Community Science Institute **www.communityscience.org**
Volunteer Monitoring **Watershed Science** **Risk Communication**

April, 2014

Synoptic Sampling

A training manual for volunteers

About CSI

The Community Science Institute is a nonprofit organization that operates a state-certified water quality testing lab which partners with groups of volunteers to monitor water quality and disseminate scientifically credible data to the public. The mission of the Community Science Institute (CSI) is to empower citizens to understand their local water resources and manage them sustainably. CSI recruits and trains groups of volunteers as our community partners in monitoring local streams and lakes. Synoptic monitoring is one of three types of CSI-volunteer monitoring partnerships.
For more information, please visit our website at www.communityscience.org.

Synoptic Sampling Summary

Synoptic Sampling is CSI's original and longest-running volunteer monitoring program, beginning in 2002 with the Fall Creek Watershed Committee monitoring Fall and Virgil Creeks. The goal of Synoptic Sampling is twofold: 1) Produce ongoing scientifically credible data that informs water resource management decisions by local governments and 2) Educate and empower citizens to become stewards of their local environment by participating in monitoring programs. The outcome of this program will be to characterize water quality under base flow and stormwater conditions, identify contaminants of concern and investigate their sources.

There are two major components to producing management-grade water quality data:

1) Collection of a sample that is representative of the point in the stream or the lake where the sample is taken
2) Accurate and precise analyses of chemical, physical and microbiological indicators of water quality.

It is essential to assure both the quality of the water analyses and the quality of the sample collection process. For CSI-volunteer monitoring partnerships, the quality of water analyses is assured by the CSI lab's certification through the New York State Department of Health – Environmental Laboratory Approval Program (NYSDOH-ELAP, ID #11790). The other component of producing management-grade data, the quality of sample collection, depends on volunteers.

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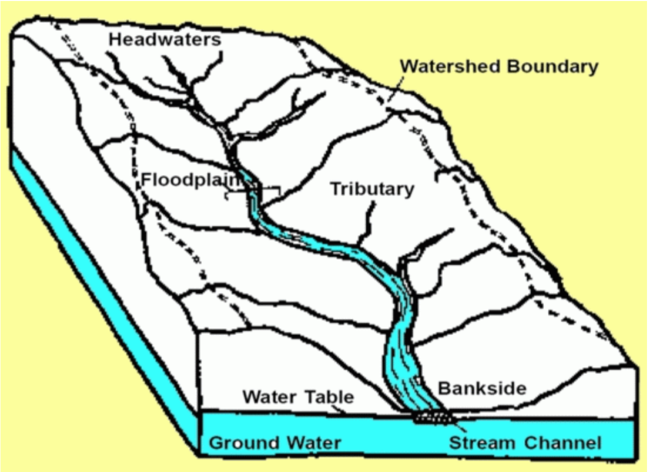
Goals and Objectives

This workshop will introduce the Community Science Institute and its monitoring partnerships, present background concepts related to water monitoring, and discuss criteria for selecting sampling locations. We will focus on the collection of stream samples, the use of test kits to perform measurements in the field, finalizing sampling locations and working out logistics of water monitoring events.

Volunteers will finalize the selection of monitoring locations and the organization of teams with the aid of paper maps and electronic maps. CSI staff will provide one-on-one assistance with electronic mapping and site selection, as needed

Background

Following are a few basic concepts that frame water quality monitoring:



Watershed – The land which water moves through and over to a surface water body such as a creek, stream, river or lake. "Land" includes subsurface geology as well as surface features such as forests, agricultural fields and urban areas. At base flow, or under normal conditions, most of the water in a stream comes from groundwater. A stream's natural chemistry results from minerals leaching out of subsurface rocks into groundwater as it moves down-gradient by gravity and enters the stream. Whereas hydrogeology determines a stream's basic chemistry, the features of a watershed on the land surface determine the quantity and chemistry of the runoff that results from rain and snowmelt. Pollutants transported to the stream in runoff include sediment, nutrients such as phosphorus and nitrogen, and pathogenic bacteria.

Point source pollution – Refers to pollution that originates from a specific source such as a pipe or outfall, and enters a stream directly, for example, from a factory or a sewage treatment plant. Point-source pollution is regulated under the Clean Water Act by a system of permits (see below).

Non-point source pollution – Refers to "diffuse" pollution that originates from diverse sources in a stream's watershed as opposed to single identifiable points. Examples are fertilizers like phosphorus and nitrogen from agricultural fields, lawns, and golf courses, and sediment from eroding streambanks.

