Quality Assurance Project Plan (QAPP) for the
Flint River Watershed Benthic Macroinvertebrate Monitoring Program

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Approved Returned for modifications

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Signature of Reviewer Date

Benthic Macroinvertebrate Monitoring Program in the Flint River Watershed
Quality Assurance Project Plan

SIGNATURE / APPROVAL PAGE

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Robert Day, Chief, NPS Unit, EGLE Date

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Distribution List

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1.0 Project Management

1.1 Project/Task Organization

Table 1 lists key personnel with the assigned role/responsibility.

Table 1. Project/Task Organization

Key Personnel	Organization	Specific Role/Responsibility
Jaime Welch	Flint River Watershed Coalition	Monitoring Coordinator – recruits volunteers, handles and displays educational materials, provides volunteer training, handles samples and delivery to laboratory, specimen identification, and oversees the coordination of the Lapeer Chapter FRWC Monitors.
Rebecca Fedewa	Flint River Watershed Coalition	Quality Assurance Officer – provides project oversight & data review.
Darren Bagley	MSU-Extension	Monitoring Chair/Primary Quality Assurance Officer – provides project oversight, training coordination, data review, and is in charge of maintaining and enforcing QAPP. Also Laboratory contact, handling samples, specimen identification/classification.

2.2 Problem Definition and Background

The Flint River ***Watershed**** located in the Lake Huron Basin in the middle region of Michigan's lower peninsula. It encompasses all or parts of Genesee, Lapeer, Oakland, Saginaw, Shiawassee and Tuscola Counties.

The Michigan Department of Natural Resources and Environment has identified numerous beneficial use impairments in waters of the Flint River Watershed and proposed or established TMDLs for resolving them, as indicated in its 2010 Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report (see Appendix D).

The University of Michigan-Flint Center for Applied Environmental Research has developed Watershed Management Plans for Gilkey Creek, Swartz Creek and the South Branch Flint River in the Flint River

***** Words and acronyms in bold are defined in Glossary on Page 28

Watershed. Additionally, the Genesee County Drain Commission's Surface Water Management Division has developed Watershed Management Plans for Kearsley Creek as well as for the Lower, Middle and Upper Flint Watershed to assist in water quality improvements in Genesee County. Some of the goals and desired uses stated in these Watershed Management Plans relate to the activities carried out through the volunteer monitoring program, including:

- Reducing inputs of priority ***nonpoint*** source pollutants, identified as pathogens, sediments, nutrients, and temperature to the Flint River Watershed to meet water quality standards.
- Reducing the impact of priority pollutants in impaired/critical areas to improve aquatic habitat conditions.
- Maintain coldwater and warmwater fisheries.
- Create, restore and enhance recreational use.
- Protect riparian corridors.
- Promote and establish educational programs that support watershed goals and objectives.
- Establish watershed stewardship, awareness, and responsibility among the public.

To aid in accomplishing these goals and to advocate for the protection and improvement of the ecosystems in the Flint River Watershed, the Flint River Watershed Coalition (FRWC) was formed in 1997 as collaboration between educational institutions, local government, local businesses, environmental groups, and concerned citizens. In 1999, FRWC established a ***Benthic*** Macroinvertebrate Monitoring Committee (now named: Water Monitoring Committee) to organize and plan monitoring activities as a way of assessing the health of the watershed and involving volunteers from the community. In June of 1999, FRWC began sampling 15 sites and compiling benthic ***macroinvertebrate*** data. In an effort to expand the capacity of the Benthic Macroinvertebrate Monitoring Program and better facilitate the exchange of data with the State of Michigan, FRWC committed resources in 2009 to the development and adherence to this Quality Assurance Project Plan (***QAPP***) for benthic macroinvertebrate monitoring. It is the intent of FRWC to utilize this QAPP as the approved guidance document required for any potential grant funded monitoring activities, and to help promote water quality improvements.

The intent of FRWC's monitoring program is to: a.) educate the public on water quality issues within the Flint River Watershed; b.) evaluate current conditions of the MDNRE determined TMDL areas; c.) track trends in water quality changes as land use activities change; and d.) as a way of strategically preparing for watershed management activities, climate and environmental issues. The intent of this program is also to establish and continue annual sampling events as a way of promoting watershed ownership and stewardship among the watershed community. In particular, the monitoring data is used to assess the impact of municipal separate storm sewer discharges on receiving waters in the MDNRE-designated Flint Urbanized Area.

2.3 Program Description

Benthic macroinvertebrate monitoring in the Flint River Watershed was first instituted by FRWC in 1999 and has since been implement every consecutive year for the past decade. However, until now, a monitoring program QAPP has not been developed. Instead, the FRWC Monitoring Program has operated under the guidance of assorted Standard Operating Procedures (SOPs) derived from Clinton River Watershed Council resources. Project quality assurance has been guided by the FRWC Benthic Macroinvertebrate Monitoring Committee.

The monitoring program in the Flint River Watershed is intended to extend indefinitely, as long as funding and volunteer participation remains viable. It is a goal of FRWC to seek sustainable funding sources and build the capacity of the monitoring program so that it may continue to reach out to more

sites and more volunteers. As the longevity of this program has proved, recruiting and retaining interested volunteers helps to institutionalize the continued implementation of the program.

The goal of the Monitoring Program is to collect accurate and representative macroinvertebrate population data for use as a biological measure of water quality, as well as obtaining qualitative habitat assessment data pertaining to the sites of macroinvertebrate collection. This data will be used as a tool to help identify areas of nonpoint source pollution as well as educate the public regarding these local water quality conditions. This program is administered by FRWC and uses volunteers from the local communities in which monitoring activities take place. Volunteers are solicited on an annual basis, through FRWC education/outreach efforts such as newsletters, community events and press releases. Individuals volunteering to assist in monitoring activities will learn: proper sampling techniques, how to use macroinvertebrates as indicators of water quality, and information regarding existing watershed conditions. Confirmed volunteer monitors will be contacted with reminders of monitoring events periodically throughout the year. Ideally, four volunteer monitors would be recruited for each site collection event, although a minimum of two per site is permissible.

In order to representatively assess watershed conditions and gain information on the critical areas of the Flint River Watershed, monitoring activities are widely distributed throughout the watershed *where suitable stream access is available*. FRWC established 15 monitoring locations in 1999 and have added additional sites to their program. Currently, a total of 32 sites are part of their active program. These 32 sites (*Table 3*) will serve as the base network of sites for the monitoring activities defined in this QAPP. They will be reviewed annually for their ***representativeness*** of the water body. These sites include both tributary and main branch locations. In some cases, multiple sampling locations are present on the same stream.

Table 3. Distribution of Monitoring Sites in the Flint River Watershed, as of 2021

County	Current # of Sites
Genesee	19
Lapeer	11
Other Counties	4
TOTAL	34

Past results indicate that the current cadre of monitoring sites vary broadly in quality of habitat (poor-excellent, as rated by FRWC based on the 3 page standardized Volunteer Stream Survey Form provided by the MDNRE), and therefore highlight a broad spectrum of habitat conditions in the watershed. This broad spectrum of results can be attributed to the great variety in type and geographic location of sites chosen to be sampled. Therefore, FRWC's current set of monitoring sites are thought to aptly capture a diverse and accurate representation of the many land use types present in the watershed. The 30 sites actively being monitored cover both rural and urban land cover, and are comprised of both very small (1st order tributaries) to very large (4th order main branch of the Flint) stream dimensions.

Some of the current monitoring sites are also located in stream reaches that are either impaired or have had approved TMDLs established. Although additional sampling methods would be necessary to evaluate all of the conditions of the TMDL parameters, some basic water quality conditions of these critical areas can be gained and tracked over consecutive years through macroinvertebrate sampling. For this reason, it is a priority to include as many impaired or threatened reaches as feasible, as additional sites are added in the future.

Established sites are monitored twice per year, once in late April/early May and again in late September/early October. Sites are required to be completed within a two-week timeframe starting from the date the first site is monitored. At each site benthic macroinvertebrate samples are collected and

stream habitat data is recorded. Once macroinvertebrate specimens are collected they are separated by type (specifically separating out aggressive or predatory specimens- see *Section 3*) and preserved for further analysis. Specimen samples are then transported to a biology laboratory. At the lab, specimens are classified to the taxonomic level of Order and when possible a subset of sites will further be identified down to the Family level. Identification is done with the assistance of trained volunteers.

When all macroinvertebrate samples have been identified for a site, a site is then scored based on the quantities of habitat sensitive, somewhat sensitive and tolerant specimens found. For ***accuracy***, site information is reviewed by the Monitoring Coordinator or a Quality Assurance Officer before it is logged into the FRWC database. This monitoring database is later reviewed and analyzed by FRWC and distributed to the public through reports, newsletters and the FRWC website.

2.4 Data Quality Objectives

A primary objective of this monitoring program is to characterize areas of the Flint River Watershed in terms of aquatic benthic macroinvertebrate diversity. In doing so FRWC intends to collect and analyze macroinvertebrate data that meets six important data quality objectives: comparability, accuracy, ***precision***, representativeness, ***completeness*** and ***bias***. Methods to analyze these data quality objectives will be used during the data collection and review process. Work being conducted outside of a certified laboratory will be verified by the Program Coordinator or one of the program's Quality Control Officers.

2.4.1 Comparability

In order to produce consistent and comparable results, a Stream Habitat Assessment and Macroinvertebrate Sampling will be conducted at each designated sampling site, following methods adapted from MDNRE's Procedure 51 sampling protocol and FRWC's Benthic Macroinvertebrate Collection Standard Operating Procedure (***SOP***). Benthic macroinvertebrate sampling has proven to be a useful assessment method and is utilized by state and local governmental agencies, as well as nonpoint source pollution and Michigan Clean Water Corps grantees. All monitoring site locations must be recorded in as much detail as possible on the Stream Habitat Data Collection Form used by FRWC (Appendix A), including stream name, road name, and latitude & longitude if applicable.

2.4.2 Accuracy

Identification and counting accuracy will be assured through identification verification by either Dr. Pace, Darren Bagley, a trained professional, and/or the Monitoring Coordinator. Use of identification keys, comparison of voucher specimen samples kept on hand in the laboratory, and adherence to the quality control guidelines found in this QAPP are made available for this process. Dr. Pace, Darren Bagley, a trained professional, and/or the monitoring coordinator will make necessary changes to misidentifications before the macroinvertebrate scoring sheets are finalized and returned to the Monitoring Coordinator.

2.4.3 Precision

Precision is the degree of agreement among repeated measurements. Measures of precision are critical to assuring that a program's data is credible and reflect actual conditions. The following components of macroinvertebrate collection will be reviewed on an annual basis to evaluate the precision of results:

- Sample collection style (must be thorough and vigorous).
- Habitat diversity (must include all representative habitat types at a site and thoroughness of each one).
- Transfer of collected macroinvertebrate from the net to the sample jars (consistent thoroughness is critical).
- Duplicate scoring calculations (2nd check to be completed by Monitoring Coordinator).

Since there is inherent variability in accessing the less common taxa in any stream site and program resources do not allow program managers to perform independent (duplicate) collections of the sampling sites, our goal for quality assurance is conservative. A given site's Stream Quality Index (SQI) score or total diversity (D) measure across macroinvertebrate taxa will be noted as "preliminary" until three spring sampling events and three fall sampling events have been completed. At least two of these six measures will be collected by different volunteer teams. The resulting measures of D and SQI for each site will be compared to the composite (median) results and each should be within two standard deviations of the median.

2.4.4 Representativeness

Representativeness will be addressed by selecting sites as outlined in Section 3.2. Site selection and watershed representativeness will also be qualitatively discussed by the Monitoring Committee on an annual basis. For accurate representativeness of data, the Monitoring Committee should evaluate the need for altering monitoring sites locations based the following criteria:

- Correlation to impaired water bodies
- Correlation to waterbodies with established TMDL parameters
- Correlation to current watershed Best Management Practices (BMPs)
- Changes in land use activities
- Long term precision of the data collected at a given site
- Volunteer participation at a given site
- Ease of access
- Habitat, climate or other environmental change

2.4.5 Completeness

Completeness is ensured as described in Section 3.3. Data quality sufficient for this objective will be achieved by training volunteer monitors on the monitoring procedures and confirming the accuracy of the field reports with photo-documentation and follow-up site visits. The need for photo-documentation and follow-up site visits will be a determination of the Program Coordinator. Based on this compilation of data, the Program Coordinator will also assess how well the program is functioning overall. Data completeness will be assessed by dividing the number of measurements considered valid by the number of total measurements performed. An overall monitoring event should be considered complete/successful if every measurement is determined to be at least 90% complete.

2.4.6 Bias

Bias is a measure of systematic error. Bias may be determined by the Program's Quality Assurance Officers by taking into account all of the above measurements for a given site, as well as considering the RPD of measurements as compared to the long-term data medians for the site. Bias may be a result of variation in individual sampling styles, equipment failure or weather/event conditions. For this reason, volunteers should not try to "improve" their stream's score by spending more time searching for invertebrates! To guard against bias, volunteer monitors should not be assigned to collect from the same site location for three consecutive years in a row (or for more than 5 consecutive sampling events) and instead rotate to at least one other site within every 3 year period. To assist in this, a team of "master monitors" will be formed and rotated to a different site each collection event. The Master Monitoring team will consist of trained Monitoring Committee members. This frequent engagement by the Master Monitoring team will keep volunteers connected to the Monitoring Committee and will keep volunteers cognizant of precise monitoring techniques. Bias will be taken into consideration when the Program's Quality Assurance Officers evaluate data precision once every three years. To aid in determining bias, volunteer monitors will be required to include as much site and event information on data forms as possible. Results determined to be

biased by the Program's Quality Assurance Officers should be thrown out, following the guidelines described above in the discussion of *Precision*, volunteer monitors suspected of the bias should be re-trained by the Program Coordinator, and bias as a result of site conditions should be taken into account when evaluating representativeness.

