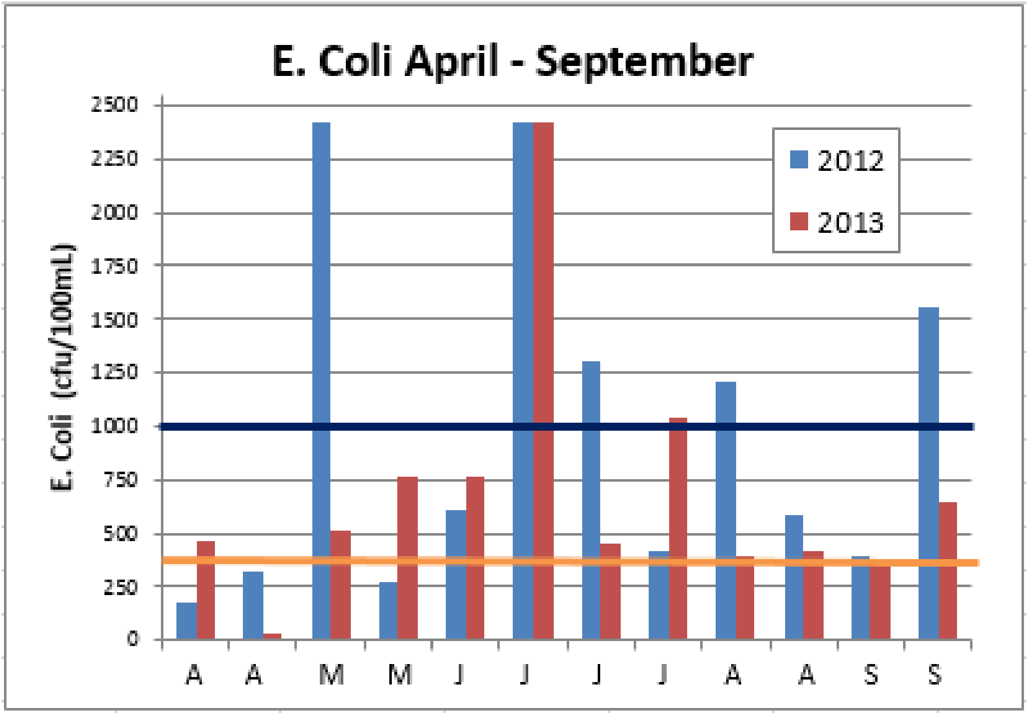




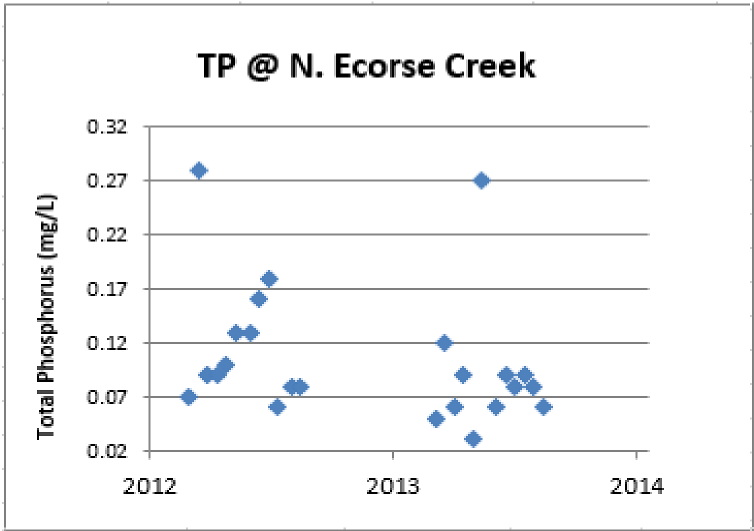