Land uses – Forested, agricultural, and urban are examples of broad land use categories. These can be broken down into smaller categories, for example, cropland and pasture (agricultural uses) and residential and commercial (urban uses). Land uses can contribute to non-point and point source pollution. Land uses are essential for selecting what parameters should be tested for in a monitoring program, as different land uses are associated with different types of pollution.

Clean Water Act – A federal law passed in 1972 that continues to govern the protection of surface water. States implement the Clean Water Act jointly with the EPA. Two important features of the law are: a) The State Pollution Discharge Elimination System (SPDES) requiring point sources to obtain permits enforced by the state government that specify the quantities of pollutants they are allowed to discharge. The point source permitting system has cleaned up discharges nation-wide and is considered a big success; and b) Anti-degradation provisions that require states to monitor surface water bodies and take steps to remediate those which are found to be impaired. Every water body has a specific “designated use,” for example, as a source of drinking water, for contact recreation, natural habitat, or for trout fishing. A water body is considered to be impaired if it can no longer serve its designated use. The anti-degredation provisions require remediation if a water body is impaired. CSI's volunteer monitoring programs are designed to tie into government regulation of water quality under the Clean Water Act.

Stream Ecology:

Stream monitoring is based on an understanding of a stream and its watershed as a whole. Streams are aquatic ecosystems that incorporate interacting physical, biological and chemical characteristics. Synoptic Sampling focuses on chemical indicators of pollution that are found in the stream itself. Benthic Macroinvertebrate monitoring focuses on biological indicators of pollution. However, the physical environment of a stream, such as the stream’s own physical features as well as the hydrogeology and land uses in its watershed, shape a stream’s chemistry and biology. Becoming familiar with a stream’s physical environment is a big help when interpreting chemical and biological monitoring results.

Visual Surveys:

The Visual Assessment Manual published by the Alliance For Aquatic Resource Monitoring (ALLARM) at Dickinson College in Carlisle, PA (http://www.dickinson.edu/uploadedFiles/about/sustainability/allarm/content/Visual%20Assessment%20Manual.pdf) provides a good introduction to the physical characteristics of streams and how human activities can degrade them. A visual survey is not absolutely required for monitoring, but is suggested. Volunteers are encouraged to read the ALLARM manual and to conduct visual surveys of the locations they are monitoring.

Selection of monitoring locations

Selecting Synoptic monitoring locations is as much art as it is science. Criteria to consider when selecting monitoring sites are (in no particular order):

1. Safe and legal access, including parking
2. Position in a watershed relative to land uses of interest
3. Proximity to volunteers' homes
4. The size of the upstream drainage area
5. Distance and relationship to other Synoptic monitoring locations

CSI will assist the group in using both paper maps and electronic maps to select monitoring locations. The process for selecting locations will begin in the first workshop. It is anticipated that volunteers will visit locations between workshops to assess their suitability as monitoring locations. The monitoring sites will be finalized in the second workshop.

Maps

There are two electronic mapping approaches that CSI recommends to volunteers as instructive in selecting monitoring sites and exploring potential sources of contamination in watersheds. There is only space here to mention these resources; computer savvy individuals can follow the links and learn how to use these tools intuitively or through online guides. CSI will provide additional mapping assistance in the context of its volunteer training sessions.

Google Earth: The first approach is to use Google Earth (**http://www.google.com/earth/download**) to open and visualize numerous free data layers. Kml and Kmz files are native to Google Earth and can be readily opened and visualized with no previous knowledge of mapping software.
An excellent place to start is with the **WATERS** dataset: **http://water.epa.gov/scitech/datait/tools/waters/tools/waters_kmz.cfm.** This data is from the EPA and has all the streams, rivers, watersheds, lakes, and other water features for the entire country. Since this is a lot of data, this kmz file works by only downloading the data for the areas that you zoom into. In other words, if you don't see a given stream immediately, you will have to zoom in closer to view it. You can click on the features that appear as part of the WATERS data set to get feature names and additional information.

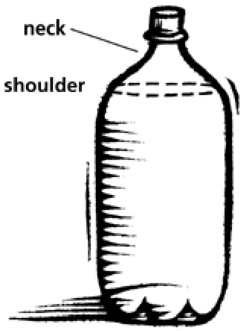
A second approach is to find out more about a watershed's hydrology, physical and land use characteristics using **StreamStats** for NY: http://water.usgs.gov/osw/streamstats/new_york.html StreamStats is an online program best accessed with Microsoft Internet Explorer. By going to the interactive map of NY, you can use the interface to zoom into a map of your area of interest. The maps are USGS maps that don't have distinct layers. Once you identify a potential monitoring site, you can use the *"Watershed Delineation from a Point"* tool to click on a stream where you would like to delineate the upstream area. The software will return a map with the watershed upstream of your point. At this point, you can use the *"Generate Flow Statistics"* tool which will return estimated flow stats for a basin without a flow gauge. The "Basin Characteristics" tool will allow you to generate information including the area of the watershed, the mean annual runoff, the length of the mainstem, and forest and urban cover in the watershed. StreamStats is a great way to compare different watersheds and begin to understand why they might have different flow regimes or water quality. Keep in mind the results are estimated based on regression equations. You can also access real USGS stream flow data by clicking on the stream gages on the map in StreamStats.