2.5 Training Requirements

Proper training on the Benthic Macroinvertebrate Collection SOP (to include sampling methods, preliminary specimen sorting, specimen handling, stream measurements, equipment usage and data form completion) is required for volunteer monitors. FRWC will provide one local training session in early spring (April) for volunteers before the first monitoring event for a given year takes place. Training sessions will be instructed by a trained representative from the FRWC Water Monitoring Committee. The trained representative from FRWC must have been trained directly by MDNRE or MiCorps personnel. In addition, it is suggested that whenever possible, at least two members from the Monitoring Committee will attend the MiCorps Annual Conference in October every year prior to another monitoring year. Monitoring Committee Members attending these trainings will report back with new information to the rest of the Monitoring Committee. These training opportunities may also be encouraged for volunteers, depending on funding and volunteer availability.

For macroinvertebrate scores to be considered valid at least one trained and "certified" volunteer monitor must be present for each monitoring event at each site. It will be the responsibility of the Program Coordinator to assign at least one trained and certified volunteer to every monitoring group. All other (or new) volunteer participants will be considered under the supervision and guidance of the trained volunteer monitoring certified by the FRWC Program Coordinator until an approved training session may be attended by the individual. To be considered "certified" in macroinvertebrate collection procedures by the Program Coordinator, the volunteer must have attended one of the above mentioned training programs prior to engaging in monitoring activities. A written acknowledgement of training certification will be provided to volunteers by the Program Coordinator. These certified volunteers will serve as the primary contacts for coordinating monitoring events. Certification is recorded in the volunteer monitor database maintained by FRWC.

2.6 Documentation and Records

2.6.1 Documentation

A Stream Habitat Data Collection Form (Appendix A) developed by FRWC will be completed for each collection event at each sample site. This designated data form consists of the following four components:

- Section 1: General site information
- Section 2: Flow Measurement
- Section 3: Bank & Riparian Conditions
- Section 4: Stream & Riparian Habitat
- Section 5: Plant Community & Streambed Substrate
- Section 6: Sources of Degradation
- Section 7: Stream Map
- Section 8: Macroinvertebrate Identification & Assessment

Volunteer monitors will be required to complete the first three Sections in-field. Although preliminary specimen sorting will be conducted at each collection event, Section 4 will not be completed until proper identification can be conducted in the laboratory in the presence of Dr. Pace, Darren Bagley, a trained professional; and/or the Monitoring Coordinator; and/or a trained volunteer; using the SOP control measures documented in *Section 3.5*. Additional Monitoring Committee members and willing

volunteers may assist in these identification activities as available. Once macroinvertebrate identification is complete, it is the responsibility of either Dr. Pace or the Program Coordinator to score, or certify a score completed by a volunteer from each site with his or her signature.

2.6.2 Records

Volunteer monitors will place completed forms with the macroinvertebrate samples and deliver to the Monitoring Coordinator or to the laboratory for processing by the end of the day of a collection event. For nearby sampling sites (i.e., in Genesee County), data forms, along with the sample collections, shall be delivered to the laboratory by the Monitoring Coordinator immediately after collection. For remote sampling sites (i.e., in Lapeer, Oakland, Saginaw or Tuscola Counties), volunteer monitors will deliver completed forms and sample collections to the Monitoring Coordinator along with the macroinvertebrate samples by the end of the day of a collection event. The Monitoring Coordinator will then deliver samples to the laboratory for use in macroinvertebrate identification by Dr. Pace, Darren Bagley, and other trained volunteers.

After completion of the sample identification for a site, Dr. Pace, Darren Bagley, a trained professional, and/or the Monitoring Coordinator will verify and sign their approval if accurate. Calculations are reviewed for accuracy by the Monitoring Coordinator, and when all is complete, data forms will then be collected by the Monitoring Coordinator or held by Laboratory Coordinator and forwarded to the Monitoring Coordinator within ten business days. At this point, FRWC staff will enter the data, generate necessary reports and file the field data forms. It is recommended that the Monitoring Coordinator (or an appointed assistant of the Coordinator) enter the resulting data into the FRWC benthic macroinvertebrate master database within 30 days of receipt in order make results available for quality assurance evaluations by the monitoring committee. Data will be entered into MDNRE's MiCorps online database during the length of MiCorps grant funding received. FRWC plans to continue supporting efforts to enter the water monitoring data beyond MiCorps grant support. Sample macroinvertebrate collections will be kept in laboratory storage for a minimum of three years, and may also be submitted to MDNRE or another state-designated laboratory if necessary. The master database of macroinvertebrate collection data will be electronically housed with FRWC indefinitely, while paper copies of field forms will be stored by FRWC for one year following its collection event. Duplicate copies of electronic files are stored off-site.

3.0 Study Design

3.1 Purpose

This benthic macroinvertebrate monitoring program will be used to establish characterizations of the water quality and aquatic habitat conditions of the Flint River Watershed, taking into account that results will pertain most reliably to the stream reaches in closest proximity to the sites being sampled. The results of this study will serve to establish a baseline for which future BMP and TMDL effectiveness can be evaluated against. The Stream Quality Index and/or Total Diversity results derived from these monitoring activities will help to direct the watershed management efforts of FRWC and local governing agencies.

Monitoring activities will consist of macroinvertebrate sample collection from shallow, wadable streams in the Flint River Watershed along with detailed measurements, observations and record taking of stream habitat conditions. Macroinvertebrate identification will occur later, most often on the same day as collection and in a laboratory setting. The intent is to have volunteers collect the samples during the monitoring event and then transport these samples from each sampling site to the laboratory or classroom, where macroinvertebrate specimen identification will take place, as soon as possible and no longer than one week after sampling.

3.2 Site Selection

Monitoring sites in the Flint River Watershed have been selected based on full geographic representation of the watershed, ease of access, landowner permissions, avoidance of hazardous conditions and by visual site evaluations conducted by FRWC prior to monitoring. Each site selected contains a variety of habitat types, including gravel/cobble, boulders, woody debris and undercut banks. See Appendix C for FRWC Site Map monitoring locations. It is preferable that a standard check-off form be used to assess the characteristics of a new 300-foot stream segment.

Expansion of monitoring activities to currently under-represented stream reaches is anticipated, but will be dependent upon landowner permission, funding, and volunteer monitor participation. Sites within close proximity or directly downstream of an outfall or piped discharge should be avoided for macroinvertebrate monitoring. If permissible, additional sites would be targeted at additional reaches of TMDL waterbodies and at tributary streams not currently being monitored. FRWC is currently in the process of seeking funding to develop a standardized tool for use in selecting the most representative sites.

Redistribution of sites will be qualitatively discussed on an annual basis among Monitoring Committee members, as part of routine data quality reviews. When new sites are selected for sampling, a site visit will be conducted to verify the suitability for use. At this time, appropriate photo-documentation will be taken and kept on file by the Monitoring Coordinator. The dominant soil type of the new site will also be identified and a USGS soils map will be kept on file with the site photos.

3.3 Program Timetable

The first official monitoring event held under the guidance of this QAPP is slated to take place in Spring 2010. In 2010, and in every consecutive year to follow, monitoring activities will be held once in the spring (April/May) and once in the fall (September/October). The timeline for each round of monitoring can vary slightly, depending on volunteer availability and local weather conditions. Generally, monitoring all sites takes several days within a two-week window due to the large number of sites to sample. If sites cannot be visited within the two-week window, they will be omitted from that season of sampling and a hole in data will represent the site until it can be sampled from again in a subsequent monitoring season (the two-week window should be held firm to ensure comparability of long term data). During these times, volunteer monitors will visit sites designated by the Monitoring Coordinator, conduct macroinvertebrate collection and complete the necessary field data forms. Prior to the first monitoring event of the spring (March or April), an annual monitoring training workshop is held locally in order to prepare volunteer monitors for the upcoming season Table 4 gives a general outline of the order of monitoring events to take place in a given year. *Note:* Regular Monitoring Committee meetings are not mandatory (as specified in Table 4), and may take place as frequently or infrequently as deemed necessary by the Monitoring Committee.

Table 4. Monitoring Program Timeline

Month	Monitoring Activity
January	Data review of prior year
	Comprehensive data analysis* *(only once every three years)
	Annual report of prior year
	Review/amendment of QAPP, SOP, site distribution or training requirements by Monitoring Committee
February	Solicit Volunteers
	Monitoring Committee Meeting
March	Monitoring Committee Meeting
April	
	FRWC Volunteer Training
	Spring macroinvertebrate collection/ identification
May	
	Collection data entry
June	Data review of spring event
	Monitoring Committee Meeting MiCorps Stream Training
July	Solicit Volunteers
	Monitoring Committee Meeting
August	Monitoring Committee Meeting
September	Fall macroinvertebrate collection/ identification
October	
	MiCorps Annual Conference
November	Monitoring Committee Meeting
	Collection data entry
December	
	Data review of year

3.4 Methods for Measuring Stream Habitat

3.4.1 General Information

A representative stream reach (300 feet) should be surveyed to evaluate stream characteristics and habitat quality. If the access point to the reach is a road crossing, then the assessment should be made while walking 300 feet upstream from the road crossing.

The volunteer monitor shall write the stream name, site number, location, monitoring date, and the times you begin and end your monitoring activities on this section of the stream survey form. Some of this may be already entered.

3.4.2 Weather Conditions

The volunteer monitor shall vote current weather conditions, especially whether there has been any precipitation during the 5 days prior to the survey. The volunteer monitor shall then measure the air temperature first, allowing several minutes for the thermometer to register an accurate temperature. The stream temperature is measured second, allowing the thermometer to hang down into the water in midstream for several minutes. It is advised that three readings from several areas of the stream are taken and then average the values.

3.4.3 Stream Habitat

When volunteers fill out the Stream Habitat data sheet they should place an "x" for all null values in every blank where the characteristic does not apply for that site. This method will aid in the ease of use for subsequent data checkers.

Average stream width and depth:
Stream width is the distance from the water's edge on one side of the stream to the other side. The volunteer monitor shall take three measurements of width and depth at random points along the 300 foot long sampling area (preferably in stable ***substrate***), and average these values for the mean width and depth. For depth, it is advised that measurements are taken at the ***thalweg*** and within two feet from each stream bank for each of the three sites measured in the sampling area. If the stream is too deep to take measurements, an estimate will suffice.

Channelization:
Note whether the stream segment being monitored has been channelized. Channelization is indicated by long, straight stretches of stream without bends or meanders, and there may possibly be old spoil piles present on one bank.

Water clarity / coloration and water odor:
The volunteer monitor shall examine the stream reach for any unusual color, odor, or trash accumulations. To the extent possible, try to describe any unusual observations in these areas, for example, a rotten eggs smell.

Trash:
The volunteer monitor looks for debris in riparian (stream bank) vegetation. Such accumulations suggest how high the water level can rise during storm events or spring runoff. This can be trash or grass and leaves, or other natural debris.

Substrate:
Substrate composition ((stream bottom material - gravel, cobble or boulders) is a critical habitat component in determining the benthic macroinvertebrates that will be present in the stream. Estimate the relative abundance of various substrate types in the stream reach. The most abundant substrate type should receive a rank of "1", the next most abundant a rank of "2", etc. *If a substrate type is absent, place an "X" in the spot indicating that this was reviewed and found absent.*

Siltation:
If silt or sand is the dominant substrate, is it because of the absence of gravel and cobble, or does the silt / sand cover the gravel / cobble? If it is the latter, answer "yes". That is an indication of heavy siltation.

Substrate embeddedness:
This is related to question 3.9., and refers to the extent to which gravel, cobble, or boulders are covered by fine material (silt or sand). The more embeddedness, the less surface area is exposed to the water and available for colonization by invertebrates. Using your best judgment, indicate the extent to which the gravel, cobble, or boulders are embedded. If no rocks are visible in the substrate, the volunteer monitor shall dig down a few inches to see if the natural substrate is rocky. Your stream may be naturally sandy so no rocks will be present.

Riparian vegetation:
The plants found along the side of a stream can have a profound effect on aquatic life. Along the 300 foot stream segment, estimate the relative abundance of trees, shrubs, herbaceous (non-woody) plants, grasses, and bare banks to a distance of 20 feet from the stream. The most abundant riparian vegetation type should receive a rank of "1", the next most abundant a rank of "2", etc. *If a vegetation type is absent record an "X" in the space indicating that this was reviewed and found absent.*

Stream shading:
To determine percent shade, the volunteer shall stand in the middle of the stream and look up. Approximately what percent of stream is shaded by the vegetation?

Bank erosion:
Extensive bank erosion can be a major source of sediment to a stream and have a big effect on the aquatic life in that stream. Using best judgment, the volunteer monitor determines whether the extent of erosion is extensive, moderate, or little.

Estimated width of riparian vegetation:
It is also useful to know the width of the riparian vegetation corridor, that is, the width of the vegetative strip stretching back from the stream. An estimation of the distance will suffice. If the distance is greater than 100 feet, the volunteer monitor simply indicate " > 100 feet ".

Stream habitat:
Riffles (shallow, rapid flow where the water surface "ripples"), ***runs*** (usually deeper than riffles, with rapid smooth water flow), pools (deep, low flow), and ***eddies*** (backflowing areas, usually behind rocks or logs) all provide different flows and habitat for various aquatic organisms. Indicate which of these habitats are present in the 300-foot stream-segment.

