Appendix A.

Monitoring Progress for TMDLs in the Middle Huron Watershed

The MS4s in the Middle Huron River Watershed have already made significant progress toward achieving TMDL pollutant reduction targets. The below sections highlight the progress that has been made (through 2012) to date for each TMDL listed in stormwater permits for municipalities in the watershed. Additional, detailed monitoring results can be obtained from the 2011 and 2012 monitoring reports on the HRWC website at http://www.hrwc.org/middle-huron-sag/.

A. *Excessive nutrients (phosphorus) and algae in Ford Lake and Belleville Lake*

The following is excerpted from the *Phosphorus Reduction Implementation Plan for the Middle Huron River Watershed*.

Water Sampling Data Summary

In September 1991, a hazardous material response team was summoned to investigate a reported "green paint spill" in Ford Lake. The "paint" was really a severe algae bloom. This incident brought MDEQ field scientists to the lakes to conduct intensive monitoring of the Huron River and its tributaries from 1992-1994; this monitoring formed the basis for the development of the phosphorus TMDL. The primary water quality parameter measured by MDEQ was Total Phosphorus (TP).

MDEQ has continued to conduct water quality monitoring in the Huron River and in Ford and Belleville Lakes since the development of the TMDL through 2006, and then again in 2009. Each monitoring season, from April to October, state field scientists visited the watershed one time per month to measure nutrients and ambient water quality parameters at two river sites — the Huron River at Bandemer Park, and the Huron River at Michigan Avenue, just upstream of where the Huron enters Ford Lake. In addition, they measured water clarity, chlorophyll a, various nutrients, and other water quality parameters at various depths at four locations within each of the two lakes. Every five years, MDEQ conducts more intensive and extensive monitoring in the middle Huron through its basin monitoring program. The Huron River Watershed has been monitored through this program in 1997, 2002, and 2007; 2012 is the next year in which MDEQ will monitor the Huron.

In addition to monitoring conducted by the State, in 2002 HRWC developed a companion monitoring program for nine of the tributaries flowing into the middle Huron. HRWC staff and trained volunteers measure stream discharge, collect grab samples for lab analysis of TP, Nitrate + Nitrite, and Total Suspended Solids, and monitor other water quality parameters. Each site was originally visited one time per month. In 2006, analysis for *E. coli* was added. In 2008, storm sampling was added and monitoring frequency was increased to twice per month. Finally, in 2010, monitoring at stormwater investigative sites was added. A river site upstream of the confluence of Mill Creek is monitored for upstream conditions, and 9 tributary sites from Dexter to Ypsilanti are included in the program[1].

The data collected by the State is used to measure the progress towards meeting the phosphorus TMDL. Now, HRWC's tributary monitoring program is the only program collecting

[1] For more information including site maps and data reports, visit the program website: http://www.hrwc.org/our-work/programs/water-quality-monitoring/

data on nutrients in the tributaries flowing into the middle Huron, while the University of Michigan, in partnership with the City of Ann Arbor, monitors river sites. One shortcoming of the program is that it does not monitor Total Nitrogen, which would enable estimating the ratio of TP:TN, an indicator of conditions favorable to the formation of nuisance algal blooms. Dr. John Lehman at the University of Michigan conducted a study of this ratio from 2003-06 and concluded that TP is the limiting nutrient for blooms under most conditions.

A few general comments can be made about the data. TP concentrations entering and within Ford Lake have generally decreased over time. Analysis of 2009 data by MDEQ showed that concentrations entering Ford Lake were below the TMDL target of 50 µg/l every month except August (see Fig. 1). Concentrations within the lake were below the target except for in April and August. However, concentrations in Belleville Lake have been consistently above its lower target of 30 µg/l. In 2009, the Belleville Lake concentration target was met only once.

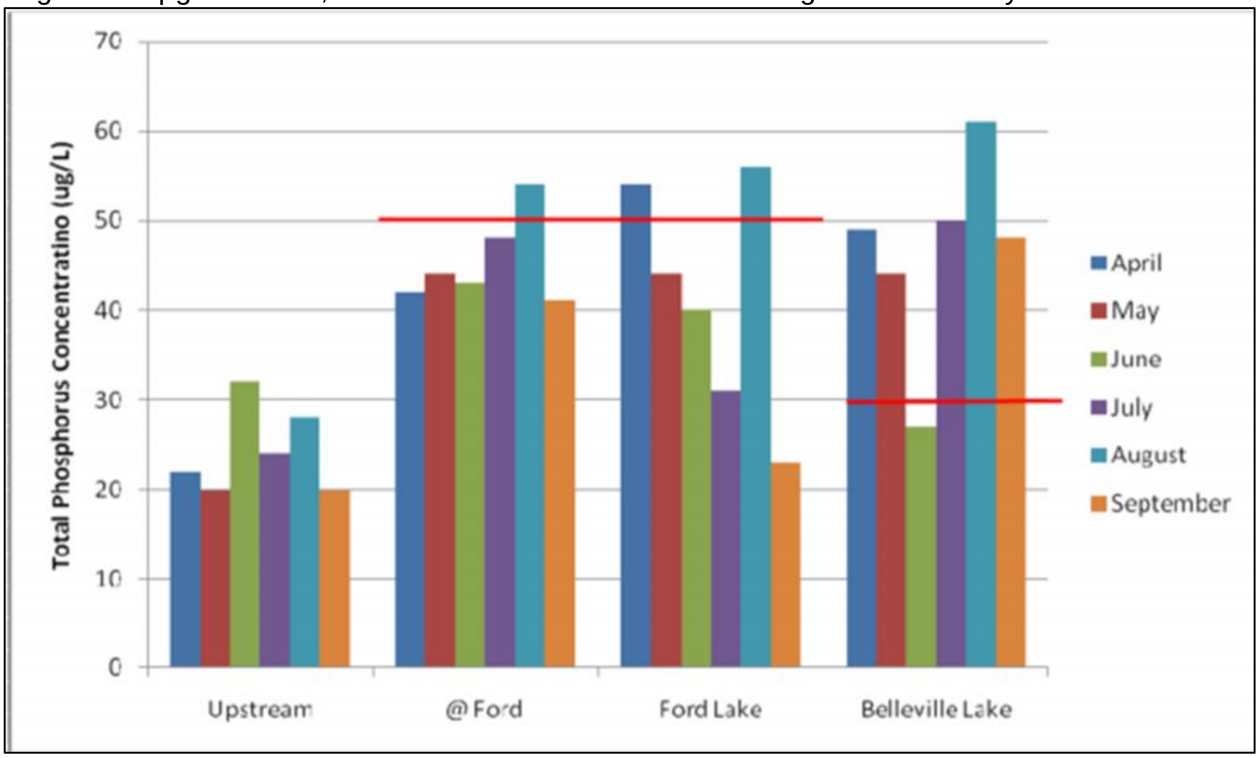

Figure 1. Total phosphorus concentrations at stream and lake stations sampled by MDEQ from April through September, 2009. There were only three instances for Ford Lake where results showed greater phosphorus concentrations than the goal of the TMDL. Belleville Lake was often well over its threshold for phosphorus loading.

Tributary monitoring indicates similar trends. Generally, total phosphorus concentrations have decreased in tributaries, especially those in urban areas, though 2010 results were highly variable. Concentrations outside of the urban area averaged 37 µg/l between 2008-10, while those inside the urban area around Ann Arbor averaged 52 µg/l. However, tributaries in urban areas declined by 28% from 2003-06 levels, while less-urban creeks only declined 17%. Finally, data from the station at the entry to Ford Lake showed an average concentration between 2008-10 of 53 µg/l, just above the target level of 50 µg/l (Fig. 2).

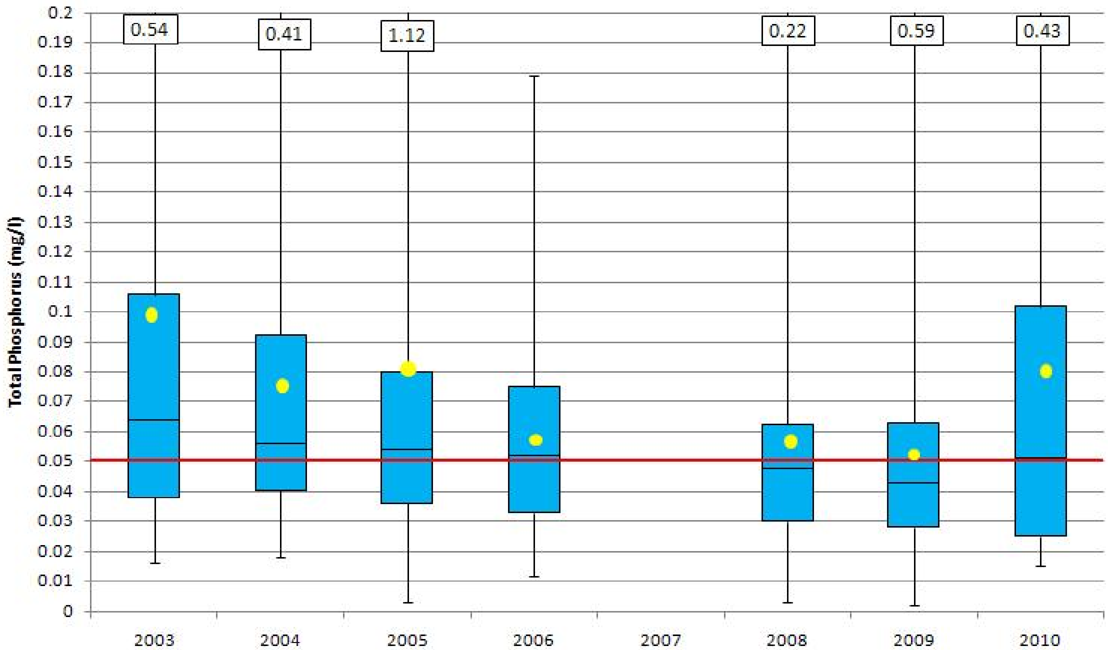

Figure 2. Total phosphorus concentrations for sampling across 10 tributary sites up to twice per month from May to September 2003 to 2010. Annual quartile and medians are shown in boxes, with maxima and minima in whiskers and annual means illustrated with points. Note the general decrease in total phosphorus concentrations from earlier years, especially 2003.

Phosphorus loading has also been assessed using a number of approaches. Extrapolating into seasonal loads suggests that the maximum load should reach 28,036 lbs April through September to be compliant with the TMDL. The TMDL assumes that about half (39,574 lbs) of the total modeled load comes during this growing season. This requires a total load reduction of 11,538 lbs. Of the total load, 24,293 lbs (61%) were estimated to be coming from nonpoint sources, with the remainder (15,561 lbs) from point sources. Again extrapolating from load allocations, the load reduction required of nonpoint sources is 14,035 lbs over the April to September growing season, while point sources are required to reduce by 1,165 lbs.

Based on past reporting, point sources have reduced loading to 9,438 lbs/yr or 34% below waste load allocations, though some monthly violations still occur. This represents a load reduction of 6,123 lbs from 1996 levels. The point source reduction represents a solid buffer for any load reduction shortfalls. Monthly point source load limit violations will need to be eliminated, and nonpoint source load reductions also must be accounted for to reach the TMDL for phosphorus in the watershed.

Current annual loading estimates vary from the original TMDL model. For 2003, the point source phosphorus load was reported as 23,800 lbs/yr. As indicated previously, the most recent reporting indicates an annual load of 24,355 lbs/yr by point sources – a significant reduction from 1996 levels. Loading from tributaries estimated by the 1996 model used for TMDL development indicates 22,000 lbs/yr was being contributed by nonpoint sources (see Table 5).