Collection of water samples:

When collecting a water sample from a stream, the goal is to obtain water that is representative of the stream at the point where the sample is taken. Volunteers collect what are known as "grab" samples: They place a sample bottle in the stream and allow it to fill with water. Specifically, volunteers do not use specialized equipment that integrates sample water across the width and depth of a stream. Under almost all conditions, carefully collected grab samples are equivalent to width- and depth-integrated samples with respect to most parameters.

Here are the different ways to collect a water sample:

Wading into the stream: In order for a grab sample to be representative of the stream at the sampling site, the water in the sample should be well mixed and free of extraneous debris. Assuming the stream is not too deep, a representative sample can be collected by wading into the center of the stream; facing in an upstream direction so that the water is flowing toward you; immersing the bottle half-way down; and opening the bottle under water, allowing the air to bubble out as it fills to the shoulder, and capping it under water. Dissolved oxygen bottles must be filled completely without air bubbles.



Sampling from shore: If the stream is too deep, or if the current is too swift, a grab sample can be collected from the stream bank. To make sure the sample is representative, collect it from a point where the current is flowing well and the water appears well mixed. *Avoid sampling from a pool, an eddy or a back-current.* Collect the sample the same as when wading into a stream: Face the bottle upstream; immerse it; uncap it, allow it to fill to the shoulder, and recap it underwater to avoid surface debris.

Sampling from a bridge: In the event that samples are collected under stormwater conditions, the current may be so swift that it would be unsafe to attempt to sample by wading into the stream or by leaning out over the stream from the stream bank. Some sites may only be accessible from bridges year-round due to steep banks or private property. If there is a bridge nearby, a sample can be collected by lowering a clean bucket into the current, then filling the sample bottles by dipping them in the bucket. *The bucket must be rinsed with stream water at least once before collecting the sample*. Care must be taken to swirl the bucket and make sure the sample is well mixed before filling the sample bottles from the bucket.

After collecting the water sample, three things need to happen right away:

- Measure temperature
- Fix Dissolved Oxygen sample by adding first two chemical reagents
- Record field conditions

Temperature: Temperature is an important component of water quality. Volunteers are provided with metal pocket thermometers to measure the temperature of stream water on-site, at the time they collect the samples. Immerse the thermometer directly in the stream or by pouring some water into a separate container than your sample bottles. Check every 10-15 seconds until it's stable, and record the result on the tracking sheet. It is not recommended to immerse thermometers directly in the stream if the stream is moving rapidly. This measurement should be done within a minute or less because the temperature of the sample changes quickly.

Dissolved oxygen (DO): Collect a sample by completely filling the small glass bottle provided in your sampling kit, cap and invert to check for air bubbles. If there are bubbles, discard the sample and collect another sample. "Fix" the dissolved oxygen by adding eight drops of each of the first two chemicals as described in the instructions provided by LaMotte (Manganous Sulfate and Potassium Iodide Azide). You can either complete the test immediately or store the sample cold and in the dark and take it to the lab or complete the test yourself up to eight hours later

Recording sampling information: As soon as the sample is collected, record the date and time of sample collection on the sample bottle and on the tracking sheet. Also on the tracking sheet, record the name and initials of the sample collector, the sample storage conditions, and how the sample was collected.

Volunteers are asked to observe general stream conditions and record them on the tracking sheet: The general appearance of the water, e.g., clear, brown, or full of debris; whether stream flow is judged to be low, medium or high; and the approximate depth and width of the stream at the sampling point. (Note that estimating the velocity of the stream requires a float and a stopwatch and is optional.) Record any unusual conditions, for example, a construction site nearby, cattle or other farm animals in the stream, or unidentified outfall pipes. Volunteers' observations can provide valuable context when interpreting results.

Flow Conditions

Volunteer groups will collect samples under both base flow and stormwater conditions. Sampling is synoptic, meaning that volunteers collect samples from all locations on the stream within a few hours of each other. This ensures that flow and weather conditions are more or less uniform at all sampling locations so that the results provide a snapshot of water quality along the entire stream. Repeated synoptic sampling of the same set of sites results in a high degree of confidence in the results. Confidence is greater than would be possible if, for example, sub-sets of sites were sampled sporadically, or if sites were changed periodically. On the other hand, more sites may be added to the synoptic sampling regimen when monitoring results show there is an adverse impact and volunteers decide to investigate the source.