Woody debris:
Logs and woody debris in the stream can slow or divert water to provide important habitat for fish and benthic invertebrates. Using best judgment, the volunteer monitor checks the category on the form that best describes the amount of wood in the stream reach. As a general "rule of thumb": if the volunteer monitor is frequently stepping on or over woody debris, the site would be classified as having "abundant" woody debris. Although highly visible, log jams do not always indicate abundant woody debris at a site. It is recommended that volunteers walk up and down the stream segment whenever possible before making the woody debris observation.

Dams present:
Note whether any dams are present in the stream reach and indicate whether these are man-made or beaver dams / log jams.

Aquatic plants:
While aquatic plants in the stream can serve as an excellent food source for aquatic organisms, excessive plant growth is indicative of nutrient enrichment. Indicate if periphyton (algae tightly attached to solid substrates, feels slippery), filamentous algae (long strands or "stringers" of algae attached to rocks and often extending into the water column), and / or macrophytes (aquatic plants that are generally rooted, and submerged under, floating on, or extending out from the water) are present in the stream reach. Note whether any of these are extremely abundant, ie. if they constitute "nuisance" conditions. Until a standardized qualitative assessment can be developed for assessing the amount of aquatic plants at a site, it is left up to the discretion of the volunteer monitor to determine if a site has "excessive" plant growth or not.

Surrounding Land Use:
Land use has a major influence on the character of streams. The relative abundance of the various land use types surrounding the stream reach is estimated from the list on the survey form. The most abundant land use should receive a rank of "1", the next most abundant a rank of "2", etc. *If a land use type is absent, record an "X" in the spot indicating that this was reviewed and found absent.*

Obvious Pollution Sources:
Note any obvious pollution sources that are visible and the approximate locations. These can include both point and nonpoint sources. The volunteer monitor shall indicate if there are signs of cows/horses using or crossing the stream.

Observation of fish or wildlife:
Note and describe any signs of fish or other wildlife at your stream reach.

Other observations:
The volunteer monitor writes any other pertinent observations here. These may include the presence or signs of people using the stream for recreation boating, swimming, fishing, or some unusual event or observation.

3.5 Methods for Monitoring Benthic Macroinvertebrates**

3.5.1 Overview

Samples should be taken from at least three different (preferably all) habitats within the 300 foot long study site that contain the highest diversity of macroinvertebrates as listed in Table 5. Consistency in terms of total time spent collecting is very important. Having 2 people on one Stream Team spend 45 minutes working together to collect is a reasonable standard. This means if there are 4 people collecting on one Stream Team, then each should spend only up to 22.5 minutes collecting, so that the total "person-time" (90 minutes) is the same. If there are 3 people collecting, then the amount of time spent collecting should be adjusted accordingly. This ensures that final scores will be comparable across the watershed. *Volunteers should not try to "improve" their stream's score by spending more time searching for invertebrates!*

All organisms collected from the site will go together to form one combined site sample, and may be transported together in the jar(s) or other containers to the laboratory for identification. Sample transport containers should be clearly labeled with the site name and collection date before going into the lab.

Table 5. Macroinvertebrate Diversity

Diversity	**Habitat**
Most Diverse Habitat	
	Leaf packs
.	Tree roots, snag areas, & submerged logs
	Undercut banks (overhanging vegetation)
	Submerged macrophytes (aquatic plants)
Least Diverse Habitat	Sediments

Samples must be taken from all habitats within the study site that contain the highest diversity of macroinvertebrates (benthos). If a certain habitat type isn't present, it must be verified by another team member standing on the stream bank.

Utilizing the benthic nets provided as indicated in below, samples can easily be obtained from diverse habitats. Once on the streambank, the volunteer monitor should remove the aggressive species and separate them into their own jar, to avoid damage of any other species. No sorting should be done while in the water.

In the next section, each habitat type is handled separately, in the order of most diverse to least diverse.

3.5.2 Riffles

Riffles are areas with shallow, rapid flow where the water surface "ripples".

The volunteer monitor shall select the fastest and slowest moving areas of the riffle. Organisms collected from both of these sites will constitute one riffle sample. Sampling is began at the downstream end of the reach to be sampled and work upstream. This keeps the working area undisturbed.

With the net opening facing upstream, the volunteer monitor places the bottom of the net flush on the stream bottom immediately downstream of the riffle, being careful not scoop the substrate with the net. The handle should be positioned perpendicular to the stream flow.

While one volunteer holds the net (the "netter"), another volunteer (the "collector") picks up large rocks (2 inch or greater diameter) within a 1 foot by 1 foot area directly in front of the net opening and gently rubs them in the net opening to remove any clinging organisms. *Volunteer Monitors should be sure to hold the rock under the water in front of the net so that flowing water will carry the materials into the net opening.* Volunteer monitors shall place (do not toss) the cleaned rocks outside the sampling area. If only one volunteer collector is available at a site, the person with the net may replicate this same procedure by using their foot.

When all the rocks (or as many as possible) are removed from the sample area, the "collector" stands approximately one foot upstream of the net opening and kicks the stream bed vigorously to dislodge any remaining organisms into the net. The volunteer monitor shall kick down approximately two inches into the substrate for one to two minutes while moving toward the net.

When done kicking, the "netter" sweeps the net in an upward fashion to collect the organisms, being careful not to scoop up substrate into the net.

Note: If the net is relatively empty after sampling at the first riffle, these steps may be skipped and the net emptied only as necessary.

A volunteer monitor shall carry the net to the stream bank. While one person holds the plastic sampling tray steady, another empties the net's contents into the tray. Using the squirt bottle filled with stream water, volunteer monitors rinse the inside of the net into the plastic tray to collect all the organisms. Any clinging organisms should be removed and placed directly into a sampling jar or baggie. This process eliminates the use of baggies of water/debri collected.

A total of three riffle samples are collected by repeating the steps described above.

3.5.3 Leaf Pack

A volunteer monitor shall look into the stream for leaves that are about four to six months old. These old leaf packs are dark brown and slightly decomposed. Only a handful of leaves is necessary.

Sampling should be started at the downstream end of the reach and worked upstream. This keeps the working area undisturbed.

With the net opening facing upstream, volunteer monitors place the bottom of the net flush on the stream bottom immediately downstream from the leaf pack. Net handle position should be kept perpendicular to the stream flow.

Volunteer monitors should gently shake the leaf pack in the water to release some of the organisms, then quickly scoop up the net, capturing both the organisms and the leaf pack in the net.

Note: If the net is relatively empty after sampling the leaf pack, these steps may be skipped and the net emptied only as necessary.

Volunteer monitors shall carry the net to the stream bank. While one volunteer holds the plastic sampling tray steady, another empties the net's contents into the tray. Using the squirt bottle filled with stream water, volunteer monitors rinse the inside of the net into the plastic tray to collect all the organisms. Clinging organisms should be removed and placed directly into a sampling jar.

A total of three leaf pack samples are collected by repeating the steps described above.

3.5.4 Tree Roots, Snag Areas, and Submerged Logs

Snags are accumulations of debris caught or "snagged" by logs or boulders lodged in the stream current. Caddisflies, stoneflies, riffle beetles, and midges commonly inhabit these areas.

Volunteer monitors shall select an area on the tree roots, snap, or submerged logs which is approximately 3 feet by 3 feet in size. Sampling is started at the downstream end of the reach and worked upstream. This keeps the working area undisturbed.

Volunteer monitors shall scrape the surface of the tree roots, logs, or other debris with the net while on the downstream side of the snag (with the net opening facing upstream). Volunteer monitors may also disturb such surfaces by scraping them with their foot or large stick, or by pulling off some of the bark to get at the organisms hiding underneath. In all cases, *volunteers should take care to position the net downstream from the snag, so that dislodged material floats into the net.*

Volunteer monitors may remove a log from the water to better sample from it, but should take care to replace it when done.

Note: If the net is relatively empty after sampling at the first station, these steps may be skipped and the net emptied only as necessary.

Volunteer monitors shall carry the net to the stream bank. While one person holds the plastic sampling tray steady, another empties the net's contents into the tray. Using the squirt bottle filled with stream water, volunteers rinse the inside of the net into the plastic tray to collect all the organisms. Again make note of any macroinvertebrate predators, and remove them to their own jar.

A total of three tree root samples are collected by repeating the steps described above.

3.5.5 Undercut Bank

Undercut banks are areas where moving water has cut out vertical or nearly vertical banks, just below the surface of the water. It is in these areas of overhanging vegetation and submerged root mats where that arbor dragonflies, damselflies, and crayfish may be found.

Note: Volunteer monitors are not to collect crayfish in sample jars, but instead their presence is noted, and the number you see that are alive.

Volunteer monitors shall place the net below the surface under the overhanging vegetation.

Volunteers shall move the net in a bottom – up motion, jabbing at the bank five times in a row to loosen organisms.

Note: If the net is relatively empty after sampling at the first station, these steps may be skipped and the net emptied only as necessary.

Volunteer monitors carry the net to the stream bank. While one person holds the plastic sampling tray steady, another empties the net's contents into the tray. Using the squirt bottle filled with stream water, volunteer monitors rinse the inside of the net into the plastic tray to collect all the organisms. Again make note of any macroinvertebrate predators, and remove them to their own jar.

Volunteer monitors shall collect a total of three undercut bank samples by repeating steps U.1 – U.3.

3.5.6 Sediments

Areas of mostly sand and / or mud can usually be found on the edges of the stream, where water moves more slowly, allowing the materials to "settle out".

A "netter" stands downstream of the sediment area with the net resting flush on the stream bottom with the net opening facing upstream. The handle should be placed perpendicular to the stream flow. A collector disturbs the sediment by kicking it to a depth of about two inches as he or she approaches the net.

The "netter" sweeps the net upward to collect the loosened organisms as the kicker approaches, being careful not to scoop up the substrate with the net.

Note: If the net is relatively empty after sampling at the first station, these steps may be skipped and the net emptied only as necessary.

Volunteer monitors shall carry the net to the stream bank. While one volunteer holds the plastic sampling tray steady, another empties the net's contents into the tray. Using the squirt bottle filled with stream water, volunteers rinse the inside of the net into the plastic tray to collect all the organisms. Again make note of any macroinvertebrate predators, and remove them to their own jar.

A total of three sediment samples are collected by repeating the steps described above.

3.5.7 Macroinvertebrate Identification and Counting

Streamside Sorting After Collection (still in-field!)

After the sediment has settled in the sampling trays, volunteer monitors start searching for invertebrates. Many of the larger kinds will probably be very obvious. Other smaller kinds will hide underneath leaves or other debris in the tray. Volunteers learn at training which macroinvertebrates to keep separate, such as Dragonfly larvae and scuds & aquatic worms. If it will take considerable time to have the samples taken to the lab, such as 2.5 hours or longer, (some Lapeer sites); volunteers should place their samples in rubbing alcohol. (Ethanol is used later for long-term storage.)

There are several tools to help catch organisms. Volunteer monitors can seize them with forceps - being careful not to accidentally dismember them - and then place them into the alcohol in the Petri dish. If they are too small to use forceps, volunteer monitors can draw them into a pipette, expelling most of the excess water very carefully back into the sampling tray while keeping the organism inside the pipette, and then expelling the organism into the alcohol in the Petri dish.

3.5.8 When Finished Collecting

When volunteer monitors are finished collecting at your stream site, containers used to transport the organisms are all labeled with site name and collection date. Jars are placed into the bottom of the equipment bucket, along with the rest of the equipment. Stream water is used to rinse the sediment and other debris out of the net. Volunteer monitors should take care to bring back as little mud and debris as possible to the laboratory!

Collection Evaluation

All workers should be sure to complete an evaluation form before leaving for the day. The ongoing improvement of the Flint River Volunteer Water Quality Monitoring project depends on continued feedback from everyone who is involved.

Laboratory Location

After volunteer monitors have completed all monitoring activities at the stream site, samples and data forms and all equipment shall be brought to the designated laboratory space. Typically, this space is located in the invertebrate laboratory, located in Room 261 of the Murchie Science Building at the University of Michigan-Flint. Other locations may include Mott Community College Lapeer and Flint campuses.

Volunteer monitors should bring everything to the lab to turn back into project coordinators, and report any missing or broken equipment.

Volunteer monitors should spend one to two hours in the lab, identifying and counting your benthic invertebrates.

Equipment and Tools Needed In The Lab

Volunteers find empty workspace at one of the lab benches where their Stream Team can work together. Microscopes may be used for identifying smaller organisms. Volunteer monitors should ask for assistance when using certain types of microscopes not previously used, as even minute adjustments can make a huge difference in what is seen. College science departments may generously donate the use of their lab equipment for monitoring activities. As they are very expensive to replace, volunteer monitors must keep track of tools provided, and try not to mix them up with the stream equipment sets.

Volunteer monitors will need to use either plastic sampling trays or one of the larger metal sampling trays available in the lab, a forceps (like tweezers), a pipette (like an eyedropper), 12 to 15 Petri dish bottoms, and a bottle of alcohol to use as preservative for the invertebrates. Petri dish lids are ok to use too, but the bottoms are deeper and therefore easier to use. The Petri dishes and alcohol are available in the lab. Volunteer monitors will also need page 8 of the data sheets handy to keep track of your organisms.

Dr. Pace, Darren Bagley, trained volunteers, and/or the Monitor Coordinator will be working with volunteers in the lab and will have final authority on benthic invertebrate identification. Dr. Pace, Darren Bagley, or the Monitor Coordinator will initial your data sheet after he has seen all invertebrates sorted into separate Petri dishes.