Table 5. Total Phosphorus Loading from Tributary Sources (Source: Kosek, 1996)

Significant Sources	Load from '96 Sampling	Load from '96 Model	Percent of Total	Percent Difference
Upstream Sources	30,000	30,000	37.5%	
Boyden Creek		961	1.2%	
Honey Creek		1,039	1.3%	
Other sources (upper section)	2,000		0.0%	
HBP Subtotal	32,000	32,000	40.0%	
Allens Creek	1,000	1,813	2.3%	81%
Traver Creek		1,855	2.3%	
Malletts Creek	700	3,945	4.9%	464%
Miller Creek		1,957	2.4%	
Swift Run	300	1,210	1.5%	303%
Other sources (middle section)	9,700	920	1.2%	-91%
Dixboro Road Subtotal	43,700	43,700	54.6%	
Ann Arbor WWTP	28,000	28,000	35.0%	0%
Fleming Creek	1,300	1,300	1.6%	0%
Superior Drain			0.0%	
Other sources (lower section)	7,000	7,000	8.8%	0%
Michigan Avenue Total	80,000	80,000	100.0%	

However, due to the large set of data obtained through monitoring, there is a much richer set of data available for loading analysis. Instead of using land use models or extreme extrapolation from a few data points, HRWC was able to apply statistical techniques based on flow-concentration relationships that provide much more accurate and current loading estimates (Table 6). Load estimates were computed using all monitoring data for tributary sites from 2003-10. The statistical model also accounts for the sampling months. See Appendix A for statistical modeling details. Data from 1995 was also modeled for comparison.

Table 6. Total phosphorus loading estimates (lbs/day) for select river and tributary locations.

Site	TP Mean Daily Load Est. (2003-10)	TP Mean Daily Load Est. (1995)	% Difference
Huron @ N. Territorial (upstream)	50.99	41.07	+24.2%
Mill Creek	39.51	30.25	+30.6%
Honey Creek	4.62	2.22	+108.1%
Allens Creek	3.27	2.74	+19.3%
Traver Creek	1.06	5.08	-79.1%

Fleming Creek	6.55	3.52	+86.1%
Millers Creek	0.38	5.36	-92.9%
Malletts Creek	11.72	14.76	-20.6%
Swift Run	1.60	0.82	+95.1%
Superior Drain	0.76	NA	NA
Huron @ Ford Lake (US-12)	151.43	200.59	-24.5

Overall, this analysis indicates that loading to Ford Lake has decreased by an estimated 25%. Total phosphorus loading to Ford Lake over the April to September TMDL period is estimated to be 27,655 lbs, which is 381 pounds below the TMDL target.

In 2003, the U.S. EPA awarded a 3-year STAR grant to the University of Michigan for a new study of the middle reach of the Huron River and Ford Lake and Belleville Lake that provides a more comprehensive assessment of nutrients and the factors that influence nuisance algal blooms. Dr. John Lehman was the Principal Investigator. His team found the following results:

1. From June 2003 to December 2004, 33427 kilograms (kg) of total phosphorus (TP) entered Ford Lake. During the same time period, AAWWTP reports discharging 12,427 kg TP to the Huron River (37%).
2. Of the 12,427 kg P that AAWWTP discharged to the Huron River, only 8,854 kg (71%) emerged from Superior Pond. This represents 26% of the load to Ford Lake.
3. More TP entered Ford Lake during May 2004 as a result of the 22 May flood than had been discharged by AAWWTP in the previous year.
4. From June 2003 to March 2005, 4,279 kg of dissolved phosphorus (DP) was discharged from Barton Pond into the Huron River above Ann Arbor. During the same time, 12,205 kg DP was present below Geddes Pond and upstream of the AAWWTP outfall. This represents an increase of 7926 KG added within Ann Arbor above its WWTP.
5. Also from June 2003 to March 2005, 22,804 kg DP exited Superior Dam, an increase of 10,599 kg from upstream of the WWTP (N.B. This is less than the reported discharge by AAWWTP owing to retention within Superior Pond).
6. 23,002 kg DP entered Ford Lake, an increase of 198 kg from Superior Rd. to Spring St.
7. For Particulate P (PP; DP + PP = TP), 16,771 kg discharged from Barton Pond; 12,043 kg discharged from Geddes Pond. This is a net loss of 4,728 kg PP removed by Argo and Geddes Ponds. The balance between PP retention and DP release resulted in the net addition of 3,198 kg P to the River within Ann Arbor.
8. From June 2003 to March 2005, 16,190 kg discharged from Superior Dam. This is an increase of 4,147 kg compared to upstream of the AAWWTP. The N/P ratio of this added particulate matter is too low for it to be biological matter. It is almost surely eroded soil. 18,349 kg PP entered Ford Lake. This is an increase of 2,159 kg. The N/P ratio of this particulate matter is too low for it to be biological matter. It is soil, too.
9. 41,351 kg TP entered Ford Lake and 32,445 kg exited. This was a removal of 8,906 kg or a retention of 21.5%. The proportioning between dissolved and particulates was such that 19.3% of DP and 24.3% of PP were retained. [i]

The STAR project contributed much needed information on the role resuspension of phosphorus particles in Ford Lake plays in the production of nuisance algal blooms.

- Phosphorus release rates of sediment core samples in Ford Lake were up to 3X greater than release rates from multiple other eutrophic lakes located in western Michigan. Internal loading was found to play a key role in seasonal bloom development in Ford Lake.
- Internal loading of phosphorus is complicated, and interwoven with concentrations of other nutrients like nitrogenous compounds. Phosphorus release was found to be more prevalent with oxygen depletion of the lower water column, a common problem in the summer; an iron trap forms that causes phosphorus and iron to leach from the bottom sediments and into the open water, exacerbating the algal bloom.[ii]

Summary of Phosphorus Loading Reduction and Current Status

HRWC and volunteers have collected data since 2003 at nine tributary monitoring stations within the TMDL drainage area. The University of Michigan and DEQ have collected samples at Ford Lake, Belleville Lake and several sites in the Huron River. Seasonal (April – September) and annual loads were calculated based on original 1995 data collected by DEQ[iii] and 2003-10 data collected by HRWC[iv] and Dr. John Lehman at the University of Michigan[v].

- Sampling in pre-ordinance years (before local ordinances to reduce phosphorus use in lawn fertilizers were mandated), 2003-2007, at Ford Lake showed an average total phosphorus concentration of **0.0526 mg/L**, which translates into an estimated **TP load of 48,527 lbs/yr**.
- Since 2008, the **mean TP concentration entering Ford Lake was 0.0528 mg/L**, which is approximately the same as the concentration from 2003-2006. Through 2009, the mean concentration was much lower than when results from 2010 are taken into account. Mean concentration was much higher in 2010 than in previous years pulling the mean concentration upward.
- The total TP concentration from 2003-10 was 0.0527 mg/L, which translated into an estimated **TP load of 54,382 lbs/yr, or 27,191 lbs over the growing season (TMDL limit period).** This total figure is below the total load limit calculated from the TMDL.
- Sampling from tributaries indicated a strong decrease in phosphorus concentrations through 2009, with greater variability in 2010.
- Reporting from point sources showed that, collectively, they discharged well below their cumulative waste load allocation, though a small number of exceedences of monthly limits occurred. Thornton Farms was not included in the analysis.

B. *Excessive bacteria (E. coli) in the Huron River and tributaries downstream of Argo Dam to Geddes Dam*

The following is excerpted from the *Bacteria Reduction Implementation Plan for the Middle Huron River Watershed*.

Sampling Effort and Data Summary

The Huron River (Geddes Pond) was placed on the Section 303(d) list in August, 2001, due to impairment of recreational uses by the presence of elevated levels of pathogens. Historical exceedances of state standards and high bacteria counts were common in the 1970s, 1980s, and 1990s, although improvements have been made since the peaks of the 1980s. The Huron

River Pollution Abatement program of the late 1980s and early 1990s identified numerous sources of pathogens in the TMDL area and pursued their elimination. A compilation of this historical data is contained in Appendix C (Limno-Tech, Inc., 2000). These data indicate that Lower Geddes Pond has consistently exhibited the highest bacteria concentrations among all Huron River reaches in the Ann Arbor area. Geddes Pond is also the receiving water for three direct tributaries (Millers Creek, Malletts Creek and Swift Run Creek), plus Traver Creek and Allens Creek that enter upstream of Island Park. Historic data indicate that each of these tributaries exceed the WQS for pathogens as well. Background (upstream) levels of *E. coli* in Barton Pond were determined to be 10 *E. coli* per 100 ml. Additional sampling conducted in 2001 by the DEQ corresponds with the findings of the historical data and indicates that the listed reach and its tributaries continue to exceed the WQS for *E. coli*. These sampling results are included in Appendix D.

In 2002, sampling efforts were focused on source identification. With the input of stakeholders, appropriate sampling locations were selected throughout each tributary and sampled on a rotating basis from May to October, 2002. In addition, routine monitoring was conducted at the mouth of each tributary and on Geddes Pond. These sampling results are included in Appendix D. The Huron River Watershed Council (HRWC) established long-term monitoring sites on these tributaries and at the Allens Creek outfall in 2003 and began monitoring for E.coli in 2006 through present day. Sampling results from this effort are included in Appendix F.

The results of the 2002 data indicate that Geddes Pond exceeded the 30-day geometric mean (130 *E. coli* per 100 ml) for full body activities during the second half of July, and all of August. There was an additional single sampling event that exceeded the full body activity daily maximum standard (300 *E. coli* per 100 ml) in September. Each tributary sampled had elevated *E. coli*, and seemed to be influenced by wet weather events. Data collected by the HRWC over the past five years shows that the seasonal average *E. coli* concentration for each tributary still exceeds the 30-day standard of 130 E.coli per 100 ml, despite surrounding area municipal strategies to mitigate this situation. These data are shown in Figure 1. Although these seasonal averages are high, there were several individual sampling results at each site with *E. coli* concentrations that were below single event and 30-day standards. These lower results mostly occurred in May 2009. (see Appendix F).

Attempts were also made to identify the sources of *E. coli* to determine if the source was human, non-human, or a combination thereof. Initially, one DNA sampling event was conducted in August 2002, with results being inconclusive. In 2005, the Washtenaw Drain Commissioner's office (now known as the Washtenaw County Water Resources Commissioner) conducted a study with the Ann Arbor municipal storm sewer system to identify species-specific sources of *E. coli*, applying library-based genotypic bacteria source tracking (BST) (see Appendix G). Storm sewers on Buckingham Rd and Sheridan Rd, the subjects of the study, are integral to the Malletts Creek IDEP program, and were found to have no illicit sewer connections during an IDEP investigation conducted in 2003. However, *E. coli* sampling results indicated that high concentrations of the bacteria were still present in the storm sewers, even in dry weather conditions (see Figure 3). BST analysis of samples collected in spring and fall of 2005 indicated that pets (primarily cats) and raccoons were the primary sources of *E. coli* in the storm sewers at both sites. Human sources were also identified in a couple of the samples.