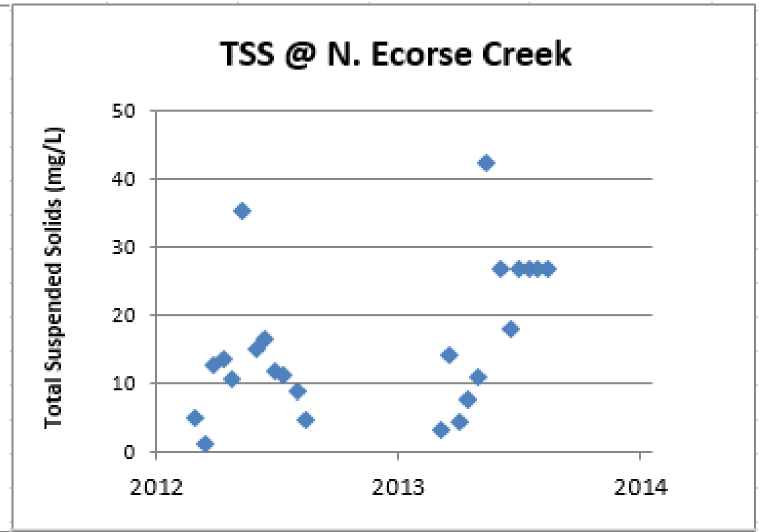


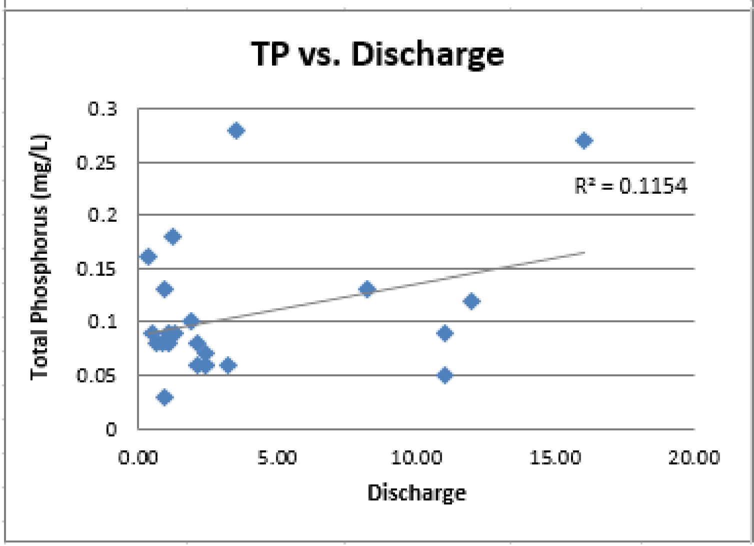
S. Branch, Ecorse Creek – ADW 04