Preparing the Sampling Tray And Petri Dishes

Volunteers are to keep samples from different sites separate. To avoid mixing samples from different sites, volunteers empty containers of benthic samples one site at a time into sampling trays. If there is a lot of sediment or substrate material in the container, volunteers may want to add some clear water to the tray to help dilute the murkiness. Allowing the sediment to settle for a few minutes will also help. The idea is to be able to see the organisms swimming or moving around in the tray, so that they may be seized with forceps.

While volunteer monitors are waiting for the sediment to settle, they prepare several Petri dishes. These will be used to keep the different kinds of invertebrates separated until the end so that volunteer monitors may be able to count each kind all at the same time. Volunteers pour 1/4 inch or so of

alcohol into the Petri dishes, enough to cover any organisms placed into them. Volunteer monitors will probably need 5 or 6 dishes to begin with; and prepare more as needed.

Using a Dichotomous Key (Appendix B)

A dichotomous key is a tool that is used to help identify things. Volunteers should begin at the top of key. At each junction of lines volunteer monitors will be asked a question to make a choice. The first question is "does the organism have a shell or no shell". If it has a shell, volunteers go to the left side of the key. Does it have a single shell (like a snail), or a double shell (like a clam)? And so on. If the organism has no shell, go to the right side of the key. Does it have legs or no legs? If it has legs, does it have 10+ legs or 4 pairs of legs or 3 pairs of legs? If it has 3 pairs of legs, does it have wings or no wings? And so on. At each junction of the lines, volunteers choose whichever option is appropriate for your organism, and each choice will further refine the final identification. Identifications will be to the level of "Order". When possible, a subset of sites will further be identified down to the "Family" level. Identification is done with the assistance of trained volunteers.

It may be tempting to jump to the bottom of the key and simply look for pictures that look similar to organisms. However, volunteer monitors may miss an important attribute of the organism along the way that could make a difference in your identification. With practice, volunteer monitors should become adept at the identification process, and in fact will know what to look for at the first glance.

Sorting the Organisms

As volunteer monitors look at each organism to identify it, they may find the need to use the microscope to be able to see if a particular attribute is present or absent. Volunteer monitors are advised to ask for assistance in adjusting the microscope the first time, as it will make a huge difference in what are seen.

Using the dichotomous key to decide what each organism is, they are sorted by Order, then like-Orders are placed into a Petri dish—different Orders in different dishes.. Accuracy is important, so volunteer monitors are encouraged to ask for help if unsure of identification! Trained professionals are available to help, as are other volunteers and workers in the lab.

After volunteer monitors find all of the organisms that are visible in the sampling tray, leftover contents are emptied into the bucket that is available for that purpose (NEVER empty a tray into a sink! The sand and debris will clog the drain), and the next container of benthic samples is emptied into the tray, and the process begins again.

If volunteer monitors transport some of their invertebrates (for example, invertebrate predators) from the stream to the lab in their own separate jars, volunteer monitors can identify them and then put them straight into the alcohol in the Petri dishes. These obviously do not need to go into the sampling trays first.

There are a few organisms on the dichotomous key that are not represented on the data sheet, meaning they "don't count" towards the final index score. This is because these organisms can survive and reproduce in either polluted or non-polluted conditions. Knowing that these organisms are present therefore does not indicate the health of the stream, because they can survive and reproduce anywhere.

Other things that "don't count" on the data sheet are organisms or parts of organisms that were not alive when collected. This is why it's important not to dismember the organisms when catching them. Dead invertebrates do not indicate healthful conditions in a stream, because there is no way of knowing how they died.

Exceptions to this are for crayfish and clams. Stream Teams should not collect any live crayfish at the stream site, but only count the number of live ones seen and note their number on the data sheet. Clams or clam shells should **not** be collected or brought back to the lab. Again, workers should count the total number of live clams seen, but should try not to disturb clams if they are lodged in the substrate. The numbers of live crayfish and clams seen do count toward the final index score.

Trained volunteers will check all Petri dishes to make sure they have been accurately identified. After they are sure that identification and all final counts are correct, the trained professional will initial volunteer data sheets.

After the data sheets have been initialed, volunteer monitors may place all invertebrates together into one final jar that has been filled 2/3rds full with alcohol. A label will be provided for each jar with the date, and name and location of the stream.

The invertebrates are preserved in 70% ethanol so that they may be sent to the DNRE along with copies of the data sheets for each site if ever needed. There the samples can be checked once again for identification, accuracy and can be kept as a permanent record for that stream site location and time. DNRE biologists may even further identify the invertebrates to the level of "Genus, affording them even more information about the conditions of the stream. The DNRE uses the information gathered from volunteer monitoring activities to supplement their own fieldwork and studies.

Identification Evaluation

Before leaving for the day, volunteer monitors should take a few moments to complete an evaluation form, and make sure that all equipment is turned back into the project coordinator.

Cleaning and Inventory of Materials

After monitoring results are reviewed, FRWC staff cleans the monitoring equipment (nets, jars, pipets, spoons, tweezers, petri dishes, and waders) using non-phosphorous cleaning agents. Inventory and condition of the supplies are recorded. Lapeer items are returned to the Lapeer Chapter.

Invasive Species Decontamination

Decontamination is of utmost importance in stopping the spread of invasive species and the transport of aquatic diseases. Refer to CISMA liaison each season to maintain and update the watch list species sheet for volunteers.

Team leaders will ensure the following decontamination steps are completed:

1. Conduct a visual inspection of gear before and after field work.

2. If going to another monitoring site, thoroughly inspect and remove all plants, dirt, mud, and any other visible debris like seeds, shoots, animals, insects, and eggs from clothing and equipment. If going to another site on the same sampling day, Team Leaders will supervise the use of a decontamination kit to disinfect all equipment with dilute bleach and allow it to sit for 10 minutes before rinsing with tap water and towel dry all equipment before leaving the site. (See below for a list of the decontamination kit contents).

3. Remove plant and debris from equipment and let it dry for at least 5 days.

4. If necessary, Team Leaders should use high pressure hot washes to clean monitoring equipment if areas are known to be infected by invasive species.

5. Be on the lookout for New Zealand mudsnails.

COVID-19 decontamination procedures and precautions implemented as of May 2020.

All equipment will be cleaned and sterilized using approved CDC and/or EPA methods prior to distribution and upon return. Gloves, disinfecting wipes, and hand sanitizer will be provided in buckets, disposable masks will be provided upon request. Volunteers are advised to follow state guidelines while monitoring and at labs. Lab equipment will be wiped down between uses and before and after lab days. Lab space will be thoroughly wiped down before and after lab events, including all touch points. Lab stations will be set up six feet apart when space allows.

3.6 Monitoring Instruments/Calibration

Every year prior to monitoring, all equipment will be inspected and checked to ensure proper working condition. All reusable equipment will be cleaned prior to use in the field. The nets used for sample collection will be remarked with measured increments of tenths of feet. It will be the responsibility of the Monitoring Coordinator to ensure sample collection supplies are in sufficient supply and appropriate condition prior to every monitoring season.

3.6.1 Equipment used

Equipment may be defined as objects used in monitoring activities that are reused from year to year. The equipment readily utilized in the FRWC Benthic Macroinvertebrate Monitoring Program includes:

- Nets – two per site per collection event will be available. These nets are considered heavy duty "D-ring" collection nets and are used on an individual basis. The nets are marked with depth measurements (in tenths of feet) along the handle and therefore double as a depth measuring device. Nets will be replaced as needed.
- Tweezers/forceps – used in separating specimens or collecting from net. Any type of tweezers or forceps will suffice. These will be replaced as availability runs low.
- Trays – large durable trays are used for sorting specimens after they are collected from the nets. White trays are recommended so that the macroinvertebrate contrast with the bottom of the tray and become easily identifiable. Trays should be of a hard plastic or other durable material so that replacement is seldom required.
- Thermometers – waterproof mercury thermometers, measured in degrees Farenheight and/or Celsius. Used for both ambient air and water temperature readings. When used in the water, it is suggested that the device be tied to a stationary object or a highly visible floatation device. Thermometers will be replaced as needed.
- Measuring tape – a thin, pliable, 2-sided measuring tape will be used in measuring distances across the stream. At least one side of the tape should be measured in tenths of feet. This tape should also be a minimum of 100 feet in length.
- Chest waders – currently, access to 10 pairs of felt-bottom wader for volunteer use. As funding permits, more waders of larger size will be obtained.
- Buckets – to assist in carrying equipment and supplies.
- Microscopes – dissecting microscopes will be utilized in the laboratory for specimen identification. The particular models used will be depending on the current inventory of the college's laboratory. These microscopes will be updated or replaced at college's discretion.
- Computer – to be made available to Monitoring Coordinator and equipped with Excel and/or Access for data entry.

3.6.2 Supplies used

Supplies may be defined as objects used in monitoring activities that are replaced on an annual basis. The supplies readily utilized in the FRWC Benthic Macroinvertebrate Monitoring Program include:

- Jars – small collection jars are used to store, transport and preserve specimens. Airtight lids for the jars are a necessity to prevent alcohol evaporation.
- Bags – plastic bags are used for transporting groups of sample jars and may also be used for transporting other supplies. Small, re-sealable plastic baggies may be purchased and used for holding collected samples.
- Gloves – disposable rubber or latex gloves will be provided to volunteer monitors for use in sorting through substrate material or picking up trash at a site.
- Labels – needed for identifying, samples with vital data such as date, sites, group, etc. Labels may also be used for identifying specimens when final identification has taken place.
- Markers – any writing device will do. Needed for data taking and labeling samples.
- Paper – much paper will be used for printing and copying data forms, waivers, vehicle sign, evaluation forms, notices and reports.
- Pipettes – plastic pipettes are used to draw up water and macroinvertebrate specimens to aid in separation and identification. Thin plastic pipettes are preferable because they can be squeezed easily and may be disposed of when cracked or soiled.
- Spray bottles – squeezable water bottles with a streaming nozzle are recommended for use in initial collection and sorting. These plastic bottles are a good tool for separating out live organisms from detritus and other substrate material.
- Postage – for mailing notices and benthic reports.
- Clip boards – used to keep forms and assist monitors recording data.
- Antibacterial soap – used by monitors to keep hands clean as needed.
- Sharpened pencils – for writing and recording data.
- Magnifying lens – used to help sort organisms in field.
- Rubbing alcohol – to permanently preserve specimens when used as solution in sample jars.

3.6.3 Calibration Methods

Prior to entering the stream, an ambient air temperature will be taken and recorded as a means of calibration. In doing so, a monitoring team will leave the thermometer in the open air for a minimum of 10 minutes. After this air temperature is recorded, a water temperature will then be taken. This temperature will also be recorded after a period of no less than 10 minutes in the water. To guard against skewed results, temperature readings should not go in the reverse order. Once per year, all FRWC owned thermometers will be checked against themselves. Any thermometer with an outlying reading will be discarded. Thermometers would be replaced only at this time.

Prior to timing the floating object to determine surface water velocity, a stopwatch will be timed against a second hand of a watch to ensure the stopwatch is working properly. (Stop watches are not currently owned or supplied by FRWC to volunteer monitors but are to be sought as equipment acquisition if funding allows.)

Prior to each collection event, the net will be inspected for holes in the net webbing, as well as for faded or absent depth markings. If any depth marking intervals appear to be missing or skewed, it is recommended that the handle of the net is reconciled against the measuring tape (used in measuring stream width, Section 3.7.4) and remarked.

Calibration of the dissecting microscopes will be the assumed responsibility of FRWC staff, Dr. Pace, other science faculty members, or other authorized laboratory personnel. This calibration will take place at a minimum of once per year.

These calibration activities will be administered as frequently as described above and will be recorded each time. Calibration records may be as simple as a brief note regarding the outcomes of the calibration activities. However, this note is to be signed off on by a Quality Assurance Officer and delivered to the Monitoring Coordinator to be kept on file with this QAPP. Any additional calibration activity not described here may be at adopted according to any specific manufacturer's instruction.

3.7 Data Presentation

Data from Stream Habitat Data Collection forms will be entered into a master benthic macroinvertebrate database, maintained by FRWC. This information will be compiled into an annual monitoring report and made available to all volunteer participants and the community. Annual monitoring reports may also be distributed to the FRWC circulation of members, if funding allows.

Maps will also be created and kept on file with up-to-date representations of all monitoring sites. While GPS is not a necessary component of stream habitat data collection, all monitoring sites will be GPS marked at least once (at the onset of their use) for geographic reference purposes.

3.8 Quality Control

It will be the responsibility Program Quality Control Officers to review field records and determine if sampling methods are being performed adequately upon conclusion of every monitoring season. (See Section 2.4 for Program Data Quality Objectives.)

During the project duration, it will be assumed that a single sample is not representative of that location. Macroinvertebrate results will instead be considered reliable after repeated collections at the same location spanning at least three years (or six collection events). The results can be compared to other studies at the same locations within the watershed (i.e. MDNRE water quality monitoring, MDNR biological surveys, USGS flow monitoring, water quality monitoring of local agencies, etc.)

Some field checks will be conducted by the Monitoring Coordinator prior to each monitoring season so as to avoid any potentially hazardous site condition, and additionally when data review by the Program Quality Assurance Officers reveals a significant spike or change in data results for a given site. The Monitoring Coordinator and/or trained volunteer will also conduct evaluation during sample identification to insure each volunteer is using the same techniques and is accurately identifying samples. For this purpose, identification keys and ***duplicate samples*** will be kept on hand in the laboratory to aid in identification.