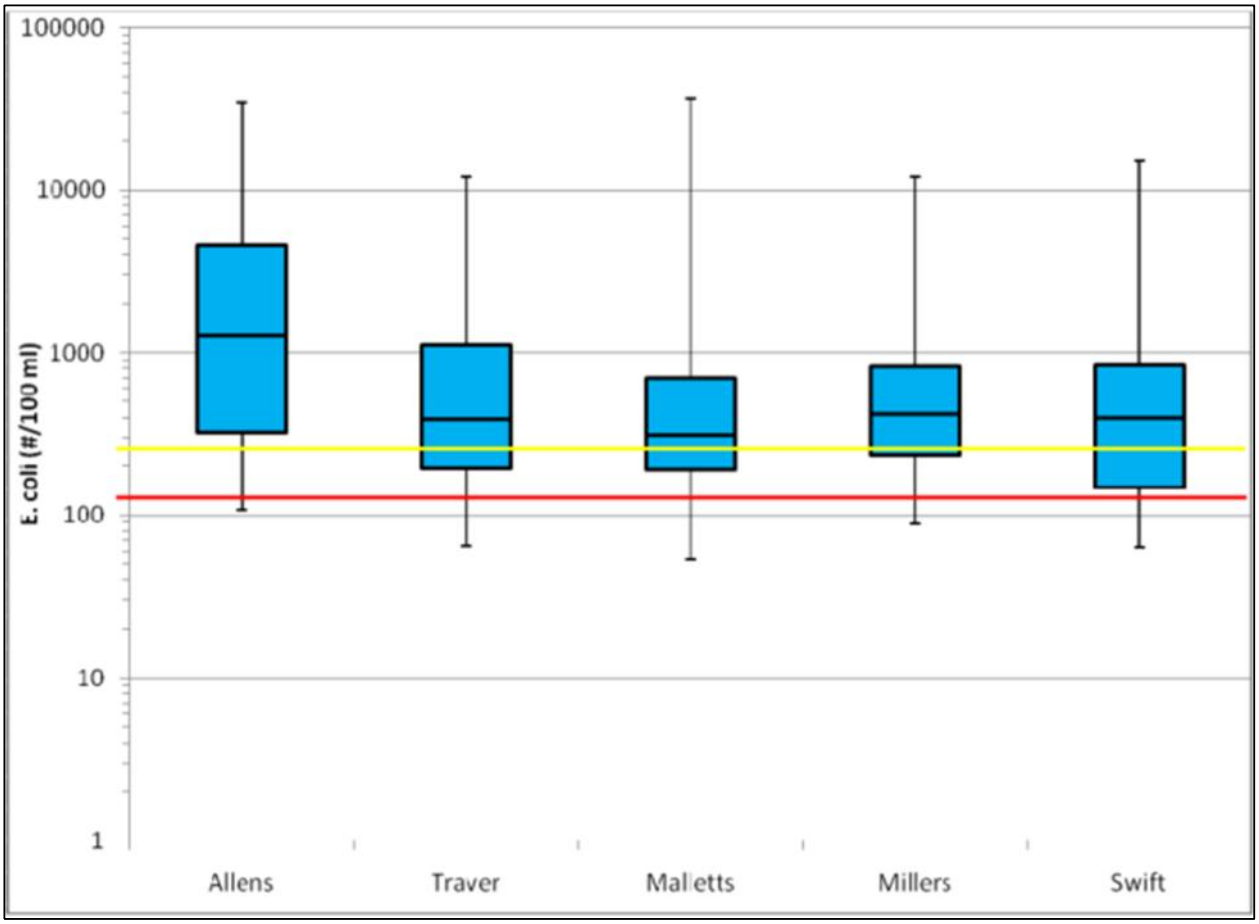

Figure 3. Range of E. coli sample results from monitoring 2006-10 at 5 tributaries to the TMDL section of the Huron River. Boxes represent 25-75% quartile data range, with the center bar representing the median. Wiskers represent minimum to maximum sample results. Lines indicate the full-body contact standard.

C. *Excessive bacteria (E. coli) in Honey Creek*

Note: the implementation plan for Honey Creek is currently under development. A summary from this plan will be provided upon completion and prior to October 1, 2013.

D. *Aquatic biota impairment in Malletts Creek*

The following is excerpted from the *Implementation Plan for the Malletts Creek Biota TMDL*.

Water Quality Sampling Data Summary
Water Quality data collected since 2003 by HRWC and partners at the Malletts Creek monitoring station at Chalmers Drive (Figure 4) is the primary source information to gauge TSS levels. The HRWC Water Quality Monitoring Program collects water samples for analysis of TSS, among other variables. Since the data collection began in 2003, the **average TSS concentration is 18.1 mg/L**, with samples showing a slight declining trend over that period of time. The mean concentration is well below the target of 80 mg/L. But this average represents all samples collected across a variety of conditions (i.e., wet and dry). **Wet weather** monitoring resulted in event concentrations of 33 and 222 mg/L or an **average of 127.5 mg/L** (Figure 5).

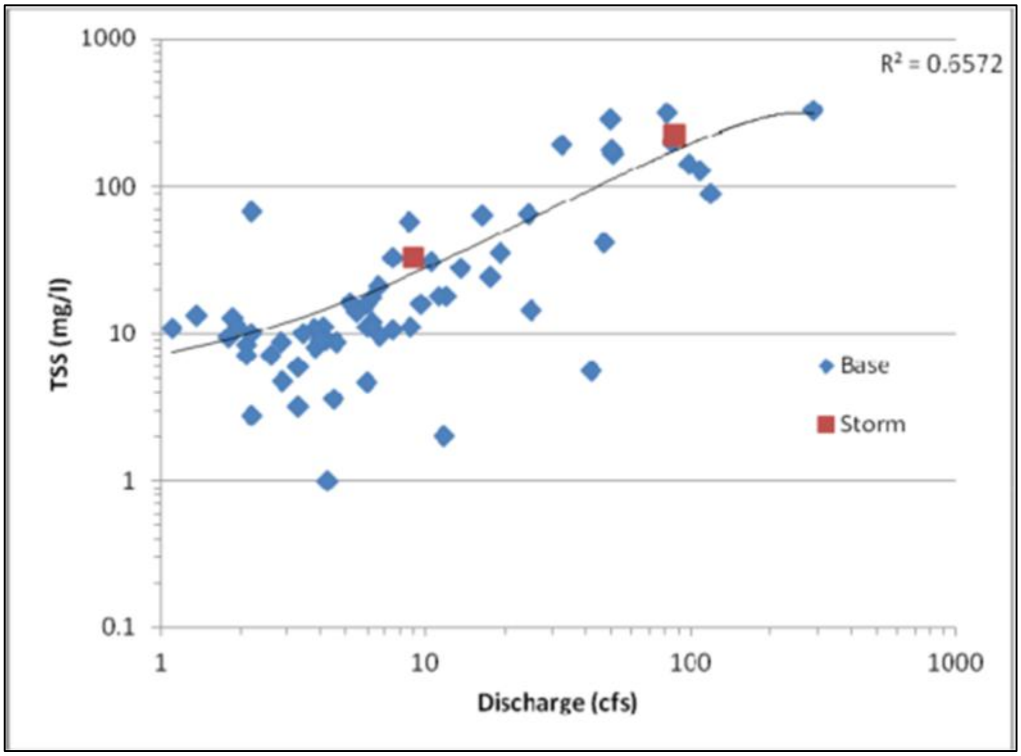

Figure 4. TSS samples showing the relationship to observed stream discharge in Malletts Creek at Chalmers Rd.

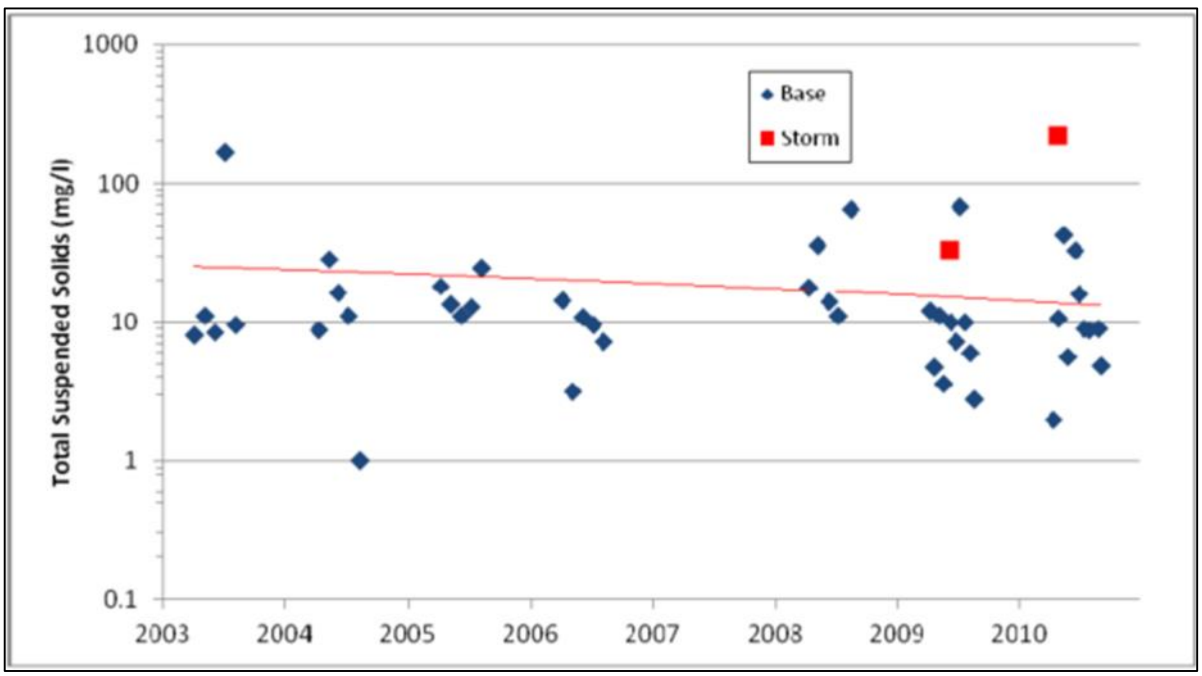

Figure 5. TSS samples by year from Malletts Creek at Chalmers Rd. Red line indicates a slight downward trend in concentration.

The estimated average daily load range is calculated at two to three times the target load. Inputting stream flow and the TSS sample concentrations into a load estimation model (LOADEST) results in an estimated average daily load range of 6,213 to 8,527 lb/day or roughly 1,100 to 1,500 ton/yr (2,464,000 to 3,360,000 lb/yr). The original TMDL model was based entirely on land use projections, while the estimation from HRWC is based on sampling data, so the estimates are not directly comparable. Further, the load estimates are imprecise because the sampling data were quite variable (Figure 5). The full 95% confidence interval of load estimates ranges from 502 to 3,721 ton/yr (1,124,480 to 8,335,040 lb/yr).

Macroinvertebrate Sampling Data Summary

Macroinvertebrate data collected since 1992 by HRWC and partners at four monitoring stations is the primary source of information on the benthic macroinvertebrate community in Malletts Creek.

Insects living in the creek compose the benthic macroinvertebrate population, along with clams and other mollusks, crayfish, and some other taxa. Typically, monitoring focuses on insects (in aquatic stages of development) as they are representative of a variety of trophic levels, are sensitive to local environmental conditions, and are easy to collect. Since the benthic population depends on the physical conditions of the stream as well as water quality, its composition indicates the overall stream quality. Greater insect diversity indicates good stream quality, and is measured by the number of different insect families. Eighty-seven benthic insect families are found in the Huron River watershed.[vi]

Much of the benthic macroinvertebrate data cited is from HRWC's Adopt-A-Stream Program, which relies on trained volunteers to monitor more than 70 sites in the watershed, including 30 in the Middle Huron watershed. Monitoring data has been gathered since as early as 1992 at some sites through annual spring and fall collection days, and a winter stonefly search each January. All sites have been monitored at least once per year since the commencement of the monitoring at that site.

Insect families belonging to the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are known as the EPT families, which are indicators of alterations in stream flow, temperature, oxygen and other changes that raise metabolic rates. Sensitive insect families, such as Perlidae (Perlid stonefly) and Brachycentridae (log-cabin caddisfly), are highly sensitive to organic pollution; 19 of the 87 benthic insect families living in the Huron River watershed are sensitive.[vii]

Winter stoneflies, which are active in January and require high levels of oxygen, are indicators of good stream quality. Absence of winter stoneflies suggests that toxic pollutants may be present. This is because organic pollutants, such as fertilizer and human or animal waste, are associated with stormwater runoff in warmer months. Because there is usually little or no stormwater runoff in January, there is a greater likelihood that any pollutants in the stream are persistent (long-lasting) inorganic toxic substances that are present in the bottom of the streambed. Conversely, at a site where insect diversity is lower than expected but winter stoneflies are present, organic pollutants are more likely to be the problem.

The Adopt-A-Stream Program also rates the "ecological conditions" at each site, which are determined by both the biological and physical conditions of the site. Biological conditions include the diversity of insect families, EPT families, and sensitive families. Physical conditions are determined by conductivity results and "measuring and mapping" assessments of habitat. These assessments involve examining characteristics such as the stream banks, stream widths and depths, and bed material (such as sand, gravel, or muck). When interpreting the biological and physical conditions, more diversity is generally expected at larger sites or sites with cooler summer stream temperatures.

Following are the site summaries through January 2011:

Malletts Creek @ S. Main Street
This monitoring site is located on a headwater tributary to Malletts Creek and drains about 2 square miles. Approximately 75% of the watershed is developed. Monitoring began here in 1999 and has been visited 23 times by the Adopt-A-Stream program. Insect diversity is poor, and neither sensitive families nor winter stoneflies are present. The conditions of stream banks, streambed, and streamside vegetation are average. Water quality is poor.

The overall condition per the Adopt-A-Stream Integrated Model is POOR.

Malletts Creek near I-94
This monitoring site has a watershed of 4 square miles. Approximately 81% of the watershed is developed. Monitoring began at this site in 1992 and has been visited 31 times. Insect diversity is poor, and neither sensitive families nor winter stoneflies are present. The conditions of stream banks, streambed, and streamside vegetation are poor. Flashy stream flows are evident. Water quality is poor.