In order to accomplish synoptic sampling, the volunteer group responsible for monitoring a stream organizes itself into teams, and each team is responsible for sampling a specific set of sites. It may not always be possible to organize a synoptic monitoring event, particularly under stormwater conditions when there may not be enough lead time. As a rule, every effort is made to perform synoptic sampling for every stream sampling event, practical limitations and reasonable exceptions notwithstanding.

Sampling under base flow conditions profiles water quality across the watershed when there is little or no runoff, and the water in the stream comes largely or entirely from groundwater. Sampling under stormwater or high flow conditions profiles water quality across the watershed when surface and subsurface runoff mixes with groundwater in the stream.

Runoff consists of water from rain or snowmelt that does not have a chance to percolate down into the ground, either because the ground is already saturated, or because its surface is impervious (e.g., asphalt). Runoff includes water flowing over the ground surface and water moving through the shallow sub-surface. The heavier the rain or snowmelt, the more runoff there is and the higher the flow is in the stream. Generally speaking, streams are at or near base flow conditions roughly 80% of the time and under varying degrees of stormwater conditions roughly 20% of the time.

Stormwater runoff is generally a major source of stream pollutants, for example, eroding soil, phosphorus and nitrogen nutrients, pathogenic bacteria and, in some locations, toxic chemicals. The amounts of pollutants entering a stream are typically the opposite of flow conditions, that is, roughly 80% or more of pollutants enter streams during the roughly 20% of the time when streams have elevated flows.

It is important to characterize water quality under base flow conditions for several reasons: it is the water quality in the stream most of the time; base flow monitoring can reveal adverse impacts that are not related to stormwater runoff; and because base flow monitoring makes it possible to assess the magnitude of impacts due to runoff. It is equally important to characterize water quality under stormwater conditions because that is when most adverse impacts typically occur, and because comparison with base flow makes it possible to investigate the magnitude as well as the sources of pollutants in stormwater.

Logistics:

In order to hold successful stream monitoring events, there are several logistical items that must fall into place.

1) Sampling Kits - Volunteer teams obtain sampling kits from the CSI lab. Each location has one sampling kit per event. The lab will provide three bottles for each location: A 60 ml sterile plastic bottle for bacteriological analysis, a 1-liter plastic bottle for chemical analyses and a 60ml glass dissolved oxygen bottle. CSI provides the bottles in a 1-gallon plastic bag with a sample tracking sheet. The bottles, tracking sheets, and bag are clearly labeled with the sample location code for each individual location. Volunteer teams are responsible for coordinating pickup of sampling kits with CSI staff.

2) Group and Team Contact Person: Volunteers work in groups to monitor water quality in a given watershed. These groups split into teams to collect samples from fixed

monitoring locations. To simplify communication between volunteer teams and CSI, each group and each team must have a contact person that CSI can reach, particularly regarding time-sensitive issues such as stormwater events, and that can take responsibility for contacting the other members of the team.

3)Transport of samples to CSI lab: Each volunteer team is responsible for transporting samples on ice to the CSI lab. Due to the distance traveled by some volunteer teams, it is recommended that groups designate a person to take responsibility for gathering samples from each of the teams and delivering the samples to the CSI lab. Volunteers and CSI lab staff sign the chain of custody at the bottom of the tracking sheet. CSI lab staff reserve the right to reject samples that appear to be seriously compromised, for example, if the sample bottle is cracked or melted, if the temperature of the sample is exceptionally high, if the sample cannot be identified unambiguously, or if the volunteer team reports any condition or incident that could compromise the integrity of the sample. Once the sample is accepted by the CSI lab, quality assurance and quality control are conducted within the framework of the CSI lab's ELAP-approved Quality Manual.

Other Opportunities:

Biological Monitoring (BMI)

CSI works with volunteer groups to perform biological monitoring using aquatic insects known as benthic macroinvertebrates, or BMI. The composition of the BMI community is an excellent indicator of a stream's overall health. BMI monitoring complements chemical monitoring and is used extensively by NYSDEC and other agencies as a cost-effective strategy for tracking basic water quality. CSI offers a separate BMI workshop and ongoing technical support for volunteers who are interested in BMI monitoring. CSI also offers a BMI module for high school teachers and their classes.

Recommended Equipment:

It is recommended, but not required that volunteers acquire the following equipment for their monitoring events:

- Waterproof boots - at least knee high, or waders
- A clipboard with space to store papers
- A thermometer with a lanyard attached
- Measuring tape and tennis ball for estimating flow