In general, the routine reviews of all ***DQO***s listed in Section 2.4 will be used to evaluate program success and will be used to refine the project over time.

4.0 Data Management

Once all records are completed and delivered back to the Monitoring Coordinator (see Section 2.6), final Stream Quality Scores will be calculated and applied by the Monitoring Coordinator, following the methods outlined above. Results are entered into the master database for macroinvertebrate collection results within 30 days of receipt and forwarded on to the Program's Quality Assurance Officers. The Quality Assurance Officers will then be responsible for checking for completeness of results within 30 days of receipt (or, 60 days from completion of the collection event). In addition to this general overview of result completion, Quality Assurance Officers will also conduct an annual data review within 60 days of receipt of the final collection data of the year from the Monitoring Coordinator (generally in December or January). Methods for this review may be variable as long the interpretation methods outlined in Section 2.4 are followed. Every three years, this annual review should include more comprehensive interpretation methods, including evaluation of data precision (Section 2.4) and trend assessment. Conclusions drawn from the annual data reviews will be noted by the Quality Assurance Officers and provided to other Water Monitoring Committee Members at the following Monitoring Committee meeting, prior to the commencement of the next year's monitoring activities. Upon completion of the yearly data review, an Annual Monitoring Report will also be generated. [Format and level of detail of monitoring report at the discretion of FRWC management] This document will be available to volunteers, partnering agencies, and others chosen by FRWC. Copies of each year's annual report will kept on file with FRWC.

5.0 Data Validation

5.1 Field Data Review, Verification and Validation

The Stream Habitat Data Collection Form will be checked for completion by the Monitoring Coordinator/Quality Assurance Officers. Collection data may be thrown out by the Monitoring Coordinator if the volunteer data taker denotes a problem with the original collection (such as equipment failure or collection interruption due to bad weather). The site where rejected data was collected will not, however, be revisited by the Monitoring Coordinator (or any other committee member or volunteer monitor) until the following collection event, taking into consideration that the hatch schedule would be different than when the site was originally sampled.

For macroinvertebrate identification, a skilled volunteers will be used to spot check samples and provide general identification oversight. During macroinvertebrate identification, volunteers use microscopes and dichotomous keys.

Collection data will be evaluated by the Quality Assurance Officers on an annual basis. The long-term nature of this benthic macroinvertebrate monitoring program and the database it generates allows for comparison of new data to previous data collected at the same site. If data appears abnormal or deviates

beyond the Data Quality Objectives described in Section 2.4, it may be flagged by the Quality Assurance Officers. During this process data may also be compared to well-known reference standards. Once subsequent monitoring at the flagged site is completed and the cause of deviation is determined, it will be up to the discretion of the Quality Assurance Officers to reject or accept the data (see Section 5.2).

Once justification for the data rejection is documented, a Quality Assurance Officer would have the ability to delete said data record from the FRWC Macroinvertebrate Monitoring Database. Any other reasons for rejecting or qualifying data will be made by the consensus of Monitoring Committee. All corrective actions will be documented in the Annual Monitoring Report.

5.2 Reconciliation with Data Quality Objectives

All collection data will be assessed for completeness and accuracy within 60 days of the collection event. All other Data Quality Objectives (DQO) will be thoroughly assessed once every three years. Any inconsistencies or misrepresentations detected by the Quality Assurance Officers will be discussed by the Monitoring Committee and dealt with as described above.

If site data from a single collection event deviates from the DQOs of this program (stated in Section 2.4), it will be rejected and not be re-sampled until the next collection event to during the same season the following year. Continued monitoring of the site should confirm whether deviant data resulted from conditions or from sampling error –

- *If continued monitoring confirms the reliability of the original data, then those data are preserved.*
- *If continued monitoring confirms sampling error, then those data are rejected and volunteer monitors should be re-assigned and/or re-trained.*
- *If continued monitoring reveals that the deviant data was the result of event conditions, then those data should be rejected and site redistribution should be considered.*
- *If continued monitoring reveals possible equipment failure, then those data should be rejected and equipment should be replaced as expeditiously as possible.*

Upon review of data, Quality Assurance Officers will document whether or not DQOs were met during sample collection. If DQOs were not met, improvements for next year's collection events will be discussed and incorporated into the Program and the Program's QAPP or SOPs (as necessary) prior to beginning another year of monitoring.

6.0 Reports & Response Actions

6.1 Reports

Any Annual Monitoring Reports will be completed by the Monitoring Coordinator and included as a tool for Program evaluation by the Monitoring Committee. The report will include a program summary, data results, interpretation, conclusions, and a discussion of any quality assurance issues that arose during the course of the year. This report will be available to all volunteer participants, all Monitoring Committee Members, FRWC Members and all listed under Section 1.0 of this QAPP. If applicable, additional grant reports will be completed and submitted to the grant administrator in a timely manner. Additionally, data may be submitted to MDNRE for entry into the STORET and MiCorps databases.

6.2 Response Actions

All sites with a Stream Quality Score of less than 19 (rated as poor) will require a follow up visit by a member or members of the Monitoring Committee for photo-documentation and additional water quality

assessments (such as chemical monitoring, turbidity analysis, stream bank assessments, etc) if available. Site information will be brought to attention of the State or other professional environmental experts as decided by the Monitoring Committee.

As stated above, volunteers may be encouraged to repeat a training program if their sampling methods are deemed of poor quality. Likewise, the opinions of seasoned or expert volunteers who participate in monitoring events are valued and will be taken into account during year-end program reviews.

If deviation from the QAPP is observed at any point during monitoring, macroinvertebrate identification or data entry, the data may be deleted from the database at the discretion of the Program's Quality Assurance Officers. All response actions will be documented and kept on file with FRWC.

References

1. ASTI Environmental. *Quality Assurance Project Plan for the Upper Grand River Adopt-A-Stream Program*. Jackson, MI: revised October 1, 2007.

2. Branch County Conservation District. *Quality Assurance Project Plan for a Bank Erosion Hazard Index (BEHI) Inventory of the Hodunk-Messenger Chain of Lakes Watershed*. Coldwater, MI: August 13, 2007.

3. Casell, Vito R. Westinghouse Savannah River Company. *SRTC Speadsheet to Determine Relative Percent Difference (RPD) for Duplicate Waste Assay Results and to Perform the RPD Acceptance Test*. WSRC-TR-2002-00055. Aiken, SC: 2002.

4. Huron River Watershed Council. *Quality Assurance Project Plan for the Huron River Watershed Council River & Stream Monitoring Study of the Ecological Condition of the Creek*. Version 2.0, July 2008.

5. Michigan. Department of Environmental Quality. Water Bureau. NPS Unit. *QAPP Guidance Document*. 2003.

6. Michigan. Department of Environmental Quality. Water Bureau. Qualitative Biological and Habitat Survey Protocols for Wadeable Streams and Rivers. WB-SWAS-051,Revised December 2008.

7. The Nature Conservancy and Office of the Livingston C. Drain Commissioner. Shiawassee River Watershed Benthic Macroinvertebrate Monitoring Program. December 5, 2007.

8. Sommerfield, Cathlyn. Northwestern Michigan College Research Services. *Statewide Storm Water Education Project Existing Conceptions Survey Quality Assurance Project Plan, #2002-0301*. June 17, 2003.

9. United States. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. *The Volunteer Monitor's Guide to Quality Assurance Project Plans*. EPA 841-B-96-003, September 1996.

10. Volunteer Stream Monitoring Resources Website. Michigan Clean Water Corps. June 2008 http://www.micorps.net/streamresources.html.

Glossary

Accuracy – A data quality indicator, accuracy is the extent of agreement between an observed value (sampling results) and the accepted, or true, value of the parameter being measured. High accuracy can be defined as a combination of high precision and low bias.

Benthic – The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers.

Bias – Often used as a data quality indicator, bias is the degree of systematic error present in the assessment or analysis process. When bias is present, the sampling result value will differ from the accepted, or true, value of the parameter being assessed.

Completeness – A data quality indicator that is generally expressed as a percentage, completeness is the amount of valid data obtained compared to the amount of data planned.

Duplicate Sample – Used for quality control purposes, duplicate samples are two samples taken at the same time from, and representative of, the same site that are carried through all assessment and analytical procedures in an identical manner. Duplicate samples are used to measure natural variability as well as the precision of a method, monitor, and/or analyst. More than two duplicate samples are referred to as *replicate samples.*

DQOs – "Data Quality Objectives" define how Benthic Macroinvertebrate Monitoring data will be evaluated based on objective assessment of each of the defined measures.

Eddies – the water current in a stream moving contrary to the direction of the main current, especially in a circular motion.

Macroinvertebrate – An animal without a backbone that is visible with the naked eye.

Nonpoint Source Pollution – pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water.

Precision – A data quality indicator, precision measures the level of agreement or variability among a set of repeated measurements, obtained under similar conditions. Precision is usually expressed as a standard deviation in absolute or relative terms.

QAPP – Short for Quality Assurance Project Plan, a QAPP is a formal written document describing the detailed quality control procedures that will be used to achieve a specific project's data quality requirements.

Representativeness – A data quality indicator, representativeness is the degree to which data accurately and precisely portrays the actual or true environmental condition measured.

Riffle – shallow, rapid flow where the water surface "ripples".

RPD – "Relative Percent Difference" is the numerical interpretation of comparing two values with one another. It is often used as a quantitative indicator of quality assurance and quality control for repeated measurements where the outcome is expected to be the same.

Runs – an extended stretch of fast moving water, usually deeper than riffles, with rapid smooth water flow.

SOP – "Standard Operating Procedures" provide specific documentation for various processes, usually highly-technical processes.

Standard Deviation – Used in the determination of precision, standard deviation is the most common calculation used to measure the range of variation among repeated measurements. The standard deviation of a set of measurements is expressed by the positive square root of the variance of the measurements.

Substrate – the earthy material that exists in the bottom of a marine habitat, like dirt, rocks, sand, or gravel.

Thalweg – The line defining the lowest points along the length of a river bed or valley.

TMDL – Short for "Total Maximum Daily Load", a TMDL is a regulatory term in the U.S. Clean Water Act (CWA), describing a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

Watershed – The area of land draining to a common river, river system, or other body of water

- APPENDICES -

STREAM HABITAT ASSESSMENT

Stream Macroinvertebrate Datasheet

*Please complete your specimen collection **first***

Stream Name:

Location: **Circle One**: Monitoring *Upstream* –or— *Downstream* of road?

Collection Start Time: _____ (AM / PM)

Date: _____ Site ID: _____

County: _____ Township: _____

Major Watershed: Flint River Watershed HUC Code (if known): _____

Latitude: (if known) _____ Longitude: (if known) _____

Monitoring Team:

Name(s) of Person(s) Completing Datasheet : _____

Name(s) of Person(s) Collecting : _____

Other Team Members: _____

Macroinvertebrate Collection: Check the habitats that were sampled. Make sure you are sampling **all** habitats present. (within a 300 foot sampling reach as described in your site directions)

_____ Riffles	_____ Large Rocks	_____ Submerged Wood/Woody debris
_____ Overhanging Vegetation	_____ Leaf Packs	_____ Other/Describe Below:
_____Rooted Aquatic Plants	_____ Pools	_____
_____Runs	_____ Eddys	_____
_____ Undercut banks/Overhanging Vegetation		_____

Did you see any: **Live Crayfish?** --or-- **Live Clams?** (*Crayfish & Clams are Not Collected, just counted.)*

( ) Yes - how many live crayfish? _____ ( ) No ( ) Yes - how many live clams? _____ ( ) No

-- If yes, remember to include them in the assessment at end.

Collection Finish Time: _____ (AM / PM)

Comments: *Were other wildlife present, including fish? If yes, please list what was seen and how many.*

Safety First!

- Do not walk in an unstable riverbank area or wade in water too deep, or too fast flowing. Keep safety in mind when choosing measuring locations. If the stream is too deep to take measurements, an estimate will do.

II. Flow Measurement

To take a correct stream flow measurement, face upstream in a straightaway with your partner 12 feet *downstream*. Throw your float at least 10 feet *upstream* from where you stand (away from your partner). This allows the float to fully accelerate by the time it reaches you. Begin timing once it reaches you. Stop when it reaches your partner.

Flow Measurement Data

Average stream width and depth:

- Stream width is the distance from the water's edge on one side of the stream to the other side.

- Monitors shall take three measurements of width and depth at random straightaways along the 300 foot long sampling area, avoiding sand bars, curves, and debris.

Measurement	Width (feet)	Depth (feet)				Flow Measurement Data	
		1/4 Way Across Stream	Middle of Stream	3/4 Across Stream	Average depth	Time (sec)	Distance (feet) *(always 12 feet)*
1st							
2nd							
3rd							
Results - *Office Use only*	Average width:	Average depth:				Average Flow:	

EXAMPLE: *Measurement Data*

Measurement	Width (ft)	Depth (ft)				Time (sec)	Distance (feet)
		1	2	3	4		
1	25	1.7	2.1	2.2	2	12.0	12
2	24	2.2	2.3	2.4	2.3	15.0	12
3	21	2.0	1.8	1.7	1.83	13.0	12

III. Bank Conditions

Undercut bank angles (<90°) often improve the habitat. While doing monitoring, measure the bank heights and record the angle of the bank as indicated on the data sheet. Left/right banks are identified by looking **downstream**.