The overall condition per the Adopt-A-Stream Integrated Model is POOR.

Malletts Creek @ Scheffler Park
This monitoring site is located on the main channel of Malletts Creek and drains 11 square miles. Approximately 85% of the watershed is developed. Monitoring began here in 1992 and has been visited 29 times by the Adopt-A-Stream program. Insect diversity is poor, and neither sensitive families nor winter stoneflies are present. The conditions of stream banks, streambed, and streamside vegetation are fair to poor. Water quality is poor.

The overall condition per the Adopt-A-Stream Integrated Model is POOR.

Malletts Creek @ Chalmers Road
This monitoring site is located on the main channel close to the outlet into South Pond. Approximately 85% of the watershed is developed. Monitoring began here in 1993 and has been visited 31 times by the Adopt-A-Stream program. Insect diversity is poor, and neither sensitive families nor winter stoneflies are present. The conditions of stream banks, streambed, and streamside vegetation are fair. Flashy stream flows are evident. Water quality is poor.

The overall condition per the Adopt-A-Stream Integrated Model is POOR.

The health of the macroinvertebrate community is not very different than conditions reported in a 1999 bioassessment of Malletts Creek completed as part of the Malletts Creek Restoration Plan (Riseng, C. and K. Lawrence. May 6, 1999. For the Washtenaw County Drain Commissioner, the City of Ann Arbor and Pittsfield Township) that included habitat and macroinvertebrate surveys based on data collected from six stations. In general, the macroinvertebrate community observed during the field survey was indicative of small, warmwater streams with high sediment loads and organic pollution. Based on calculation of the Procedure 51 summary metrics the quality of the macroinvertebrate community in Malletts Creek varied from acceptable to poor. The results of the habitat survey and rating metrics indicated the habitat structure in Malletts Creek ranges from fair to poor. The report’s authors concluded that extreme flashiness of Malletts Creek controls channel morphology, limits bank vegetation and stability and, therefore, limits the aquatic community diversity and stability.

Based on the monitoring results for TSS and macroinvertebrates to date, one must conclude that the impairment of the designated use for indigenous aquatic life and wildlife persists in Malletts Creek.

The Role of Flashiness in Malletts Creek

The documented poor habitat conditions and insect populations that persist in Malletts Creek highlight the continued need to look beyond TSS to the stream flow regime if sustained restoration is going to happen, and to ameliorate the use of practices that can reduce extreme flows. One measure to assess the ecological function of a stream from a flow perspective is to evaluate the "flashiness," or the rate and degree to which the stream increases and decreases in flow rate in response to a rain storm or event. The Richards-Baker Flashiness Index was developed for wadeable Michigan streams to provide a standard measure of flow dynamics[viii]. The index varies from 0 to over 1, where an index of 0 would represent a stream that never changes flow rate and 1 would indicate a highly variable and rapidly changing stream.
The USGS manages flow gages in Malletts Creek at Mary Beth Doyle Park (#04174514) and at Chalmers Road (#04174518). HRWC analyzed daily mean discharges at the Chalmers Rd. station from 1999 to 2010. Year to year, the flashiness of Malletts Creek has varied slightly with a slight downward trend (Figure 6). The most recent 3-year average flashiness index value is 0.723, which is among the flashiest quarter of all similarly sized streams in Michigan. It is also well above the median stream flashiness in a six-state Midwestern survey.

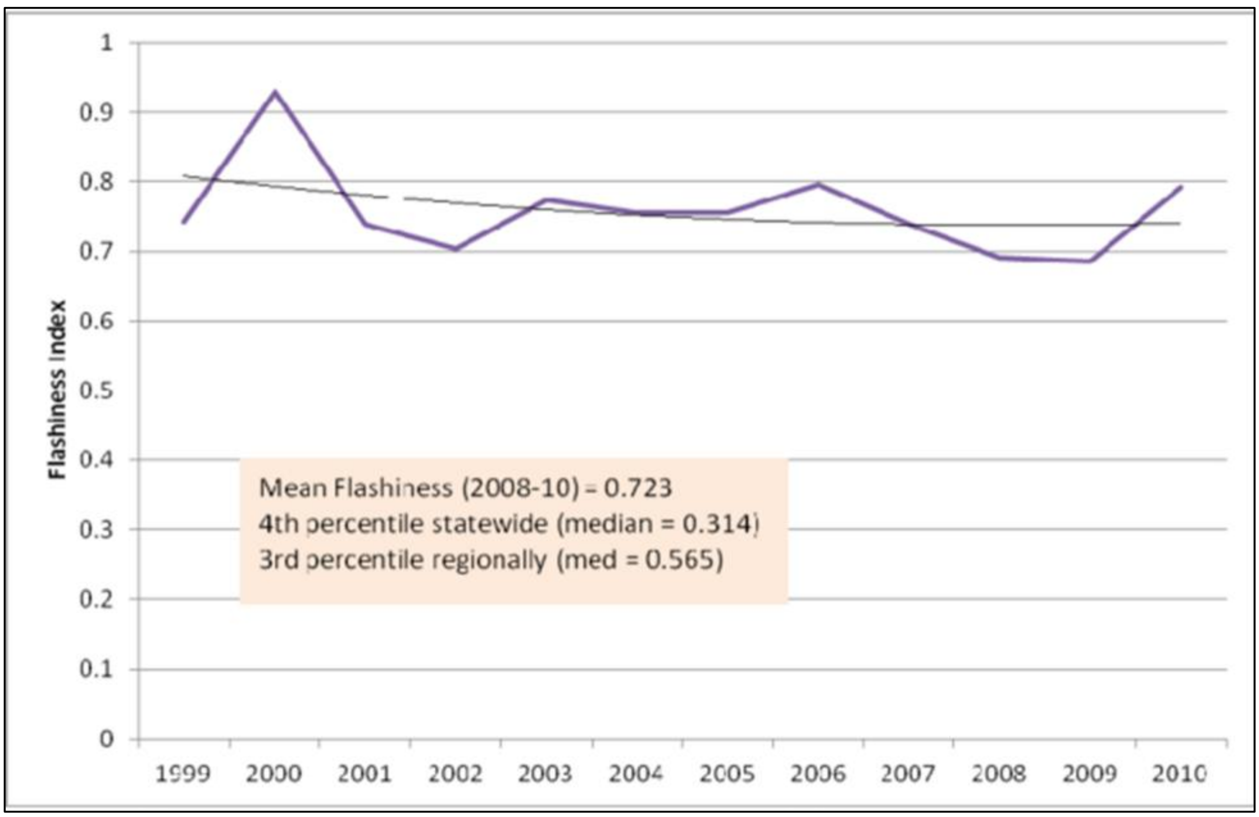

Figure 6. Observed stream discharge in Malletts Creek @ Chalmers Rd, from 1999-2010.

Erratic flows have been recognized as a key problem for Malletts Creek by others. Hydraulic and hydrologic modeling conducted for the Malletts Creek Restoration Project[ix] found that 22 percent of the land area in the watershed is impervious surface directly connected to the stormwater system and creek. In fact, half of the flow to the creek is contributed by runoff from just 20 percent of the watershed, known generally as the Burns Park neighborhood. This part of the watershed contains some of the oldest residential and commercial neighborhoods mostly built prior to the era of stormwater management.

At the writing of the TMDL, the stream flow conditions of Malletts Creek were described as unstable and flashy in response to storm events captured by the USGS records at Chalmers Road. “This condition results in excessive stream bank erosion, sedimentation, and erosivity of otherwise stable, inhabitable substrate suitable for macroinvertebrate colonization and fish community development,” notes the TMDL’s authors, “Therefore, the sources of sediment loadings to Malletts Creek are primarily attributable to periodic erosion and storm water runoff from impervious surfaces . . . in the watershed”[x] . The TMDL allocates loading of TSS among WLAs and Las, yet does not attempt to set targets for stormwater volumes directly.

While the creek appears not to be meeting the TSS load limits despite a downward trend, and continues to exhibit measures of impaired biota and altered flow profiles, it is recommended that the DEQ consider revising the TMDL to include targets for stream flow.

Precedence for this approach has been established by states and their EPA Regional Offices, as mentioned earlier, that have employed stormwater flow reductions in TMDLs to meet aquatic life designated uses. While more study is warranted, recent scientific research has sought to quantify the impact of flows on the functions of river ecology. Researchers in the United Kingdom found in a study of 83 river basins in England and Wales that variables associated with the magnitude of the flow regime consistently produced the strongest relationships with macroinvertebrate community metrics.[xi]

E. *Aquatic biota impairment in Swift Run*

The following is excerpted from the *Implementation Plan for the Swift Run Biota TMDL*.

Water Quality Sampling Data Summary

The authors of the TMDL recognize that sufficient, site-specific data regarding the stream flow and TSS concentration relationship (i.e., TSS loading) associated with stormwater sources was insufficient at the writing of the TMDL to establish specific numeric targets. This TMDL, then, was established as a phased TMDL to allow for additional data collection that could result in additional TSS targets that are flow-related. In response to the lack of data, the watershed entities under the leadership of HRWC developed a monitoring program for Swift Run Creek in 2003 to capture these data.

Data collected since 2003 by HRWC and partners at the Swift Run Creek monitoring station at Shetland Drive (Figure 7) is the primary source information to gauge TSS levels. The HRWC Water Quality Monitoring Program collects water samples for analysis of TSS, among other variables. Since data collection began in 2003, the **average TSS concentration is 18.4 mg/L**. Including stream flow, this equates to an average daily load of 353 lbs/day or 128,933 lbs/yr (64 tons/yr) – well below the target load for the creek of 80 mg/L. However, these data are from routine sampling, rather than wet weather events. One wet weather event was sampled for TSS in Swift Run, and it resulted in a flow-weighted event concentration of 30 mg/l, still well below the target. Results from the 2011 monitoring season will be incorporated into this plan when available.

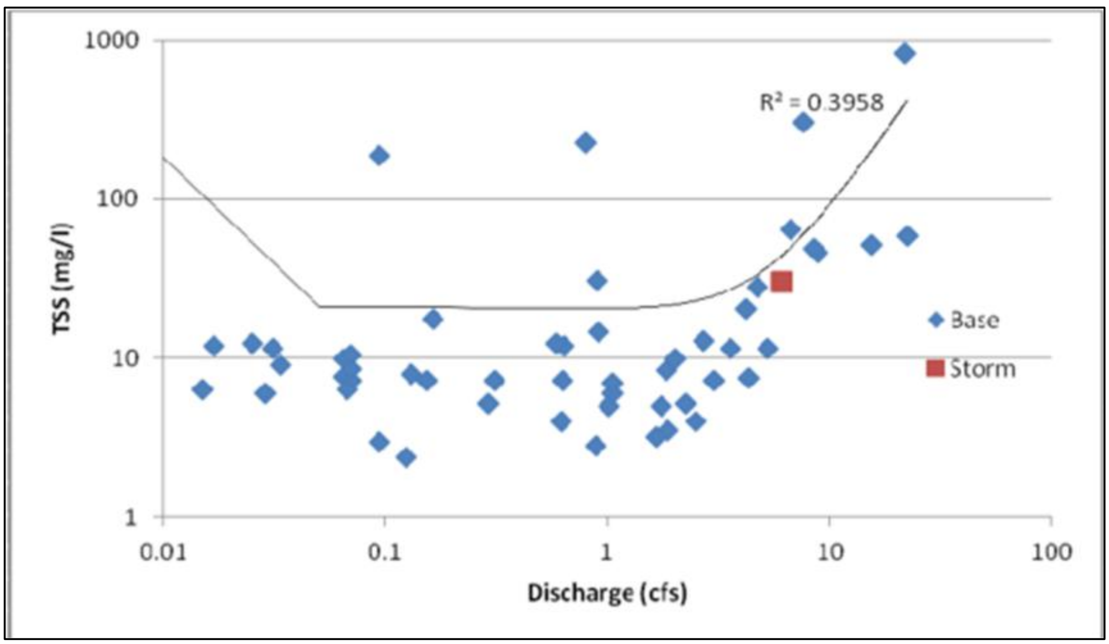

Figure 7. TSS samples showing the relationship to observed stream discharge in Swift Run Creek at Shetland Dr.