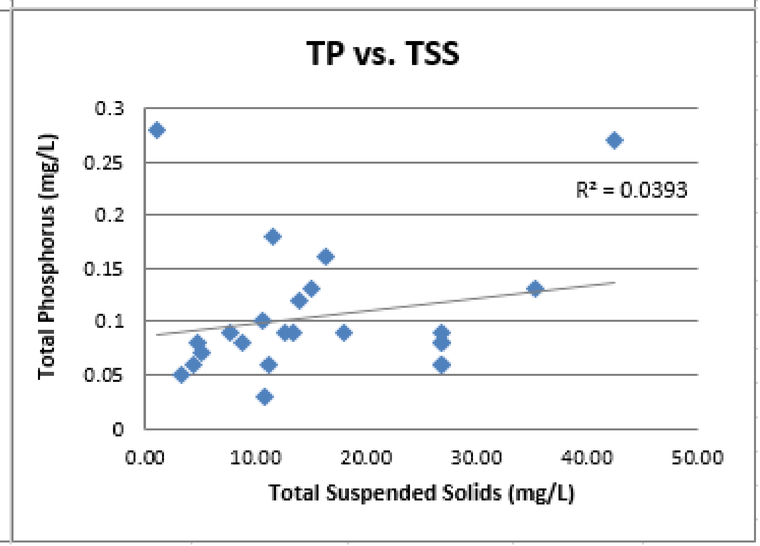


N. Branch, Ecorse Creek – ADW 05

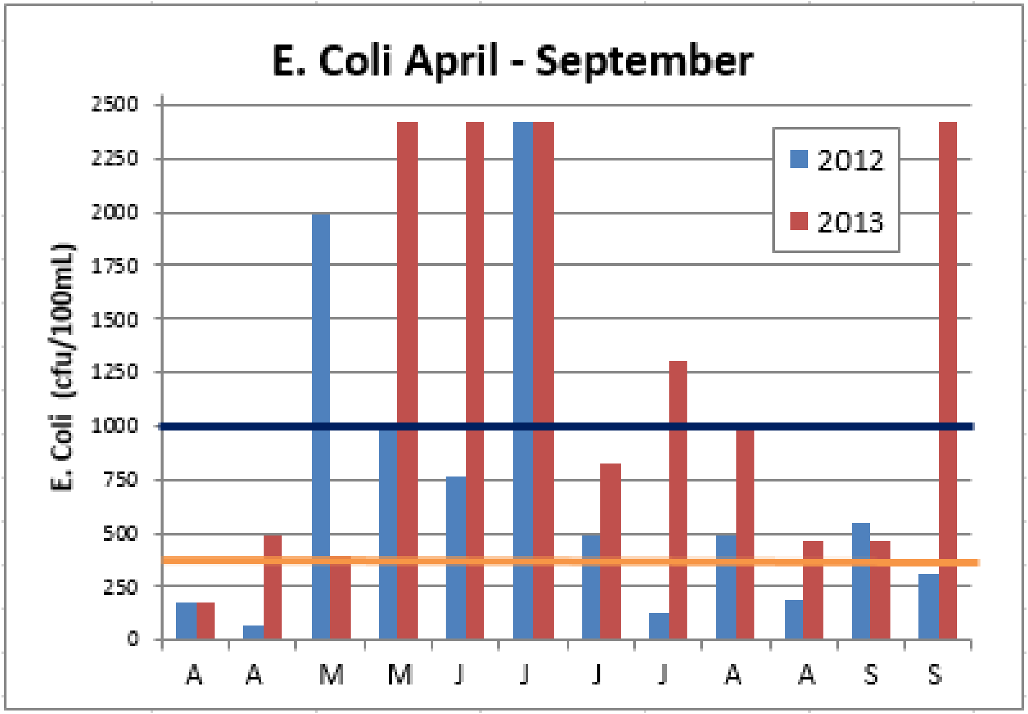