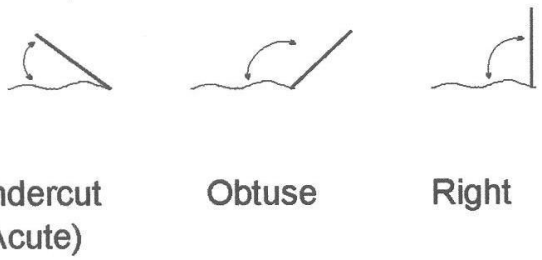
Data use: Calculate the percentage of banks with acute (undercut), obtuse, and right angles. Right angles indicate higher erosive potential, while acute angle improve the habitat structure of a stream.

Undercut (Acute)%_____

Obtuse %_____

Right %_____

Sketch examples:



B. Bank stability and erosion

Summarize the extent of erosion along each bank separately on a scale of 1 through 10, by circling a value below. Left/right banks are identified by looking downstream.

Excellent	Good	Marginal	Poor
Banks Stable. No evidence of erosion or bank failure. Little potential for problems during floods. < 5% of bank affected.	Moderately stable. Small areas of erosion. Slight potential for problems in extreme floods. 5-30% of bank in reach has areas of erosion.	Moderately unstable. Erosional areas occur frequently and are somewhat large. High erosion potential during floods. 30-60% of banks in reach are eroded.	Unstable. Many eroded areas. > 60% banks eroded. Raw areas frequent along straight sections and bends. Bank sloughing obvious.
LEFT BANK 10 - 9	LEFT BANK 8 - 7 - 6	LEFT BANK 5 - 4 - 3	LEFT BANK 2 - 1 - 0
RIGHT BANK 10 - 9	RIGHT BANK 8 - 7 - 6	RIGHT BANK 5 - 4 - 3	RIGHT BANK 2 - 1 - 0

C. Riparian Zone

1. Left Bank (looking downstream)

Circle those land-use types you can see from this stream reach:

Wetlands Forest Residential Lawn Park Shrub, Old Field Agriculture

Construction Commercial Industrial Highways Golf Course Road Other _____

1. Right Bank (looking downstream)

Circle those land-use types you can see from this stream reach:

Wetlands Forest Residential Lawn Park Shrub, Old Field Agriculture

Construction Commercial Industrial Highways Golf Course Road Other _____

3. Summarize the size and quality of the riparian zone along each bank separately on a scale of 1 through 10 by circling a value below:

Excellent	Good	Marginal	Poor
Width of riparian zone >150 feet, dominated by vegetation, including trees, understory shrubs, or non-woody macrophytes or wetlands; vegetative disruption through grazing or mowing minimal not evident; almost all plants allowed to grow naturally.	Width of riparian zone 75-150 feet; human activities have impacted zone only minimally.	Width of riparian zone 10-75 feet; human activities have impacted zone a great deal.	Width of riparian zone, 10 feet; little or no riparian vegetation due to human activities.
Left bank = 10 9	Left bank = 8 7 6	Left bank = 5 4 3	Left bank = 2 1 0
Right bank = 10 9	Right bank = 8 7 6	Right bank = 5 4 3	Right bank = 2 1 0

IV. Stream and Riparian Habitat

D. General Information		***Circle** one or more answer as appropriate*				
1	Monitoring Event Conditions	Rain	Sunny	Windy	Other:	
2	Water Temperature (°C)					
3	Air Temperature (°C)					
4	Channel Condition (Stream shape constrained through human activity?)	Natural	Recovering	Maintained		
5	Has this stream been channelized (stream shape constrained through human activity)?	Yes, currently	Yes, sometime in the past	No		
6	Estimate of current stream flow	Dry	Stagnant	Low	Medium	High
7	Highest water mark (In feet above the current level.)	<1	1-3	3-5	5-10	>10
8	Estimate of turbidity	Clear	Slightly Turbid (can barely see bottom)		Turbid (cannot see bottom)	
9	Is there a sheen or oil slick visible on the surface of the water?	Yes	No			
10	If yes to # 9, does the sheen break up when poked with a stick?	**Yes** (most likely **natural**)		**No** (most likely **artificial**)		
11	Is there foam present on the surface of the water?	Yes	No			
12	If yes to #11, does the foam feel gritty or slippery? (please circle one)	**Gritty (**most likely natural)		**Slippery (**most likely artificial)		
13	If the water **smells**, please describe:					
14	Has it rained in the last 5 days?	Yes	No	If yes, approximate the number of inches:		

E. Plant Community

Estimate the percentage of stream covered by overhanging vegetation (near the water) _____%

Estimate the percentage of stream covered by overhanging tree canopy _____%

Estimate the relative abundance of the following types of vegetation present using the scale below:
Scale: 0 = Absent,1 = Rare, 2 = Common, 3 = Abundant, 4= Dominant

Plants in Stream				Plants on Bank and in Riparian Zone			
Algae on Surfaces of Rocks or Plants		Filamentous Algae (Streamers)		Shrubs		Trees	
Macrophytes (Standing Plants)		Other		Grasses		Other	

F. Streambed Substrate

Estimate percent of stream bed composed of the following substrate and percent embedded for larger substrate.

Substrate type	**Size**	**Percent of stream bed**	**Percent Embedded**
Boulder	>10" diameter		
Cobble	2.5 - 10" diameter		
Gravel	0.1 - 2.5" diameter		
Sand	coarse grain		
Fines: Silt/Detritus/Muck	fine grain/organic matter		
Hardpan/Bedrock	solid clay/rock surface		
Artificial	man-made		
Other (specify)			

V. Sources of Degradation

Based on what you can see from this location, indicate the potential causes and level of severity of this degradation using the scale below:

Additional comments:

Severity: S – slight (0-25%); M – moderate (26-75%); H – high (76-100%) Clarify below if necessary							
Crop Related Sources	**S**	**M**	**H**	Signs of cows/horses/etc. using or crossing the stream	**S**	**M**	**H**
Grazing Related Sources	**S**	**M**	**H**	On-site Wastewater Systems	**S**	**M**	**H**
Intensive Animal Feeding Operations	**S**	**M**	**H**	Silviculture (Forestry)	**S**	**M**	**H**
Highway/Road/Bridge Maintenance and Runoff	**S**	**M**	**H**	Resource Extraction (Mining)	**S**	**M**	**H**
Channelization	**S**	**M**	**H**	Recreational/Tourism Activities (general)	**S**	**M**	**H**
Dredging	**S**	**M**	**H**	• Golf Courses	**S**	**M**	**H**
Removal of Riparian Vegetation	**S**	**M**	**H**	• Recreational Boating (water releases)	**S**	**M**	**H**
Bank and Shoreline Erosion/ Modification/Destruction	**S**	**M**	**H**	• Recreational Boating (bank or shoreline erosion)	**S**	**M**	**H**
Flow Regulation/ Modification (Hydrology)	**S**	**M**	**H**	Debris in Water	**S**	**M**	**H**
Land Fill	**S**	**M**	**H**	Debris in Trees (natural sources)	**S**	**M**	**H**
Urban Runoff	**S**	**M**	**H**	Trash in trees along bank	**S**	**M**	**H**
Impoundment –Dam (natural or man-made)	**S**	**M**	**H**	Industrial Point Source	**S**	**M**	**H**
Construction: Highway, Road, Bridge, Culvert	**S**	**M**	**H**	Municipal Point Source	**S**	**M**	**H**
Construction: Land Development	**S**	**M**	**H**	Source(s) Unknown	**S**	**M**	**H**
Natural Sources (i.e. log jams)	**S**	**M**	**H**	Does a team need to come out and collect trash?	**Y**	**N**	

Identification and Assessment

To record the approximate numbers of live organisms collected in each taxa found in the stream reach, use letter codes: **R** (rare) for 1 to 10; and **C** (common) for 11 or more.
**Do NOT count empty shells, pupae, or terrestrial macro invertebrates.

Group 1: Sensitive

_____ Caddisfly Larvae (Trichoptera)
Except Net-spinning caddis (listed in Group 2)
_____ Hellgrammites (Megaloptera)
_____ Mayfly nymphs (Ephemeroptera)
_____ Gilled (right-handed) snails (Gastropoda)
_____ Stonefly nymphs (Plecoptera)
_____ Water Penny (Coleoptera)
_____ Water Snipe fly (Diptera)

Group 2: Somewhat Sensitive

_____ Alderfly larvae (Megaloptera)
_____ Beetle adults (Coleoptera)
_____ Beetle larvae (Coleoptera)
_____ Black fly larvae (Diptera)
_____ Clams (Pelecypoda)
_____ Crane Fly larvae (Diptera)
_____ Crayfish (from count) (Decapoda)
_____ Damselfly nymphs (Odonata)
_____ Dragonfly nymphs (Odonata)
_____ Net-spinning caddisfly larvae (Hydropsychidae, and Trichoptera)
_____ Scuds (Amphipoda)
_____ Sowbugs (Isopoda)

Groups 3: Tolerant

_____ Aquatic worms (Oligochaeta)
_____ Leeches (Hirudinea)
_____ Midge Larvae (Diptera)
_____ Pouch snails (Gastropoda)
_____ True bugs (Hemiptera)
_____ Other true flies (Diptera)

STREAM QUALITY SCORE

Group 1:

_____ # of R's x 5.0 = _____

_____ # of C's x 5.3 = _____

Group 1 Total = _____

Group 2:

_____ # of R's x 3.0 = _____

_____ # of C's x 3.2 = _____

Group 2 Total = _____

Group 3:

_____ # of R's x 1.1 = _____

_____ # of C's x 1.0 = _____

Group 3 Total = _____

Total Stream Quality Score = _____

(Sum of totals for groups 1-3; round to nearest whole number)

Check One:

_____ Excellent (> 48) _____ Fair (19 – 33)

_____ Good (34-48) _____ Poor (< 19)

Identifications Made by: _____

Rate your confidence in these identifications: Quite Confident 5 4 3 2 1 Not Very Confident

Datasheet checked for completeness by: _____ Datasheet Version 10/08/05

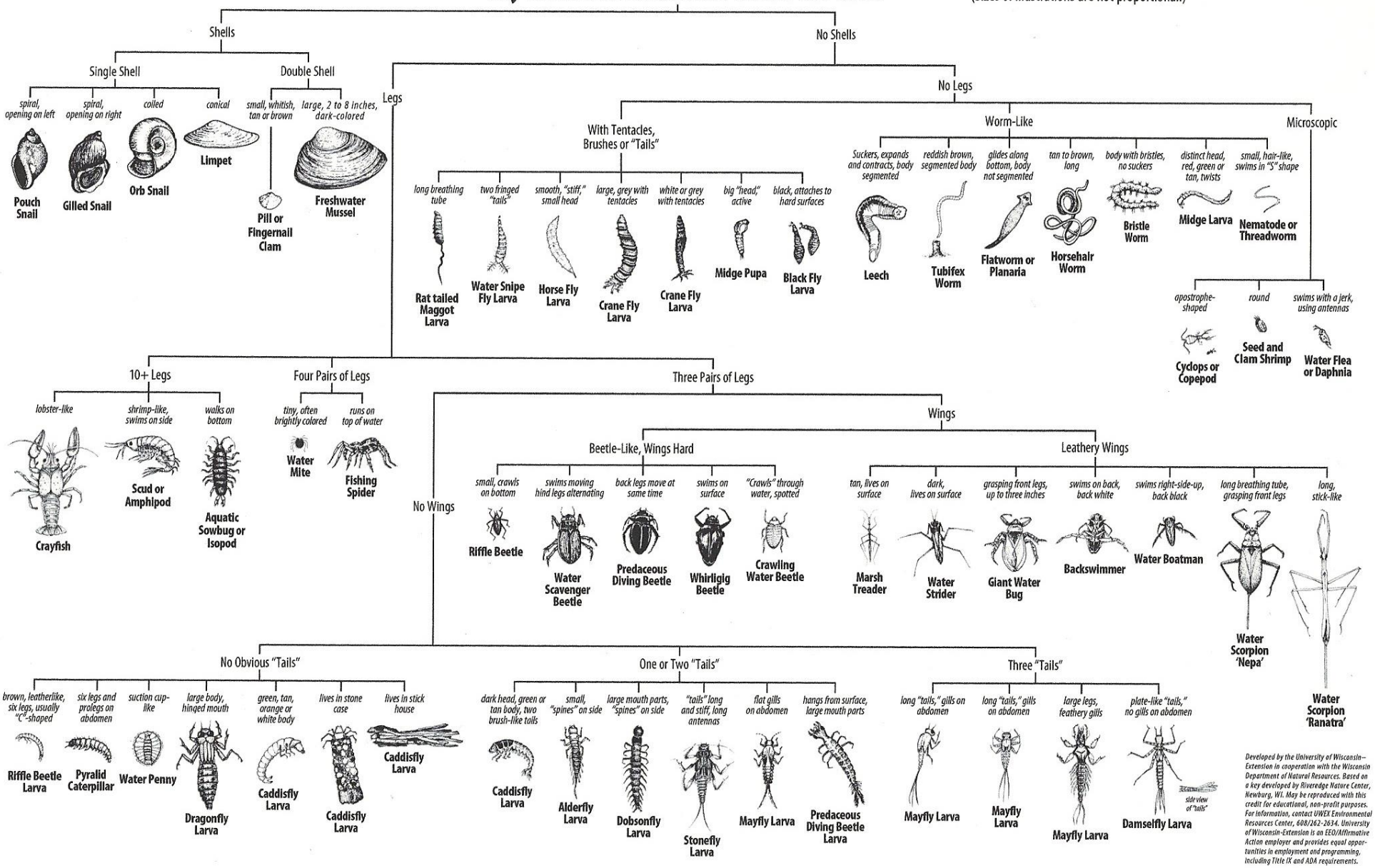
Data entered into MiCorps database by: _____ Date: _____

Credits

This habitat assessment was created for the MiCorps Volunteer Stream Monitoring Program from a combination of habitat assessments from the Huron River Watershed Council, the Friends of the Rouge River, and the Michigan Department of Environmental Quality. Version 1.0, June 2009.
Revised by the Flint River Watershed Coalition, Nov. 2010

Key to Macroinvertebrate Life in the River

(Sizes of illustrations are not proportional.)



