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

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Rough Guide to "Red Flag" Monitoring

Introduction

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. "Red flag" monitoring is one of several types of CSI-volunteer monitoring partnerships. For more information, please visit our website at www.communityscience.org.

The goal of "red flag" monitoring is to understand baseline water quality in local streams. Having a baseline makes it possible to detect contamination if and when it occurs, not only catastrophic contamination events but also low-level contamination that can degrade water quality gradually over time.

CSI recommends five "red flag" indicators of water quality that trained volunteers can measure accurately in the field. They are temperature, pH, dissolved oxygen, conductivity and total hardness. The first three, temperature, pH and dissolved oxygen, are general water quality characteristics that can be impacted by many different stressors. Conductivity and total hardness, on the other hand, are believed to be good indicators of contamination from shale gas operations, or "hydrofracking." If high volume hydraulic fracturing is approved in New York, having baseline data on these five "red flag" indicators should make it possible to detect whether or not streams are being contaminated by shale gas operations nearby.

CSI trains "red flag" monitoring groups in three half-day workshops. By the end of the third workshop, the group will have selected monitoring locations, organized itself into several teams of two to five volunteers, and be ready to perform accurate field measurements of temperature, pH, dissolved oxygen, conductivity and total hardness on a monthly basis (more or less) and report results to CSI. CSI will screen volunteers' results based on specific data quality objectives, and data that meet acceptance criteria will be entered in CSI's open, publicly accessible database at www.communityscience.org. Experience has shown that with practice, field measurements performed by trained volunteers satisfy CSI's acceptance criteria over 90% of the time.

In addition to monitoring the five "red flag" indicators approximately once a month, CSI recommends a comprehensive set of certified baseline tests at least once a year for as many "red flag" monitoring locations as funding permits. A comprehensive baseline for

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possible “hydrofracking” contamination costs $300 plus travel for paid lab staff to collect the samples and includes the following tests: Temperature, pH, dissolved oxygen, conductivity, total hardness, alkalinity, turbidity, total suspended solids, total dissolved solids, chloride, sulfate, chemical oxygen demand, total Kjeldahl nitrogen, calcium, barium, strontium, and gross alpha and gross beta radioactivity. Methane and volatile organic compounds (VOCs) are not included because they are expected to volatilize quickly from streams and therefore be difficult to detect.

In addition to monthly “red flag” monitoring and annual comprehensive baseline testing at a subset of “red flag” locations, CSI also recommends 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 “red flag” volunteers who are interested in BMI monitoring. CSI also offers a BMI module for high school teachers and their classes.

<u>First “Red Flag” Workshop (~3 hours)</u>

<u>Introduction</u>

Ideally, 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. “Red flag” and BMI monitoring focus on chemical and biological indicators of pollution that are found in the stream itself. However, the physical environment of a stream, i.e., 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. 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. “Red flag” volunteers are encouraged to read the ALLARM manual and to conduct visual surveys of the streams they choose to monitor. A visual survey is not absolutely required for “red flag” monitoring, however.

Following are a few basic concepts that frame “red flag” monitoring:

1. <u>Land uses</u> – 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.