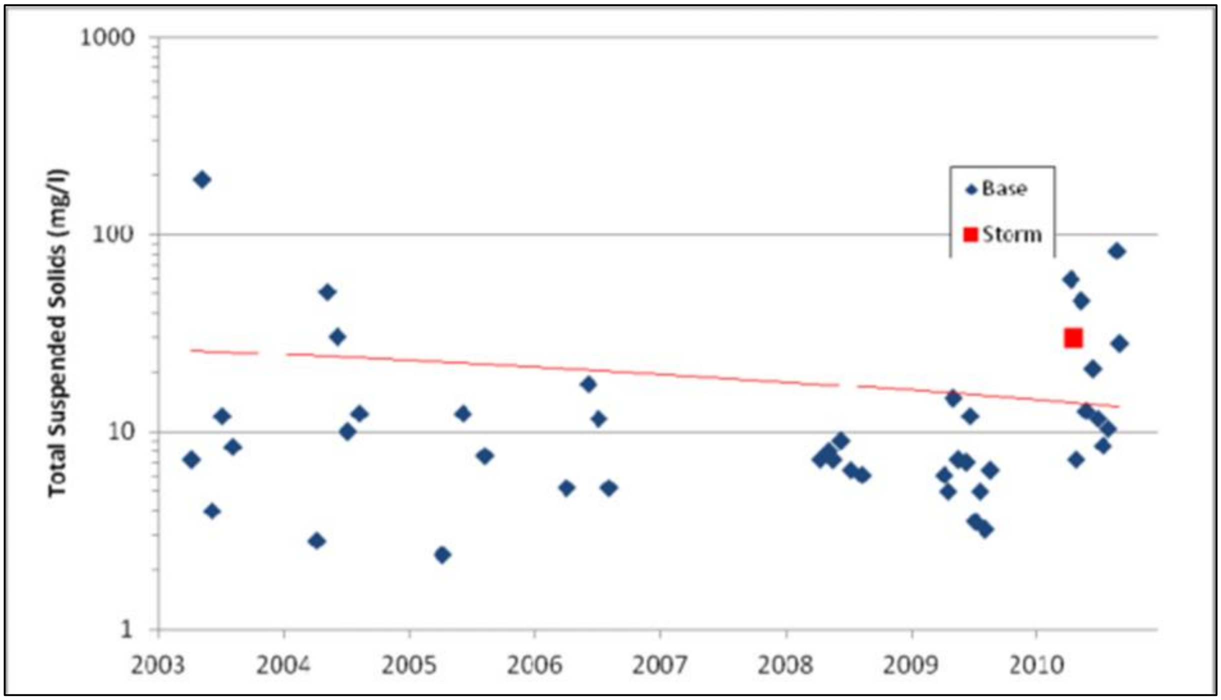

Figure 8. TSS samples by year from Swift Run Creek at Shetland Dr. The red line indicates a slight downward trend in concentration.

The original TMDL model was based entirely on land use projections, while the estimation from HRWC is based on sampling data, so the estimates are not directly comparable. Further, the sampling data was quite variable (Figure 8), so load estimates are not precise. The full 95 percent confidence interval of load estimates ranges from 31 to 119 tons/yr. ***Thus, based on monitoring data, Swift Run Creek is currently below TSS targets and is meeting the secondary TMDL target.***

Macroinvertebrate Sampling Data Summary

Data collected since 1992 by HRWC and partners at a single monitoring station is the primary source of information on the benthic macroinvertebrate community in Swift Run Creek. Insects living in the creek compose the benthic macroinvertebrate (no backbone) population, along with clams and other mollusks, crayfish, among other taxa. Typically, monitoring focuses on insects (in aquatic stages of development) as they are representative of a variety of trophic levels, are sensitive to local environmental conditions and are easy to collect. Since the benthic population depends on the physical conditions of the stream as well as water quality, its composition indicates the overall stream quality. Insect diversity indicates good stream quality, and is measured by the number of different insect families. Eighty-seven benthic insect families are found in the Huron River watershed.[xii]

Much of the benthic macroinvertebrate data in this plan is from HRWC's Adopt-A-Stream Program, which relies on trained volunteers to monitor more than 70 sites in the watershed, including 30 in the Middle Huron watershed. Monitoring data has been gathered since as early as 1992 at some sites through annual spring and fall collection days, and a winter stonefly search each January. All sites have been monitored at least once per year since monitoring began at the site.

Insect families belonging to the orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are known as the EPT families, which are indicators of alterations in stream flow, temperature, oxygen and other changes that raise metabolic rates. Sensitive insect families, such as Perlidae (Perlid stonefly) and Brachycentridae (log-cabin caddisfly), are highly sensitive to organic pollution; 19 of the 87 benthic insect families living in the Huron River watershed are sensitive.[xiii]

Winter stoneflies, which are active in January and require high levels of oxygen, are indicators of good stream quality. Absence of winter stoneflies suggests that toxic pollutants may be present. This is because organic pollutants, such as fertilizer and human or animal waste, are associated with stormwater runoff in warmer months. Because there is usually little or no stormwater runoff in January, there is a greater likelihood that any pollutants in the stream are persistent (long-lasting) inorganic toxic substances are present in the bottom of the streambed. Conversely, at a site where insect diversity is lower than expected but winter stoneflies are present, organic pollutants are more likely to be the problem.

The Adopt-A-Stream Program also rates the “ecological conditions” at each site, which are determined by both the biological and physical conditions of the site. Biological conditions include the diversity of insect families, EPT families, and sensitive families. Physical conditions are determined by conductivity results and “measuring and mapping” assessments of habitat. These assessments involve examining characteristics such as the stream banks, stream widths and depths, and bed material (such as sand, gravel, or muck). When interpreting the biological and physical conditions, more diversity is generally expected at larger sites or sites with cooler summer stream temperatures.

- Site summary for **Swift Run Creek @ Shetland Drive** through January 2011:

This monitoring site is located in the downstream reach of Swift Run Creek and drains five square miles. Approximately 50 percent of the watershed is developed or cultivated. Monitoring began here in 1992 and has been visited 30 times by the Adopt-A-Stream program. Insect diversity is poor, and neither sensitive families nor winter stoneflies are present. However, results in 2010 show a slight improvement in the insect community. Future monitoring will show if that trend continues or if the improved community stabilizes. The conditions of stream banks, streambed, and streamside vegetation were rated as average when the last assessment was made in August 2010. Recent anecdotal observations at the site during water quality sampling suggest that the stream banks are eroding. Water quality is poor, based on high conductivity readings.

The overall condition per the Adopt-A-Stream Integrated Model is POOR.

The health of the macroinvertebrate community is not very different than conditions reported in the TMDL that summarized habitat and macroinvertebrate surveys conducted in 1997 and 2003 in Swift Run Creek. In general, the macroinvertebrate community observed during the field survey was indicative of small, warmwater streams with high sediment loads and organic pollution. Based on calculation of the Procedure 51 summary metrics the quality of the macroinvertebrate community in Swift Run Creek was poor. The results of the habitat survey and rating metrics indicated the habitat structure in Swift Run Creek ranges from good to fair. The report’s authors concluded that extreme flashiness of Swift Run Creek controls channel morphology, limits bank vegetation and stability and, therefore, limits the aquatic community diversity and stability.

Based on the monitoring results for macroinvertebrates to date, one must conclude that the impairment of the indigenous aquatic life and wildlife persists in Swift Run Creek, and that the suitability of TSS as a secondary TMDL target may be a questionable loading measure to relate to stream biota.

The Role of Flashiness in Swift Run Creek

The documented poor habitat conditions and insect populations that persist in Swift Run Creek highlight the continued need to look beyond TSS to the stream flow regime if sustained restoration is going to happen, and to ameliorate the use of practices that can reduce extreme flows. One measure to assess the ecological function of a stream from a flow perspective is to evaluate the "flashiness," or the rate and degree to which the stream increases and decreases in flow rate in response to a rain storm or event. The Richards-Baker Flashiness Index was developed for wadeable Michigan streams to provide a standard measure of flow dynamics[xiv]. The index varies from 0 to over 1, where an index of 0 would represent a stream where flow never changes and 1 would indicate a highly variable and rapidly changing stream.

HRWC installed a flow gage in Swift Run Creek at Shetland Drive in 2010. Data was collected between May and November. A gage was also installed previously and slightly upstream at Salem Court in 2007. HRWC analyzed daily mean discharges at these stations. In 2010, the flashiness index value for Swift Run Creek was 1.02, which makes it one of the flashiest streams of all similarly sized streams in Michigan. It is also well above the median stream in a six-state Midwestern survey. That year, the stream exhibited a peak flow of 273.5 cfs in response to a 2.6" rain event. In 2007, the gage measured flow only from June through August. Over that time period, the flashiness index was 0.418, with a peak flow of only 22.3 cfs following a 1.4" rain event. It is likely that the mean flashiness index for Swift Run is somewhere between the two years, but much higher than the average for its stream size. The stream is also being gaged in 2011 at Shetland Drive.

Erratic flows have been recognized as a key problem for Swift Run Creek by others. At the writing of the TMDL, the stream flow conditions of the creek were described as unstable and flashy in response to storm events as captured by the flow extremes recorded during June, July and August 2003 surveys conducted by LTI for MDEQ. Excessive stormwater runoff to Swift Run Creek from the built areas of the watershed is considered the most probable cause of the creek's impairment. The TMDL allocates loading of TSS among WLAs and LAs yet does not attempt to set targets for stormwater volumes directly.

As the creek appears to be meeting the TSS load limits, but continues to exhibit measures of impaired biota and altered flow profiles, it is recommended that the MDEQ consider revising the TMDL to include targets for stream flow.

Precedence for this approach has been established by states and their EPA Regional Offices, as mentioned earlier, that have employed stormwater flow reductions in TMDLs to meet aquatic life designated uses. While more study is warranted, recent scientific research has sought to quantify the impact of flows on the functions of river ecology. Researchers in the United Kingdom found in a study of 83 river basins in England and Wales that variables associated with the magnitude of the flow regime consistently produced the strongest relationships with macroinvertebrate community metrics.[xv]

[i] Lehman, John. "Mass Balance Study of the Middle Huron River 2003-2004: Highlights of Key Findings to Date Relevant to Middle Huron Partners." http://www.umich.edu/~hrstudy/, April 25, 2005

[ii] Lehman, John. (2011). Nuisance cyanobacteria in an urbanized impoundment: interacting internal phosphorus loading , nitrogen metabolism, and polymixis. *Hydrobiologia*, 661, 277-287.

[iii] Michigan Department of Environmental Quality Surface Water Quality Division. 1996. A phosphorus loading analysis and proposed TMDL for Ford and Belleville Lakes, Washtenaw and Wayne counties December 1994-November 1995.

[iv] Data reports can be found at http://www.hrwc.org/our-work/programs/water-quality-monitoring

[v] Archived data can be found at http://www.umich.edu/~hrstudy

[vi] Martin, J. and Dakin T. 2003b. The Quality of a Hidden Treasure: the Davis Creek Report. February 2003. Ann Arbor, MI: HRWC.

[vii] Dakin and Martin. 2003a.

[viii] Fongers, D., K. Manning, and J. Rathbun. 2007. Application of the Richards-Baker Flashiness Index to Gaged Michigan Rivers and Streams. Michigan Department of Environmental Quality.

[ix] Malletts Creek Restoration Team for the Washtenaw County Water Resources Commissioner. 2000. Malletts Creek Restoration Project.

[x] Wuycheck, J. , 2004

[xi] Monk, W.A., P. J. Wood, D. M. Hannah, D. A. Wilson, C. A. Extence, and R. P. Chadd. Flow variability and macroinvertebrate community response within riverine systems. *River Res. Applic*. 22: 595-615 (2006).

[xii] Martin, J. and Dakin T. 2003b. The Quality of a Hidden Treasure: the Davis Creek Report. February 2003. Ann Arbor, MI: HRWC.

[xiii] Dakin and Martin. 2003a.

[xiv] Fongers, D., K. Manning, and J. Rathbun. 2007. Application of the Richards-Baker Flashiness Index to Gaged Michigan Rivers and Streams. Michigan Department of Environmental Quality.