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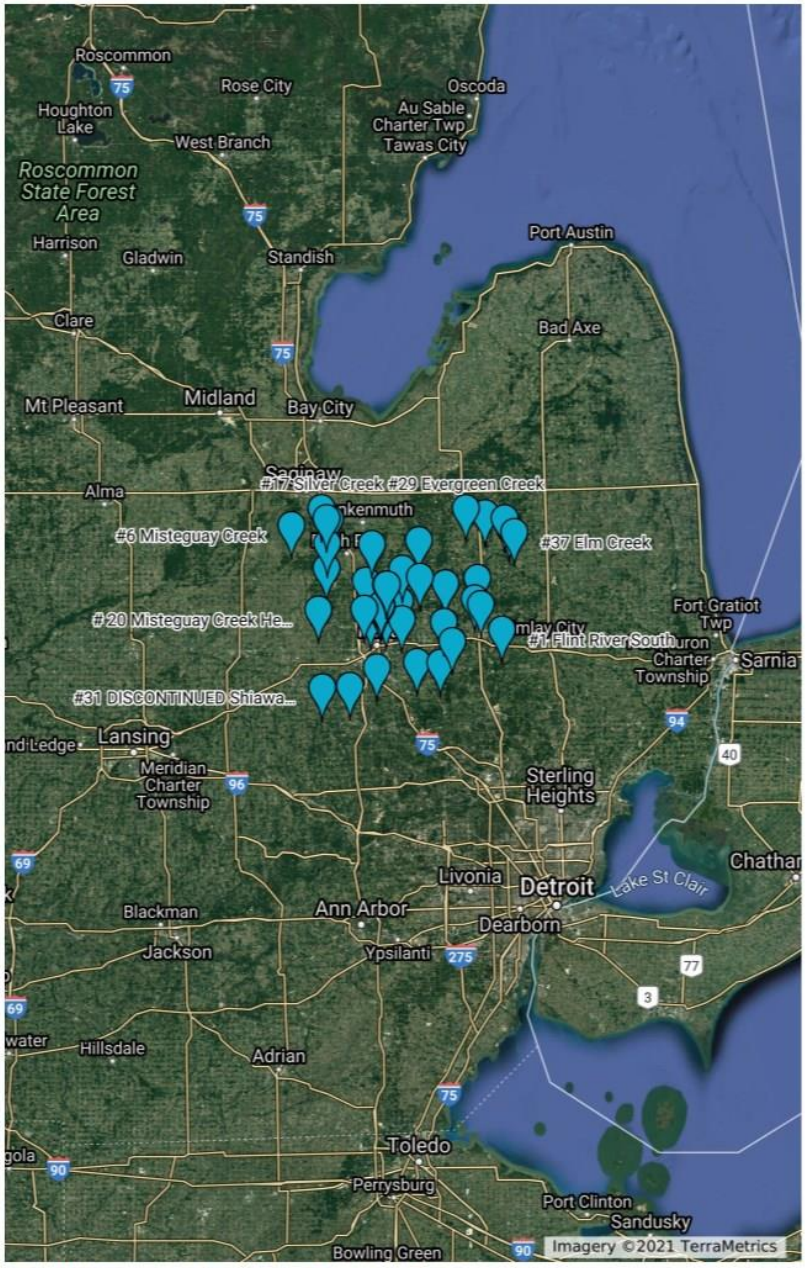
FRWC Benthic Monitoring GPS Coordinates

Site Name	GPS Coordinates	
Flint River South	42 57' 46" N 83 14' 26" W	**FRWC-Lap01**
Plum Creek	43 13' 42' N 83 12' 53' W	**FRWC-Lap02**
Hasler Creek	43 05' 00" N 83 26' 33" W	**FRWC-Lap03**
Flint River Northbranch	43 13' 42" N 83 12' 52" W	**FRWC-Lap04**
Pine Run Creek	43 15' 03" N 83 51' 15" W	**FRWC-Sag05**
Misteguay Creek	43 14' 04" N 83 59' 31" W	**FRWC-Sag06**
Flint River Flushing	43 07' 30" N 83 51' 37" W	**FRWC-Gen07**
Swartz Creek	42 59' 48" N 83 42' 29" W	**FRWC-Gen08**
Gilkey Creek	43 01' 04" N 83 40' 33" W	DISCONTINUED
Thread Creek	42 59' 54" N 83 39' 14" W	**FRWC-Gen10**
Kearsley Creek	43 02’ 28” N 83 36’ 33.998” W	**FRWC-Gen11**
Butternut Creek	43 07’ 16” N 83 35’ 46” W	**FRWC-Gen12**
Farmers Creek	43 2' 51.185" N 83 20' 18.859" W	**FRWC-Lap13**
Squaw Creek	43 15' 55" N 83 18' 02" W	**FRWC-Lap14**
Brent Run Creek	43 11' 13" N 83 51' 48" W	**FRWC-Gen15**
Silver Creek	43 16' 40" N 83 53' 06" W	**FRWC-Sag17**
Indian Creek	43 15' 08" N 83 13' 53" W	**FRWC-Lap18**
Hunters Creek	43 1' 44.273' N 83 18' 57.829' W	**FRWC-Lap19**
Misteguay Creek Headwaters	43 00' 54" N 83 53' 47" W	**FRWC-Gen20**
Brent Run Headwaters	43 4.5668' N 83 43.450' W	**FRWC-Gen-21**
Swartz Creek Headwaters	42 51' 49" N 83 41'15" W	**FRWC-Gen22**
Thread Creek Headwaters	42 52' 40" N 83 32' 37" W	**FRWC-Gen23**
Kearsley Creek Headwaters	42 52' 34" N 83 27' 36" W	**FRWC-Gen24**
Gilkey Creek Headwaters	42 59' 24" N 83 35' 50" W	**FRWC-Gen25**
Butternut Creek Headwaters	43 11' 40" N 83 32' 15" W	**FRWC-Gen26**
Hasler Creek Headwaters	42 58' 57" N 83 26' 51" W	**FRWC-Lap27**
Springbank Creek	42 55' 55" N 83 25' 03" W	**FRWC-Lap28**
Evergreen Creek	43 16' 41.899" N 83 22' 12" W	**FRWC-Tus29**
Pine Run Headwaters	43 11' 06" N 83 42' 18" W	**FRWC-Gen30**
Shiawasee River Argentine	42 48' 37.145" N 83 52' 57" W	TRANSFERRED
Shiawasee River Linden	42 48' 56" N 83 46' 58" W	TRANSFERRED
Clark Drain, Richfield Park	43 05' 59" N 83 32' 00" W	**FRWC-Gen33**
Gilkey Creek, Applewood	43 1' 17.646" N 83 40' 52.23" W	DISCONTINUED
Gilkey Creek Kearsley Park	43 01’ 46.967" N 83 40’ 21.865” W	**FRWC-Gen35**
Elm Creek	43 12.963” N 83 11.841' W	**FRWC-Lap37**
Flint River, Mott Park	43 00’59.2” N 83 43’53.7” W	**FRWC-Gen38**
Flint River, Stepping Stone Falls West	43 04’50.2” N 83 39’14.5”W	**FRWC-Gen39a**
Flint River, Stepping Stone Falls East	43 04’45.7” N 83 39’02.8” W	**FRWC-Gen39b**

FRWC Water Monitoring Sites

FRWC Benthic Monitoring Sites

- #1 Flint River South
- #2 Plum Creek
- #3 Hasler Creek
- #4 Flint River Northbranch
- #5 Pine Run Creek
- #6 Misteguay Creek
- #7 Flint River Flushing
- #8 Swartz Creek
- #9 DISCONTINUED Gilkey Creek *DISCONTINUED*
- #10 Thread Creek
- #11 Kearsley Creek (For-Mar)
- #12 Butternut Creek
- #13 Farmers Creek
- #14 Squaw Creek
- #15 Brent Run Creek
- #17 Silver Creek
- #18 Indian Creek
- # 19 Hunters Creek
- # 20 Misteguay Creek Headwaters
- #21 Brent Run Headwaters
- #22 Swartz Creek Headwaters
- #23 Thread Creek Headwaters
- #24 Kearsley Creek Headwaters
- #25 Gilkey Creek Headwaters
- #26 Butternut Creek Headwaters



Benthic testing sites for the FRWC

#27 Hasler Creek Headwaters

#28 Springbank Creek

#29 Evergreen Creek

#30 Pine Run Headwaters

#31 DISCONTINUED Shiawasee River Argentine - DISCONTINUED

#32 DISCONTINUED Shiawasee River Linden - DISCONTINUED

#33 Clark Drain Richfield Park

#34 DISCONTINUED Gilkey Creek Applewood Estate

#35 Gilkey Creek Kearsley Park

#36 DISCONTINUED Flint River Birch Run

#37 Elm Creek

#38 Flint River, Mott Park Landing

#39A Flint River Stepping Stone Falls West Side

#39B Flint River Stepping Stone Falls East Side

2010 Water Quality and Pollution Control in Michigan: Flint River Watershed

8 Digit HUC: 04080204 Flint

10 Digit HUC: 0408020401 South Branch Flint River

12 Digit HUC: 040802040101 Whigville Creek-South Branch Flint River

AUID: 040802040101-01 **Rivers/Streams in HUC 040802040101** **RIVER 53.652917 MILES**
Includes: South Branch Flint River and Whigville Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040101-02 **Rivers/Streams in HUC 040802040101** **RIVER 9.765469 MILES**
Includes: South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Cold Water Fishery	Not Supporting	Temperature, water	Y	2014		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040102 Hunters Creek

AUID: 040802040102-01 **Rivers/Streams in HUC 040802040102** **RIVER 12.741837 MILES**
Includes: Hunters Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040102-02 **Rivers/Streams in HUC 040802040102** **RIVER 12.620049 MILES**
Includes: Hunters Creek and Kintz Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040103 Pine Creek-South Branch Flint River

AUID: 040802040103-01 Rivers/Streams in HUC 040802040103 RIVER 0.945105 MILES
Includes: Unnamed Tributary to the South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040103-02 Rivers/Streams in HUC 040802040103 RIVER 11.253653 MILES
Includes: Bishop Drain and Unnamed Tributary to Bishop Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040103-03 Rivers/Streams in HUC 040802040103 RIVER 13.202273 MILES
Includes: Pine Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040103-04 Rivers/Streams in HUC 040802040103 RIVER 4.303616 MILES
Includes: UNNAMED DRAINS, LAPEER TWP.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040103-05 Rivers/Streams in HUC 040802040103 RIVER 4.687624 MILES
Includes: South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040103-06 Rivers/Streams in HUC 040802040103 RIVER 8.07534 MILES
Includes: South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Cold Water Fishery	Not Supporting	Temperature, water	Y	2014		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040103-07 Rivers/Streams in HUC 040802040103 RIVER 4.158216 MILES
Includes: South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Cold Water Fishery	Not Supporting	Temperature, water	Y	2014		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040104 Farmers Creek

AUID: 040802040104-01 Rivers/Streams in HUC 040802040104 — RIVER 8.371734 MILES
Includes: Farmers Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040104-03 LAKE NEPESSING — FRESHWATER LAKE 422.7881 ACRES
SW of Lapeer, Elba Twp.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	Mercury in Fish Tissue	Y	2011		

AUID: 040802040104-04 Rivers/Streams in HUC 040802040104 — RIVER 17.173457 MILES
Includes: Farmers Creek and Poplar Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040104-05 Rivers/Streams in HUC 040802040104 — RIVER 32.503927 MILES
Includes: Mill Creek and Spring Bank Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040104-06 Rivers/Streams in HUC 040802040104 — RIVER 12.814538 MILES
Includes: South Branch Farmers Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040105 Plum Creek Drain-South Branch Flint River

AUID: 040802040105-01 Rivers/Streams in HUC 040802040105 — RIVER 12.387656 MILES
Includes: Unnamed Tributaries to South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040105-02 Rivers/Streams in HUC 040802040105 — RIVER 6.589641 MILES
Includes: South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040105-03 Rivers/Streams in HUC 040802040105 — RIVER 53.54977 MILES
Includes: PLUM CREEK

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040106 South Branch Flint River

AUID: 040802040106-01 Rivers/Streams in HUC 040802040106 RIVER 24.092425 MILES
Includes: Sand Hill Drain and South Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

10 Digit HUC: 0408020402 North Branch Flint River

12 Digit HUC: 040802040201 Elm Creek-North Branch Flint River

AUID: 040802040201-01 Rivers/Streams in HUC 040802040201 RIVER 53.933777 MILES
Includes: Cedar Creek and Elm Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040202 Gravel Creek-North Branch Flint River

AUID: 040802040202-02 Rivers/Streams in HUC 040802040202 RIVER 23.896072 MILES
Includes: Bottom Creek and North Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040202-03 Rivers/Streams in HUC 040802040202 RIVER 2.793684 MILES
Includes: PLUM CREEK

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040202-04 Rivers/Streams in HUC 040802040202 RIVER 15.690244 MILES
Includes: Gravel Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040203 Indian Creek