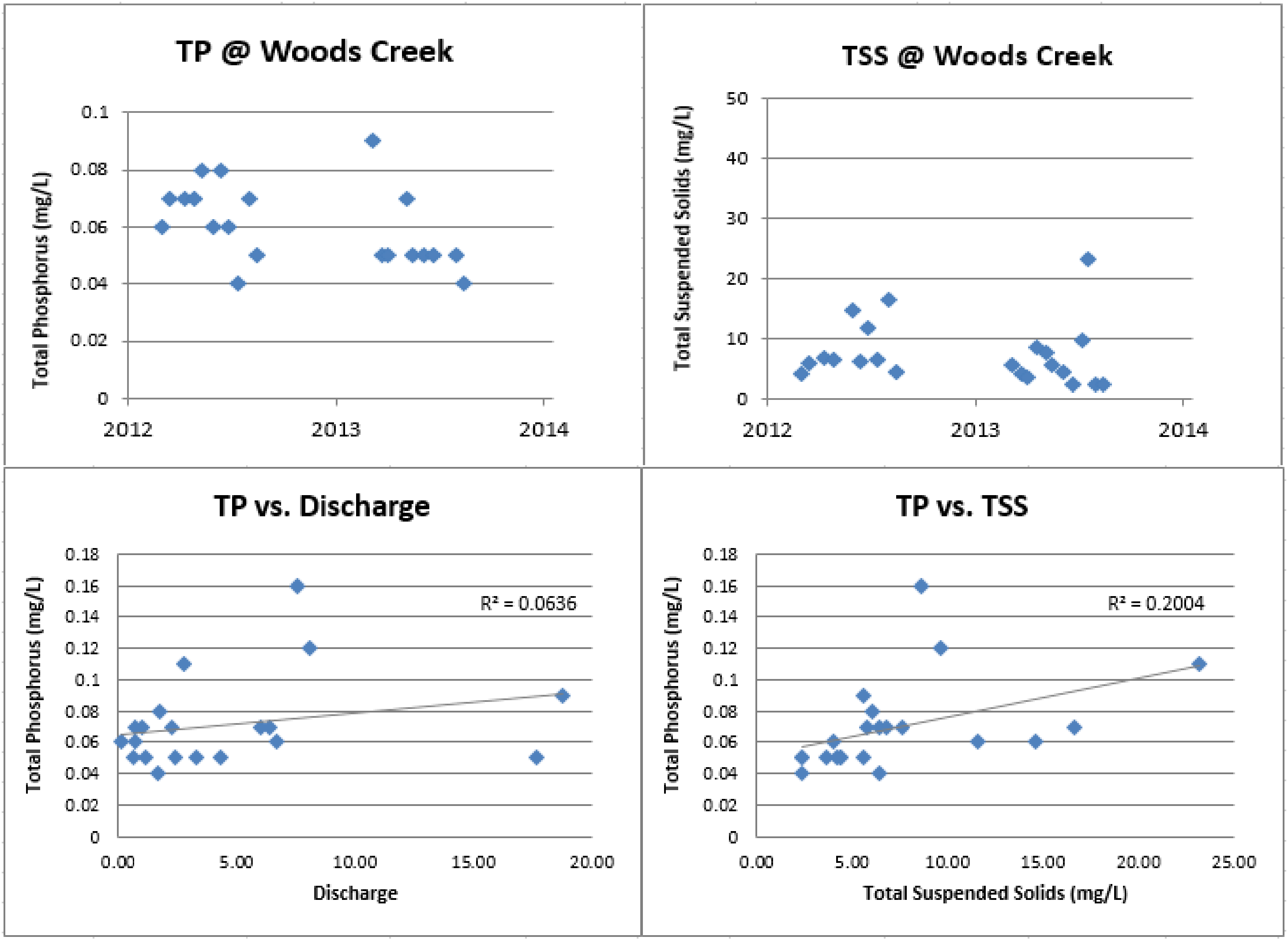




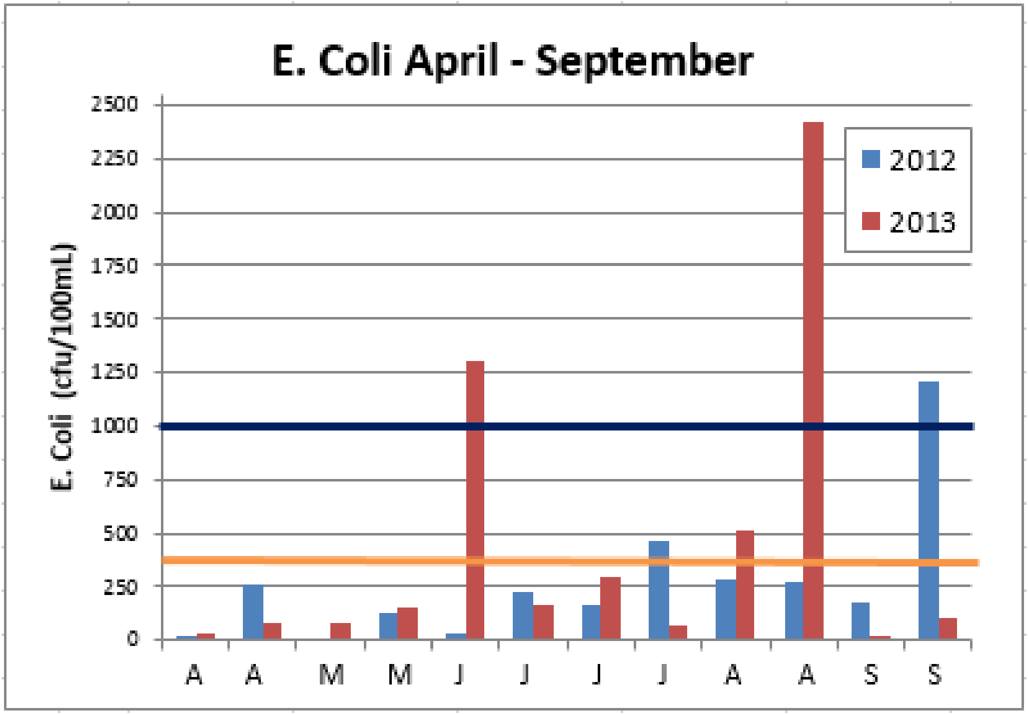
