STANDARD OPERATING PROCEDURES FOR WATER QUALITY MONITORING IN THE RED RIVER WATERSHED

Red Lake Watershed District
Red River Basin Monitoring Advisory Committee

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Red River Basin Monitoring Network
Data → Information → Action

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All revisions of this document have been reviewed by the Red River Basin Monitoring Advisory Committee. It also contains contributions from RRBMAC members.

This document was created for the purpose of explaining and standardizing the methods used for the collection o f water quality data within the Red River of the North Watershed. Its creation was guided by the following values:

- Consistency
- Accuracy
- Reliability
- Data that is representative of stream conditions
- Completeness
- Comparability
- Minimizing contamination of samples
- Safety
- Proper use of equipment
- Practicality
- Change must equal improvement

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1 ACKNOWLEDGEMENTS

This document has been reviewed by individuals from the Minnesota Pollution Control Agency, United States Environmental Protection Agency, United States Geological Survey, Red River Basin Board, University of Minnesota Crookston, University of North Dakota, City of Grand Forks Environmental Laboratory, Red Lake Department of Natural Resources, Red River Basin Monitoring Advisory Committee, and the Red River Watershed Assessment Protocol Technical Advisory Committee.

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Subsequent revisions have been created through the incorporation of notes collected from many years of water quality monitoring training sessions, research, and discussions among Red River Basin Monitoring Advisory Committee members. Specific thanks are in order for Robert M. Borasch, Wayne Goeken, Shane Bowe, Rochelle Nustad, and Bruce Paakh. Photos have been contributed by Jan Kaspari, Moriya Rufer, Bruce Paakh, Danni Halvorson, the International Water Institute, and Rachelle Winter.

2 BACKGROUND

A while ago, there was a need for more communication and information sharing among different agencies collecting water quality data. Each group was collecting data for their purposes. Some agencies monitored the same sites without knowing it. As technology improved, the sharing of data became easier. A study can now utilize data collected by numerous entities. With increased sharing of data, there came a need for the standardization of methods throughout the basin. The responsibility of accomplishing this task fell upon the Red Lake Watershed District and the Red River Basin Monitoring Advisory Committee.

The Red Lake Watershed District (RLWD) has conducted ambient water quality monitoring since 1984. The RLWD was awarded a BWSR Challenge Grant in 2001 to help improve coordination of water quality monitoring within the Red Lake Watershed District and the rest of the watershed of the Red River of the North. This document is one of the products of that project. The first “final” draft was completed in 2003. This document will need to be updated on a regular basis to keep up with technology, new types of monitoring, and improvements in methods.

The Red River Basin Monitoring Advisory Committee (RRBMAC) was established to develop a coordinated condition monitoring effort throughout the Red River Basin. The group meets semi-monthly at the Sand Hill Watershed District Office in Fertile. The group is an assemblage of water management and monitoring professionals from throughout the Red River Basin (Minnesota and North Dakota) that are involved with water quality monitoring. The group is valuable for improving the coordination of the many separate monitoring efforts within the basin. The group discusses nearly all aspects of monitoring strategies (site locations, monitoring frequency, biological and physicochemical monitoring, new technology, data analysis, etc.). This was the ideal group of people to conduct the review and approval of this document.

To ensure that the assessments and decisions made from data results are accurate, following proper procedures during project planning, implementation, and assessment as documented in these Standard Operating Procedures (SOP) and in a project's Quality Assurance Project Plan (QAPP) is imperative. The rigorous application of protocols ensures that accurate, precise, and representative river, stream, lake, and wetland data are collected. The application of uniform methods also ensures continuity in methodology and comparability of results among projects administered and carried out by multiple cooperating parties.

A Standard Operating Procedures document is a collection of detailed, written instructions designed to achieve uniformity of the performance of a specific task.

Technology and local knowledge continue to improve. While the basic principles necessary for the collection of quality data remain constant, everything we do is subject to improvement. With the latest revisions, this document has been improved visually to better communicate the methods described within, include information that was missing from previous versions, and incorporate updated methodology. It has been streamlined in some areas and expanded in others. It also contains methods for newer technology that is becoming more commonly used for water monitoring. This document is based on established methods and is augmented by knowledge gained from personal experience. If you have personal experience, comments, questions, or ideas you feel may help make this document more valuable to its users, please contact the Red Lake Watershed District Water Quality Coordinator and/or fill out the comment sheet in Appendix G.

3 QUALITY ASSURANCE / QUALITY CONTROL

3.1 GENERAL

Water quality data can be used to test the quality of a stream. How do we, in turn, test the quality of the water quality data collection process? How do we ensure that the data is of high quality?

A set of standard operating procedures is one component of an integrated quality system. Other quality related components of the water quality monitoring program include Quality Assurance Project Plans (QAPP) and sampling and analysis plans (SAPs). A QAPP documents the quality assurance/quality control (QA/QC) requirements for water quality monitoring programs/projects. QAPPs are currently required for TMDL studies, Surface Water Assessment Grants, and Clean Water Partnership projects funded by the MPCA. A project SAP, or project work plan, must include project specific monitoring requirements in terms of sampling schedules, sampling sites, sampling media (e.g., biological community, water, and sediment) and parameters to be analyzed. Each SAP/QAPP references the SOPs that are to be followed in sample collection.

Environmental data quality management practices that support informed decision-making demand that the decision maker(s), data user(s), project management, and field personnel participate in project planning. One purpose of this up-front involvement of all participants is to establish sampling and data quality requirements, ensuring that the right kind, quality, and quantity of data are collected. Another purpose is to inform all participants of their project roles and responsibilities and to record this

information in the project's QAPP. Project planning must result in defining the parameters or variables that need to be measured and the quality needed in the results so that field personnel will be sure to collect the appropriate samples and make the correct measurements. While the QAPP includes this definition of data needs and sample requirements, this information also needs to be found in the SAP since the QAPP is seldom carried into the field.

It is the intent of this document to provide a comprehensive list of all standard operating procedures that will be required by water quality monitoring projects. If a SAP/QAPP references sampling and analysis procedures for which no documentation exists, either document these procedures in an SOP or describe the required operations in detail as a component of the SAP/QAPP. Routinely carry your SAP/QAPP and this SOP manual into the field on all water quality monitoring exercises.

Table 1. Elements of Quality Assurance Documents

Quality Assurance Document Elements	Procedures	Detailed Procedures	Quality Control and Quality Assurance	Helath and Safety	Interferences	Definitions	Data and Records Management	Site Locations	Project Personnel and Contacts	References	Project Goals, Background, and Objectives	Project Schedule	Monitoring Plan	Laboratory ID	Budget	Watershed Description	Reporting Requirements	Data Management	Data Analysis	Instrument-specific Methods	Equipment Specifications	Sampling Rationale	List of Parameters to be Monitored	Other Project components (Implementation, Public Ed.)	Sample Handling and Custody
SOP	☑	☑	☑	☑	☑	☑	☑			☑								☑		☑					☑
QAPP	☑		☑				☑	☑	☑	☑	☑		☑	☑		☑	☑	☑	☑	☑	☑	☑	☑		☑
SAP/Work Plan	☑						☑	☑	☑	☑	☑	☑	☑		☑	☑	☑				☑	☑	☑	☑	☑

3.2 QUALITY MANAGEMENT PROCEDURES

Quality management begins with initial project planning and continues through sample collection and data analysis. The collection of QA/QC data can be used to "grade" the quality of the data that is being collected. It can be used to test the precision, completeness, and accuracy of a monitoring program. The measures and equations used to assess QA/QC data can be found in Section 3.22 of the Red River Watershed Water Quality Reporting Handbook (http://www.redlakewatershed.org/WQDataHandbook.html).

Another great resource for quality assurance in water quality monitoring is the EPA's *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (http://www.epa.gov/volunteer/qappcovr.htm).

This document focuses on the specific needs of field operations. QA/QC in the field requires some basic handling procedures. These can be generalized into four main areas: 1) sample collection, 2) QC sampling, 3) sample custody, and 4) equipment calibration and preventive maintenance.

Starting with Revision 7, the *Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed* will be discussed, approved, and/or revised by the Red River Basin Monitoring Advisory Committee on a yearly basis at the start of each monitoring season.

3.2.1 KEEPING THE "QUALITY" IN WATER QUALITY DATA

There are many different specific methods for sample collection in different situations. These will be covered in Section 8. To ensure that each sample is representative of actual water quality conditions, there are some basic procedures that must be followed in most situations:

1. All sampling equipment must be clean and free from dust, dirt or other contamination. If the sampling equipment is visibly dirty, clean the equipment at the truck and not at the sampling site. In the field, rinse equipment three times with the stream, lake, or wetland water that is to be sampled just prior to sample collection. This should be done in a location or position that will not jeopardize the integrity of the actual sample (e.g., just downstream from the sampling location, or on the other side of the boat from which the sample is to be collected). When not in use, properly store equipment in order to avoid possible contamination.
2. Rinse equipment with distilled water in between sampling sites to avoid cross-contamination.
3. The sample container must be appropriate for the sample parameter(s) requested for analysis. Clean and rinse sample containers properly to avoid possible contamination. Only use sterile bottles from the laboratory that have been received with caps intact. If there is any question about how sterile a bottle is, do not use it and, instead, send it back to the laboratory. Bring extra sterile sample bottles when sampling in case a sample bottle is contaminated and it cannot be used.
4. Properly preserve each sample once it is collected.
5. The sample must be properly labeled and entered into the sample log maintained by the sampler, project, or program.
6. Properly fill out field data sheets, log books, and chain of custody forms.

3.2.2 QUALITY CONTROL SAMPLING

Quality control (QC) sampling is part of every project that collects field data. In general, QC sampling includes the collection of field duplicate, field blank, equipment blank, field split, blind, and double blind samples. To the extent possible, collect duplicate samples from the same location and at the same time, while field blank samples must be collected at the same time as the sample(s). Some of these concepts can also be applied to other types of monitoring such as biological monitoring.

Table 2. QA/QC Sample Collection Frequency

QA/QC SAMPLE TYPE	PURPOSE OF TEST	COLLECTION FREQUENCY
Field Duplicate	**Precision of Sampling Methods**	**1 out of every 10 sets of samples, or whenever a set of blank samples is collected.**
Field Blank	Accuracy of Sampling Methos	1 out of every 10 sets of samples collected directly from the stream by hand-dipping
Equipment/ Sampler Blank	**Accuracy of Sampling Methods**	**1 out of every 10 sets of samples collected with a sampler bottle device**
Field Split	Lab Precision	Yearly for each lab
Blind	**Lab Accuracy**	**Yearly by the Red River Basin Monitoring Network**
Double Blind	Lab Accuracy	Yearly by the Red River Basin Monitoring Network

Field duplicates

Collect duplicate samples for every tenth set of samples you collect to test the precision of your monitoring methods. Duplicate samples are commonly collected to assess the repeatability of sampling methods. Collect your regular samples, and then collect duplicate samples from the same location at approximately the same time if possible. Collect duplicate field measurements along with each set of duplicate samples, if you have the equipment to do so.

To collect a duplicate sample, first make sure your regular sample bottles are labeled. They are easy to write on when they are dry. Label the regular sample bottles. Label the field duplicate sample bottles exactly the same as the bottles for the site where the duplicate is taken, with the exceptions of sample location and sampling time. Label the bottle that will contain the field duplicate with the project name, date, and names of samplers as usual. Put the code FD or Dup after the sample site identifier to indicate that the sample is a field duplicate. If the site is XX1, label the field duplicate as XX1 FD or XX1 Dup.

The other labeling difference is for the time of sample. Duplicates are normally collected immediately after regular samples. On the duplicate sample bottles, record a time that is 1 minute later than the time recorded for the first sample. For instance, if you plan to collect field duplicates at site XX1, and the XX1 sample is collected at 08:45 hours, you will mark the XX1 FD bottle with a time of 08:46 hours. Although the samples are taken from the same spot at relatively the same time, the two different times will ensure that the regular sample and the duplicate sample are recorded as two separate samples.

Field rinse the sampling gear. Collecting the field duplicate involves collecting the regular sample first. The sampler is then lowered again into the stream/lake and a second sample is drawn for the field duplicate and placed into the FD bottle. Treat this bottle just as you would a normal sample. Field duplicate sampling is simply taking a second, independent, follow-up sample at the site.

You can calculate the precision of your sampling methods by calculating the relative percent difference (RPD) between your regular sample results and your duplicate sample results. Sampling and/or analytical precision may be determined from split or duplicate samples by calculating the Relative Percent Difference (RPD) as follows:

$$\mathbf{RPD = (A - B) \div ((A + B) / 2) \times 100}$$

A = the larger of the two duplicate sample values

B = the smaller value.

Where three or more replicate samples or measurements have been taken, calculate the Relative Standard Deviation (RSD) instead of the RPD as follows:

$$\mathbf{RSD = (s/\chi) \times 100}$$

s = the standard deviation of the replicate values

χ = the mean of the replicate values.

If you can achieve RPD values between 0% and 10%, your sampling methods are precise. If your precision results frequently exceed the standards in the following tables, you should evaluate your sampling procedures and think of ways to make improvements.

Table 3. Allowable relative percent difference (RPD) results for analysis of duplicate sample precision

Parameter	Maximum RPD	Reporting Limits	Units	Ref
E. coli Bacteria	+/- 30%	1	MPN/100 ml	1
Fecal Coliform Bacteria	+/- 30%	1	CFU/100ml	2
Ammonia Nitrogen	+/- 30%	0.01	mg/L	1
Nitrates & Nitrites	+/- 20%	0.02	mg/L	3
Total Kjeldahl Nitrogen	+/- 20%	0.5	mg/L	5
Total Phosphorus	+/- 30%	0.005	mg/L	1
Orthophosphorus	+/- 30%	0.015	mg/L	2
Total Suspended Solids	+/- 20%	1	mg/L	3,5
Total Dissolved Solids	+/- 20%	4	mg/L	5
Dissolved Oxygen	+/- 20 %	--	mg/L	3,4
Optical Dissolved Oxygen	+/- .1 mg/L	0.01	mg/L	1
Biochemical Oxygen Demand	+/- 20%	2	mg/L	5
pH	+/- .3 units	--	Standard Units	1
Specific Conductivity (>100 uS/cm)	+/- 12%	4	uS/cm	4
Temperature	+/- 0.8 deg C	0.01	Degrees Celsius	4
Turbidity (<40 NTRU)	+/- 8 NTRU	--	NTRU	4
Turbidity (>40 NTRU)	+/- 20%	--	NTRU	3
Turbidity (<40 FNU)	+/- 8 FNU	0.1	FNU	4
Turbidity (>40 FNU)	+/- 30%	0.1	FNU	1

Ref 1 = *Thief River Watershed Sediment Investigation CWP Project Quality Assurance Project Plan Revision 1*

Ref 2 = Assumed/Extrapolated from similar parameters

Ref 3 = *State of the Red River of the North...* April 2006

Ref 4 = British Columbia Ministry of Environment's *Continuous Water-Quality Sampling Programs: Operating Procedures*

Ref 5 = EPA Methods

Field and Equipment Blanks

To help validate the quality of your monitoring methods, it is important to test the amount of contamination that occurs during sampling. This can be done by collecting blank samples. Collect a set of blank samples for every tenth set of regular samples (10%).

Blank samples help determine if sampling device decontamination procedures are sufficient and evaluate the amount of sample contamination that is caused by sampling techniques. When a blank sample is required for a site, distilled (or deionized) water is run thorough every piece of equipment that was used to collect the regular sample at that site. As you would rinse sampling equipment three times with sample water before collecting a sample, you should do the same with a blank sample. Rinse the sampling equipment 3 times before filling it up with distilled water and emptying it into sample bottles. Place the blank sample in the appropriate sample containers for analysis. If the site is shallow enough to allow direct sampling with the dip method, distilled water may be poured directly from the jug into the sample bottles.

To ensure the integrity of field blanks, they should be collected, stored, and shipped with the other samples. What is the point of this? Even when samples are collected by dipping the sample bottle directly in the river, there are still many ways for it to be contaminated (although one main source – sampling equipment - is eliminated). Some of these forms of contamination include atmospheric contamination (including debris blown into the sample or dropped into the sample bottle), contamination within the bottle, and sediment stirred up from the bottom of the stream. Stream sediment contamination, however, wouldn't be manifested in a blank sample.

Some monitoring programs collect samples using different sampling methods (hand dipping, Van Dorn, depth integrated sampler). The sampling method can differ dependent upon the site and flow conditions. Make sure that the blank analysis is representative of the sampling methods used in a monitoring program. To keep track of the sampling methods used at each site, start keeping track of each sample and how it was collected in a sample log book, or leave a space for equipment on your field data sheets (Figure 8-6). For a program that uses both dip and Van Dorn sampling methods, a blank sample will be collected for every tenth set of samples collected by hand dipping and every tenth set of samples collected using a Van Dorn sampler. That way, for example, if half of a monitoring

We collect blank samples for every tenth set of samples to test the accuracy of our monitoring methods.

Use distilled or deionized water for blank samples

Sampler Blanks measure contamination from sampling devices.

program's samples are collected using a Van Dorn sampler, half of the blank samples will be sampler blanks that were run through a Van Dorn sampler.

Field Blanks measure contamination from the sampling environment, bottles, and handling.

Field-collected blank samples can be classified more specifically as equipment blanks or field blanks. There are other types, but these two are the most commonly collected types in the Red River Basin. Equipment blank samples are collected by running distilled water through a sampler bottle device (Van Dorn, Sampler, etc.). The sources of contamination using this method would include the sampling device, sample containers, atmosphere, and the sampling personnel. The sampler is rinsed 3 times with distilled or DI water just as it would be with sample water. After the 3rd rinse, it is filled and the VD sampler is used to fill sample bottles the same way they would be filled during regular sample collection.

To test the accuracy of dip samples, bottles are filled directly with distilled or deionized water. This is referred to as a field blank. The sources of contamination for this method are limited to the atmosphere, sample containers, and the sampling personnel.

By comparing contamination levels from different sampling methods, you can know which sampling methods will give you the lowest chance of sample contamination. When you get to a site, try to collect samples with the cleanest method. If this is not possible, then choose the next cleanest method. For example, let's say that your field blanks (simulated hand-dipping method) have less contamination than your equipment blanks (simulated Van-Dorn or Sampler sampling method). Samples should then be collected directly from the stream with the hand-dipping sample collection method whenever the stream is suitable for wading.

Blind and Double Blind Samples

Blind and double blind samples are samples of a known concentration that are sent to a laboratory for analysis to assess the lab's ability to accurately determine sample concentrations. Blinds are utilized by the Environmental Protection Agency and the Minnesota Department of Health to evaluate a laboratory's performance during the lab certification process. This procedure can also be utilized by monitoring programs to test the lab's proficiency and provide proof of the credibility of the laboratory results and the monitoring program's data.

Blind samples are sent in situations when the lab knows that they are being checked for performance prior to analyzing the sample. The samples are considered blind because, although laboratory staff know that they are analyzing performance standards, they do not know the concentration. This type of performance evaluation should hold up in court if proof is needed of the accuracy of sample analysis. Proficiency testing samples for nutrients, solids, etc. can be purchased from companies such as the Analytical Products Group. These samples arrive at the laboratory sealed so there is no chance of contamination and voiding of the samples' certification.