2. Watershed – The land through and over which water moves to a surface water body such as a stream or a lake. “Land” includes subsurface geology as well as surface features such as forests, agricultural fields and urban areas. At base flow, virtually 100% 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 downgradient 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, phosphorus and nitrogen nutrients and pathogenic bacteria.
3. 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 phosphorus and nitrogen nutrients from agricultural fields and suburban golf courses and sediment from eroding streambanks.
4. Point source pollution – Refers to pollution that originates from a specific source and enters a stream directly via a pipe or a culvert, for example, from a factory or a sewage treatment plant.
5. 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 or for trout fishing. A water body is considered to be impaired if it becomes degraded and can no longer serve its designated use. “Red flag” monitoring is designed to tie into government regulation of water quality under the Clean Water Act.
6. NYSDEC’s 2011 draft Supplemental Generic Environmental Impact Statement (dSGEIS) – Does not explicitly address stream contamination by “hydrofracking” operations except to ban the industry from the New York City and Syracuse watersheds based on the potential contamination of their unfiltered drinking water supplies by sediment, phosphorus, pathogenic organisms and toxic chemicals. Addresses contamination of surface water and groundwater: a) By treating drill pads as point sources subject to SPDES permits and stormwater regulations; b) by treating waste from shale gas wells as “industrial wastewater” (i.e., not hazardous waste) that may be disposed of at appropriately retrofitted Publicly Owned Treatment Works (POTWs) (wastewater treatment plants); c) by requiring “closed loop” handling of flowback at the drill site, i.e., no open storage pits; and d) by requiring gas companies to pay to test private drinking water wells within 1,000 feet of the drill pad for an abbreviated list of “signature chemicals.” These and

other strategies may or may not be sufficient to hold the environmental impacts of shale gas wells to acceptable levels.

Portable test kits

CSI staff will bring five sets of “red flag” test kits to the first workshop and demonstrate their use. Volunteers are invited to try the tests themselves at the first workshop. The second workshop will focus on sample collection and how to perform the “red flag” tests and record and report results.

One of the goals of “red flag” training is for the group to organize themselves into teams of 2-5 volunteers who will share a set of test kits. Once teams have formed, we ask that they pool their resources and purchase a set of four test kits from CSI at a one-time cost of $187.12. The cost of a thermometer is separate. The team can use any thermometer they wish as long as they calibrate it (see second workshop for calibration procedure). In addition to purchasing the test kits and meters, CSI asks that teams take responsibility for ordering replacement chemicals as they expire every year or two (see expiration dates on bottles). Replacement chemicals may be ordered directly from LaMotte at a cost of roughly $5-$15.

Selection of monitoring locations

Selecting “red flag” monitoring locations is as much art as it is science. Selection criteria include:

1. Proximity to volunteers’ homes
2. Access
3. Position in a watershed relative to land uses of interest
4. Proximity to existing gas wells or to leased land
5. The size of the upstream catchment area
6. Road density
7. Distance and relationship to other “red flag” monitoring locations
8. Proximity to an agency monitoring site, e.g., an SRBC remote sonde

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 using paper maps. The process will continue in the second and third workshops using both paper maps and electronic maps until the group finalizes its selection of monitoring sites by the end of the third workshop.

Maps: CSI will bring a paper map to the first workshop to help launch the site selection process. CSI will also provide a Google Maps tutorial that interested volunteers can use to begin exploring possible monitoring sites. Electronic maps like Google have the potential to enhance and facilitate the site selection process, however, they are not absolutely necessary. Locations can also be selected on the basis of paper maps and volunteers’ own knowledge of their local streams.

Second "Red Flag" Workshop (~3 hours)

Goals and objectives
This workshop will focus on the collection of stream samples, the use of test kits to perform measurements in the field or at home, data quality objectives and documentation, reporting results to CSI, and CSI's criteria for accepting results and posting them in our open online database.

The second workshop will also continue the processes of exploring possible monitoring sites and organizing the group into monitoring teams. CSI staff will provide one-on-one assistance with electronic mapping (assuming an internet connection is available).

Time will also be allowed for continued questions and discussion of background information and concepts of the "red flag" monitoring program.

Use of portable kits and meters to measure "red flag" indicators

Collection of water samples: The goal of sampling 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 "red flag" parameters. It is acceptable to use mason jars or other sample containers from home as long as they are thoroughly clean and are rinsed three times with stream water before collecting a 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 devoid of extraneous debris. Under base flow conditions, 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 to a depth of about a foot or half-way down, whichever is less; and opening the bottle under water, allowing the air to bubble out as it fills to the shoulder, and capping it under water.