N. Branch, Ecorse Creek – ADW 05



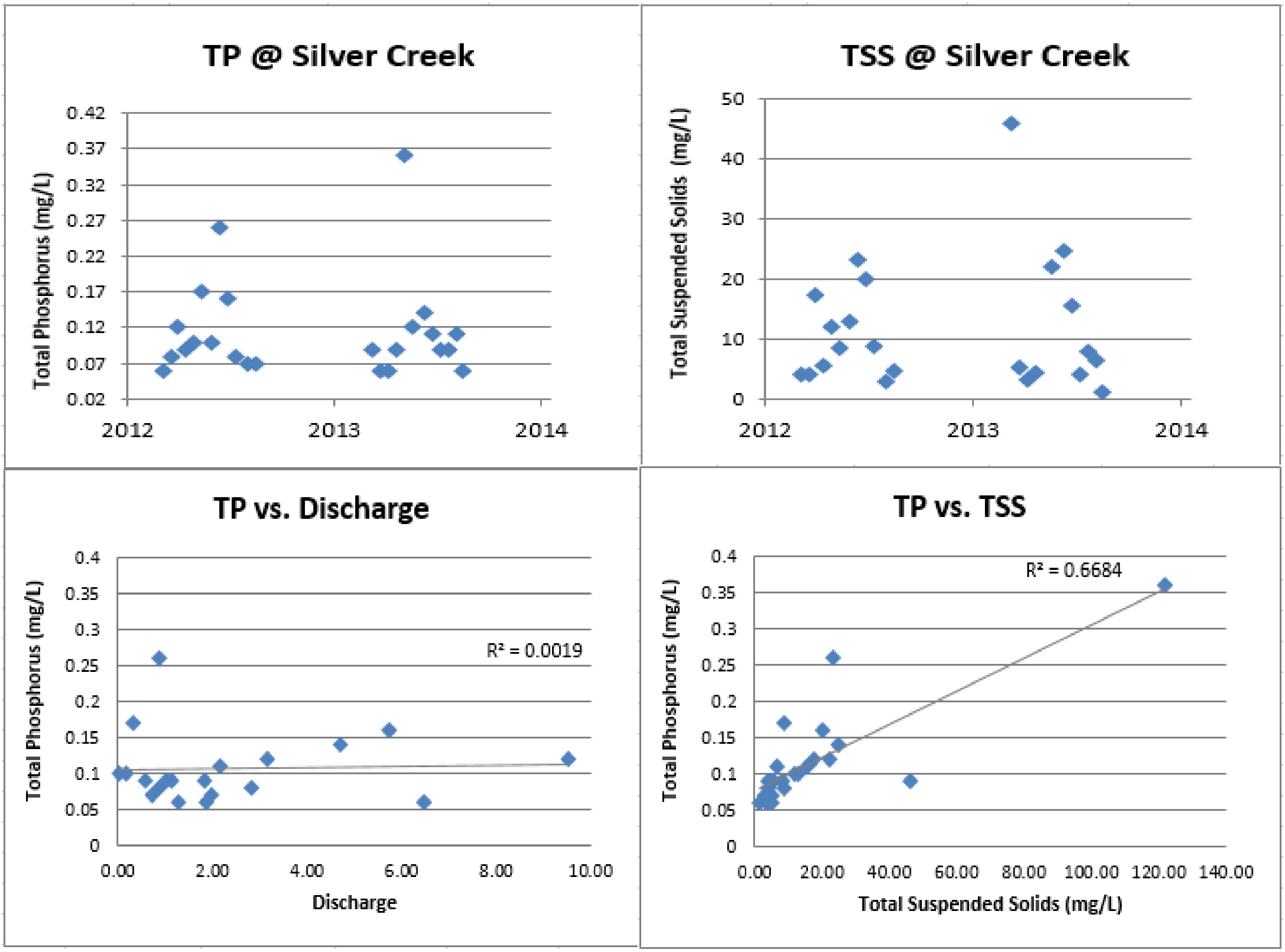
Woods Creek – ADW 06