Double blind samples evaluate a laboratory on a completely blind basis. Samples are considered double blind when the lab not only does not know what the concentration of the sample is, but also does not know that the sample is a performance evaluation because it has been disguised as a real sample. One method of disguising performance evaluation samples is by pouring the performance evaluation sample (blind sample) into a sample bottle that is of the same type used for regular samples. Make sure the bottle is labeled and logged in such a manner that the lab does not know that it is a performance evaluation, yet the results are not confused with real results for a monitoring site when they are received from the laboratory. This method does have some drawbacks, since opening the sealed performance standard and emptying it into another sample container introduces the possibility of sample contamination. Therefore, the concentration of the sample is no longer certified. When performing a double blind performance evaluation in this manner, send a blank sample at the same time so that the amount of contamination from the bottle can be quantified. The results from the blank sample may help explain any discrepancies in the results from the double blind results.

Churn sample splitter

There are factors you should consider when determining whether to send blinds or send double blinds. When at all possible, you should attempt to send double blinds. When a lab receives a blind, the sample may be treated differently from normal samples because the lab knows it is testing a performance evaluation. It may run triplicates and may rerun the samples a few times to check for repeatability. Double blind samples should receive the same handling as real samples, and that is what should be desired during a performance evaluation. Double blind program services are provided by several companies and can increase the effectiveness of the performance evaluation as long as the samples can be sufficiently disguised.

Field Split Sampling

Field split sampling determines the ability of a lab to accurately measure 2 samples that have originated from the same sample (split). It helps evaluate how repeatable the lab methods are for the chosen parameters. Use this procedure to assess the comparability work from two different labs on the same sample. If a need arises for changing analytical labs, conducting a split sample study with both labs near the time of the change can give you some perspective of how the lab results may differ. This can help greatly when assessing and interpreting the data at a later time.

To conduct a split sample, prepare and field rinse the sampling gear. Collect and pour a sample into a field rinsed churn. If additional sample volume is needed, take a second sample, and empty it into the churn with the first sample. Churn the sample at a uniform rate of 9 inches per second with strokes that are as long as they can be without breaking the surface of the water. The disc should touch the bottom on every stroke. Churn for at least 10 strokes at a uniform rate before filling each bottle. The first subsample collected from the churn should be collected with the bottle that holds the largest volume. Continually activate (mix) the churn at the same rate while collecting subsequent samples so that the water in all the sample bottles is from the same, large, well-mixed sample.

If a churn is not available, collect a split sample from the sampling device only if the sample can be well mixed as the samples are collected. Mixing the sample is necessary during a split sample to assure that each of the splits is "identical" in water quality to the others. If the sample is not well mixed, sediment can begin to settle and can cause one sample to have different water quality characteristics. This would nullify the results of the split and potentially result in misleading, inaccurate data and the subsequent, inaccurate interpretation of the results.

In cases where a churn is unavailable and the sampling device is not large enough to collect the entire sample needed for the split, the following procedure can be utilized. Arrange your sample bottles so that the nutrient bottles are together, general chem. together, bacteria, metals, etc. Label the bottles with the same site, date, time, and analysis requested. Determine how much volume is needed for each pair of samples (nutrients, metals, etc). Draw a sample utilizing proper protocol. Mix the sample and fill the sample bottles in pairs so that all the bottles for the same parameter are filled from the same sample. If you cannot fill each bottle from the same grab sample, then empty the sampler and resample so that when you fill the bottles for a particular parameter, the bottles are always split from the same, well-mixed sample. This procedure and a well-mixed split sample will ensure that the results you obtain from the lab(s) will give you an accurate comparison and will not have variability that results from two different grabs or a poorly mixed sample.

It is a good idea to agitate your sampler bottle device during all sample collection to keep the contents from settling and affecting the representativeness of your samples.

3.2.3 SAMPLE CHAIN OF CUSTODY, FIELD DATA SHEETS, AND LABELING

The following is a description of field procedures, forms, and labels used to ensure the orderly and consistent handling of all samples and data collected for the Red Lake Watershed District and cooperative agencies. This SOP manual and/or the project's SAP describe field procedures, forms, and labels that are unique to a specific sampling event or project. Use these sample chain-of-custody procedures as a guide for all field sampling and data collection events.

For each set of samples, including duplicate and blank samples, submitted to the laboratory for analysis the sampler must fill out and submit a sample identification form from the cooperating lab or a chain-of-custody record (Appendix B or QAPP). This is a form that contains information on the project, the station, the date, sample collection time, and the analysis requested (Total Phosphorus, Ammonia, etc.). Upon receipt of the sample(s) submitted, laboratory personnel check the sample labels against the information written on the form. If there are any discrepancies the lab contacts the sampler or the organization's quality assurance representative. The lab then assigns a laboratory log number to the set of samples and returns a copy of the form to the project personnel or sampling agency. The lab keeps the original copy for their records.

Handle field and laboratory samples and data in an orderly and consistent manner so their integrity is not compromised. Chain of custody (COC) is defined as the unbroken trail of accountability that ensures the physical security of samples, data and records. A sample is under custody if it is in your possession, it is in your view after being in your possession, it was in your possession and then you locked it up to prevent tampering, or it is in a designated secure area.

When project personnel collect a sample for analysis, record all associated field data and descriptive information on the Field Report Form. This report form includes information such as project name, sampling/gauging station identification or watershed number, observer (s), date and time of sample collection, sample station description, and ambient weather information such as ambient air temperature, wind speed and direction, percent cloud cover, and most recent precipitation. Snow cover and ice thickness are also recorded during the winter. Field measurements such as ambient air and water temperature, dissolved oxygen, pH, and specific conductance are also recorded on this form.

In addition to the field report form, field personnel are responsible for filling out the sample log form for each water chemistry sample. The sample log allows the sampler to track the samples collected for each project and is a way to determine and document when to collect duplicate and blank samples.

Each sample submitted for analysis must have a label. The sample label contains information about the sample station ID number/description, the name of the client (agency or organization) collecting and submitting the sample, date and time of sample collection in military time such as 16:00 for 4:00 p.m., sample preservation method (sulfuric acid, if used), and the name(s) of field sampling personnel collecting the sample (sampler, may be initials).

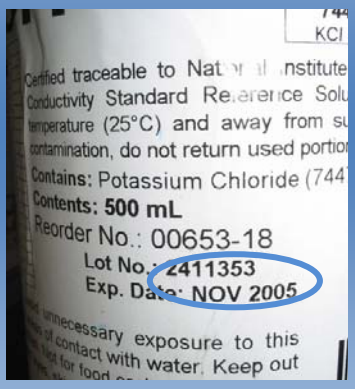
4 INSTRUMENT CALIBRATION AND PREVENTIVE MAINTENANCE

Maintain all equipment used in the field according to manufacturer's recommendations. Check and examine each of the field instruments before sampling to ensure that the equipment will work properly. In addition, for some equipment (e.g., dissolved oxygen probes, specific conductivity meters, and pH meters) following a specific preventive maintenance schedule and calibration procedure is required. Each agency is responsible for attaching the maintenance and calibration procedures required for each instrument as an appendix at the back of this manual.

Keep spare parts such as batteries, probes, O-rings, standard solutions, glassware, etc. on hand in the office of the participating agency or entity. Have spare parts for frequently used field instruments available in the vehicle used for sampling. Keep your lab/office supplied with Q-tips for cleaning sensors.

Record calibration, preventive maintenance, or repairs in equipment logbooks kept for each major field instrument (Outlined in Section 7.0).

Pay attention to expiration dates for standard solutions



When transporting equipment, the probes on most multi-parameters need to be stored in a moist, cool environment. This can be accomplished by placing a small amount of tap water (couple spoonfuls) within the instruments transport/storage cup. The probes do not need to be immersed in water. Another way to keep the probes moist and cool between monitoring sites is to wrap a moist towel around the probe guard (approved and recommended by YSI, Inc.). The wet towel technique lowers the risk of damage to probes from removing and replacing the storage cap and probe guard. It also is a time saving measure and the wet towel's padding can help protect the sonde from

shock and vibration.. The method you choose will depend upon how your equipment is stored and/or transported and either method will help maintain your probes' calibrations. The storage cap must be used for day-to-day storage of the instrument. Do not allow probes to freeze, as this will damage them. With either storage/transportation technique, rinse the probes of your sonde with clean water before putting it away for transport to the next site. This will help reduce the possibility of cross contamination between sites. Also, make sure you rinse your equipment at the end of the day.

Calibrations should be done in the order of "cleanest" to "dirtiest." Dissolved oxygen is the cleanest calibration method since it uses tap water. Specific conductance calibration must always be done before pH calibration. The pH buffer solutions have extremely high levels of specific conductivity and turbidity. Triple rinses with distilled or deionized water are used between each step, but just a small amount of residual ph solution can be detrimental to the accuracy of the specific conductivity calibration if the order of calibrations is reversed.

It is very important, and may soon be required, that you keep track of your calibrations in a calibration log. The River Watch calibration log is included in the YSI Instrument calibration instructions in Appendix A. A general portable multi-parameter sonde calibration sheet is also included in this document as a table near the end of this section. Here's a link to some additional calibration tips for YSI sondes that is recommended by local monitoring staff: http://www.ysi.com/media/pdfs/YSI-Calibration-Maintenance-Troubleshooting-Tips-6-Series-Sondes-2-8-10.pdf

Calibration Solutions

- Calibration standard solutions should be purchased from reputable dealers and should be certified traceable to National Institute of Standards and Technology Standard Reference Materials.
- Do not perform calibrations with standard solution with expiration dates that have expired.
- Use fresh calibration standard. Avoid performing calibrations with standards that have been open for more than one month. When you open a bottle, write the date on the bottle so you know how long it has been since its seal was broken.
- Standard solutions are usually less expensive per unit of volume if purchased in bulk. If you are unable to use all of the solution before it is no longer usable, then the excess will go to waste. Purchase standards in container sizes that you can use up in one month's worth of calibrations. For example, if you only calibrate one instrument once each month, you would want to purchase the small 500 ml bottles of standard solutions. If you are calibrating more instruments (e.g. for a continuous monitoring network), you may be able to purchase larger bottles of standard solutions and use them up in a timely manner.
- Triple rinse the probes in every step of the calibration process
    - 3 rinses with calibration solution before filling the calibration cup
    - 3 rinses with water after each step to remove the calibration solution.
    - Discard solution or water after each rinse
- Do not re-use standards solutions for calibrations.
    - Red River Basin monitoring staff currently agree on one allowance that helps conserve calibration solution. You may save the standard that is used during the actual calibration for the rinsing of the probes during subsequent calibrations for that same parameter. You can only use it for the first two rinses of the probes prior to the next calibration. The final rinse prior to calibration must always be with fresh standard solution. Of course, the concentration/level/brand of the rinsing solution needs to be identical to the solution that is used for calibration.
- Ideally, however, all rinses will be made with fresh standard.
- Use consistent calibration standard solution concentrations to ensure data comparability.
- If you have questions about the quality of your calibration solutions, perform a second source verification. Compare measurements taken in solution of the same value from the brand you are using and another brand.
- Don't return used solution to a bottle that contains fresh solution.

Dissolved Oxygen

There are two general types of dissolved oxygen probes that are commonly used. The most common is the clark cell style probe that uses a membrane. A new technology that improves the accuracy and reliability of measurements is optical measurement of dissolved oxygen.
In general, membrane-equipped dissolved oxygen probes require that the probe is cleaned, dried, and placed in an environment of air saturated with water. This environment is normally achieved by placing a small amount of water within the calibration cup and lightly replacing the cap without sealing the calibration cup. This environment does not reach a state of 100% saturation instantaneouly, so it is imperative that the probe readings are given ample time to stabilize within this environment before going through with calibration. Allow a minimum of 5 minutes for stabilization. After the calibration is completed, the percent saturation reading should be as close as possible to 100.00%. If the meter wasn't allowed enough time for stabilization, the reading will continue to drift noticeably away from the 100% mark. If there is moisture on the DO membrane during calibration, it is being exposed to a different environment than what you are telling the instrument it is in.

- Calibrate membrane dissolved oxygen before each daily round of monitoring.
- Calibrate optical dissolved oxygen probes according to the manufacturer's instructions.

Most calibrations require input of the current barometric pressure. Some instruments have a built in barometer to acquire this number. If your instrument does not have a built in barometer, you may purchase a digital barometer. If you don't have either of these instruments, the barometric pressure from a local weather station can be used. This information can be accessed through a weather website or toolbar such as weather.com or accuweather.com. This information is also accessible on cell phones through a subscription to weather application. The barometric pressure values stated on the internet or cell phone based services is corrected to sea level elevation. You will need to adjust ("un-correct") the weather service's barometric pressure number using a conversion factor based upon your elevation.

1. Convert the weather service's corrected BP from inches Hg to mm Hg.
    - mmHG = inHG * 25.4
2. "Un-correct" the weather service's barometric pressure reading
    - True BP in mmHg = [corrected BP in mmHg] – [2.5*(Local Altitude in feet/100)]
    - If most of your calibrations are done in the same place (lab), you can write the [2.5*(Local Altitude in feet/100)] value on the top of your calibration log sheet so you don't have to recalculate it every time you do a calibration. You can just subtract the same number from the BP (in mmHG) reported by the weather service.

Specific Conductance

The specific conductance standard solutions used should reflect the range of specific conductivity levels found in the waters to be tested. Some instruments require a 2-point calibration and some only require a 1-point calibration. Consult the user's manual for your instrument to get specific instructions. The first point of the 2-point calibration is usually a zero point (dry conductivity cell) and the second is near the upper end of the range of values found in the waters that you are monitoring.

- In the Red River Basin, use a standard that is 1000 uS/cm or higher for your one-point calibration and as the second point in a two-point calibration method.
- Triple rinse the probes and calibration cup with distilled or deionized water before and after each step of the calibration.
- Make sure the sensors in the conductivity channel are clean.
- Calibrate monthly, at a minimum.

pH

This parameter is calibrated either with a 2-point or with a 3-point calibration, dependent upon the range of pH values that are found in the waters to be tested.

- Calibration starts with the pH 7 buffer solution. The order of buffer solutions is important.
- Select pH buffers with values that bracket the expected pH of the environmental sample.
    - For waters that normally have a pH between 7 and 10, the calibration can be concluded with the pH 10 buffer solution.
- For waters that may have pH levels below 7, the calibration should be extended to include a 3rd point that uses pH 4 buffer solution.
- Triple rinse the probes and calibration cup with distilled or deionized water before and after each step of the calibration.
- Fill the cup above the probe that is indicated in the directions. This is often necessary for the pH probe to work correctly because the pH probe's ground may be on another probe.
- At a minimum, calibrate pH probes monthly.
- Replacing the pH electrolyte improves the response time of the probe. On probes with refillable pH electrolyte reservoirs (Hydrolab, Eureka), you may replace the pH electrolyte after the calibration. It doesn't affect the calibration, just the response time. (Dave Kamps, Hydrolab Corporation)
- Refillable pH electrolyte reservoirs should be emptied and refilled with fresh electrolyte at least quarterly.
- Check the temperature-correction factors provided by the manufacturer in order to assign the correct pH value to the buffer for the temperature of the buffer at the time of calibration.

Turbidity

Turbidity can be measured with a portable turbidimeter, lab turbidimeter, or probe. Portable turbidimeters, such as the HACH 2100P, are used by many monitoring organizations in the Red River Watershed. Turbidity probes are available as an optional addition to a multi-parameter sonde or as a stand alone instrument. Each different make and model of turbidity instrument measures differently than others. Most of these instruments display turbidity readings in Nephelometric Turbidity Units (NTUs).

Turbidity is an optical property. The readings received by an instrument can vary with differences in instrument designs, light sources, detection angles, and detectors. A USGS Office of Water Quality Technical Memorandum has established different reporting units for the different instrument designs. The units label that is used by most turbidity measuring instruments is still NTU. Despite this, it is important to acknowledge the differences in turbidity measurements. Indicate the method(s) of turbidity measurement that was used by applying the new turbidity units. Measurements collected with HACH 2100P portable turbidimeters are now recorded as NTRU (nephelometric turbidity ratio units). Turbidity measurements made with a probe on a sonde are generally recorded in FNU (formazin nephelometric units). NTU reporting units are reserved for laboratory instruments used primarily for drinking water applications (HACH 2100 AN, 2100 N).

For more specifics on the reporting unit(s) associated with your instruments(s), refer to the Office of Water Quality Technical Memorandum 2004.03 (http://water.usgs.gov/admin/memo/QW/qw04.03.html) or Chapter 6 of the USGS Field Manual (http://water.usgs.gov/owq/FieldManual/Chapter6/6.7_contents.html).

HACH 2100P Calibration

These portable turbidimeters come with a set of StablCal turbidity standards in sealed vials that you will use for calibrating the instrument. Perform the calibration at a minimum rate of once every 3 months if your instrument has been proven to be stable. The recommended minimum calibration frequency for all measurements (pH probes, specific conductivity probes, and turbidity probes) is monthly (or more frequently). HACH 2100P Portable Turbidimeters are stable enough to go much longer between calibrations without significant calibration drift. This doesn't mean that we should try to go as long as we can between calibrations. Portable turbidimeter calibrations are much cheaper than the calibrations of other standards because the StablCal vials are reusable until their expiration dates. Monthly calibration is recommended to make sure the instrument's readings are as reliable as possible. It is important to perform daily calibration checks using Gelex standards. Check the percentage of drift for the readings on each Gelex vial since the most recent calibration. Recalibrate the instrument with StablCal standards if the Gelex readings drift 5%, even if it's been less than a month since the last calibration.

1. **Prepare the StablCal Stabilized Standards** in Sealed Vials.
    a. If the vials haven't been used for more than a week, make sure that the vials are well mixed. If they have been used recently (daily, weekly use), skip to part b. of this step.
        i. Slowly invert the 20, 100, and 800 NTU vials 2-3 times.
        ii. Do not shake the <.1 NTU vial (You don't want to generate bubbles in the solution)
    b. Allow the standards to stand undisturbed for 3-5 minutes

    c. Clean and oil the vials.
    d. Let the vial stand for one minute.
2. Select the <0.1 NTU standard sample cell
3. Pick the cell up and examine it to make sure its exterior is free of blemishes that may affect the calibration.
4. **Insert the <0.1 NTU** sample cell in the turbidimeter's cell compartment. Align the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid. Press **I/O**.
5. Press **CAL.**
6. Press **READ.**
    a. Wait while the instrument counts down from 60 to 0.
    b. When done, the display will show **S1** and **20 NTU.**
    c. Remove the sample cell from the cell compartment.
7. Select the 20 NTU standard sample cell.
8. Pick the cell up and examine it to make sure its exterior is free of blemishes that may affect the calibration.
9. **Insert the 20 NTU sample** cell into the cell compartment. Align the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.
10. Press **READ.**
    a. Wait while the instrument counts down from 60 to 0.
    b. When done, the display will show **S2** and **100 NTU**.
    c. Remove the sample cell from the cell compartment.
11. Select the 100 NTU standard sample cell.
12. Pick the cell up and examine it to make sure its exterior is free of blemishes that may affect the calibration.
13. **Insert the 100 NTU sample** cell into the cell compartment. Align the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.
14. Press **READ.**
    a. Wait while the instrument counts down from 60 to 0.
    b. When done, the display will show **S2** and **800 NTU.**
    c. Remove the sample cell from the cell compartment.
15. **Insert the 800 NTU sample** cell into the cell compartment. Align the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.
16. Press **READ.**
    a. Wait while the instrument counts down from 60 to 0.
    b. When done, the display will go back to the **S0** display.
    c. Remove the sample cell from the cell compartment.
17. Press **CAL** to accept the calibration. The instrument automatically returns to measurement mode.
18. Soon after calibration, use Gelex standards to establish the target values for each vial that will be used for calibration checks until the next calibration.
    a. Follow steps 1 through 4 of the calibration check methods (below).
    b. Record the displayed value for each vial on a small piece of tape and place it on the top of the respective vial's cap. Also, record the target values in an instrument log book.
    c. Repeat for each Gelex standard vial.