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: As a rule, "red flag" monitoring is conducted under base flow conditions. In the unusual 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 and risking falling into the current. 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. Care must be taken to swirl the bucket and make sure the sample is well mixed before filling the sample bottles from the bucket.

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 field data sheet. Also on the field data sheet, record the name and initials of the sample collector, note how the sample was collected, and make "eyeball" estimates of stream flow volume and velocity, the water level, and how the water appears to you. Document your estimates in the spaces provided on the field data sheet. Use the margins and the back of the field data sheet to record your observations of any conditions that catch your eye and that might impact water quality, for example, a construction site nearby, cattle or other farm animals in the stream, or an outfall pipe.

Performance of "red flag" measurements: Measurements of temperature and pH should be performed right away. Dissolved oxygen can be measured immediately or, alternatively, the sample can be collected, "fixed" and stored cold and dark for up to eight hours before completing the test. You can wait up to 14 days to measure total hardness and up to 28 days to measure conductivity if you store your sample of stream water in the refrigerator.

Temperature: Immerse the thermometer directly in the stream, check every 10-15 seconds until it's stable, and record the result on the field data sheet. Perform and record a duplicate temperature measurement for at least one of your monitoring locations each and every day your team conducts a monitoring event. You can also measure temperature by immersing the thermometer in a sample you've collected in a container, however, the measurement should be done within a minute or less because the temperature of the sample changes quickly.

pH: Before taking a sample at the first location of the monitoring day, measure the pH 7 standard provided by CSI to verify that the test is functioning properly, and document that you tested the standard by recording the result on your field data sheet in the space provided. Measure the pH of stream samples at the stream, and record and initial the result, date and time on a separate field data sheet for each monitoring location and each monitoring event (i.e., one field data sheet needs to be filled out per monitoring location per monitoring event). At the first sampling location, perform a duplicate pH measurement and document the result of this quality control test on your field data sheet. If the pH standard and duplicate meet data quality objectives at the first monitoring location, the pH measurements at the team's other monitoring locations will also be considered valid for that day.

Dissolved oxygen (DO): Collect a sample in the small glass bottle provided in the LaMotte kit, cap and invert to check for air bubbles. Discard if there are bubbles and collect another sample. "Fix" the dissolved oxygen by adding eight drops of each of the first three chemicals as described in the instructions provided by LaMotte. You have a choice of either completing the test immediately or storing the sample cold and in the dark and completing the test up to eight hours later. At the first sampling location, perform a duplicate measurement. Document your results including the duplicate by recording and initialing each result, date and time on the field data sheet for each location. If the duplicate meets data quality objectives (see below), the DO measurements at all the team's other monitoring locations will also be considered valid for that day.
Conductivity: Measure conductivity either streamside or up to 28 days after sample collection if the sample is refrigerated. Before testing any samples, calibrate the conductivity meter using the 353 uS/cm standard provided by CSI. Perform a duplicate measurement on the first sample of the day. Document that you performed the two quality control tests by recording the results, date and times on the field data sheet for that location. If the standard and duplicate meet data quality objectives (see below), the conductivity measurements at all the team's other monitoring locations will also be considered valid for that sampling event.
Total hardness: Measure total hardness either streamside or up to 14 days after sample collection if the sample is refrigerated. Before testing any samples, check to make sure the test is functioning properly by measuring the standard provided by CSI, either 20 or 100 mg $CaCO_3$/L. In addition, perform a duplicate on the first sample of the day. If the standard and duplicate meet data quality objectives (see below), the total hardness measurements at all the team's other monitoring locations will also be considered valid for that sampling event.