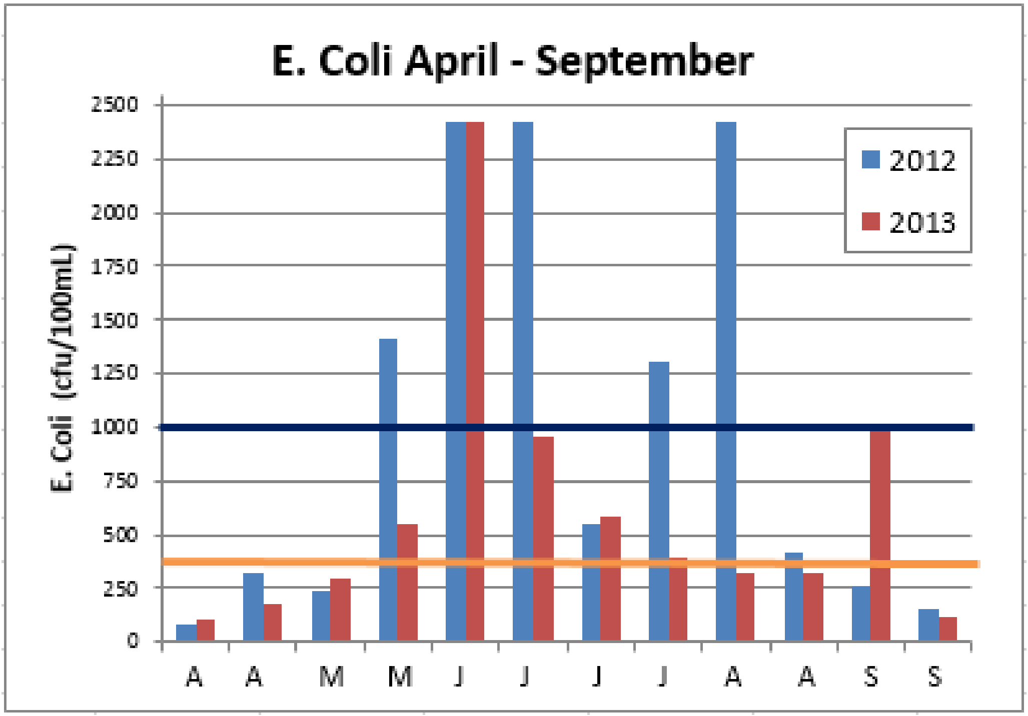
Woods Creek – ADW 06



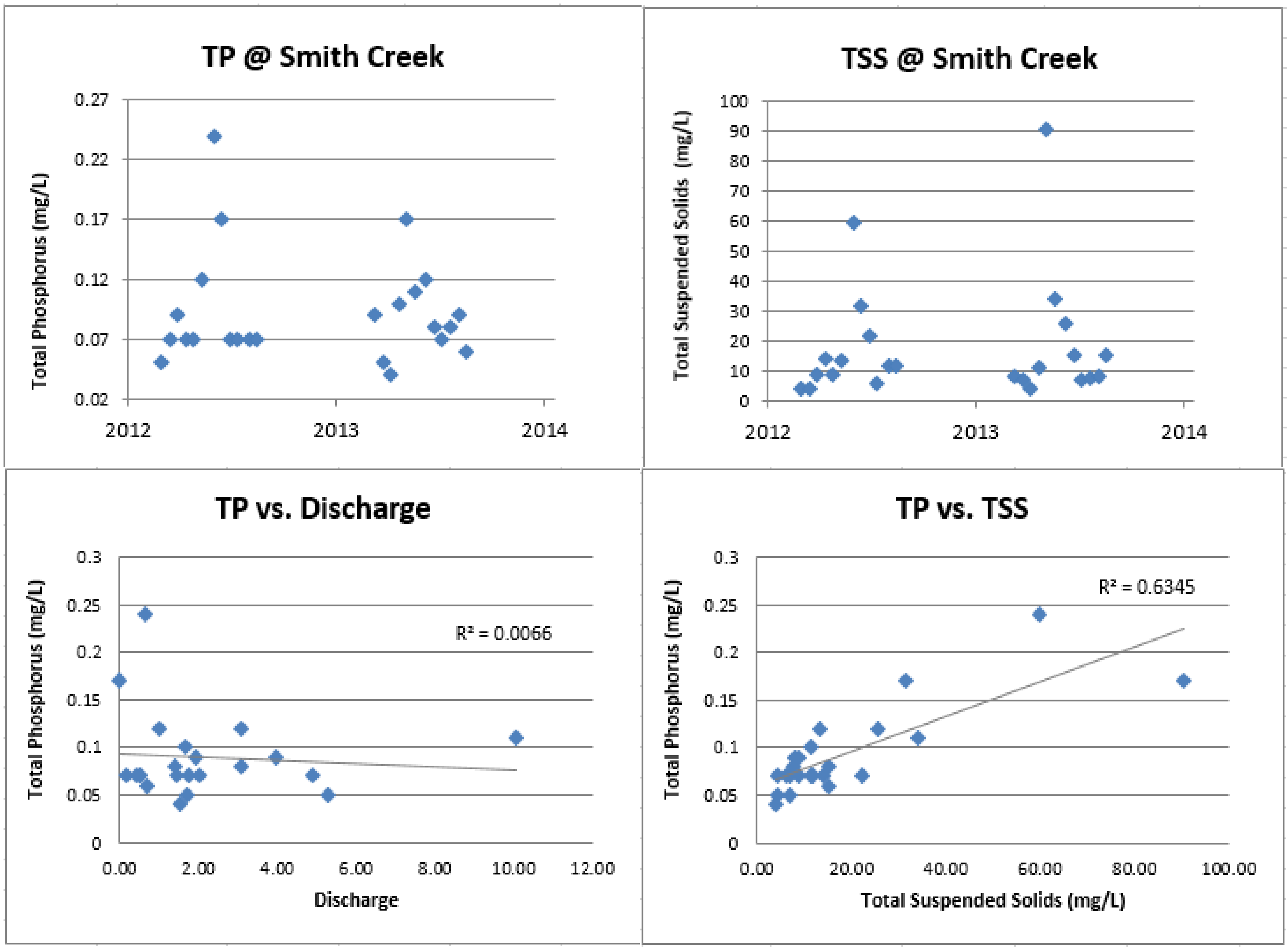
Silver Creek – ADW 08



Silver Creek – ADW 08



Smith Creek – ADW 09



Smith Creek – ADW 09