Consult the HACH 2100P manual for explanations of error messages and elaboration of calibration methods and reasoning.

HACH 2100P Calibration Checks

NOTE: Handle Gelex standard vials and sample cell vials only by the top to minimize dirt, scratches, and fingerprints in the light's path.

1. Press the power key to turn the instrument **ON**.
2. Select automatic range mode using the **RANGE** key. Confirm that the **SIGNAL AVERAGE** mode is turned on.
3. Select the 0-10 NTU Gelex standard vial and clean the outside with a Kim-Wipe. Apply a small bead of silicone oil from the top to the bottom of the cell. Wipe with a soft, lint-free cloth. This masks minor imperfections and scratches in the glassware. Avoid application of excess oil. After a number of applications the lint-free cloth becomes somewhat saturated with the oil allowing a wiping of the vials with the cloth without applying oil each time.
4. Place the standard vial in the cell compartment so the diamond on the vial aligns with the orientation mark on the instrument. Close the cover.
5. Press **READ**. Record the displayed value and compare with the value listed on the vial. The value should be within **5%** of the target value. If it is not, the turbidimeter must be recalibrated using StablCal standards or a formazin solution.
6. Repeat Steps 3 to 5 for the other Gelex standards (0-100 and 0-1,000).
7. Keep track of calibration check results

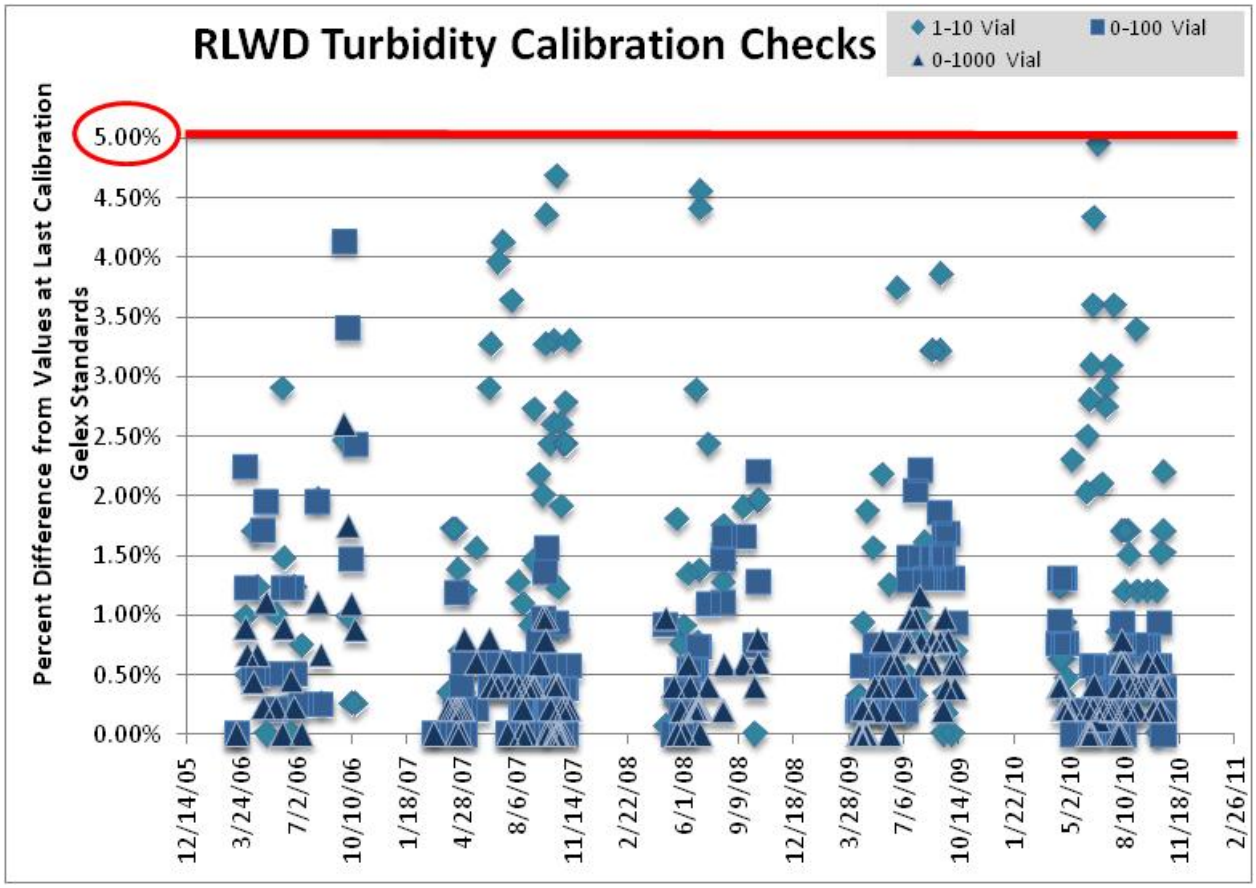


Figure 1. Example calibration check results

Table 4. Turbidity calibration and calibration check worksheet.

Turbidity Calibration/Calibration Check Worksheet

Meter Model	Meter Serial Number	Date & Time	Formazin Calibration Solution Concentrations (every 3-6 mos.)				Target Values and Calibration Check Results from Gelex Standards (At Each Sample Outing)			Difference from 6 elex Values at Last Calibration			Percent Difference from Values at Last Calibration (recal. @ >5% difference)		
			S0	S1	S2	S3	1-10	0-100	0-1000	1-10	0-100	0-1000	1-10	0-100	0-1000
HACH 2100P	0611C019776	7/19/2007	X	X	X	X	5.5	51.6	513	Target Values					
HACH 2100P	0611C019776	7/26/2007					5.7	51.9	511	0.2	0.3	2	3.64%	0.58%	0.39%
HACH 2100P	0611C019776	8/7/2007					5.57	51.9	511	0.07	0.3	2	1.27%	0.58%	0.39%
HACH 2100P	0611C019776	8/13/2007					5.47	51.7	513	0.03	0.1	0	0.55%	0.19%	0.00%

Turbidity Probe Calibrations

Turbidity probe calibration involves a 2-point or 3-point calibration in standard solutions that are representative of conditions that will be found in the rivers to be monitored. The first point is a zero turbidity point that can be accomplished by placing the turbidity probe in a zero turbidity solution or in distilled/deionized water. Do not use tap water. Rinse the probe with the zero turbidity liquid at least three times. Check the calibration cup after the third rinse. If there is any visible sign of contamination in the cup, keep rinsing until there is none. The second calibration should be made with a solution near the maximum values that will be measured in the field. If you desire to have increased accuracy in the 100-1000 NTU range and your probe is capable, add a third point to the calibration. There are several things to remember when conducting this type of calibration:

1. Consult the manual for your instrument to get the specific methods for your turbidity probe.
2. Turbidity probes are optical instruments and may be affected by ambient light.
3. Debris or contamination in the solutions will affect the accuracy of the calibration.
4. For the most accurate calibration results, use turbidity standard solutions recommended by your instrument's manufacturer.
5. For the sake of safety, purchase an instrument that uses polymer bead standard solutions. Formazin standards contain a material that can cause cancer. The convenience of having a turbidity probe on your multi-parameter sonde is not worth increasing your risk of cancer.
6. While most turbidity instruments give you readings in nephelometric turbidity units (NTUs), there now are "reporting units" that address and denote the type of instrument used to conduct the measurement.
7. If you are beginning to use a turbidity probe, its readings will differ from readings obtained from the same water with a HACH 2100P portable turbidimeter. Don't switch completely to the probe (FNU) method right away. Develop a correlation between your probe (FNU) data and portable turbidimeter (NTRU) measurements.

Turbidity calibrations should only be done in an indoor/laboratory setting to minimize light and particulate contamination. The specific techniques of turbidity probe calibrations vary a little from manufacturer to manufacturer. So, consult your instrument's manual and/or customer service representatives before proceeding with calibration. Triple rinse the probes and calibration cup with distilled or deionized water before and after each step of the calibration. Triple rinse with solution prior to each calibration point.

Because a turbidity probe is inherently an optical device, care must be taken during a calibration confirmation to ensure that external optical effects are kept to a minimum... The calibration routine is best done under natural or incandescent lighting (not fluorescent or arc).

Another critical factor is cleanliness. Any debris or water that makes its way into the calibration solutions will affect its value.

(McVan Instrument, 2007)

Table 5. Multi-parameter sonde calibration log

Instrument Make/Model:									S/N:			Owner:						
Date	Staff Initials	DO?	Barometric Pressure (mmHg)	New DO Membrane?	Pre-Cal DO %Sat	Post-Cal DO % Sat	SpCond. Cal.?	Pre-Cal SpCond uS/cm	uS/cm of SpCond Std.	Post-Cal SpCond uS/cm	Turbidity Cal.?	Turbidity Calibration Points			pH Calibrated ?	Actual pH Standard Value Adjusted for Temp		
												1st Step NTU	2					
													2nd Step NTU	Pre/ Post Cal Step 2		4	7	10
Example	*CH*	*Y*	*740*	*N*	*96.01*	*99.87*	*Y*	*1410*	*1412*	*1412*	*Y*	*0*	*7.6*		*Y*	*4.00*	*7.02*	*10.05*

5 SAMPLE CONTAINERS, PRESERVATION, TRANSPORTATION, AND HOLDING TIMES

Field equipment can reliably perform analysis or take measurements on a limited number of parameters in the field. Depending on available equipment, these may include pH, transparency tube, turbidity, dissolved oxygen, temperature, Secchi depth, conductivity, and field total dissolved solids (consult QAPP for acceptable procedure for total dissolved solids). For the majority of the other physical and chemical constituents, samples will need to be transported to an approved laboratory. For samples collected in the State of Minnesota, the lab should be certified by the Minnesota Department of Health.

Note: The more cold packs or ice in the cooler, the better. This cooler should have several more cold packs added to it.

If you are fortunate to be sampling near the lab, you may be able to deliver the samples there yourself. If driving to the lab is not feasible, the samples can be shipped to the lab via an overnight delivery service. Therefore, collecting samples in the proper containers, properly preserving the samples, and making sure the samples will remain cool during transport are all imperative for maintaining the integrity of the sample. Overnight delivery is very important because holding times on certain parameters are as short as 30 hours or less. If chemical preservation is necessary, preserve samples immediately and pack all samples in ice or, preferably, ice-packs in non-breakable coolers. Make sure glass bottles are protected by foam sleeves, bubble wrap, cardboard sleeves, etc. Do not over-fill coolers, as this will increase the chance of broken or spilled samples, as well as personal injury. If samples are held over night before shipment, refrigerate the samples and/or add enough fresh ice to the cooler to make sure that they have a temperature of 6^{o} C or less when they arrive at the lab.

Transportation/Delivery to Lab Procedures

1. Make sure there are frozen ice packs or bags of ice in the cooler while samples are being collected.
    a. Replace with fresh frozen ice packs or bags of ice prior to shipping.
2. Make sure the bottle caps are on tight. Ensure that the cooler contains as many frozen ice packs as you can reasonably fit into the cooler. If you choose to use bagged ice, bag the ice in Ziploc bags to prevent leakage.
    a. Loose ice will melt and the bags in which ice is purchased can leak. If a cooler leaks liquid, it may be quarantined and treated as a hazard by shipping companies. If this happens, your samples may fail to meet the holding times and cold storage temperatures required for accurate results.
    b. When the cooler is opened at the lab, the samples should be colder than 6^{o} C.

3. Completely fill out the chain of custody sheet (Sample Data/Chain of Custody Sheet for Lake Samples). Place this in a large Ziploc bag and place it on top of the samples in the cooler.
4. Fill out the shipping label and adhere it to the top of the cooler.
5. Close the cooler and tape the cooler lid shut.
6. Ship or deliver the cooler to the lab. Use a next-day delivery service for shipping samples. Here are the delivery options provided by RMB Environmental Laboratories:
    a. If you belong to an organization that has a designated drop off location, deliver the sample there and pick up a replacement cooler. If you are unable to deliver to your drop-off location, follow the instructions listed below as step b.
    b. Ship or deliver the cooler to RMB Environmental Laboratories at 22796 County Highway 6, Detroit Lakes, MN 56501 (218-846-1465). The lab will restock your cooler and return it to you.

E. coli samples are collected in the same type of bottles that have been used for fecal coliform samples. A separate bottle is filled with sample water for each bacteria analysis that you are requesting. If you are requesting *E. coli* and fecal coliform analysis, fill two bacteria sample bottles.

Notice in the chart on the following page that the 24 hour holding time for *E. coli* samples is shorter than all the other parameters. The holding time for enforcement sampling is even shorter (6 hours). When the general holding time for *E. coli* was reduced from 30 hours to 24 hours, this created a conflict with the goal of visiting sites early in the morning to collect dissolved oxygen measurements that are as close to the daily minimum as possible. For example, overnight sample deliveries arrive at RMB Environmental Laboratories near 10:00 AM each morning. So, to fall within the holding time, *E. coli* samples should be collected after 10:00 AM or later on any given day.

The MPCA has informed grantees and contractors that priority should be given to the *E. coli* sampling. So, it is more important that *E. coli* samples are analyzed within 24 hours than it is to measure dissolved oxygen before 9:00 am when it is necessary to collect them at the same time. On the other hand, MPCA technical staff (Roger Fisher) have stated the opinion that priority should be given to the dissolved oxygen measurements because they are more time-of-day dependent. Also, if *E. coli* samples are kept on ice, not much will happen to them during a few extra hours of holding time.

So, the bottom line is that you shouldn't let the E. coli holding time affect your daily sampling schedule unless you are conducting enforcement sampling or the 24 hour maximum holding time is mandated by a contractual agreement.

Table 6. Summary of chemical analysis, preservation methods, and holding times for a water/wastewater matrix (From the RMB QA/QC Manual).

Parameter	EPA Method	Standard Methods	Container	Minimum	Preservative	Holding Time
Alkalinity, Total	310.2		Plastic or Glass	200 ml	Cool to <6° C	14 Days
Biochemical Oxygen Demand (BOD)		5210 B-01	Plastic or Glass	650 ml	Cool to <6° C	48 Hours
BOD, Carbonaceous		5210 B-01	Plastic or Glass	650 ml	Cool to <6° C	48 Hours
Chloride	325.1	4500-Cl E-97	Plastic or glass	100 ml	None	28 Days
Chlorophyll-a		10200 H	Amber Glass	1000 ml	Cool to <6° C, Dark	14 Days
COD		5220 D	Plastic or Glass	100 ml	H2SO4 to pH<2, Cool to <6° C	28 Days
Conductance, Specific		2150	Plastic or Glass	500 ml	Cool to <6° C	28 days
E. coli bacteria		9221 D	Sterile	100 ml	Cool to <6° C	< 24 Hours
Nitrogen, Total Kjeldahl	351.2 Rev 2.0		Plastic or Glass	500 ml	H2SO4 to pH<2, Cool to <6° C	28 Days
Nitrogen, Nitrate + Nitrite	353.2 Rev 2.0	4500-NO3 H-00	Plastic or Glass	250 ml	H2SO4 to pH<2, Cool to <6° C	28 Days
Nitrogen, Nitrate	353.2 Rev 2.0		Plastic or Glass	250 ml	Cool to <6° C	48 Hours
Nitrogen, Nitrite	353.2 Rev 2.0		Plastic or Glass	250 ml	Cool to <6° C	48 Hours
Nitrogen, Ammonia		4500-NH3 B	Plastic or Glass	500 ml	H2SO4 to pH<2, Cool to <6° C	28 Days
pH		4500 H+B-00	Plastic or Glass	100 ml	None	Analyze ASAP
Phaeophytin		10200 H	Amber Glass	1000 ml	Cool to <6° C	14 Days
Phosphorus, Total	365.3		Plastic or Glass	500 ml	H2SO4 to pH<2, Cool to <6° C	28 Days
Ortho, Phosphorus	365.3		Plastic or Glass	500 ml	Cool to <6° C	48 Hours
Solids, Total Suspended		2540 D-97	Plastic or Glass	500 ml	Cool to <6° C	7 Days
Solids, Total Dissolved		2540 C-97	Plastic or Glass	500 ml	Cool to <6° C	7 Days
Sulfate		ASTM D516-02	Plastic or Glass	500 ml	Cool to <6° C	28 Days
Temperature		2550 B-00	Plastic or Glass	100 ml	None	Analyze Immediately
TOC		5310 C-00	Plastic or Glass	500 ml	H2SO4 to pH<2, Cool to <6° C	28 days
Turbidity	180.1 Rev 2.0		Plastic or Glass	250 ml	Cool <6° C, Dark	48 Hours

H_2SO_4 = Sulfuric Acid; NaOH = Sodium Hydroxide; 1000 ml = 1 Liter; 500 ml = 1 Pint

RMB Environmental Laboratories, Inc.
22796 County Highway 6 Detroit Lakes, MN 56501-7002 218-846-1465 Phone and Fax
www.rmbel.info streams.rmbel@eot.com

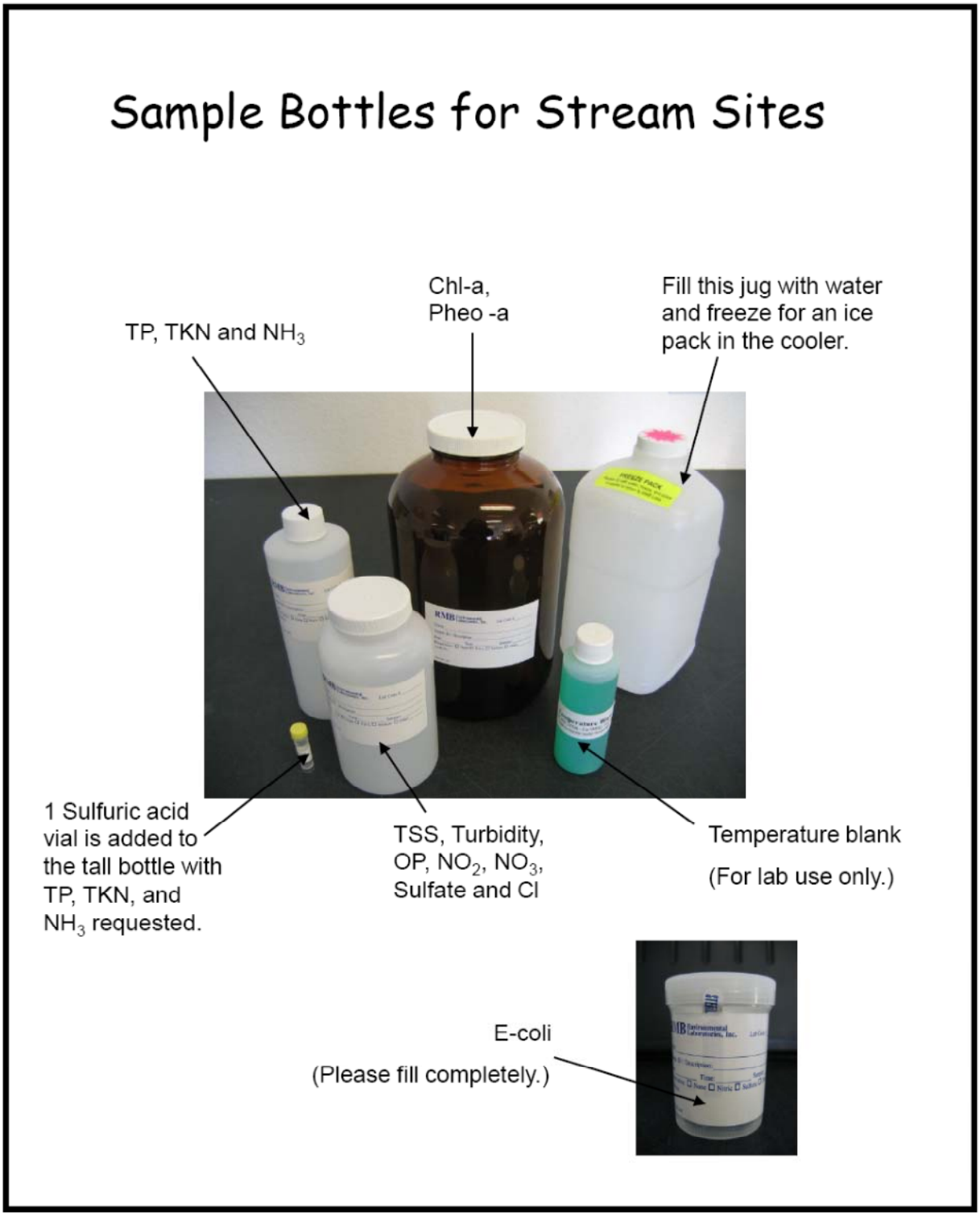


Figure 2. Sample bottles

6 SAMPLING AND PROCESSING EQUIPMENT CLEANUP AND PREPARATION

Dirty or soiled sampling equipment can adversely affect the accuracy of a sample by contaminating it. When not in use, keep sampling and processing equipment in their cases or sealed plastic bags to keep them clean. If multiple samples at multiple sites are to be collected with the same piece of sampling equipment during a particular sampling trip, then rinse the equipment with distilled water immediately prior to the collection of the first sample. Also, triple-rinse the equipment with water from the same source as the water being collected for the sample to make sure that the sample will be representative of the sample water. For further reduction of the risk of contamination, rinse the sampling equipment with distilled water when done with sampling at each site while the sampler is still wet. Take care not to disturb the integrity of the water to be sampled.