Data quality objectives: The quality of monitoring data needs to be sufficient to convince government agencies to act when there are changes in the water that indicate contamination. Data quality is typically evaluated using test results from three kinds of control samples. Volunteer teams perform two of the controls each time they conduct a sampling event: A duplicate to assess the precision of each test and a standard of known concentration to assess the accuracy of the tests for pH, conductivity and total hardness. The third control, which also measures accuracy, is a split sample, which is collected by the volunteer team and analyzed by the CSI lab for pH, conductivity and total hardness. Volunteer teams will be asked to provide CSI with split samples for every location for the first two months of the "red flag" monitoring program. The purpose of splitting all samples for two months is to troubleshoot problems and make sure volunteers know how to perform the tests accurately. After the first two months, quality control is maintained by splitting a sample from one location per team per quarter, or four split samples per year per team. No standards are required for temperature and dissolved oxygen. It is recommended that volunteer teams calibrate their thermometers using boiling water (100^{o} C). The dissolved oxygen test is accurate if performed correctly.

The criteria CSI uses to assess the quality of "red flag" data reported by volunteers are presented in Table 1. These criteria are roughly comparable to those used by certified labs. It must be emphasized that data quality cannot be evaluated, and therefore results must be automatically rejected for an entire monitoring event, whenever a team does not document the performance of acceptable standards and duplicates on the field data sheets for that event. For example, failure to perform and record a pH standard test at one location invalidates pH results at all locations on that day; failure to perform and record a dissolved oxygen duplicate test invalidates dissolved oxygen tests at all locations on that day; and so on.

Table 1. Quality control criteria used to evaluate field data reported by "red flag" volunteer teams

	Temperature	pH	Dissolved Oxygen	Conductivity	Total Hardness
Data Acceptance Criteria					
Precision - Acceptance of Duplicates	± 1°C	± 0.5 pH Units	± 20%	± 10%	± 20%
Accuracy - Acceptance of Standards	N/A	± 0.5 pH Units	N/A	± 1%	± 20%
Splits - Comparison with certified lab	N/A	± 0.5 pH Units	N/A	± 20%	± 20%

Standards: The CSI lab will provide a continuous supply of standards for the pH, conductivity and total hardness tests. If you suspect that a standard has become contaminated, discard it immediately and ask CSI to replace it with a fresh standard.

Field data sheets and tracking sheets: CSI provides field data sheets for volunteers to report results. In order to maximize the credibility of your data, we ask that teams fill out the field data sheets carefully and completely and mail the original hard copies to CSI. Volunteers are encouraged to make copies for their own records. CSI will keep the original field data sheets, first, as a permanent record of your results, and second, to assess data quality. Data that meet the criteria in Table 1 will be accepted and entered in CSI's open online database. CSI also provides tracking (chain of custody) sheets for volunteers to use to document the collection of split samples. Split samples can be as small as 100 ml (roughly 3/8 of a cup) and may be sent to CSI through the mail.

Chemical waste: Most of the chemicals in the "red flag" tests are not hazardous. Exceptions are concentrated sulfuric acid and azide in the dissolved oxygen test. Fortunately, the quantities are tiny and the hazard is therefore small. The waste can be disposed of by pouring down the sink at home without harming the septic system. It is noted that Tompkins County residents have the option of dropping off hazardous waste at the county recycling facility in Ithaca, and other counties may have similar programs for their residents, as well. While not recommended, the waste could, in an emergency, be disposed of outdoors on the ground or even in the stream without undue harm to the environment, because the quantities of harmful chemicals involved are miniscule.

Third "Red Flag" Workshop (~3 hours)

The third and final workshop will focus on:

- Naming the group (if it doesn't have a name by then);
- Finalizing the selection of monitoring locations and the organization of teams with the aid of paper maps and electronic maps;
- Reviewing data quality control procedures and documentation, to include split samples at all locations for the first two months;
- Planning a synoptic monitoring event in the first or second month of the program;
- Setting up a fourth workshop for BMI monitoring if there is enough interest; and
- A discussion of strategies for raising funds from local sources to continue "red flag" monitoring beyond 2012 and to conduct comprehensive baseline testing at a subset of "red flag" locations at least once a year.