[xv] Monk, W.A., P. J. Wood, D. M. Hannah, D. A. Wilson, C. A. Extence, and R. P. Chadd. Flow variability and macroinvertebrate community response within riverine systems. *River Res. Applic*. 22: 595-615 (2006).

Appendix B.

Quality Assurance Project Plan for the Work Plan Entitled: "TMDL Implementation Planning in the Middle Huron River TMDL Watersheds"

Version 1.2
Date: August 31, 2010

Grantee: Huron River Watershed Council for the Washtenaw County Water Resources Commissioner
MDNRE Tracking Code: #8635-0010
Funding Source: TMDL Implementation Planning

Project Administrator: Rachel Matthews

MDNRE Use Only:

☐ Approved

☐ Returned for Modifications

____
Signature of MDNRE Reviewer Date

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1. Project Description

1.1 Project Organization and Distribution List

Table 1. Personnel, Affiliation and Role/Responsibilities of each in the monitoring project

Personnel	Affiliation	Role/Responsibilities
Rachel Matthews	MDNRE	Project Officer
Harry Sheehan	WCWRC	Grant Administrator
Laura Rubin	HRWC	Program oversight and review
Ric Lawson	HRWC	Program management, data management and reporting, and quality assurance
Debi Weiker	HRWC	Field data collection management, volunteer coordination, and quality control
Donna McNeff	Ann Arbor WTP	Laboratory management
Middle Huron Partners	Local government	Supplemental funding, program review and guidance
Middle Huron Stormwater Advisory Committee	Phase II Watershed Group	Supplemental funding, program review and guidance
Volunteers	HRWC	Assist with field data collection

Project Administrator
Rachel Matthews
Michigan Department of Natural Resources and the Environment
(517) 780-7917
matthewsr@michigan.gov

Monitoring Subcontractor
Huron River Watershed Council
1100 N. Main, Suite 210
Ann Arbor, MI 48105

Executive Director
Laura Rubin
(734) 769-5123 ext. 606
lrubin@hrwc.org

Program and Quality Assurance Manager
Ric Lawson
(734) 769-5123 ext. 609
rlawson@hrwc.org

Field Manager
Debi Weiker
(734) 426-5762
dweiker@hrwc.org

Laboratory Project Manager
Donna McNeff
City of Ann Arbor Water Treatment Plant
919 Sunset Rd
Ann Arbor, MI 48103
(734) 994-2840

Review and Advisory Teams
Middle Huron Partners
Middle Huron Stormwater Advisory Committee
(current contact list included in Appendix 1)

Volunteer Data Collectors
Program volunteers change annually and will assist in data collection under the supervision of Debi Weiker and Ric Lawson. Standard Operating Procedures (SOPs) will be distributed at training, and the QAPP will be made available to them upon request.

All others involved with monitoring will receive a copy of this Quality Assurance Program Plan (QAPP) and any revisions.

1.2 Project Description

This monitoring project aims to evaluate collective progress of NPS best management practices towards minimizing stormwater-related impairments and improving overall water quality within the middle Huron River system, including the two TMDL areas at Ford and Belleville Lakes. An updated project description and current information about the program can be found at www.hrwc.org/our-work/water-quality-monitoring/.

1.2.1. Statement of Water Quality Concerns

The Middle Huron River watershed drains 217 square miles and lies primarily within Washtenaw County. The watershed culminates in two impoundments: Ford and Belleville Lakes. Both of these have Total Maximum Daily Loads (TMDLs) for phosphorus enrichment, the first TMDLs to be established in the State of Michigan. The watershed is characterized by a mix of urban, agricultural, and natural areas. As of 2000, the watershed was 48% urban, 21% rural, and 27% forest or wetland. Altered watershed hydrology, poor riparian management, and fecal contamination are impacting many of the streams and lakes in the watershed, as indicated by several reaches that appear on the state's list of impaired waters.

The Huron River Watershed is home to one-half million people, numerous threatened and endangered plant and animal species, abundant bogs, wet meadows, and remnant prairies of statewide significance. The Huron is the only state designated scenic river in southeast Michigan. It supplies drinking water to 140,000 people, and its watershed contains two-thirds of the public recreational land in southeast Michigan. Protection of the Huron River system is vital to both the physical health of residents and to the economic health of local communities. However, portions of the system fail to meet minimum water quality standards. Michigan's 303(d) list of impaired waters identifies five waterbodies in the middle Huron that require the development and implementation of TMDLs for either nonpoint source or municipal separate storm sewer system (MS4) related impairments. They are listed below.

Table 2. Non-Point Source and stormwater impairments in the middle Huron River watershed.

HUC	Waterbody	Designated Use	Cause
040900050403 040900050404	Ford & Belleville Lakes	Aquatic life and wildlife	Phosphorus (total) Excessive algae
040900050402	Huron River (Allen Creek to Geddes Pond)	Total body contact	Escherichia coli
040900050402	Malletts Creek	Warm water fishery Aquatic life and wildlife	Flow alteration
040900050402	Swift Run	Aquatic life and wildlife	Flow alteration Sedimentation/siltation
040900050309	Honey Creek	Total body contact	Escherichia coli

One TMDL has been established in the watershed for phosphorus enrichment. The defined drainage area for this TMDL covers the entire Middle Huron River watershed. TMDLs for *E. coli* are more limited to river and creek sections in Ann Arbor. Watershed management plans (WMPs) have been developed for the middle Huron (see map) as a whole and for Allen Creek, Fleming Creek, Geddes drainage (TMDL plan), Malletts Creek (TMDL plan), Millers Creek, and Mill Creek within the larger middle Huron. Additionally, a Nonpoint Source Reduction Implementation Plan has been developed for the Ford and Belleville Lakes TMDL and a point source plan is under development. The Huron also is listed on the state's Unified Watershed Assessment (UWA) as a Category 1 watershed, indicating its high restoration priority. The top impairments listed in the WMPs in the middle Huron are high sediment and nutrient loadings, altered hydrology, and pathogens, mirroring the TMDL impairments. The main causes of these impairments are related to urban development without proper stormwater impact planning.

The Washtenaw County Water Resources Commissioner (WCWRC), with assistance from the Huron River Watershed Council (HRWC), has regularly convened a number of watershed advisory groups for the middle Huron since the first TMDL was developed, beginning in 1994. The communities and agencies within this watershed have engaged in substantial voluntary effort to develop projects and programs to address TMDLs and other potential impairments through the Middle Huron Initiative. The agencies permitted under stormwater regulations now meet regularly as the Middle Huron Stormwater Advisory Group (SAG). This group has developed a budget and work plan to address regulatory requirements and coordinate ongoing activities within that framework. Planning and implementation of monitoring are both parts of this work plan. Funding for those activities, followed by TMDL activity planning and prioritization, will help fulfill the overall goal of meeting TMDL goals.

The Middle Huron Stream Nutrient Monitoring Program was developed in response to community interest in increasing the data available on nutrient contributions to the middle Huron River. The data is intended to lead to a better understanding of pollution contributions from non-point sources in this portion of the watershed. In 2006, data collection for E.coli was added to the list of water quality concerns for certain stretches of tributaries within the middle Huron system. An improved understanding of pollution sources and water quality trends will help the Partners of the Middle Huron Initiative and the Middle Huron Stormwater Advisory Committee to focus and track pollution reduction efforts as they strive to meet the phosphorus TMDL for Ford and Belleville Lakes and the E.coli TMDL for specific tributaries of the middle Huron River.

1.2.2 Project Goals

Goal 1: Collect, synthesize and disseminate data that complements past data and is useful to the Partners of the Middle Huron Initiative and the SAG to evaluate the collective progress of NPS best management practices (BMPs) in improving water quality in the TMDL areas.

GOAL 2: Identify hot spots and characterize phosphorus loading and *E. coli* dynamics
Objectives under this goal include:

- refine the implementation priorities for locations, commitments, timeline, and costs; and
- establish a baseline for evaluating the success of implementation projects.

Targeted monitoring of potential hot spots will help confirm and better define critical areas that have previously been measured or modeled to be pollutant sources. The associated loadings of phosphorus and *E. coli* will be quantified with initial monitoring. The data also will help to obtain better projections for the likely impact (i.e. loading reductions) of potential projects. The monitoring plan and the monitoring itself also will address the need to establish a better baseline for evaluating the success of future implementation projects, as well as progress toward NPS load reduction targets. Once we have obtained measures of phosphorus concentrations and loading and *E. coli* counts, both during various dry weather flow and during storm events, a baseline will be established that can be used to determine the nature and degree of reductions (or increases) from future projects. This approach has been utilized with great success broadly in the Middle Huron River, where specific phosphorus reductions were measured following the implementation of a phosphorus fertilizer ordinance.

1.3 Project Tasks and Schedule

Following is an annual work plan and schedule for the monitoring program. It is anticipated that this program will be sustained following the completion of the grant period.

Task	Staff Responsible	% of Time	Deliverables & Results (deliverables in italics)
1) Measure stream discharge at 10 sites		35%	
Subtasks			
1.1 Develop and submit QAPP for DNRE approval	Lawson; Weiker		*Approved QAPP*
1.2 Solicit and train volunteer corps to provide field support for discharge measurement	Weiker		Trained field support of 5-8 volunteers
1.3 Collect discharge measures as needed at a range of water levels at each site to complete rating curves	Lawson; Weiker		Stream discharge data for 10 sites
1.4 Respond to wet weather events as needed. High discharge levels will be targeted for measurement following events.	Lawson; Weiker		High discharge data for 10 sites
1.5 Download data from pressure sensors and gauge stations; record data and conduct analyses including completion of stream rating curves;	Lawson; Weiker		*Database files and analytical results*

1.6 Share data with project partners and develop annual data reports	Lawson; Weiker		*Reports for 2010, 2011 field seasons; press releases; presentations*
1.7 Solicit evaluation of data and draft products from Middle Huron Partners, SAG and HRWC staff	Lawson		
2) Collect water quality samples and field data at 10 sites		50%	
Subtasks			
2.1 Develop and submit QAPP for DNRE approval	Lawson; Weiker		*Approved QAPP*
2.2 Calibrate equipment prior to field visits	Weiker		Equipment prepared to manufacturers' specs
2.3 Solicit and train volunteer corps to provide field support during baseline monitoring and wet weather events	Weiker		Trained field support of 8 volunteers, at minimum
2.4 Collect baseline grab samples, autosample wet weather events, and record ambient conditions.	Lawson; Weiker		Minimum 20 sample sets per month plus storm samples; field data for DO, pH, conductivity, temp.
2.5 Collect grab samples at 4-5 investigative sites upstream from long-term monitoring sites	Lawson; Weiker		Minimum 8 sample sets per month for total phosphorus, E. coli and TSS
2.6 Deliver samples to WTP lab for analysis	Lawson; Weiker		*Water sample analysis data*
2.7 Record data and conduct analyses	Lawson; Weiker		Nutrient and TSS load calculations for 10 sites; trend analyses of all parameters for 10 sites; paired sample analysis of investigative sites
2.8 Share data with project partners and develop annual reports	Lawson; Weiker		*Annual reports for field seasons; press releases; presentations*
2.9 Solicit evaluation of data and draft products from Middle Huron Partners, SAG, and HRWC staff	Lawson		
3) Administer and Report		15%	All required documents and deliverables
Subtasks			
3.1 Develop and submit status reports following WRD guidance to WCWRC	Lawson		*Quarterly status reports*
3.2 Develop and submit annual report to WCWRC and partners.	Lawson		*Draft Report; Final Report*

Timetable
The grant project will began in February, 2010 and conclude in September 2011. The timeline below is established on an annual timeframe, however, to represent a long term strategy for continuous monitoring activities beyond the scope of this specific project.