Rinse sampling equipment with distilled water before sampling, after each site, and before storage.

A more thorough cleaning with phosphorus-free detergent is needed to remove contaminants that may have accumulated in spite of rinsing procedures. This should, at a minimum, be done at least once a year. The first step is to break the equipment down into the smallest possible components. Wash the components with a strong, non-phosphate-type detergent, followed by a thorough rinse with tap water, and then triple-rinse the components using deionized or distilled water and allow them to air dry thoroughly. After drying, reassemble all components properly and place the cleaned equipment into sealed plastic bags until needed. Polyethylene beakers, if used to collect the samples, should be washed daily.

Decontaminate the field monitoring equipment (probes, meters, etc.) according to the manufacturer's recommendations.

Also, make sure you clean out the case (or other container) that you use to transport your sampling equipment. Sand, dust, and other contaminants can accumulate in the case, be trapped by the foam padding, and work to diminish the benefits of your rinsing procedures. Equipment can be transported in plastic bags to protect it from contamination during storage, although it may not be feasible for use in transportation during windy conditions.

An analysis of your equipment blank results will reveal whether or not your sampling equipment decontamination methods are sufficient.

See Appendix A for the YSI instrument maintenance log – included in calibration procedures.

Before using the sampler bottle, inspect it to make sure all of its components are in working order. The rubber tubing in Van Dorn style samplers can be prone to mold. Minimize this by opening the vents and at least one of the ends of the sampler bottle during storage.

To make sure your sampler is not lost to the river, check the rope and trigger mechanism before collecting each sample. If the rope is beginning to fray, remove the fraying section and tie a new knot to reattach the rope to the sampler. It is good to have some replacement parts available for the occasions when trigger mechanisms and valves get broken. When sampling from tall bridges, you may use a bumper (plastic or rubber cylinder threaded onto rope between messenger and trigger mechanism) to lessen the shock of the blow from the messenger upon the trigger mechanism.

7 LABORATORY ANALYTICAL METHODS

Make sure that the Minnesota Department of Health has approved the analytical methods used by a cooperating laboratory and the laboratory has received MDH certification. Separate Quality Assurance Project Plans and the Standard Methods for the Examination of Water and Wastewater or the Environmental Protection Agency (EPA) Manuals outline and describe the analytical procedures used in the analysis of samples.

8 EQUIPMENT LOG BOOK PROCEDURES

Establish and maintain logbooks for each meter (e.g., dissolved oxygen, pH, conductivity, multi-parameter, flow or current meter). Establish one logbook for all of the automatic stream gauges. The logbook must contain the make, model, and serial number of the instrument or equipment. The logbook provides a record of all preventive maintenance, repair and calibration procedures that are conducted during the equipment's life span.

All logbook entries must contain the date and/or time of the procedure. The person(s) making the entry must also initial or sign each entry.

Refer to the appendices in the back of this book for specific calibration procedures.

All instrument problems must be recorded and repaired promptly. The project managers should inspect logbooks regularly.

9 WATER QUALITY MONITORING AND SAMPLING PROCEDURES

The following are descriptions of the standard methods used in conducting water quality monitoring operations.

9.1 WATER QUALITY MONITORING OF STREAMS AND RIVERS.

Summary

Water quality measurements provide important information about the integrity of rivers and streams. This document provides the information necessary to monitor water quality and collect samples for measuring chemical and physical parameters of a stream or river. This section focuses on the act of collecting water quality samples and field measurement data. **Everyone performing water quality sampling under the auspices of the Red Lake Watershed District, Red River Basin Monitoring Network, River Watch, and other monitoring programs in the Red River Watershed shall use this SOP manual and follow the "General" Section 8.1, for every monitoring project and use the other appropriate sections, based on which parameters are being monitored. If a specific project's Quality Assurance Project Plan requires more rigor than what is presented in this document, the QAPP's methods should be used for that particular action.**

9.1.1 GENERAL METHODS FOR WATER QUALITY MONITORING OF STREAMS AND RIVERS.

Discussion

Field personnel and project managers need to know which parameters need to be measured to accomplish the objectives of the project so that the results will meet the data user's needs. The Quality Assurance Project Plan (QAPP) and/or Sampling and Analysis Plan (SAP) need to identify and provide useful information for the parameters that need to be measured. When setting up a monitoring program you will need to make decisions about the number of sites, site locations, number of samples at each site, timing of sample collection, etc. Will samples target high flows? Will they be randomly scheduled for assessment purposes?

What will be done during no flow conditions? Is analysis of all parameters still necessary? Which parameters are still relevant? Collection of sediment and nutrient samples during zero flow conditions may be a waste of money for a project focused on calculation of loads. Absence of flow means there will be no loading or transport of nutrients. If there is still water in the stream, however, there may still be aquatic life and recreation uses to be protected. When monitoring a stream to make sure it supports aquatic life and recreation, field measurements and bacteria samples are still very important. Oxygen

demand is another parameter that would still have importance in a low flow or no flow situation since these are the occasions when oxygen levels drop below acceptable levels.

General Equipment and Supplies for all types of monitoring

1. Field report form.
2. Maintenance kits for any instruments used.
3. Pencil, permanent ink pen, or permanent marker. Note: a ballpoint pen can be used, but be careful for smearing. A felt tip pen should never be used. Test for smearing with water. A permanent marker works well for labeling bottles, especially if pre-printed labels aren't available.
4. Project area map depicting monitoring sites.
5. Sample collection equipment as needed.
6. Multi-parameter sonde
7. Measuring tape
8. GPS Unit
9. Safety equipment
    a. Safety vests
    b. Traffic cones
    c. First-aid kit
10. For ice-on conditions (i.e., when the sampling location is frozen over) equipment should include:
    a. Ice auger
    b. Ice skimmer
    c. Meter stick
    d. Sled or toboggan
    e. Shovel

General Procedures

1. Enter available information on the field report form:
    a. Record the name of the water course;*
    b. The site name/number*
    c. Description of the location;
    d. Name(s) or initials of field person(s)*
    e. Date of the monitoring, including the year*
    f. Time when sampling began and ended
    g. Latitude and Longitude
    h. Township, range, and section
    i. Description of the site (Reference point location: Bridge? Culvert? Which culvert?)*

    *Required
2. Record the weather conditions including:
    a. Current and/or recent precipitation.
    b. Current air temperature to the nearest degree Celsius or Fahrenheit.

c. Wind speed (example: 5-10 mph) and direction (examples: N, NW, NNW) in the general area of the sample location (in the open).
d. Percent of cloud cover to the nearest 5%.

3. Record the water level reading. Some lakes will have a staff gauge near the access that is used to measure the water level in the lake.
4. Record all samples collected along with parameters to be measured and the sampling device used each time a sample is taken.
5. Record any unusual characteristics including:
   a. Any odors associated with the water;
   b. Any unique colors of the water;
   c. Plants, animals, and any debris noticed at the site along with their position compared with the sampling site.
6. Measure and record the ice thickness and snow depth during winter conditions.

9.1.2 DIRECT MEASUREMENTS OF DISSOLVED OXYGEN, pH, SPECIFIC CONDUCTANCE, TOTAL DISSOLVED SOLIDS, TURBIDITY, TRANSPARENCY, AND WATER TEMPERATURE IN STREAMS AND RIVERS.

Discussion

A limited number of water quality characteristics can be measured in the field and at the monitoring site using portable equipment. There are instruments available from many different companies for measurement of these parameters. When using specific instruments a specific SOP should be used for that instrument, usually in the form of a manual provided by the manufacturer. Attach these procedures to the Appendix portion of this manual. Usually temperature measurement devices do not need calibration, but crushed ice and water can be used as a check for a temperature of zero degrees Celsius. Check the specific instrument's manual.

Those conducting turbidity measurements are strongly encouraged to find the instrument/method you utilize and immediately begin reporting your turbidity in the reporting units identified within this document. The information within this document supersedes your instruments manufacturers suggested reporting units as each instrument in the list was researched by the USGS and correctly positioned with all other instruments that use the same method for turbidity. By correctly identifying the technology used to collect data, we can utilize the data for any assessments we will perform and be able to properly correlate your data to the units (NTUs) that our state water quality standard uses. *B. Paakh (Personal Communication. March 11, 2008)*

Equipment

TIP
Hold the vial up to the sky or a light source to look for surface imperfections that may affect results.

1. This SOP recommends the use of meters for direct (in-situ) measurement of water quality characteristics. The probes are sold as separate units or, most preferably, as multi-parameter sondes.
    - pH meter/probe
    - Dissolved oxygen probe/meter
        - Dissolved oxygen is essential for the support of aquatic life
        - Choose between cost effective Clark cell (membrane) probes and the more reliable and accurate optical probes
    - Specific conductance/total dissolved solids probe
    - Portable turbidimeter
        - The "standard" method for measuring turbidity in the Red River Basin has been the HACH 2100P portable turbidimeter
    - Turbidity probe
        - New technology that allows for quicker measurements of turbidity from portable instruments and collection of a continuous record of turbidity from deployed instruments.
        - Turbidity probes significantly add to the cost of your instrument
        - Turbidity probes and portable turbidimeters will get different measurements when testing the same water.
    - Water temperature
        - This is also important for aquatic life, particularly cold water fish species like trout. \
2. Maintenance kit (KCl solution, spare membrane, o-rings, etc.).
3. Plastic beaker and/or water sampling devices (if necessary)
4. Disposable rubber gloves for protection from sulfuric acid.
5. Clean water for rinsing equipment and probes

Procedures for collecting direct (in-situ) field measurements using multi-parameter sondes.

1. Before collecting data, calibrate the multi-parameter sonde using the manufacturer's recommended procedures.
2. Fill out the metadata (date, time, comments, and site information) on the field report form.
3. Locate the main current of the stream or river. **Note:** When drilling a hole through ice, avoid disturbing the water column with undue agitation. Clear loose snow and ice from around the hole, avoid contamination while drilling, and skim ice from hole with clean plastic sieve.
4. With the meter turned on, remove the storage cap from the probe(s). If necessary, attach the probe guard to the sonde (if equipped).
5. Turn on your instrument. If the multi-parameter sonde is equipped with a circulator. Turn it on to improve the stability and accuracy of dissolved oxygen measurements in low to moderate flow conditions. If the stream is flowing faster than 1ft/s the circulator may be left off. If less, use the circulator.

6. Lower the probe to the correct depth.
    a. The depth goal should be to get the probe to a point that is approximately 3/5 of the total water depth below the surface or 2/5 of the total water depth above the streambed.
        - Certain conditions such as high velocity flow or very shallow depth may make it difficult to achieve this depth.
        - High velocities make it difficult to measure the depth of the stream, thus making it difficult to set a target depth.
        - Adding weight to a multi-parameter sonde may help get the sonde to sink lower beneath the water surface.
        - Multi-parameter sondes equipped with depth sensors help the user know the depth of the sonde's probes, even when the sonde is carried out of sight by current.
        - If it is not possible to get the sonde to a point (3/5)*depth below the surface, lower the sonde to a point that is as close to mid-depth as possible.
        - Probes must be fully submerged, especially for conductivity measurement, which use a flow-through style sensor.
        - Multi-parameter sondes are commonly carried out of sight by flows with high velocity. If the sonde is not equipped with a depth sensor, it is difficult to know if the sonde is deep enough within the water column. If too little cable is supplied, the sonde may skim along the surface of the water. This will not yield representative readings. Take measurements from the downstream side of the bridge in these conditions so that you have a clear view of the sonde.
        - Pay attention to conductivity readings. If they are unstable or abnormally low, the probes may not be fully submerged.
    b. If it is not possible to lower the meter into the stream or river, depending on the situation, a water sample can be taken using the sampler bottle device or by taking a dip sample.
        - Removing the water from the stream can alter some of its characteristics. Only use this method for situations in which it is not possible to get accurate measurements directly from within the stream.
        - In this situation, collect a water sample using the methods in section 8.1.3 and place the sample water in a beaker or other clean container (bucket) that is large enough to allow submersion of the water quality probes you are using.
        - The container will need to be rinsed 3 times with sample water prior to being filled for water quality analysis.
        - After collecting the sample, place your multi-parameter sonde in the container holding the water sample, making sure the circulator is turned on, and proceed with making the measurement.
7. Give the parameters time to stabilize.
    a. Temperature is usually the fastest to stabilize; dissolved oxygen usually takes the longest amount of time.
    b. Activating the circulator can help dissolved oxygen readings stabilize faster.
    c. If the readings from your turbidity probe appear to be unstable and/or appear to be abnormally high, activate the turbidity wiper to clean the offending contamination from the lens of the sensor.
    d. Conductivity readings may not be realistic or stable if the sensor is not fully submerged.
8. Record the measurements on the field report form.

a. As you record each measurement, think about how it compares to other measurements from that day and to past measurement at the same site.

9. Turn the meter off between sites and at the end of the day to conserve battery power. With some models that take a long time to warm up, there may be some advantages to leaving the probe turned on and "warmed up" between sites. Just make sure you will have enough battery power to make it through the day if you choose to do this.
10. Rinse the probe(s) with distilled water to help prevent cross-contamination and replace the storage cap.

Procedures for turbidity analysis using Hach Model 2100P Portable Turbidimeter

Perform turbidity analysis on water samples that are free of debris and course, rapidly settling sediments. Collect samples in clean plastic or glass bottles. Collect a duplicate and a field blank sample at 1 out of every 10 sampling sites. Turbidity should be determined on the day of collection. If this is not possible, samples can be stored in the dark at 4+/-2 degrees Celsius for 24 hours. **Samples should be at room temperature and mixed thoroughly before analyzing.** Cold vials of water can collect condensation.

NOTE: Hach recommends recalibration with formazin once every three months, or more often as experience dictates. Red River Basin operators have found that the Hach 2100P Turbidimeter maintains stable readings throughout the six to eight month sampling season typical in the Red River Basin. Despite this attribute, calibration should be conducted monthly. The HACH 2100P standards are sealed in vials and, thus, are reusable until their expiration date. So, frequent calibration is quite practical for this meter.

Figure 3. HACH Model 2100P Portable Turbidimeter

You are now ready to read your samples. Before inserting each sample vial into the turbidimeter for testing, **gently invert** the sample bottle several times to ensure any sediment that may have settled is completely mixed in solution. Do not shake, as this will introduce air bubbles, which will affect the reading.

1. Perform a calibration check at the beginning of each sampling day to verify that the meter has maintained its calibration. Record the result on the appropriate data sheet.
2. Turn on the turbidimeter at the monitoring site.
3. Fill an empty sample vial with the sample to be tested.
4. Cap and clean the vial with a Kim-wipe.
5. Inspect the vial for blemishes. Apply silicone oil and/or wipe with the lint-free cloth.
6. Insert the sample vial into the cell compartment. Align the diamond on the vial with the orientation mark on the instrument. Close the cover.
7. Press the READ key. The turbidity in NTU will be displayed on the screen (unit displays readings in NTU, but remember that readings are recorded in NTRU). Record this value on the turbidity lab data sheet.
8. Repeat steps 7-9 until all samples, field blank and duplicate have been tested. Triple rinse

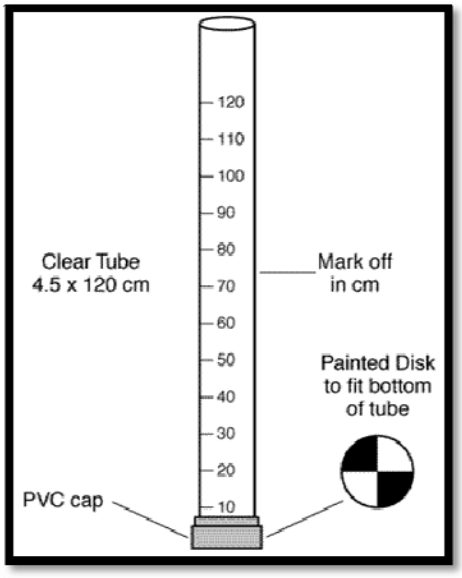
sample vials with deionized water from wash bottle between tests.

9. Turn the meter off. Clean the inside and outside of the sample vials used by washing with laboratory detergent. Triple-rinse the vial with deionized water. Handle vials only by the top to minimize dirt, scratches and fingerprints.

The *HACH 2100P Portable Turbidimeter Instrument and Procedure Manual* offers some suggestions for ensuring quality turbidity data from the instrument. Proper measurement techniques will help minimize the effects of instrument variation, stray light, and air bubbles.

- Always cap the sample cell to prevent spillage of sample into the instrument.
- When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.
- Always close the sample compartment lid during measurement and storage.
- Always use clean sample cells in good condition. Dirty, scratched, or damaged cells can cause inaccurate readings.
- Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.
- Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).
- Avoid operating in direct sunlight.
- Make certain cold samples do not "fog" the sample cell.
- Avoid settling of sample prior to measurement.
- Keep sample compartment lid closed to prevent dust and dirt from entering.

Procedures for transparency tube analysis



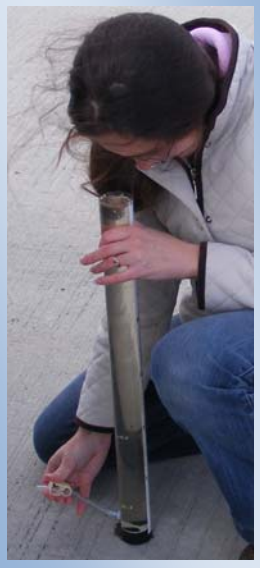
Just as a Secchi disk is a measure of water clarity within a lake, a transparency tube can estimate the clarity of water in a stream. A drain tube with a crimp is located at the bottom of the tube so the sample water can be drained off until the "Secchi" pattern appears. Citizen groups, schools and local governments can use transparency tube readings as a relative measure of water clarity and quality within their streams. Transparency tube readings correlate well with total suspended solids and turbidity measurements.