AUID: 040802040203-01 Rivers/Streams in HUC 040802040203 RIVER 65.483203 MILES
Includes: Indian Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040204 Wilson Drain-North Branch Flint River

AUID: 040802040204-01 Rivers/Streams in HUC 040802040204 RIVER 33.19862 MILES
Includes: North Branch Flint River, Wilson Drain, North Branch Drain and Hobson Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040205 Squaw Lake-Squaw Creek

AUID: 040802040205-01 Rivers/Streams in HUC 040802040205 RIVER 60.368697 MILES
Includes: Silver Creek and Squaw Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040206 Squaw Creek

AUID: 040802040206-01 Rivers/Streams in HUC 040802040206 RIVER 57.472486 MILES
Includes: Evergreen Creek and Squaw Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040207 Fitch Drain-North Branch Flint River

AUID: 040802040207-01 Rivers/Streams in HUC 040802040207 RIVER 37.372992 MILES
Includes: North Branch Flint River and Fitch Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040208 North Branch Flint River

AUID: 040802040208-01 Rivers/Streams in HUC 040802040208 RIVER 43.560606 MILES
Includes: Forest Drain, Joslyn Drain, Kester Drain and North Branch Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040208-03 Rivers/Streams in HUC 040802040208 RIVER 8.90922 MILES
Includes: Crystal Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

10 Digit HUC: 0408020403 Swartz Creek-Flint River

12 Digit HUC: 040802040301 Kimball Drain

AUID: 040802040301-01 Rivers/Streams in HUC 040802040301 RIVER 23.846362 MILES
Includes: Kimball Drain, Lum Drain, and Unnamed Tributaries to Kimball Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040302 Dollar Lake-Swartz Creek

AUID: 040802040302-01 Rivers/Streams in HUC 040802040302 RIVER 52.854455 MILES
Includes: Swartz Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040302-02 BIG SEVEN LAKE (SEVEN LAKES) FRESHWATER LAKE 149.9897 ACRES
2.5 miles NW of Holly.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	Mercury in Fish Tissue	Y	2011		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040303 Zimmerman Branch-Thread Creek

AUID: 040802040303-01 Rivers/Streams in HUC 040802040303 RIVER 32.883585 MILES
Includes: Thread Creek and Zimmerman Branch

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040303-05 WILDWOOD LAKE FRESHWATER LAKE 117.8667 ACRES
5 miles E. of Holly.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	Mercury in Fish Tissue	Y	2011		

AUID: 040802040303-07 Rivers/Streams in HUC 040802040303 RIVER 14.943355 MILES
Includes: Thread Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040304 West Branch Swartz Creek

AUID: 040802040304-01 Rivers/Streams in HUC 040802040304 RIVER 30.66094 MILES
Includes: West Branch Swartz Creek, Hewitt Drain and Howland Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040305 Indian Creek-Swartz Creek

AUID: 040802040305-01 Rivers/Streams in HUC 040802040305 RIVER 32.181435 MILES
Includes: Swartz Creek and Seaver Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040305-02 Rivers/Streams in HUC 040802040305 RIVER 19.351363 MILES
Includes: Indian Creek, Petry Branch and Dawe Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040306 Thread Creek

AUID: 040802040306-01 Rivers/Streams in HUC 040802040306 RIVER 1.867841 MILES
Includes: Thread Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040306-02 Rivers/Streams in HUC 040802040306 RIVER 37.37672 MILES
Includes: Bush Creek, Pierson Branch and Thread Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040306-03 THREAD LAKE RESERVOIR 80.5546 ACRES
Upstream of Rt. 475. Vicinity of Flint.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		

12 Digit HUC: 040802040307 Swartz Creek

AUID: 040802040307-01 Rivers/Streams in HUC 040802040307 RIVER 20.354877 MILES
Includes: Includes: Swartz Creek, Carman Creek, Gibson Drain and Sherwood Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040307-02 Rivers/Streams in HUC 040802040307 RIVER 3.996659 MILES
Includes: Call Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Bacterial Slimes	Y	2020		
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Cause Unknown	Y	2020		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

10 Digit HUC: 0408020404 North Branch Flint River

12 Digit HUC: 040802040401 Whipple Drain-Flint River

AUID: 040802040401-01 Rivers/Streams in HUC 040802040401 RIVER 38.085083 MILES
Includes: Clute Drain, Flint Riverand Hemmingway and Whipple Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040402 Hasler Creek

AUID: 040802040402-01 Rivers/Streams in HUC 040802040402 RIVER 38.259688 MILES
Includes: Hasler Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040403 Holloway Reservoir-Flint River

AUID: 040802040403-01 Rivers/Streams in HUC 040802040403 RIVER 12.74308 MILES
Includes: Flint River and unnamed tributaries

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040403-02 Rivers/Streams in HUC 040802040403 RIVER 0.011806 MILES
Includes: Flint River and Hasler Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040403-03 Rivers/Streams in HUC 040802040403 RIVER 16.294216 MILES
Includes: Flint River and Henry Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040403-05 HOLLOWAY RESERVOIR RESERVOIR 1177.4315 ACRES
NE of Richfield Center (Flint area).

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Nutrient/Eutrophication Biological Indicator	Y	2015		
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Phosphorus (Total)	Y	2015		
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		

12 Digit HUC: 040802040404 Duck Creek-Kearsley Creek

AUID: 040802040404-01 Rivers/Streams in HUC 040802040404 RIVER 68.485669 MILES
Includes: Duck Creek and Kearsley Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040405 Cummings Drain-Kearsley Creek

AUID: 040802040405-01 Rivers/Streams in HUC 040802040405 RIVER 60.317745 MILES
Includes: Cartwright Drain, Kearsley Creek and Paddison Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040406 Black Creek

AUID: 040802040406-01 Rivers/Streams in HUC 040802040406 RIVER 15.482706 MILES
Includes: Simon Branch

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040406-03 Rivers/Streams in HUC 040802040406 RIVER 16.923044 MILES
Includes: Black Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040407 Butternut Creek

AUID: 040802040407-01 **Rivers/Streams in HUC 040802040407** **RIVER 46.534489 MILES**

Includes: Barden Branch, Butternut Creek and Jackson Branch

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040408 Kearsley Creek

AUID: 040802040408-01 **Rivers/Streams in HUC 040802040408** **RIVER 3.827025 MILES**

Includes: Chipmunk Creek and Kearsley Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040408-02 **Rivers/Streams in HUC 040802040408** **RIVER 32.112463 MILES**

Includes: Kearsley Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040408-03 **KEARSLEY RESERVOIR** **RESERVOIR 155.9201 ACRES**

Flint River confluence just u/s of Western Road.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040409 Clark Drain-Flint River

AUID: 040802040409-01 Rivers/Streams in HUC 040802040409 RIVER 3.546786 MILES
Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-02 Rivers/Streams in HUC 040802040409 RIVER 21.155203 MILES
Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-03 Rivers/Streams in HUC 040802040409 RIVER 13.446472 MILES
Includes: POWERS-CULLEN DRAIN

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-04 Rivers/Streams in HUC 040802040409 RIVER 31.420256 MILES
Includes: Clark Drain, Flint River, Riegle Drain and Zufelt Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-05 C.S. MOTT LAKE BLUEBELL BEACH INLAND LAKE SHORELINE 0.2 MILES
Impoundment of the Flint River u/s of Flint.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Total body contact recreation	Not Supporting	Escherichia coli	Y	2011		

12 Digit HUC: 040802040410 Gilkey Creek-Flint River

AUID: 040802040410-01 Rivers/Streams in HUC 040802040410 RIVER 3.488377 MILES
Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040410-02 Rivers/Streams in HUC 040802040410 RIVER 18.79275 MILES
Includes: Gilkey Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040409 Clark Drain-Flint River

AUID: 040802040409-01 Rivers/Streams in HUC 040802040409 — **RIVER 3.546786 MILES**

Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-02 Rivers/Streams in HUC 040802040409 — **RIVER 21.155203 MILES**

Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-03 Rivers/Streams in HUC 040802040409 — **RIVER 13.446472 MILES**

Includes: POWERS-CULLEN DRAIN

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-04 Rivers/Streams in HUC 040802040409 — **RIVER 31.420256 MILES**

Includes: Clark Drain, Flint River, Riegle Drain and Zufelt Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040409-05 C.S. MOTT LAKE BLUEBELL BEACH — **INLAND LAKE SHORELINE 0.2 MILES**

Impoundment of the Flint River u/s of Flint.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Total body contact recreation	Not Supporting	Escherichia coli	Y	2011		

12 Digit HUC: 040802040410 Gilkey Creek-Flint River

AUID: 040802040410-01 Rivers/Streams in HUC 040802040410 — **RIVER 3.488377 MILES**

Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040410-02 Rivers/Streams in HUC 040802040410 — **RIVER 18.79275 MILES**

Includes: Gilkey Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204	Flint

8 Digit HUC: 04080204 Flint

10 Digit HUC: 0408020405 Flint River

12 Digit HUC: 040802040501 Cole Creek-Flint River

AUID: 040802040501-01 Rivers/Streams in HUC 040802040501 RIVER 21.685233 MILES
Includes: Cole Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040501-02 Rivers/Streams in HUC 040802040501 RIVER 24.690184 MILES
Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040501-03 Rivers/Streams in HUC 040802040501 RIVER 12.797139 MILES
Includes: Mud Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040501-05 Rivers/Streams in HUC 040802040501 RIVER 4.773373 MILES
Includes: Pirnie Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040502 Freeman Drain-Flat River

AUID: 040802040502-01 Rivers/Streams in HUC 040802040502 RIVER 9.429929 MILES
Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040502-02 Rivers/Streams in HUC 040802040502 RIVER 19.402315 MILES
Includes: Brent Creek and Freeman Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040503 Brent Run

AUID: 040802040503-01 Rivers/Streams in HUC 040802040503 RIVER 56.199918 MILES
Includes: Brent Run

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040504 Armstrong Creek-Flint River

AUID: 040802040504-01 Rivers/Streams in HUC 040802040504
Includes: Armstrong Creek
RIVER 24.402489 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040504-02 Rivers/Streams in HUC 040802040504
Includes: Flint River
RIVER 11.251168 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040505 Crawford Drain-Misteguay River

AUID: 040802040505-01 Rivers/Streams in HUC 040802040505
Includes: Misteguay Creek and Crawford Creek
RIVER 49.067819 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040506 Onion Creek-Misteguay River

AUID: 040802040506-01 Rivers/Streams in HUC 040802040506
Includes: Misteguay Creek and Rush Creek
RIVER 26.345517 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040506-02 Rivers/Streams in HUC 040802040506
Includes: Rush Creek
RIVER 14.151729 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040506-03 Rivers/Streams in HUC 040802040506
Includes: Onion Creek
RIVER 19.603639 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040507 Reed Drain-Misteguay River

AUID: 040802040507-01 Rivers/Streams in HUC 040802040507
Includes: Misteguay Creek and Porter Creek
RIVER 68.651575 MILES

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040508 Northwood Creek

AUID: 040802040508-01 Rivers/Streams in HUC 040802040508 RIVER 76.862374 MILES

Includes: Northwood Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040509 Mitchell Creek-Misteguay River

AUID: 040802040509-01 Rivers/Streams in HUC 040802040509 RIVER 59.811327 MILES

Includes: Misteguay Creek, Mitchell Creek and Northwood Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040510 Pine Run

AUID: 040802040510-01 Rivers/Streams in HUC 040802040510 RIVER 59.15578 MILES

Includes: Benjamin Run, Parker Creek and Pine Run

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040511 Silver Creek

AUID: 040802040511-01 Rivers/Streams in HUC 040802040511 RIVER 59.555322 MILES

Includes: Alexander Drain, Bogart Drain, Hutchinson And Young Drain, Silver Creek and Silver Creek Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

12 Digit HUC: 040802040512 Misteguay River

AUID: 040802040512-01 Rivers/Streams in HUC 040802040512 RIVER 47.845582 MILES

Includes: Bortle Drain, Misteguay Creek and Pattee Creek

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204 Flint

8 Digit HUC: 04080204 Flint

12 Digit HUC: 040802040513 Flat River

AUID: 040802040513-01 Rivers/Streams in HUC 040802040513 RIVER 52.302678 MILES

Includes: Atwell Drain, Flint River, Pitch Creek and Spring Brook Drain

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Mercury in Water Column	Y	2011		
Other Indigenous Aquatic Life and Wildlife	Not Supporting	PCB in Water Column	Y	2013		
Fish Consumption	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

AUID: 040802040513-02 Rivers/Streams in HUC 040802040513 RIVER 10.262566 MILES

Includes: Flint River

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule	TMDL Completion	Expected to Attain
Other Indigenous Aquatic Life and Wildlife	Not Supporting	Mercury in Water Column	Y	2011		
Other Indigenous Aquatic Life and Wildlife	Not Supporting	PCB in Water Column	Y	2013		
Fish Consumption	Not Supporting	Mercury in Water Column	Y	2011		
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013		
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013		

04080204	Flint

Appendix E

List of Additional Macroinvertebrate Identification Resource Websites:

- http://people.virginia.edu/~sos-iwla/Stream-Study/Key/Key1.HTML
- http://wrc.umn.edu/Publications/supplyquantityandquality/guidetoaquaticinverts/
- www.discovercarolina.com/html/s05nature09a02b.pdf
- http://www.hudsonbasin.org/bulletinboard.html
- http://www.roaringfork.org/images/other/aquaticinvertebratesheet.pdf
- http://www.waterbugkey.vcsu.edu/
- www.epa.gov/bioiweb1/html/benthosclean.html
- www.epa.gov/bioiweb1/html/benthosid.html
- www.learnnc.org/lp/media/lessons/EddieHamblin3252003179/