Work Plan Activity	Project Months											
	January	February	March	April	May	June	July	August	September	October	November	December
Task 1) Measure stream discharge at 10 sites												
1.1 Develop and submit QAPP for DNRE approval (update in subsequent years)		■	■									
1.2 Solicit and train volunteer corps to provide discharge measurement support			■	■								
1.3 Measure discharge across a range of water levels at all sites				■	■	■	■	■	■	■		
1.4 Respond to wet weather events as needed				■	■	■	■	■	■	■		
1.5 Record data and conduct analyses; download data from level sensors and gauge stations				■	■	■	■	■	■	■	■	
1.6 Share data with project partners and report results	■											■
1.7 Solicit evaluation of data and draft products from Middle Huron Partners, HRWC staff	■											■
Task 2) Collect water quality samples and field data at 10 sites + designated investigative sites												
2.1 Develop and submit QAPP for DNRE approval (update in subsequent years)		■	■									
2.2 Calibrate equipment prior to field visits			■	■	■	■	■	■	■			
2.3 Solicit and train volunteer corps to provide field support during baseline monitoring and wet weather events			■	■								
2.4 Collect baseline and investigative grab samples, autosample wet weather events,				■	■	■	■	■	■			

Work Plan Activity	Project Months											
	January	February	March	April	May	June	July	August	September	October	November	December
and record ambient conditions.												
2.5 Deliver samples to WTP lab for analysis												
2.6 Record data and conduct analyses												
2.7 Share data with project partners and report results												
2.8 Solicit evaluation of data and draft products from Middle Huron Partners, HRWC staff												
Task 3) Administer and Report												
3.1 Develop and submit status reports following WRD guidance												
3.2 Develop and submit annual report to WCWRC and partners.												

1.4 Training Requirements

The program manager and field manager have been trained in all collection techniques as part of professional education programs. Technical advisors from the DNRE and University resources will be sought as necessary to consult for questions on details and analyses. All volunteer collectors receive training at the beginning of the sampling season and are accompanied by the program or field manager on their first sampling experience. Training includes instruction and demonstration of all field techniques, SOPs and data handling procedures.

2. Measurement and Data Acquisition

2.1. Project Objectives

Objective 1: Collect data during dry and wet weather at tributary sites that are comparable to existing data in order to compute loading changes for Total Phosphorus (TP), Total Suspended Solids (TSS), and Nitrate-Nitrite (N-N).

Objective 2: Identify phosphorus loading hot spots and E. coli sources to improve targeting of watershed management strategies.

Objective 3: Measure stream discharge (Q) at tributary sites in the Middle Huron dry and wet weather conditions for use in calculating seasonal load estimates and flow profiles.

Objective 4: Analyze key water quality indicators at tributary sites (TP, TSS, N-N, Dissolved Oxygen (DO), *E. coli,* conductivity, pH, and temperature) across dry and wet weather conditions to detect trends and discover anomalies.

Objective 5: Report data analysis results to the Middle Huron Partners, SAG and the MDNRE and assist partners with assessment of current BMP implementation and plan future BMPs.

2.2 Project Design

HRWC will conduct stream monitoring from May through September (moving to an April start in 2011) at one main river site and nine tributary sites in the middle Huron following standard field procedures (see Appendices 2 and 3). Additionally, a set of rotating "investigative sites" will be selected upstream of long-term monitoring sites to allow for pairwise evaluation. The monitoring program will be based on the existing program that was designed to complement MDNRE's monitoring program at Ford and Belleville lakes, such that monitoring occurs during the months that the TMDL is in effect and the identical parameters are measured.

Stream discharge and water quality indicators will be measured at each site during dry and wet weather conditions in order to measure ambient conditions and any impacts from stormwater runoff on the sites. Fixed water level loggers will be placed at sites that do not already have gages, on an annual rotating basis to allow for flow profiling across an entire season. Grab samples will be taken at each of the study sites twice monthly. Additional samples will be taken during wet weather events. Water samples will be collected and analyzed in a lab according to US EPA accepted procedures (City of Ann Arbor WTP).

The proposed long-term and investigative monitoring sites (Table 3) are located on major tributaries to the middle reach of the Huron River and represent a mix of land uses. The long-term locations were selected based on historical sampling by HRWC, MDNRE, HRWC's Adopt-A-Stream program (macroinvertebrate and habitat data), significant subwatershed phosphorus loading modeling estimates, and a desire to capture the range of subwatershed and upstream conditions. Land use and land cover data have been collected for drainage areas to the monitoring points. These data will be used to help select investigative sampling locations and inform an understanding of relationships between land cover and ecological stream health. A current map of monitoring sites can be found as Figure 1. A live, updated map of long-term and investigative monitoring sites is maintained as a public Google map at www.hrwc.org/our-work/water-quality-monitoring/.

Table 3. Location and information on monitoring sites in the Middle Huron Monitoring Program

Long-Term Sites				
Site #	**Water Body**	**Cross-street**	**Drainage Area (km^2)**	**Land Use**
MH01	Huron River	N. Territorial Rd	1,394	Woodland, wetland; Natural River District
MH02	Mill Creek	Parker Rd	336	Agricultural; drain confluence
MH03	Honey Creek	Wagner Rd	60	Low-density residential
MH04	Allens Creek	outfall to Huron River	13	High-density urban
MH05	Traver Creek	Broadway St.	18	High-density residential; commercial
MH06	Fleming Creek	Geddes Rd	79	Woodland; wetland
MH07	Malletts Creek	Chalmers Rd	28	Low-density residential; commercial
MH08	Millers Creek	Huron Parkway	5	Woodland; medium-density residential
MH09	Swift Run	Shetland Rd	12	Medium-density residential
MH10	Superior Drain	Clark Rd	6	Agricultural; low-density residential

Investigative Sites (as of publication)			
Site ID	**Water Body**	**Cross-street**	**Rationale for selection**
SR01	Swift Run	Ellsworth Rd.	Impacted creek. Isolates land fill and agriculture from residential.
Mal01	Malletts Creek	Oakbrook Dr.	High TP loading, e. coli counts. Isolates medium-density residential branch.
Miller01	Millers Creek	Hubbard Rd.	High TP concentrations. Isolates residential from public land
AC01	Allens Creek	U of M Golf Course	Only surface access. Downstream of golf course.
HC01	Honey Creek	Jackson Rd.	E. coli TMDL. Upstream of highway. Separates creek branches.

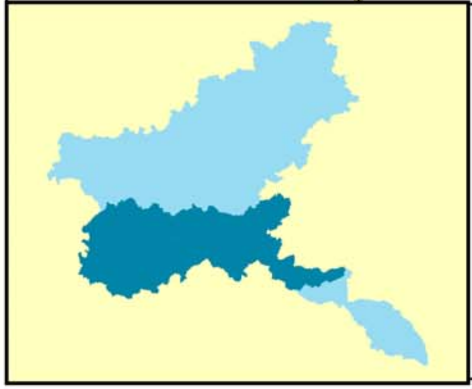
In the event of wet weather, automated samples will be taken at sites with fixed water level loggers or investigative sites upstream. Stream discharge measurements will be taken using data from equipment existing in the following streams: Malletts (USGS), Mill (USGS), and Allens (City of Ann Arbor). Water level sensors maintained by HRWC generate continuous data and were placed at the other long-term sites on an annual rotational basis. Stream discharge will be measured directly by project and volunteer staff with flow meters at all sites to develop stage-discharge rating curves.

In addition to samples taken at the long-term monitoring sites, grab samples will also be taken at 4-5 additional upstream locations each year. These paired samples will be taken in an attempt to isolate hot spots for phosphorus loading or E. coli sources. These investigative sites will be selected with the following criteria in mind:

- critical potential source area drainages and tributary drainages with historically high concentrations, counts or loadings;
- subdivision of stormwater discharge points;
- subdrainages that have a predominance of a land use likely.to be pollutant source;
- proximity to a potential source;
- hydrologic position relative to past monitoring; and
- access and logistical constraints.

Overall, the goal of site selection for investigative sites will be to subdivide critical tributary drainages to isolate probable hot spots or sources and determine their relative contribution of phosphorus, TSS and E. coli compared to paired samples from the downstream end of the tributary. Samples from investigative sites will be collected within an hour of downstream samples so that direct comparisons will be valid.

Figure 1. 2010 Middle Huron River Monitoring Sites



N

4 Miles

Monitoring sites

- Investigative
- Long-term
- Municipalities
- Surface water
- Lakes and Reservoirs
- Middle Huron River Watershed

Huron River Watershed Council

Created August 2010

2.3 Sample Collection Methods

Stream monitoring will be conducted twice monthly from May (April, starting in 2011) through September at the designated long-term and investigative monitoring sites described in section 2.2. The monitoring teams, consisting of at least two individuals, after picking up equipment at the HRWC offices, will travel to a pre-designated site and first complete a field data sheet (see Appendix 4) that documents the location, date, time, team members and weather conditions for the current and previous days. The field data sheet is also used to record information about the water samples and the water quality measurement results using the Horiba multiprobe. The team will then travel to any investigative sites on the same tributary stream and collect grab samples from that site. Upon completion of the fieldwork, the monitoring team will deliver grab samples to the AAWTP laboratory for analysis and return equipment to the HRWC office. A 'chain-of-custody' form (see Appendix 4) will be completed and submitted to the lab to follow the water samples. Copies of the chain of custody form are returned to HRWC with the lab results. Following subsections describe in detail the parameters to be measured, analytical protocols, equipment to be used, and specific protocols for grab sampling and wet weather sampling. See the Appendices for detailed sample collection protocols.

2.3.1 Parameters to be Measured

Under the support of the TMDL grant, the following parameters will be measured at each site:

- Water level and discharge (in cubic feet per second)
- Total Phosphorus (TP in mg/l)
- Total Suspended Solids (TSS in mg/l)
- *Escherichia coli* (in count per 100 ml)

With supplemental support from the Middle Huron Partners and SAG, the following parameters will also be measured at each site:

- Nitrate and Nitrite (N-N in mg/l)
- Dissolved oxygen (in mg/l)
- Water temperature (in degrees Celsius)
- Conductivity (in micro Siemens)
- pH

All parameters will be collected during each sampling event, with the exception of stream discharge. See the discussion in section 2.3.4 for stream discharge procedures. Also, only water level (later downloaded discharge), TP and *E. coli* will be collected during storm events. TSS will be analyzed for these events as laboratory staff are available and able to do so. However, the lab staff is sometimes limited in their capacity to take on extra samples. For the same reason, E. coli may not be analyzed for some storms, depending on timing, if the holding period would be exceeded. Pre and post monitoring around any new management practice will include all three parameters. Table 4 below includes analytical specifics for each parameter.

Table 4. Analytical specifics for measured parameters

Parameter	Method	Detection Limit/Range	Sample Volume (ml)	Bottle Type	Preserva-tive	Hold Time
Total phosphorus	SM20 4500-P B.5 and E	0.01 ppm	100 or 250	plastic	none	48 hrs

Total Suspended solids	SM 20 2540 D	0.1 ppm	750	plastic	none	none
Nitrate/nitrite	SM20 4500 – NO3 B / SM20 4500 – NO2 B	NO_2 - 0.1 ppb NO_3 - 0.2 ppm	750	plastic	none	48 hrs
E. Coli	SM20 9213 D	0 per 100 ml	100	Sterile Whirl-pak[1]	None[2]	24 hrs[3]
Dissolved Oxygen	Horiba U-10 water quality probe	0.0 - 19.9 mg/l	NA; measured with field instrument			
Conductivity	Horiba U-10	0 - 100 mS/cm	NA; measured with field instrument			
pH	Horiba U-10	0 - 14 pH	NA; measured with field instrument			
Temperature	Horiba U-10	0 - 50 °C	NA; measured with field instrument			
Flow	Marsh-McBirney Flomate 2000	-0.5 to +19.99 ft/sec	NA; measured with field instrument			

[1] Sterilized 100 ml (or larger) bottles will be used if they can be obtained at a reasonable cost.
[2] Thiosulfate tablets will be included in sample containers at sites where chlorine degradation is a concern.
[3] Samples will be kept on ice immediately following collection and will be stored under refrigeration until analysis can be conducted.

2.3.2 Equipment

A Horiba U-10 Water Quality Checker multiparameter monitoring instrument will be used to collect additional parameters including pH, DO, conductivity and temperature.

Stream flow measurements will be made using a top-setting rod, that allows all adjustments to be made from above water, with a Marsh McBirney Flo-Mate (Model 2000) portable flow meter.

"WaterMark" Style C staff gauges, graduated to hundredths and marked at every foot and every tenth, will be used to measure relative stream water level.

HOBO pressure loggers (model U20-001-01) from Onset Computer Corporation (www.onsetcomp.com), will be installed at long-term sites on a rotating basis at sites without other water level recording equipment. They will be used to measure water pressure, which will be converted to water level using a barometric pressure compensation program.