Transparency tubes consist of a 1-¾ inch, clear polycarbonate tube marked with black numbers on a white tape in centimeters. Three lengths are available: 60 cm, 100 cm, and 120 cm (actually 122 cm for some). Bring along all the sizes of tubes that you may need in your day's monitoring activities. Use the smallest tube that will allow you to get real numbers for both readings. The 60 cm tube, for example, will allow you to get more accurate readings than a 100 cm tube for transparencies below 20 cm, but it won't be able to give you accurate readings for transparencies greater than 60.

1. Rinse the tube with sample water.
    a. Fill the tube with sample water using the most appropriate sampling technique for the site you are monitoring. Empty the tube.
    b. Repeat for a total of 3 rinses.
2. Carefully fill the tube to its top with sample water.
3. Bring the tube to a shaded spot (e.g. next to your vehicle) and remove your sunglasses.
4. While looking straight down into the tube, use the drain tube to release water from the tube until the pattern on the bottom begins to appear.
5. Record the height of the water within the tube (nearest tenth of a centimeter) for his first measurement.
6. Release more water until the screw in the center of the pattern is clearly visible.
7. Record the height of the water within the tube (nearest tenth of a centimeter) for his second measurement.
8. Calculate the average of the first and second readings to get the final transparency result.

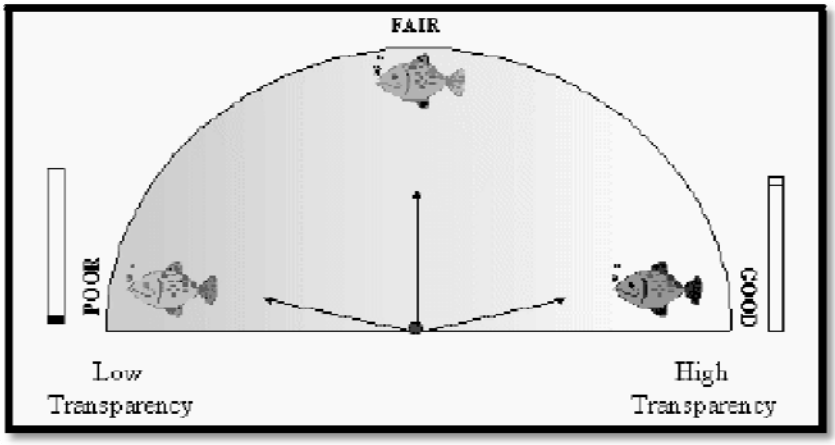
Filling the Tube

Getting a Measurement



Note: If you can still see the image on the bottom of the tube after filling it, simply record the depth as greater than the length of the tube (>100 or > 60). Make sure you try the longest tube you have with you before you resort to recording a ">" reading.

Note: If you need a 120 cm transparency tube, look into purchasing one with an extension handle for the valve. This will allow you to release water while you are observing the Secchi pattern. This allows you to collect easier, more accurate readings. Tubes with extension handles can be purchased at www.watermonitoringequip.com.



Basic Instructions for the Secchi-Tube:

The Secchi-Tube is designed to function like the traditional Secchi disk that is used in lake monitoring. A weighted Secchi disk is lowered into the tube by a line, allowing the user to raise and lower the Secchi disk within the same water sample numerous times. This method allows for averaging the water transparency readings. At the top of the Secchi-Tube is a hole that drains excess water off to bring the water sample level down to the "zero" mark on the centimeter scale.

1. Remove sunglasses. If you wear prescription glasses that darken to protect eyes from sun, wear a billed cap to shade the glasses. Turn your back to the sun and position the tube so that its full length is shaded from direct sunlight.
2. Gently pull up the inside string to remove the black and white Secchi disk from the tube.
3. Fill the tube with the sample water and allow the water to drain out of the string guide hole to the zero mark on the tape measure. (you may have to break the surface tension in the drain hole)
4. While looking down into the tube from the top, slowly lower the disk down into the tube until the disk disappears from sight. You can repeat this process until you are confident that you've identified the disappearing point.
5. Record the depth at which the disk disappears, in centimeters. Simply pinch the line against the tube and then hold the tube up so you can sight across the point at which the disk and tape measure intersect.(if the disk does not disappear because the sample water is clear there is no reading to record)
6. Slowly raise the disk until it reappears. You can repeat this process until you are confident that you've identified the reappearance point. Again pinch the line against the tube and then hold the tube up so you can sight across the point at which the disk and tape measure intersect and record this depth.
7. Calculate and record the Secchi depth (the end reading that you are after) which is the midpoint (or average) between the depth of disappearance and reappearance. For example: if the disk disappeared at 35 cm. and reappeared at 28cm. the Secchi depth would be (35 + 28)/2 = 63/2 = 31.5.
8. Use clean water to rinse the inside of the tube, the string, and the disk.

This method corresponds to the method used in viewing the Secchi disk in the lake environment, only with a much smaller disk.




9.1.3 COLLECTION OF STREAM AND RIVER SAMPLES FOR CHEMICAL ANALYSIS

Summary

Samples collected for chemical analysis must be representative of the entire stream or river. You are trying to sample from a point that will give you the average conditions within the river. To achieve this representative state, samples must be carefully collected, properly preserved, and appropriately analyzed. In general, samples should be collected from the main current of the stream or river. The sampling depth should be as close as possible to the "centroid" of flow, which is the point of average flow. The cubic feet per second (CFS) of flow and mass of a pollutant (load) above the centroid of flow is equal to the CFS and pollutant (e.g. sediment) load below the sampling point. The centroid of flow in a vertical segment of a stream is located 3/5 of the total stream depth below the surface. Samples should be collected as close to this point as possible when flow conditions allow it. Unfortunately, this can be impossible during times of high flow. You should still avoid skimming the water surface to collect your sample. We don't want to sample floating debris. So, for SOP purposes, make sure that your sampling device is submerged to a depth of at least one foot when collecting a sample from deep, swiftly flowing rivers. Your samples will still come as close as possible to representing true water quality conditions in the stream because high, turbulent flows increase the amount of mixing and homogeneity throughout the water column. In normal flows a surface grab sample will underestimate the amount of suspended sediment, so it is then important to aim for the 3/5 depth.

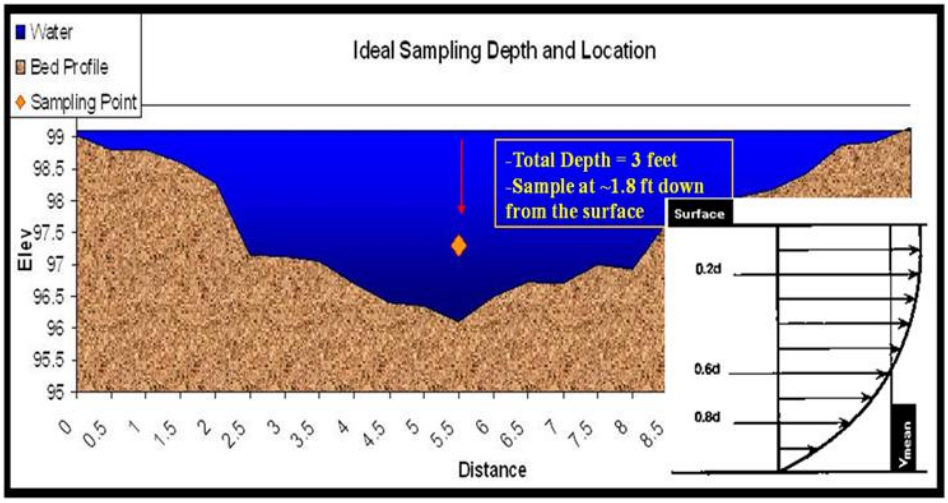


Figure 4. Ideal sampling depth and location (3/5 depth).

To ensure comparability of results over time, sampling techniques should be repeatable at each site. This is accomplished by following the methods in this SOP. Also, before you sample, identify a reference point so future samples can be collected from the same point.

Discussion

This section covers the following parameters: total phosphorous, orthophosphorus, ammonia, total Kjeldahl nitrogen, chemical oxygen demand (COD), fecal coliform bacteria, nitrates, nitrites, alkalinity, nitrates and nitrites, biological oxygen demand (BOD), total suspended solids, and other lab-analyzed parameters. Depending upon specifications outlined in the QAPP and/or SAP, field personnel may also want to collect samples for turbidity, specific conductance, and total dissolved solids for laboratory analysis.

If the stream is wadeable and there is sufficient flow, samples can be collected directly from the stream using the dip method. If wading is not safe, samples can be collected using a sampling device. There are a variety of different types of sampling devices.

Van-Dorn style horizontal sample bottles are widely used by agency and River Watch monitoring programs. Vertical sample bottles are also available. Both of these sampling devices are constructed using a cylinder made of PVC, polycarbonate, or steel. The ends of the cylinder are closed by caps with water-tight seals. The caps are held open with a trigger mechanism. A messenger weight is dropped down the rope to trigger the ends of the sampler to close and capture a water sample from the desired depth.

The vertical sampler should give better flushing as the sampler is lowered through the water column in no-flow situations, but shouldn't make a whole lot of difference if there is any velocity to the water. When using a horizontal sampler in low-to-no flow conditions, ensure a representative sample with a horizontal sampler by pulling it sideways prior to releasing the messenger. Be careful not to disturb bottom sediment when collecting samples in shallow water.

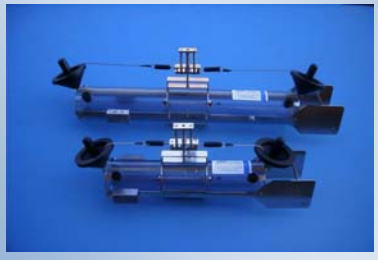
Each type of sampler (horizontal and vertical) has its pluses and minuses.

Horizontal Sampler:

- Pro: Widely used
- Pro: Easily cleaned and low risk of cross-contamination
- Pro: Less chance of disturbing bottom sediment

- Pro: Can be used in shallow water low flow (backwater) cases where wading may cause sample contamination.
- Pro: Easier to empty compared to Sampler vertical samplers
- Pro: More of a discrete, specific depth can be sampled.
- Con: Won't work for sampling through a hole in the ice.
- May cause more mixing of water from different levels as it travels downward. The sampler can be flushed with water from the desir ed depth by simply moving the sampler sideways. Water is also flushed through the sampler as it is lowered through the power of cohesion.

Adding a direction fin to a horizontal sampler will ensure flushing at the sampling depth when flow velocity exists.



Vertical Samplers:

- Pro: Water from other water levels is flushed more quickly from the sampler as it is lowered within the water column
- Pro: Less disturbance to the water column as it is lowered.
- Pro: Some models can be used for series sampling at multiple depths
- Pro: Can be used for sampling through ice
- Con: Easier for valves to come in contact with bottom sediment if they are lowered too far.
- Con: Can't be used in shallow flows
- Con: Sample depth is not as discrete
- Con: More awkward when emptying contents into a sample bottle.

Instead of choosing to use one sampler instead of the other, select the type of sampler that will be most appropriate for your sampling sites. It's not a bad idea to have both types available.

<u>Equipment and Supplies</u>

1. Sampling device with rope marked at 0.5-meter depth intervals and a messenger.
2. 200, 250, 500, 1000-ml sample bottles. Depending on what parameters are being collected, ask the lab for appropriate bottles and preservation and/or refer to Section 3. Separate bottles are used for fecal coliform bacteria samples.
3. Acid vials from the lab for sample preservation, unless the bottles contain acid or preservative already.
4. A cooler with ice or frozen gel packs.
5. Sample ID/ Custody Report.
6. Field notebook
7. Pencil/Pen, marker
8. Disposable rubber gloves for protection from sulfuric acid.
9. Waders or waterproof boots for dip sampling.

Procedures for All Stream Sample Collection

1. Find the sampling location. This may be a benchmark on a bridge or culvert. It is usually in the center of the stream where the most flow is usually occurring. In some cases, flow is not uniform across the stream due to vegetation, debris, rocks, or other factors. In these cases, take the sample from the area through which the majority of the flow is occurring and record the distance and direction from the normal sampling location in the field notes. For example, if a monitoring location has three culverts, the left and middle culverts are blocked by debris, and the right culvert is flowing, sample at the right culvert.
2. Use your best judgment to decide whether to collect samples directly by wading and hand-dipping or by using a sampler bottle device. If the stream is shallow and safe enough for wading, you can collect samples directly by hand dipping sample bottles, turbidity vials, and transparency tubes. If the stream is not safe for wading or you are unable to wade for other reasons, you can use a sampler bottle device.
3. Put on the disposable rubber gloves, if desired, to protect hands from sulfuric acid.
4. Preserve samples (if needed) within 15 minutes of sample collection.

Handle lids carefully – do not touch the inside of the lid or bottle

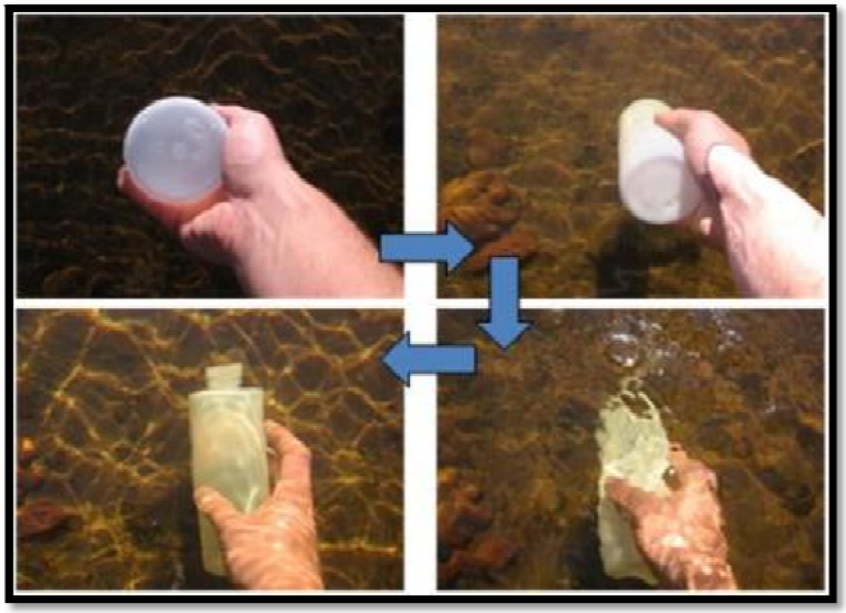
Note:
It is possible for stream flow to be <u>too low</u> for wading to collect samples. Your feet can stir up sediment that can drift in an upstream direction if there is no flow.

Collecting samples with a sampler bottle device (continued from step 3 above)

5. If this is the first use of the sampler bottle device this day, rinse the sampler bottle device with distilled water to reduce the chance of cross contamination from the previous monitoring site and to remove any contamination that may occur during storage and/or transport. If there is visible dirt in the sampling device that can't be removed by rinsing, the sampler should be cleaned with (phosphorus-free) detergent and then rinsed thoroughly.
6. Lock the sampling device open by hooking the cable loops from each end to the pins on the trip assembly. Also, make sure any air vents and/or drain valves are closed.
7. While holding the messenger in one hand, lower the sampler from the top of the bridge or culvert to the desired depth.
8. Triple-rinse the sampler bottle device with sample water by dipping it in the water three times. On each dip, lower the sampler down to the desired sample depth, pull it back up out of the water, and allow it to empty.
9. Release the messenger, allowing it to drop down the line to strike the trip assembly and close the ends of device.

10. Repeat steps 5 through 7 one more time and proceed directly to step 10.
11. Fill bottles directly from the sampler bottle device. Try to keep the sample as well-mixed as possible while filling sample bottles.
12. If mixing equipment is used for collecting split samples, use the sampler bottle device to fill this equipment. Note: If the sample bottles are sterile, you may fill them directly without needing to rinse them. If you received a bottle without its cap in place, or there is any other reason to suspect contamination of the bottle, send the bottle back to the laboratory it came from without using it.
13. If the volume of water remaining in the sampler bottle device is insufficient to fill all sample bottles, repeat steps 5-7 and 10-11.
14. Label each sample container with the site, date, time, parameter(s) to be analyzed, and name of the person who collected it. Indicate if a preservative was added, unless the bottles are pre-labeled for the appropriate tests and are pre-treated with preservative in the lab. Remember to fill out the field report form according to Section 8.1.1.
15. Place the samples in a cooler on ice for shipment to the laboratory.
16. Fill out the Sample ID/Chain of Custody Report and ship samples to appropriate lab. Follow the instruction in Section 4 for shipping and preservation.
17. Rinse the sampler bottle device and its valves with distilled water prior to transporting it to the next site.

Collecting samples directly with dip sampling (also continued from step 3)



4. Wear waders or waterproof boots.
5. Wade into the water to the center of the stream channel to a point where the water is deepest and current has the greatest velocity. Face upstream and wait until the sediment plume has been carried away or settled.
6. Lower a sampling bottle into the water. For bottles that do not yet contain preservative, hold the bottle upside down so that minimal air escapes (Note: do not touch the inside of bottle while taking the sample). For bottles that contain already contain preservative, leave the cap on the bottle until it is lowered to the desired depth. Keep the bottle upright so that none of the preservative is lost and remove the cap in order to allow it to fill. Lower the bottle to the desired depth and allow the bottle to fill at this depth. If the stream is very shallow, follow the directions above as closely as possible without touching or disturbing the streambed with the bottle.
7. Label each sample container with the site, date, time, parameter(s) to be analyzed, and name of the person who collected it. Indicate if a preservative was added, unless the bottles are pre-labeled for the appropriate tests and are pre-treated with preservative in the lab. Remember to fill out the field report form according to Section 8.1.1.
8. Place the samples in a cooler on ice for shipment to the laboratory.
9. Fill out the Sample ID/Chain of Custody Report and ship samples to the appropriate lab. Follow the instructions in Section 4 for shipping and preservation.

Special notes for sampling through ice

- Make sure that the sampling device/bottle gets down below the ice. Avoid ice chips and snow.
- Only use a vertical sampler bottle device for through-ice sampling if the water is deep enough to allow sample collection without disturbance of bottom sediment. Sample directly with sample bottles where possible. When collecting dip samples in the winter, wear insulated rubber gloves or gauntlets to protect you from the cold water.

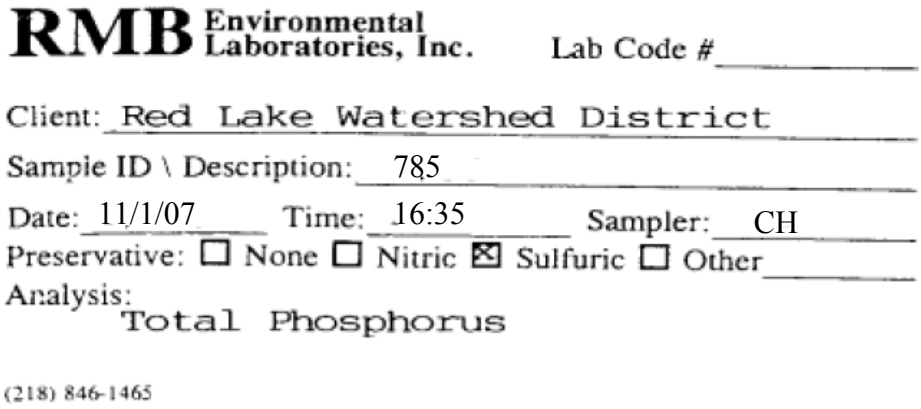


Figure 5. Example of water quality sample bottle label

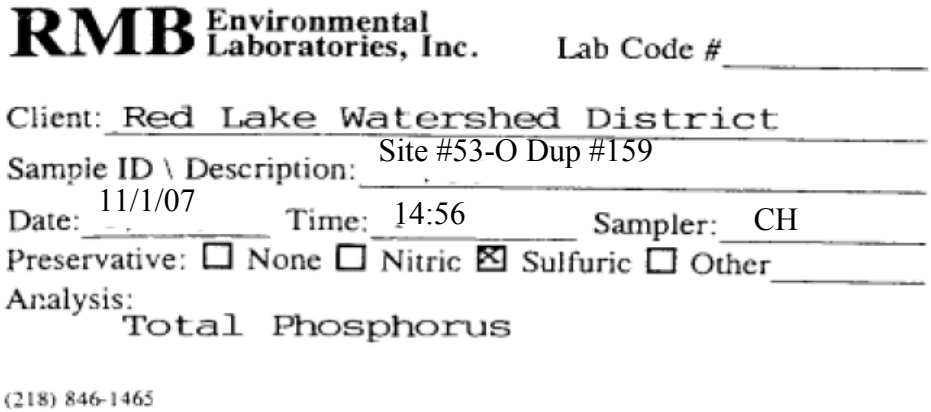


Figure 6. Example of water quality duplicate sample bottle label.

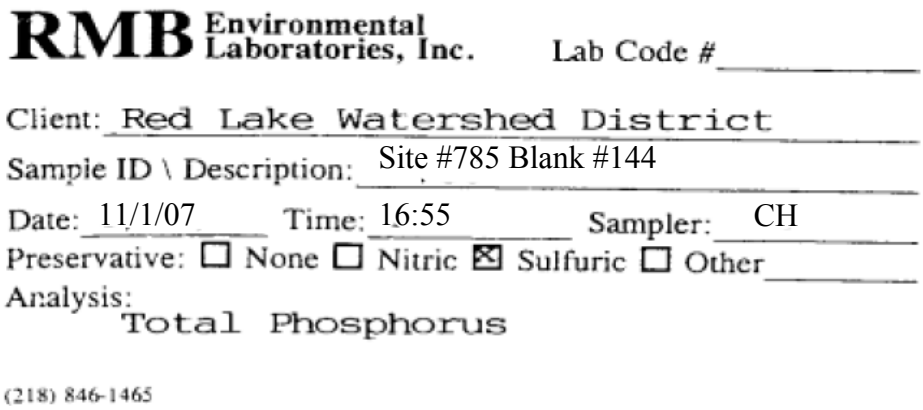


Figure 7. Example of a water quality blank sample bottle label

Table 7. RLWD water quality sample log example

Red Lake Watershed Water Quality Program Sample Log							
Sample #	Lab Code #	Date	Time	Duplicate Log #	Blank Log #	Sample Method (Dip, VD)	Method # 1-10 for each
1809		10/25/2007	14:25			Dip	6
1810		10/30/2007	9:30			Dip	7
1811		10/30/2007	13:00			Dip	8
1812		10/30/2007	13:20	* Dup 158		Dip	9
1813		10/30/2007	13:40		Blank 143	Dip	10
1814		10/30/2007	14:20			Dip	1
1815		10/30/2007	15:10			Dip	2
1816		10/31/2007	10:15			Dip	3
1817		10/31/2007	11:45			Dip	4
1818		10/31/2007	13:40			Van Dorn	9
1819		10/31/2007	14:55			Dip	5
1820		10/31/2007	15:30			Dip	6
1821		10/31/2007	16:50			Dip	7
1822		11/1/2007	14:55	* Dup 159		Dip	8
1823		11/1/2007	15:50			Dip	9
1824		11/1/2007	16:35		Blank 144	Dip	10
1825		11/7/2007	13:05			Dip	1
1826		11/7/2007	13:35			Dip	2
1827		11/7/2007	14:10			Dip	3
1828		11/7/2007	14:40		Blank 145	Van Dorn	10
				*			
A set of duplicate samples is collected for every 10th set of samples							
Blank samples are collected during every 10th set of samples collected with each different sampling method							
(blanks for every 10th set of samples collected by hand dipping, blanks collected for every 10th set collected with Van Dorn)							

ED RIVER BASIN MONITORING NETWORK / *STREAM* FIELD SHEET

Project Name: _____ **Sampler Code:** _____
Individual Observers-First and Last Names :

USE PEN IF IT WON'T BE WET. PENCIL WILL FADE OVER TIME.
MAKE SURE ALL CELLS ARE FILLED OUT.

Sonde S/N: _____
Handpad S/N: _____
Turbidimeter S/N: _____

FIELD INFO.	A	B	C	D	E	F	G	H	I	J
SITE NAME	SH1	"Common name or STORET ID								
DATE	9/10/07	Include Year								
TIME (military)	8:05	Use military time for hours								
STAGE	--									
TD: Bottom	29.90	May use a "standard" measured bottom depth from previous reading								
TD: Surface	28.52	Difficult if bad wind conditions								
Depth	1.38	Subtract TD Surface from TD Bottom								
Sample Depth: 50% of water depth	.69	Calculate 50% of depth								
GAGE TYPE	TD									
T-Tube: First / Final	18 / 11	Record First and Final tube reading and take average of two for final result			/	/	/	/	/	/
60 cm AVG (Circle length if using longer T-tube)	14.5 100 / 120				100 / 120	100 / 120	100 / 120	100 / 120	100 / 120	100 / 120
Appearance: 1A-clear; **1B**-tea-colored; **2**-cloudy; **3**-muddy; **4**-green; **5**-muddy & green										
Appearance:	5	Very subjective								
Recreation Suitability: 1-Beautiful; **2**-Excellent body contact; **3**-Body contact impaired; **4**-no swim/boating OK; **5**-recreation nearly impossible										
Recreation Suitability:	4	Very subjective								
Stream Condition High-Normal-Low; NF	L	Note NF if No Flow situation.								
Rain Event (Y/N)	N	Sampling in response to rain event. >1/2 to 1 inch in previous 24 hrs.								
Water Temp °C	13.17									
Conductivity (uS/cm)	550									
DO (% Saturation)	90.6									
DO (mg/l)	9.49									
pH	8.49									
Turbidity Hach 2100P (NTRUs) YSI Sonde (FNUs)	35.7	Circle whichever instrument is being used								
SAMPLE DEVICE (Van Dorn / None)	VD	Hand dip = None								
SAMPLE TYPE (Grab)	G	Van Dorn and Hand Dip are considered Grab								
QA (Field Dup)	--	Field Duplicate(FD) and/or Sampler Blank(SB) noted here.								

See back of sheet for additional instructions/information for above entries

Red River Basin Monitoring Network **May 1, 2008**

Figure 8. Monitoring day-based field data sheet

RED LAKE WATERSHED DISTRICT STREAM FIELD SHEET

Individual Observers-First and Last Names : _____

_____

_____

Sonde S/N: _____

Handpad S/N: _____

Turbidimeter S/N: _____

SITE ID & INFO										
FIELD INFO.	A	B	C	D	E	F	G	H	I	J
DATE										
TIME (military)										
Sample #										
STAGE: Surface*										
Sample Bottles used										
Stream Water Depth*										
Actual Sample Depth*										
GAGE TYPE*										
Appearance: 1A-clear; 1B-tea-colored; 2-cloudy; 3-muddy; 4-green; 5-muddy & green										
Appearance:										
Recreation Suitability: 1-Beautiful; 2-Excellent body contact; 3-Body contact impaired; 4-no swim/boating OK; 5-recreation nearly impossible										
Recreation Suitability:										
StreamCondition* H-N-L or NoFlow										
Rain Event (Y/N)*										
T-Tube Reading 60 cm : First / Final AVG	/	/	/	/	/	/	/	/	/	/
*(Circle which tube used if it is greater than 60cm)	100/120	100/120	100/120	100/120	100/120	100/120	100/120	100/120	100/120	100/120
Water Temp °C										
Conductivity (uS/cm)										
DO (% Saturation)										
DO (mg/l)										
pH										
Turbidity (NTUs) Hach 2100P *										
Turbidity (FNUs) Eureka Manta Sonde *										
SAMPLE DEVICE* (Van Dorn / or see instructions)										
SAMPLE TYPE* (Grab)										
QA* (Field Dup)										

* See back of sheet for additional instructions/information

Figure 9. Modified, site-based field data sheet

Observer(s):_____ Date: _____

FIELD NOTES: station name/location, vegetation status (leaf out, cropping, harvest), land use, erosion, wildlife, general phenology, wind, cloud cover, recent precipitation, ice condition, picture #, foam, any floating or suspended matter in sample or stream, etc. **Also record here if NO FLOW.**

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	

* See back of sheet for additional instructions/information

Figure 10. Field Notes Sheet.

ADDITIONAL INSTRUCTIONS

PROJECT NAME
Write down project this data is being collected for: for river watch enter: **REDRWTCH** (Other examples: Red River Conditon, FDR , etc…)

SAMPLE TYPE	ABBREVIATION	DEFINITION
Grab	G	Sampling vessel or bottle filled at one point in water column and cross section of a waterbody
Composite-F	CF	Flow-weighted with auto-sampler
Composite-M	CM	Samples from multiple locations on a waterbody, combined w/churn splitter (describe in comments)
Composite-O	CO	Composite – Other (describe in comments)

FIELD CODE OR STREAM NAME
If this is an unestablished site and you want the site established and data entered in STORET, please supply GPS coordinates and station description/location. Note these in the field observation section.

QA
FD = Field Duplicate, SB = Sampler Blank, TB = Trip Blank, BB = Bottle Blank, RB = Reagent Blank

STAGE (feet):
Stage is a measurement of the elevation or level of the water surface. It is determined by reading a staff gage, recording gage, wire-weight gage, or by subtracting a tape down measurement to water level from a fixed measuring point elevation or reference point (RP). The gage type abbreviation below should be entered into the front of the field sheet under Gage Type. Note in "field observations", any unusual conditions that affect the measurement (debris around the staff, wind catching the tape, standing waves, etc.) **Depth to Bottom:** is the measurement from the RP to the stream bottom. **Stream Water Depth:** depth to Bottom minus Stage. **Sample Depth Goal:** half or 50% of the stream water depth. **Actual Sample Depth:** is the depth at which the sample was actually collected.

GAGE TYPE	ABBREVIATION	DEFINITION
USGS Staff or Wire Weight	U-R	USGS outside reference gage, such as staff or wire-weight, at an active gage
Tape-down from RP Tape-down from known Elevation	TD	Measured distance to water level from established reference point (RP) on bridge or other structure. Tape-down to water level subtracted from established measuring point elevation (describe in comments)
Other Staff or Wire Weight	R	Outside reference gage, such as staff or wire-weight, that is maintained by a non-USGS agency (describe in comments)

STREAM CONDITION
This refers to the relative amount of water flowing in the stream channel.

L = Low:	Water covers 1/3 or less of the distance from the stream bottom to the top of the bank.
N = Normal:	Water covers 1/3 to 2/3 of the distance from the stream bottom to the top of the bank.
H = High:	Water covers 2/3 or more of the distance from the stream bottom to the top of the bank.
NF or No Flow	Water is not flowing. May be dry or water present in pool. Water quality readings may or may not be taken.

RAIN EVENT (Y/N)
Put a "Y" in the "Rain event" column if you are sampling in response to a significant rainfall event (over 1" in previous 24 hour period; an "N" if you are taking your weekly or monthly stream measurements.

SAMPLING TURBIDITY
When sampling turbidity use your YSI sonde, otherwise you can use the HACH 2100P Turbidimeter to measure turbidity (**ONLY USE ONE**).

SAMPLING DEVICE

ABBREVIATION	STORET CONFIG ID	NAME
VD		Van Dorn Type Sampler – Bottle type sampler with trip for closing ends.
None		Sample collected directly into sample bottle (hand dip)
SIM	SIMPLE	Simple Open Plastic Bucket
ROD	ROD	Telescoping Rod with Bottle
ICE1	ICE 1	Ice Conditions Water Sampler (straight rod with bottle attached to lower through ice)
DI		Depth Integrating (USGS type)
WB	WEIGHTED	Weighted Bucket with Cover (aka triple sampler, "labline")
AS		Automatic Sampler
Other		Another type of sampler (describe in notes)

Figure 11. Instructions for field data and field notes sheets.

9.1.4 COLLECTION OF SAMPLES IN WATERS INFESTED WITH AQUATIC INVASIVE SPECIES

Due to the spread of aquatic invasive species, additional requirements have been implemented for sampling in infested waters.

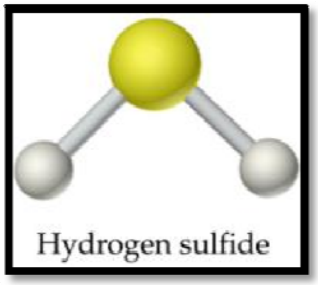
- Disinfection of monitoring equipment before using it elsewhere.
- Purchase a set of equipment that is only used on a particular infested waterbody.

All water samples coming from infested waters must be labeled "AIS" before they are sent to the lab. The lab is required to follow special procedures for disposal of infested water to prevent further spread. Attach brightly colored labels or write on the sample bottle in large letters with a permanent marker (see photo). Please make sure you write on the bottle, not the label because the label gets covered with a laboratory generated label once it is checked into the lab.

The latest list of DNR infested waters is available here:
http://files.dnr.state.mn.us/eco/invasives/infested_waters.pdf

2)

9.1.5 COLLECTION OF DISSOLVED HYDROGEN SULFIDE SAMPLES



Summary

Hydrogen sulfide is regulated under Section 116.0713, Livestock Odor, of the Minnesota Statutes 2000, and by the Minnesota Pollution Control Agency under 7050.0225 of the State Water Quality Standards. In many reservoirs during winter months this is a product of biological activity or decay as well as in waste from livestock production areas. It is toxic to fish at certain levels. There are two types of measurements: dissolved H_2S and atmospheric H_2S concentrations.

Equipment

1. Glass bottles with preservative. Make sure there are extras. The laboratory usually provides the preservative in the glass bottles. If the laboratory does not, Table 4.1 describes the recommended preservative. This should be added to the bottle before sampling.
2. Rubber gloves and insulating gloves.
3. Boat, oars, life jackets, motor, gas with oil mix (if needed after ice is gone).
4. pH monitoring equipment as outlined in Section 8.1.2.

Procedure

1. Locate center of channel and drill a hole in the ice or steer a boat to center of channel and anchor. If anchor is used, wait until the sediment plume has completely passed before proceeding with sampling activity. Remove any excess ice with skimmer. **Note:** When drilling a hole through the ice, be sure not to disturb the water column with undue agitation. Make sure that the auger and its blades are clean in order to minimize contamination of the sampling site. Also, try not to disturb the water column while skimming excess ice. If there is not too much excess ice, the field sampler should try to sample without its removal. Note any action regarding skimming on the field report form.
2. Wear disposable rubber gloves.
3. Uncap the bottle containing preservative.
4. Place the bottle under the water surface and let water flow into bottle until the bottle is full. While keeping the filled sample bottle submerged, put the cap into the water, the top of the cap should be faced downward to prevent air bubbles. Cap the bottle under the water surface, excluding any air bubbles. Wait three seconds until after the bottle has filled, then place the cap on the bottle. Pull the bottle out of the water and turn it over to look for any air bubbles.
5. If any air bubbles exist, repeat steps 3 and 4 again using fresh sample bottle(s) containing preservative.
6. Label sample bottles properly for hydrogen sulfide analysis.
7. Place samples in cooler containing ice or ice packs. Record comments and proper information outlined in Section 8.1.1 on the field report form. Also fill out the proper Chain of Custody records outlined in the appendices and QAPP.
8. Take a pH measurement following the procedure in Section 8.1.2.

9.2 STANDARD OPERATING PROCEDURES FOR THE WATER QUALITY MONITORING OF LAKES AND RESERVOIRS

Summary

Several specific segments comprise this section, depending on parameters to be measured, identifying how collection should be performed, what instruments to use, what methods to use, and what to record.

Discussion

The field worker and/or project manager must know what parameters need to be measured for their specific purpose or project and must document this information in the project's SAP. Everyone using this manual must always follow the "General Standard Operating Procedures" found in Section 8.2.1, for every monitoring project and use the other sections as appropriate, depending on what parameters are being monitored.

9.2.1 GENERAL METHODS FOR WATER QUALITY MONITORING OF LAKES AND RESERVOIRS

General Equipment and Supplies

1. Field report form.
2. Boat, oars, life jackets, motor, and gas with oil mix: RLWD: Evinrude motor 2 hp mix 50:1, and anchor.
3. Pencil. Note: a ballpoint pen can be used, but be careful for smearing. A felt tip pen should never be used.
4. Sampling equipment
    a. Integrated sampler: 2m PVC pipe with stopper
    b. Sampler for taking samples at specified depths below the surface
5. Project area maps depicting monitoring sites or where the deepest pools are.
6. GPS Unit
7. Sample bottles, cooler, field report forms, and preservative
8. Maintenance kits for any instruments used.

General Procedures

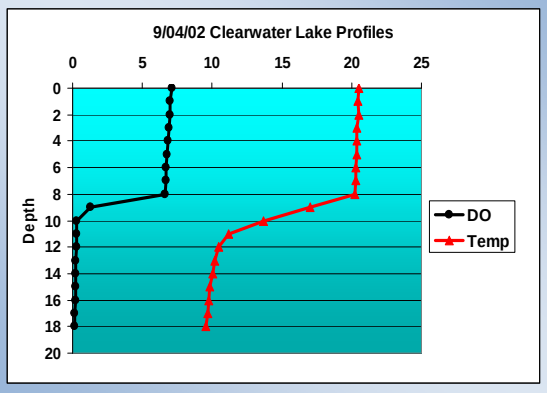
1. On the field report form: record the name of the water body, watershed number or location, the field person or persons' name(s) or initials, the date of the monitoring, and the time sampling/monitoring activity began and ended.
2. Record weather conditions such as percentage of cloud cover, wind direction and speed, precipitation (if occurring), and current air temperature.
3. Record pool level if available or established, and also record outlet and inlet gauges if present.
4. Record the type of sampling device used each time a sample is taken (usually Kemmerer sampler and/or 2 m PVC integrated sampler).
5. Record any unusual characteristics including: any odors associated with the water, any unique colors of the water, plants, animals, and any debris noticed at the site along with their position compared with the sampling site.

9.2.2 RECORDING DISSOLVED OXYGEN AND TEMPERATURE PROFILES

Summary

Temperature and dissolved oxygen measurements can provide some of the most important limnological information about a water body. Temperature and dissolved oxygen measurements also provide valuable information about the biological and biochemical reactions going on in a water body. An important use of these profiles is monitoring the stratification/mixing of a lake. The locations of the epilimnion (surface), metalimnion (thermocline) and hypolimnion (bottom) layers can be determined by viewing dissolved oxygen and temperature profile data.

Profile of a stratified lake.

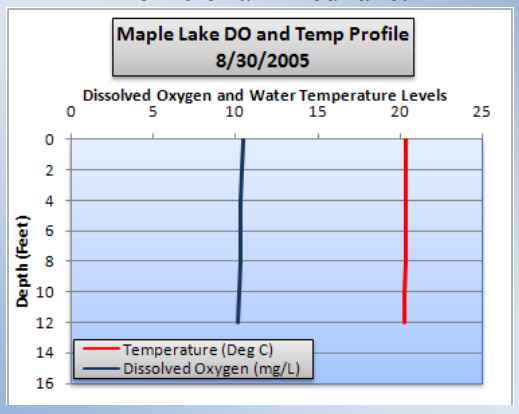


Interferences

The electrode membrane used for dissolved oxygen measurement is permeable to other gases besides oxygen, such as hydrogen sulfide (H_2S) and chlorine. Caution must be taken when using the membrane electrode in low dissolved oxygen waters since the presence of H_2S may lower the cell sensitivity. Frequently changing and calibrating the membrane electrode can reduce this interference.