Samples will be collected in 1000 ml plastic bottles and plastic sterile packs (*E. coli* only).

2.3.3 Grab Sampling

Collectors will obtain a sufficient supply of sample bottles, pre-marked labels, a cooler (with freezer pack), and field data sheets. They will follow sampling protocols (see Appendices 2 and 3) to collect grab samples and deliver to the laboratory for analysis. One duplicate sample will be collected for approximately every ten sampling sets. Most *E. coli* samples will consist of a single grab sample. Several times a year across all sites, a complete set of 3 representative samples will be collected to be consistent with the water quality standard. This sampling protocol will also be conducted for pre and post BMP monitoring.

2.3.4 Flow Monitoring

Water level and discharge will be recorded in two ways. Two sites (Mill and Malletts) have USGS stations associated with them, and one (Allens) has an automated depth-velocity logger managed by the City of Ann Arbor. At these sites, water levels will be recorded along with time during each sampling event. Water level and discharge information will later be downloaded and recorded on field sheets and entered into the database. No further flow information will be collected at these sites.

Two to three additional sites will have HOBO pressure loggers installed. These will be set to record pressure and temperature every 10 minutes. Pressure is converted to water level by adjusting for barometric pressure following procedures included in the HOBO data logger user guide, which is kept on file at the HRWC offices. Barometric pressure data will be obtained from weather stations reported through www.weatherunderground.com. A station will be selected based on closest proximity to the in stream HOBO loggers. Logger pressure data are converted to water level using the compensation tool (algorithm) in the HOBO software. Water level data points will be converted to discharge by developing rating curves for each site by collecting at least seven flow measurements spanning the range of water levels, following flow procedures included in the Appendix 3.

For the remaining sites, staff gauges have been installed. Rating curves similar to those for pressure loggers will be established for each of these gauges to translate a staff gauge level reading into a discharge estimate as indicated in the flow procedures in the Appendix 3.

2.3.5 Wet-Weather Monitoring

In addition to the twice monthly monitoring at each location, a minimum of one wet weather event will be sampled at each site with continuous water level monitoring. Following analysis, subsequent events will be monitored for sites based on data need and availability of resources. The actual number of events sampled will depend on the frequency of suitable wet weather events, thus, the distribution of events sampled is difficult to predict.

Some investigative sites may also be sampled for wet weather discharge. Targeting of investigative sites for wet weather sampling will be based on previous baseline results and the availability of water level loggers at downstream sites. Discharge data will be estimated from downstream site discharge data using drainage area ratios.

In general, wet weather events will be identified as precipitation events predicted to yield a minimum of 0.2 inches within 24 hours. Mobilization will occur when storms of the desired magnitude are predicted, based on available hourly forecast predictions. However, a “dry” period of <0.1 inches of rainfall over 48 hours should precede the potential wet weather event before a site qualifies for event sampling. This general criterion is being used to ensure that the samples collected are representative of runoff events. Tributaries respond differently to storms, however, and the true measure will be to determine if the flow in the target tributary has returned to levels near those that preceded the previous wet weather event. This may require less or more than 48 hours.

Samples will be collected using a programmable autosampler, starting at the onset of a storm and spanning a period not to exceed 24 hours. Four to six samples for analysis will be selected based on the discharge profile of the storm event hydrograph. Samples will be selected to represent the diversity of flow conditions during the wet weather event. At least two samples will be obtained on the rising side of the hydrograph or near the peak. Wet weather samples will be analyzed for TP, *E. coli*, and, if the lab has sufficient capacity, TSS. There is some concern about the accuracy of E. coli samples collected using the autosampler. When discussing those results in reporting or publications, a caveat will be included until such time that such samples are proven to be valid.

In addition to the six sample sets, one duplicate will be collected for each wet weather sampling event for quality assurance and analysis of sample variance. Specific guidance for storm event sampling is included in the sampling SOP included in the Appendix 2.

2.4 Data Quality Objectives

Accuracy and precision statistics for each of the measured parameters are included in Table 5 below.

Table 5. Accuracy and precision of measured parameters

Parameter	Accuracy	Repeatability/ Precision
Total Phosphorus	2.8% (from spikes)	3.5%
Total Suspended Solids	.0001 mg/l (from blanks)	19.6%
Nitrate/nitrite	NO_2: 6.0% (spikes) NO_3: 4.3% (spikes)	3.0% 7.2%
E. Coli	NA	
Dissolved Oxygen	0.1 mg/l	±0.1 mg/l
Conductivity	0-1 mS/cm: 0.01 mS/cm 1-10 mS/cm: 0.1 mS/cm 10-100 mS/cm: 1 mS/cm	1%/F.S.
pH	0.1 pH	±0.05 pH
Temperature	1°C	±0.3°C
Flow	± 2% of reading ± 0.05 ft/sec	± 0.05 ft/sec

For lab-analyzed chemical parameters, accuracy objectives are to stay within 10% using blanks and spikes. Precision objectives are to stay within 10% for all but TSS, and within 20% for TSS using field duplicates. These objectives will be monitored at the lab across all samples analyzed at the lab – both those run for the HRWC, as well as those for other programs. Running control plots are monitored to stay within accuracy and precision boundaries. The lab maintains a separate QAPP for their lab procedures. This can be reviewed or obtained upon request. The lab is a certified drinking water lab and has thus had their lab procedures reviewed and approved by MDNRE for compliance. The lab is also certified by U.S. EPA as to meet national waste water testing standards, and thus undergoes review and assessment by EPA. Details on these certifications can also be obtained from the lab.

Additionally, a relative percent difference (RPD) will be calculated for each field and duplicate sample pair as a measure of sample site variance for each parameter. Running program mean RPDs will be kept and reported. Any individual RPDs more than 1 standard deviation above the mean will be flagged and reported as potentially unreliable. Samples more than 2 sd away from the mean will result in nullification of that sample set.

For field parameters, the following objectives will apply.

2.4.1 Precision

Volunteers attend both classroom-style and field training to learn the procedures and protocol for collecting water quality data and measuring flow/discharge. Volunteer teams are then observed in the field periodically to audit monitoring activities. Rechecks of flow measurements selected randomly along the channel transect are used to determine precision of monitoring teams' technique.

2.4.2 Accuracy

No standards exist for field estimation of stream discharge, so efforts are made to reduce measurement error. New volunteers and student interns will receive training that includes practice in the stream. They will then take water samples, measure water quality parameters and flow in teams of two or three members, accompanied by trainers on their first outing for stream monitoring. Periodically trainers will accompany them as an additional check on proper technique and sampling protocol.

2.4.3 Representativeness

Monitoring sites have been selected to be representative of the chemical concentrations and loads entering the Huron River from tributaries. As such the measures should be the cumulative impact from each tributary. By taking baseflow samples at regular intervals, the dataset should be representative of the conditions at the output of these tributaries. Including storm samples should allow for calculation of a representative set of loadings for each tributary.

2.4.4 Comparability

Standard procedures are being followed for all measures, which have been and are being utilized in other watersheds. This should allow for results that are comparable to measurements of the same parameters elsewhere.

2.4.5 Completeness

Our objective is to complete multiple measurements of discharge at sufficient water levels to develop a rating curve for each staff gauge or level sensor installed at each monitoring site. We expect to collect samples twice per month at all monitoring sites for base flow and a wet weather event for each. Following validation by the project and field managers, the objective is to maintain results that are 95% valid and at least 90% completeness according to the above outcome objectives.

2.5 Quality Control Procedures

All field equipment and lab equipment will be calibrated with a frequency consistent with procedures in each instrument's manual. Dates on all calibration chemicals will be inspected and chemicals replaced as needed. As indicated previously, field duplicates will be collected and analyzed for laboratory parameters for use in calculated accuracy and precision. Each will be collected and analyzed at a frequency of one for every ten samples. Relative % differences will be reported for each along with the monitoring data.

2.6 External Data Acquisition

Data has been collected regularly under this monitoring program since 2003. This data will be included in annual reports, and will be distinguished from data collected under the grant project. Additional water quality datasets from outside sources will be reviewed for comparison, but no meta-analyses will be conducted unless the analysis is discussed with MDNRE and program partners.

USGS Real-time Water Data is used to obtain discharge data from stations located in Malletts and Mill Creeks. The initial data posted is provisional and subject to adjustment throughout the May – September field season. Final posting of discharge data for the season is generally completed by November and the provisional data recorded on field datasheets are checked and updated if necessary.

Discharge data for Allens Creek outfall is obtained from the flow gage maintained by the City of Ann Arbor.

In order to compute water level using the HOBO pressure sensors, a barometric pressure record covering the period of monitoring is necessary. Barometric pressure data is available from a wide network of weather stations via the Weather Underground at www.weatherunderground.com. The nearest station to the location of each sensor will be selected as the barometric pressure source. The data will be regularly downloaded from the website and processed for import into the software that accompanies the pressure sensor. The software uses an algorithm to use the barometric pressure data to compensate for the atmospheric portion of the pressure measurement recorded by the sensor and compute a water level from the remaining pressure. Since the compensation is a relative computation tied to an initial water level measurement at the time of installation, either raw or elevation-corrected barometric pressure can be used.

3. Data Validation and Reporting

3.1 Data Review, Validation and Verification

Upon completion of field sampling, collectors will deliver samples to the lab, where labels will be matched to the chain-of-custody form before the lab signs off on the transfer. The data forms will be delivered to HRWC offices where they will be reviewed by the program or field manager for completeness. All equipment will be signed back in and check for completeness. The program manager will download any water level and discharge measures and record those on the data forms prior to initialing the data forms. If any data or equipment is discovered missing, the project manager will make an effort to recover at the time of turn-in. If this is not possible, the data gap will be noted on the data form. Collectors will be instructed on any procedures that were not properly followed. A determination will then be made on the validity of the data collection. If necessary, the collection will be rescheduled.

3.2 Reconciliation with DQOs

Upon receipt of data from laboratory analysis, the results of samples and duplicates will be evaluated to confirm that accuracy and precision objectives are being met. Any exceedences will be reported to the laboratory, and corrective actions will be requested. Further, individual samples will be evaluated with lab staff to determine if any should be deemed invalid. A completeness statistic will also be computed as a percentage of samples validated against the total of samples collected. Any violations of DQOs will be included as caveats in data analysis reports.

3.3 Data Management

Once data are collected from the field, they are entered into the program database. The database is an Access database that is integrated with other monitoring data collected by the HRWC. The database helps to reduce data entry error by allowing for rapid comparison of new data with historical data to determine if any entries are missing or outside the normal range. Such entries will be rechecked for data entry error or sampling or analytical anomalies. The database is housed on the HRWC server, which is backed up nightly on-site and twice per month off-site. The data are compiled and analyzed in Excel to calculate statistics and trends for each site for the measured parameters.

3.4 Reporting

Monitoring, quality control evaluation and data analysis progress will be reported quarterly to the DNRE Project Officer. Following a comprehensive analysis of the full dataset each year, the results will be synthesized into a final report for electronic distribution to the MDNRE, Water Resources Division (WRD), community partners of the Middle Huron Initiative and SAG at semiannual meetings, and on the HRWC website. Data collected as part of this grant project will be reported separately to the DNRE Project Officer. All data will be submitted to the DNRE Project Officer at the close of the grant.

3.5 Audits

The necessity of field audits is limited as the field manager accompanies volunteer collectors on a regular basis. In addition, sampling teams will be reset each year to provide for comparison of results from different collectors. The program manager will also conduct field samples on occasion as an additional level of program evaluation.

Any systemic problems discovered through this process by either manager will be discussed and retraining will be scheduled for collectors as needed to address problems. Other programmatic corrective actions will be taken as necessary and communicated to volunteer collectors. If necessary, this program QAPP will be updated with revised procedures. All problems will be reported via quarterly reports to the DNRE project officer.

4. Appendices

Included with this document are the following appended documents:

1. Middle Huron Partners and Middle Huron Stormwater Advisory Committee Contact Lists (as of June, 2010.)
2. Field sampling and wet weather procedures
3. Flow monitoring procedures
4. 2010 Data Forms:
    a. Field Data Form
    b. Wet Weather Field Data Form
    c. Flow Monitoring Form
    d. Chain of Custody Form