Extremely low (anoxic) dissolved oxygen levels in the hypolimnion may fall outside the measurable range of our instrument. They may show up as strange, extremely high readings. Record these as zero.

Profile of a mixed lake.



Equipment and Supplies

1. Multi-parameter sonde (or separate single-parameter meters) equipped with dissolved oxygen and temperature probes and a cable long enough to reach the bottom of the lake (or at least the hypolimnion).
2. Profile Report Form
3. Kemmerer Sampler or Van Dorn Sampler (whichever is necessary), with rope marked at 0.5-meter intervals and the messenger for activating (closing) the sampler.

Procedure for multi-parameter sondes

Using a multi-parameter sonde will let you collect direct, in-situ, measurements of field water quality parameters. Most importantly, you will be able to record a vertical profile of dissolved oxygen and temperature levels. This will allow you to determine whether the lake is mixed or stratified. If the lake is stratified, depths and extents of the epilimnion, metalimnion (thermocline), and hypolimnion layers can be identified. Dissolved oxygen profiles will also identify whether or not the lower depths of the lake/reservoir are hypoxic or even anoxic.

These profiles can be made most accurate by use of a multi-parameter sonde that is equipped with a depth probe. If there is no probe, the instrument's cable can be marked in the desired increment (meters, feet). Put extra effort toward minimizing drift if your instrument does not have a depth sensor, otherwise, you will end up recording an angled profile that will make your lake seem deeper than it actually is.

Individual probes with short cable require that measurements be made in a beaker. The measurement of dissolved oxygen and temperature within a beaker is not approved by this SOP. Dissolved oxygen and temperature readings will not be representative of conditions within the water column when a sample is poured into a beaker.

1. Make sure the multi-parameter sonde has been properly calibrated.
2. Locate the deepest area of the lake or reservoir using maps or GPS and anchor boat.
3. Begin filling out the profile data sheet with site information, date, time, weather, current conditions, etc.
4. Prepare your instrument by turning it on and removing the transportation cup and making sure the probe guard is in place. Visually inspect the probes for problems that might affect readings (torn DO membrane, contaminants)
5. Lower the probe just below the water surface (0 meters).
6. Wait for the temperature and dissolved oxygen to stabilize and record the measurements and on the profile data sheet report form. NOTE: To achieve an accurate reading, use a circulator unit or gently move the probe up and down two to three inches to circulate water across the membrane.
7. Lower the probe to the next depth interval and repeat step 6. Take readings at a maximum of one-meter depth intervals. If a temperature or dissolved oxygen measurement changes significantly (more than 1_ C) from one depth to the next, measure at smaller intervals.
8. Repeat step 6 until the bottom is reached.
9. Retrieve the probe from the bottom, rinse the probe with clean water and replace storage cap.

Table 8. Lake and reservoir sampling and vertical profile sheet.

Red Lake Watershed District
Lake Water Quality Sample and Profile Form

Waterbody Name ____

Observer ______________________________ Date __________ Time ______

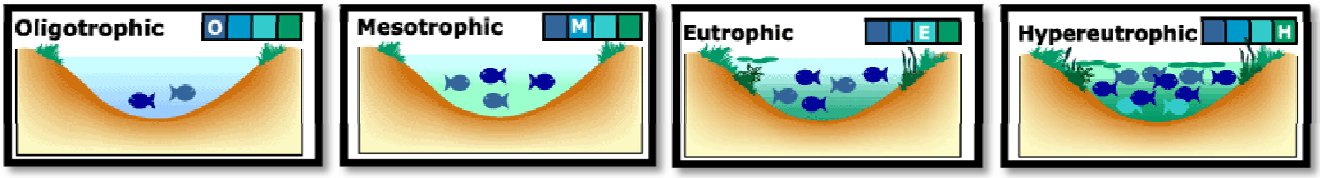
Ambient Temp. ____________ Wind Speed & Direction ____________________

Cloud Cover _________ % of 100 County _____________ Secchi _________ (m)

Comments ____

____

Depth (m) Or Location	Sample Collected	Temp ° C	D.O. (mg/l)	Comments



9.2.3 COLLECTION AND PRESERVATION OF LAKE AND RESERVOIR SAMPLES FOR CHEMICAL ANALYSIS

Summary

Lake monitoring is commonly conducted to determine the trophic state/status of the lake. The trophic state can be defined as the level of fertility and productivity of a lake as measured by phosphorus content, alga abundance, and/or Secchi depth. Total phosphorus, chlorophyll-a, and Secchi disk transparency results are converted to calculate a "score" for the trophic state index, which is a numerical scale from 1 to 100 covering the full range of possible lake conditions. The two most common forms of sample analysis performed on lake and reservoir samples are chlorophyll-a and total phosphorus. Samples may be collected for analysis of other parameters including orthophosphorus, ammonia, total Kjeldahl nitrogen, chemical oxygen demand (COD), fecal coliform bacteria, nitrates, nitrites, alkalinity, nitrates and nitrites, biological oxygen demand (BOD), total suspended solids and other solids measurements. Other field measurement parameters include turbidity and specific conductance/total dissolved solids.

Discussion

Water column samples must be reflective of the whole lake. Carefully collect samples, properly preserve them, and appropriately analyze them so that they are representative of the lake. In general, collect one to four samples from the deepest area of the lake.

For lakes or reservoirs that are two to four meters deep, for general citizen lake monitoring, or for general condition monitoring, a surface sample for Chlorophyll A and Phosphorous is taken along with a Secchi depth reading in order to determine the trophic state of the lake. These samples are collected with an integrated lake sampler.

Some studies may require additional samples to be taken at discrete depths in deeper, stratified lakes. The layers within a stratified lake can form chemical and biological barriers. The chemistry within these layers and their abilities to support aquatic life may be different. Samples can be collected at specific depths to test the water quality in each of these layers. Studies that are focused upon the biology of the lake and/or internal phosphorus loading may utilize discrete depth sampling.

Equipment and Supplies

1. Boat.
2. Motor, oars, gas.
3. Life Jackets.

4. Anchor
5. GPS Unit with the sampling site marked as a waypoint, or Map of the sampling site location
6. Integrated lake sampler with a diameter of 5 centimeters and a length of 2 meters.
    a. For lakes and wetlands that are shallower than 2 meters, a shorter tube may be used, but the amount and representativeness of the sample volume should remain the same. For, example, some people have shortened a 2 meter integrated sampler to 1 meter and collect two samples with this shortened device each time they fill the 2-liter amber sample bottle. *R.M. Borasch, (Personal communication. March 5th, 2008).*

7. Field data/chain of custody sheets and profile data sheets (if needed).
8. Cooler(s) with ice or frozen gel packs.
9. Sample containers with labels. Check with the lab about what appropriate bottles are needed for sampling. A 2-liter amber glass sample jar and a 1 pint plastic sample bottle are used for basic sampling for chlorophyll-a and total phosphorus, respectively.
10. Vials of sulfuric acid for preserving total phosphorus samples.
11. Multi-parameter or appropriate meters.
12. Distilled or deionized water for sample blanks and decontamination.
13. Sampler bottle device (Sampler or Van Dorn) with rope marked at 0.5-meter depth intervals and a messenger. **Note:** If testing for metal ions use non-metallic Sampler.
14. Plastic beaker (if necessary).

RMB Environmental Laboratories, Inc.
22796 County Hwy 6
Detroit Lakes, MN 56501
Phone/fax: 218-846-1465
Email: rmbel@eot.com

Lakes Monitoring Program
Sample Data / Chain of Custody Sheet

www.rmbel.info

Please label each bottle with the appropriate information including Organization, Lake Name, Date/Time, & Preservation.

General Information

Lake Name: _____ Sample Site ID #:_____ MN Lake ID #: _____-_____

County _____ **PROJECT CODE:** _____

Sampled By:_____ phone: (_____) _____

Sampling Details

Date:_____

Time 2 Liter Sample Collected: _____

Time Secchi Disk Reading Taken:_____

Secchi Disk Reading: _____ feet

Field Sampling Comments, Suggestions, Observations:

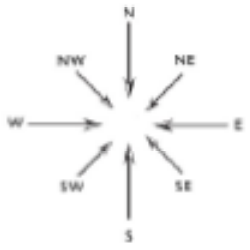
Weather Conditions – *Please check the applicable boxes*

Wind Speed

- ☐ None
- ☐ Mild 0-10mph
- ☐ Moderate 11-20mph
- ☐ High 21-30mph
- ☐ Strong 30pmh+

Wind Direction

- ☐ North
- ☐ Northeast
- ☐ East
- ☐ Southeast
- ☐ South
- ☐ Southwest
- ☐ West
- ☐ Northwest



Weather

- ☐ Sunny
- ☐ Partly Cloudy
- ☐ Cloudy
- ☐ Rain
- ☐ Snow

Surface water Temp:_____

Air Temp:_____

Recent rain date:_____

Precipitation (inches):_____

Additional Tests: *****ADDITIONAL TESTS COST EXTRA AND REQUIRE ADDITIONAL BOTTLES.*
Please contact the lab to set up these tests ahead of time: 218-846-1465.

☐ Chloride ☐ Total Suspended Solids ☐ Total Nitrogen (TKN+NO_3) ☐ Ortho-Phosphorus ☐ Alkalinity ☐ Color

☐ Nitrate ☐ Total Kieldahl Nitrogen ☐ Nitrate +Nitrite Nitrogen ☐ Fecal Coliform ☐ E. coli ☐ Other _____

Chain of Custody

Relinquished by (signature in ink): _____ _____
Date / Time (AM/PM)

Received by Lab (signature in ink): _____ _____
Date / Time

Laboratory use only

Lab Code #: _____ Condition of samples upon receipt: ☐ Good ☐ Other: _____

Temperature Blank _____ °C ☐ Recd same day of collection

Back

RMB Environmental Laboratories, Inc.
22796 County Hwy 6
Detroit Lakes, MN 56501
Phone/fax: 218-846-1465
Email: rmbel@eot.com

Lakes Monitoring Program
www.rmbel.info

Observation Data
Physical Condition \ Recreational Suitability

Observations

Please fill in this information for your primary lake site where you collected your water sample. This information will be posted on our website and is used to determine user perceptions and how they relate to recreational water quality. Choose all that apply.

1. Color of Water:
- ☐ Green
- ☐ Sediment
- ☐ Clear
- ☐ Tea Stained
- ☐ Other

2. Wave Height _____ inches

3. Physical Condition:
- ☐ Crystal Clear
- ☐ Some Algae
- ☐ Definite Algae
- ☐ High Algae
- ☐ Severe Algae

4. Recreational Suitability:
- ☐ Beautiful
- ☐ Minor Problems
- ☐ Slightly Impaired
- ☐ No Swimming
- ☐ No Aesthetics Possible

5. Lake Uses Observed
- ☐ Scuba/Snorkeling
- ☐ Swimming
- ☐ Skiing
- ☐ Fishing
- ☐ Boating

6. Erosion Problems
- ☐ Shoreline
- ☐ Construction
- ☐ Agriculture
- ☐ Forest
- ☐ Public Access
- ☐ Private Access

If you took a Secchi disk reading at an additional lake site, please submit your data to the Minnesota Pollution Control Agency Citizens Lake Monitoring Program. To obtain data sheets, visit: http://www.pca.state.mn.us/water/clmp.html **or call 1-800-657-3864.**

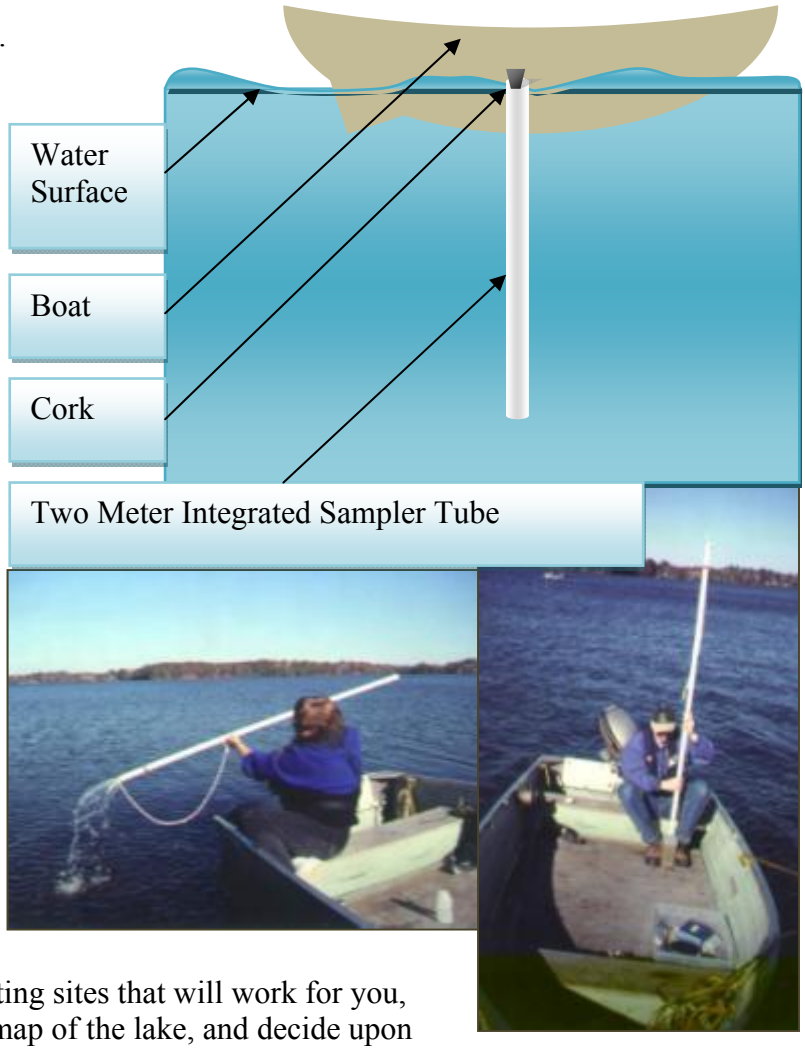
Additional field comments:

Please check to see if you have completed the sampling form correctly. Place the form into the large zip lock bag and enclose it in the cooler during shipment to the lab. ***Thank you.***

If you have questions, please contact Moriya Rufer at lakes.rmbel@eot.com, 218-847-1465 or write a note in the comments box above.

Procedure for Two Meter Integrated Lake and Reservoir Sample Collection

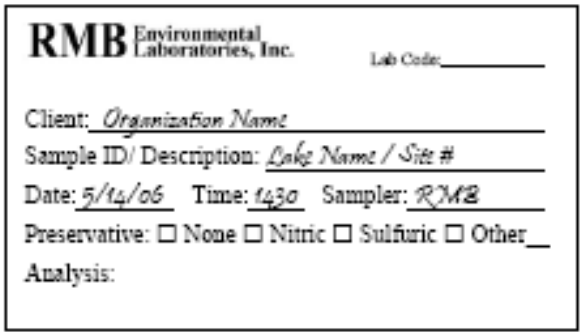
1. Prepare for your trip onto the lake.
    a. Know where you will be sampling.
        - Find out if there are any existing monitoring sites on the lake.
        - If you know the GPS coordinates of an existing site, you can create a waypoint in your GPS unit. Mark a random waypoint and then edit the latitude and longitude coordinates to match the coordinates of the sampling site. Make sure to label the point with the site name as well.



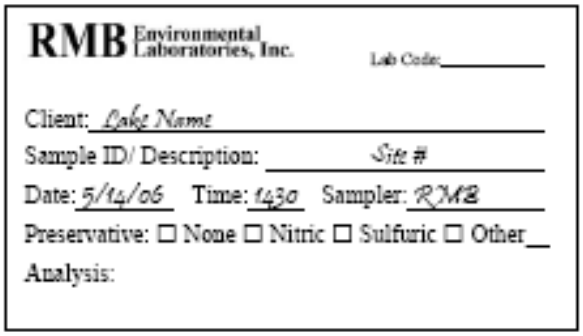
        - If there are no existing sites that will work for you, use a bathymetric map of the lake, and decide upon the location of your sampling site.
            - If you also plan to collect temperature and dissolved oxygen profiles at the site, you will want to choose the deepest part of the lake.
            - If the lake is large and of a homogenous depth, you may choose a site that is closer to shore (while still striving for maximum depth) to avoid areas of the lake where large waves may make sampling difficult and/or unsafe.
            - If the technology is available to you, you may be able to mark the sampling site using a bathymetric map of the lake on a computer (ArcGIS, ArcPad, Garmin MapSource) and store it on the GPS unit prior to your visit to the lake.
    b. Assemble the gear you will need in the boat. Make sure the ice pack in the cooler is frozen prior to the sampling date and is placed in the cooler.
    c. Record the basic information such as Lake Name, Site ID#, Sampler's Name, Date, and other information on the sample data/chain of custody sheet.
    d. Record the Lake Name, Site ID#, Sampler's Name, Date, and other information on the sample bottle labels.

Examples of Completed Bottle Label:

Organization Member



Individual Lake Association



2. Locate you sampling site using a map, depth finder, and/or a GPS unit. Approach the site by motoring into the wind/waves and ANCHORING the boat.
    a. Follow the GPS waypoint to the location or use a map to find the site. If you are relying upon a map, an aerial photo and/or description of landmarks will be useful.
    b. If you don't yet have a GPS waypoint for the site, mark the site as a waypoint the first time you are there so you can use the GPS unit to return to that same waypoint for every sampling visit.
3. Fill in the field data and observation sheet at the sampling site (weather, wind, waves, recreational suitability, etc.).
4. Record the sampling time on the sample bottles and the sample data/chain of custody data sheet and on the sample bottles
5. Rinse the 2-meter integrated sampler tube three times with the water from the sampling site on the downwind side of the boat prior to collecting each sample.
6. Fill the tube by lowering the tube with both ends open, straight down into the water. Plug the top with a stopper and then raise the tube until the bottom is just under the water surface. Suction from the top cork and experience with this sample collection technique will help you keep the sample in the tube just long enough for you move the bottom end of the tube from the water to the opening of the 2-liter amber glass sample bottle, or to a point further away from the boat (during rinsing procedures).
7. Field rinse the 2-liter amber glass jar as follows: Fill the integrated sampler with a water sample and empty the contents in to the 2 liter glass jar. Cap the jar, shake it, and dump this rinse water out.
    a. For improved success in getting the entire 2 meter integrated sample into the 2-liter amber glass sample bottle, you can close the bottom by inserting a stopper underwater.
    b. There is no need to field rinse the plastic sample bottle.
8. Collect a sample for total phosphorus analysis
    a. Use the 2-meter integrated sampler to collect the sample on the upwind side of the boat.
    b. Transfer the complete 2 meter sample to the 2-liter amber glass sample jar.
    c. Cap the bottle and mix the sample by inverting the bottle 4 to 5 times. This will ensure that the total phosphorus sample is a composite of the 2-meter integrated sample.
    a. Pour the water from the 2-liter amber glass jar into the smaller 1 pint plastic bottle. Fill to the bottom of the bottle's neck. Pour the Sulfuric Acid that is contained in the small vial

into the plastic bottle. The acid preserves the phosphorus sample by dropping the pH below 2. Cap the sample bottle and mix by inverting the bottle 4 to 5 times. Place the sample in to the cooler. Cap the acid vial and place it back in to the cooler for disposal at the lab.

- Note: If you get any acid on your hands or clothes, rinse them immediately in the lake. Your hands will begin to itch and then burn if you come in contact with the acid. It is wise to wash your hands in the lake after handling the acid vial. See the acid safety information in the Health and Safety section of this SOP.

9. Collect a sample for Chlorophyll-a analysis.
    a. Collect another sample using the integrated sampler, and then empty the water into the 2-liter amber glass jar. Tighten the cap and place the jar into the cooler. Do not double sample into the 2-liter amber glass sample jar. If you feel that you did not get enough water in the bottle, discard the sample and try sampling again.

Procedure for Lake and Reservoir Sample Collection at Specific Depths

If the lake is thermally stratified, collect a minimum of three samples. Collect the first one using the integrated sampler at the surface (epilimnion), the second one located at the mid-depth of the thermocline (metalimnion) using the sampler bottle device, and the last sample one meter off the bottom (hypolimnion) is collected using the sampler bottle device.

In some cases, more detailed data may be desired for eutrophication modeling. For these, additional samples can be collected from both the epilimnion and the hypolimnion. Take three samples from the epilimnion, one sample from the metalimnion, and three samples from the hypolimnion. In the epilimnion, take one of the additional samples just above the thermocline (bottom of epilimnion) and another sample at mid-depth using a sampler bottle device. In the hypolimnion, take samples one meter from the top, at mid depth, and 1 m from the bottom using the Sampler bottle.

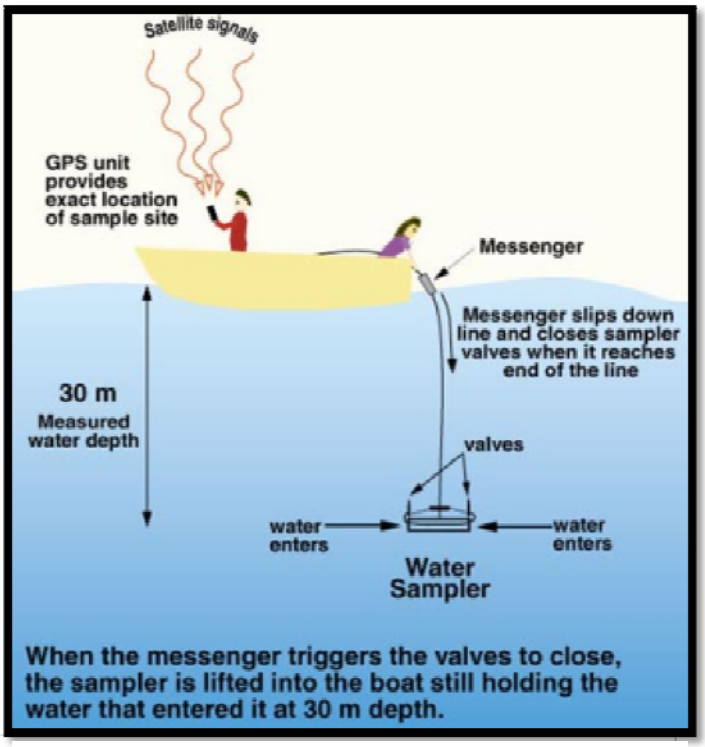


Figure 12. Discrete depth lake sampling diagram - from USGS website.

Following the determination of a temperature/dissolved oxygen profile, determine sample collection depths and follow these general rules:

- For lakes, reservoirs or wetlands two to four meters deep or less collect one sample with a sampler bottle device in the middle of the water column.
- For lakes that are deeper than four meters (and where samples are desired from multiple depths), determine whether the lake is thermally stratified from the temperature/dissolved oxygen profile.
- If the lake is not stratified, collect three samples, one using the integrated lake sampler at the surface, one at mid-depth, and the last sample one meter off the bottom. Collect these last two samples with the sampler bottle device as described later in this section
- For integrated samples, follow the procedures for two-meter integrated sample collection that are described earlier in this section.

For samples collected with a sampler bottle device, follow the steps below:

1. Lock the sampler bottle device open and while holding the messenger in one hand, lower the sampler by its cable from the side of the boat to the desired depth.
2. Release the messenger, sending down the line to close the sampler bottle device.
3. Pull the sampler bottle device back up to the boat.
4. Agitate the sampler bottle device to make sure the sample is well-mixed.
5. Fill sample bottles directly from the sampler.
6. Add appropriate acid or preservative, unless the bottles have been pre-treated.
7. Label each sample bottle properly.
8. Place the samples in a cooler with ice or a cold pack for shipment to laboratory.
9. Fill out the field report form, sample ID/Chain of Custody Record, and the water column chemistry sample log.

Field Duplicate Lake Sample Collection

One set of field duplicate samples is generally collected for every 10 water column samples collected. If the sample log indicates a duplicate sample is due to be collected, follow the steps below.

10. Collect the sample following the procedures for field sample collection. Collect the sample exactly the same way as the corresponding regular samples were collected at the site.
11. Place a label on each sample container. Be sure to indicate on the label the lake name and depth of the sample being duplicated.
12. Place the samples in a cooler on ice.
13. When a copy of the Sample ID/Chain of Custody Report is received from the lab record the laboratory log number of the duplicate sample on the sample log form.

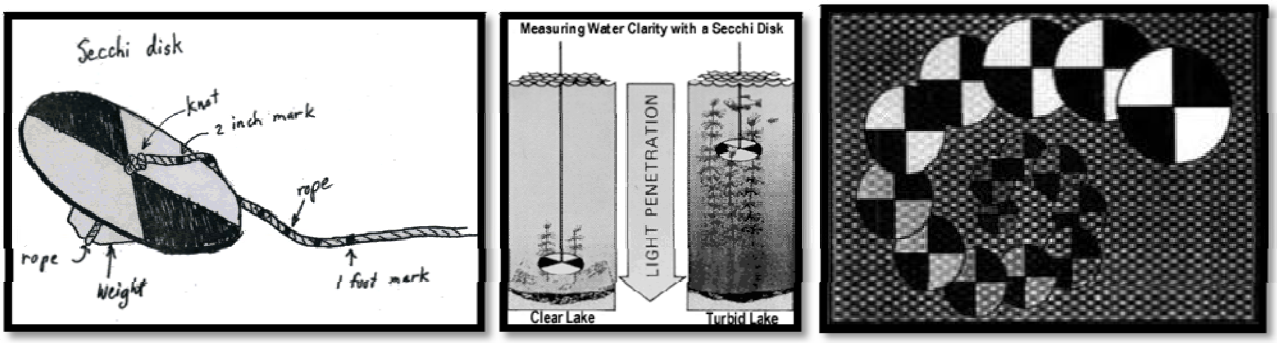
Blank Lake Sample Collection

Collect one blank sample for every 10 water column samples. If the sample log indicates a blank sample is to be collected, follow the steps below.

14. Using deionized water, triple rinse each sampling device (integrated sampler, sampler bottle

device, and/or beaker).

15. Pour the deionized water into the sampling device. From the sampling device fill the sample bottles. For integrated samples, fill the beaker first, and then use the beaker to fill the sample bottles. Fill each bottle with the deionized water from the beaker.
16. Preserve each sample appropriately.
17. Label each sample container appropriately.
18. Place the sample in a cooler on ice.
19. Fill out the blank sample log form and the Sample ID/Custody Report. When a copy of the Sample ID/Custody Report is received from the lab, record the laboratory log number on the blank sample log form.



9.2.4 MEASURING SECCHI DISK TRANSPARENCY.

Summary

Transparency is a common and inexpensive method to assess water quality in lakes and rivers. The measurement is used in volunteer citizen monitoring programs. While river transparency is low enough to be measured in a transparency tube, lake transparency is normally much greater. Lake transparency is measured using a Secchi disk, which is lowered by a rope down through the water column. While river transparency is measured in centimeters, lake transparency is measured in feet and meters. The Secchi disk transparency readings are inversely related to the amount of algae and suspended sediment in a water column. Secchi disk transparency, as an indication of the abundance of algae and nutrients, can also be a good measure of lake trophic status. Secchi disk readings can be used to calculate a score for the Carlson's Trophic State Index. Collecting Chlorophyll-a, total phosphorus, and Secchi disk data together can help you determine the extent to which the Secchi disk readings are indicative of nutrient and algae concentrations.

Interferences

Since Secchi disk is a measure of light penetration, all interferences that can affect the visibility of the Secchi disk to the human eye must be minimized. The time of the day, the position of the sun and the amount of glare are critical.

Ropes must be made of a non-stretchable material and periodically checked with a measuring tape. (Note: The rope attached to the Secchi disk will often shrink following several wet-dry cycles, affecting the accuracy of the depth measurement).

If the boat is not anchored properly and is drifting, it won't be possible to lower the disk straight down. The disk will be lowered at an angle. Since the depth is measured by the amount of rope that is played-out, this angled descent will result in a transparency reading that is higher than true conditions.

Equipment and Supplies

- A 20-centimeter (8 inch) Secchi disk with 10 meters (32 feet) of rope marked off in either 0.1-m, or 0.5 foot depth intervals. The markings on a Secchi disk are black and white alternating quadrants. The disk must have enough weight attached to sink easily.
- Field data sheets

Procedure

Observations with a Secchi disk are ideally made during the day, without sunglasses and from the shady side of the boat. The observer makes the reading by looking as close as possible to the water to minimize glare.

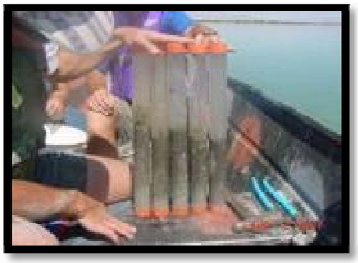
1. After anchoring the boat, drop the Secchi disk down to the point where it just disappears from view. Make a note of this depth.

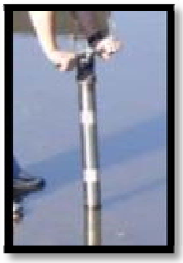
2. Lower the disk past the depth of the first reading and bring the Secchi disk up until you can just barely see it. Make a note of this second depth reading.

3. Record the average of these two readings as the official Secchi disk transparency reading.

4. Record the time of the measurement and the name of the person who collected the reading on the sample data/chain of custody sheet.

5. Double-check your reading by repeating the above procedures.




9.3 STANDARD OPERATING PROCEDURES FOR THE COLLECTION OF SEDIMENT SAMPLES.

Summary

Use sediment core samples to gather information about a lake or reservoirs' deposition. Use the samples to correlate historical information with the qualitative observations obtained (e.g. color, type of material, sedimentation rates). Some sediment samples are designed for the collection of aquatic macroinvertebrate samples.

Equipment and Supplies

1. Hydrographic lake map.
2. Sediment sampling equipment. These methods focus on the Wildco 2 inch hand corer, but there are other sediment core sampling equipment options available. Choose the right equipment to suit your needs (budget, depth of water).
    a. (Wildco) 2-inch core sampler with handles and threaded 2-meter pipes (as many as needed, judging by the depth of the lake), or other sediment sampling equipment.
        - Make sure you have clean 20-inch clear CAB plastic liner tubes with eggshell core catcher.
        - Handles for shallow water sampling.
        - Extension handles are available for water up to 15 feet deep.
    b. Aquatic suction sampler, "swamp sucker."
        - Relatively inexpensive sampler for extracting burrowing aquatic insects from wet sand or muck.
    c. K-B Corer.
        - For deep water over 100 meters.
        - Can be free-dropped up to 10 meters.
    d. Balchek Corer.
        - Can be used in water 3-200 meters deep.
        - Stabilizing fins keep the corer balanced and stable during descent.
3. Camera (digital or film).
4. Ice auger, gas/oil mix, ice skimmer and snowmobile or ATV (if done in the winter period).
5. Boat, motor, gas/oil mix, life jackets, anchors and oars (if done in the summer period).
6. Field Report Forms and field notebook.
7. GPS unit for spatial accuracy in sampling (if available).
8. Clear plastic tape.

9. Pen or pencil.

Push Handle Sediment Corer Procedure

1. With a map, locate appropriate sampling location. (Mark with GPS unit, if available.)
2. Inspect the core sampler
    a. Be sure the entire instrument is firmly assembled.
    b. Inspect the core tube and, if one is being used, the tube liner. Be sure it is free of obstruction throughout its length. The penetrating edges of the core tube should be sharp and free of nicks or dents.
    c. At the upper end of the core sampler, (on the end opposite from the penetrating edges) check the flutter valve in the sampler head for ease of movement. It needs to open easily as the sampler is pushed into the sediment. It also needs to close easily and tightly as the core sampler is withdrawn.
3. Attach the length of extension handle needed for the depth of the water. Line up the sampler, aiming it vertically for the point where the sample is to be taken.
4. Get in position for the sampling operation, keeping in mind that, if the purpose is to obtain samples containing fauna or stratified sediments, disturbance of the bottom area to be sampled should be avoided
5. Push the sampler in a smooth and continuous movement, through the water and into the sediment, increasing the thrust as necessary to obtain the penetration desired. Note: With complete submergence, the pull to remove the sampler from the bottom sediments is normally all that is needed for the automatic closure of the flutter valve. At least six inches of sediment should be retrieved with the sampler.
6. Lift the core sampler clear of the water, keeping it as nearly vertical as possible, and handle the sample according to the type of core tube and work in progress, normally following the procedure below:
    a. If a sample is to be retained in a plastic core tube for an *in situ* study:
        - Cap the bottom of the tube and tape the cap securely in place.
        - Release the flutter valve and dismount the core tube from the sampler head.
        - Cap the top of the core tube, and tape the cap securely in place.
7. Remove any sediment adhering to the outside of the tube.
8. Take at least two photographs of the sample. Describe the sample on the field report form, label the sample.
9. Seal the samples. Seal sample jars tightly. Protect cores by wrapping them in plastic film to keep them from drying-out.
10. To take additional samples, remove the cap and rinse the tube completely with distilled water. Reload the sample tube into the core sampler.

Clevis and Line Core Sampler Procedure

1. Stabilize the boat, raft, or work platform to assure a vertical drop and successful recovery.
2. Inspect and prepare the corer.
3. Position the corer over the drop point and steady it momentarily. With the line arranged to run freely, release the sampler.

4. Entry of the corer into the bottom sediments can usually be detected by the momentary slack of the line when the corer movement changes from free fall through the water to penetration of sediment.
5. When the corer has stopped, take up the slack in the line and begin to retrieve.
6. Draw the line taut and, after the initial pull that may be needed to free the corer from the bottom, bring the sampler back to the surface using a smooth, hand-over-hand recovery of the line.
7. Lift the core sampler above the water surface and, keeping it as nearly vertical as possible; bring it aboard the work station.
8. Secure and identify the new sample according t the requirement of the work in progress.
9. Seal all sample jars tightly. Protect core liners against drying out by wrapping them in several layers of plastic film.
10. Label all samples.

Benthic Grab Sediment Sampler Procedures

There are several different types of benthic grab samplers. These samplers are used for sampling of burrowing benthic macroinvertebrates in lakes and reservoirs. They are generally built out of steel and have scoops that capture a sediment sample by closing like jaws when triggered. There are several different models to choose from. These include, but are not limited to:

- Standard and Petite Ponar Grabs
- Ekman Grab/Ekman Dredge
- Peterson Grab
- Van Veen Grab
- Box Corer

Some are light enough to be operated and lifted by hand, but others require a winch/crane. This SOP only provides the basic methods for benthic grabs that can be operated by hand. Use a winch for heavier benthic grabs. There are specific instructions available for each type of benthic grab. Make sure to read the instructions that are specific to your sampler. Instructions for Wildco samplers are available online at http://www.wildco.com/vw_sbctgry.asp?sbctgry_cd=S16.

Ekman Grab Sampling Kit

1. Safety
    - **a.** Be sure you are able to keep the boat in proper balance at all times. Lifting the sampler into the boat, dumping its contents, and washing these contents may require leaning over the side of the boat.
    - **b.** Severe injury to fingers or hands can be caused by movement of the lever arms. If equipped, push the safety pin of your grab through both locking holes; unexpected movement of the lever arms or scoops can be dangerous.
2. Preliminary techniques
    - **a.** Take one or two trial samples to make sure the sampler is heavy enough to penetrate the sediment. Add weight if necessary.

   b. If something should be wedged between the jaws and prevent complete closure when the sample is being taken, that sample must be discarded.
3. Inspect the sampler.
4. Attach a line to the sampler. Tie sturdy rope to the clevis using strong, tight knots.
5. Tie the other end of the line to the boat or a float.
6. Insert the pinch pin (if equipped). The pin will stay in place as long as the line is taut.
7. Lower the sampler slowly.
8. Take your sample. Allow the sampler to sink into the sediment and perform the action that closes the sampler.
   a. In Ponar samplers, slack off the line to allow the pinch pin and horizontal locking bar to move, and then resume tension on the line to exert the closing motion of the jaws.
   b. Ekman Grabs have messenger weight and trigger mechanisms similar to those on Van Dorn water sampler bottles.

Ponar Grab

9. Retrieve your sample, maintaining tension on the cable.
10. Remove the sampler from the water and swing it inboard over a tub or bucket.
11. Empty the sampler into a tub or bucket.
12. Screen, sieve, and separate the sample
13. Analyze or preserve specimens. Make sure bottles/bags are clearly labeled.
14. Re-insert the safety pin to prevent accidental closing during washing and transportation.
15. Thoroughly rinse the sampler with fresh water to remove any residual sediment, organisms, or chemicals after each sampling session.

9.4 MERCURY SAMPLING AND OTHER TRACE METAL CLEAN TECHNIQUES.

Introduction

The purpose of trace metal clean techniques is to minimize contamination artifacts introduced during the collection and analysis of trace metal samples. The intent of the techniques presented here is not to be a complete protocol for any particular sampling task. Rather, employ these methods and general guidelines when collecting trace metal samples.

Clean Objects and other Tools

Use the clean technique whenever handling a clean object. A clean object is any collection device that comes into contact with a trace metal sample. Typically, clean objects are constructed of Teflon, quartz or acrylic. These inert materials can withstand harsh cleaning and stay relatively trace-metal free after an initial decontamination. When not being used, seal clean objects in two particle free plastic bags and store them in a low-dust/low-trace metal environment such as a clean lab. Never remove clean objects

from their plastic bags indoors unless working in a trace metal clean lab. As a general rule, only allow three types of objects to come into direct contact with clean objects. These are 1) trace metal samples; 2) clean plastic gloves or bags; 3) other clean objects.

Any equipment used with or near clean objects must be free of particles. Frequently wash nylon suits that are worn whenever handling clean objects. Wipe wrenches, tables, support stands and other such equipment clean before use. Change plastic gloves worn when handling clean objects after touching contaminated objects. Never reuse plastic gloves. Store Nylon suits, gloves, and similar equipment in dust proof containers.

Before Sampling

Whenever possible, approach a sampling site while facing into the wind. After arriving at the sampling location, put on a lint-free Nylon suit and a hat. The suits and hats reduce the amount of dust falling from street clothing into samples and on to clean objects. When working alone, face into the wind while collecting samples. When working in pairs, face each other so the wind blows from the side, sweeping between you and your partner.

Handling Clean Objects and Sampling

Ideally, two people should be involved with any trace metal sample collection. One person, dubbed "Clean Hands", wears shoulder length plastic gloves. The other, "Dirty Hands", usually wears short gloves. It is Dirty Hands' responsibility to fetch clean objects and open the outer bags in such a way that Clean Hands need only touch the inner bag and the clean object. Clean Hands must change gloves after touching anything other than inner bags or clean objects. Dirty Hands should change gloves after handling anything other than outer bags.

At times it is not practical for two people to perform some sampling tasks. In these instances, one person must play the part of both Clean Hands and Dirty Hands. Solo sampling for trace metals usually takes a bit longer and gloves must be changed more frequently. With a little practice and planning, however, one person can collect many types of samples without contaminating them.

Special Guidelines

Keep the caps off for as short a period of time as possible when filling sample bottles. Rinse sample bottles and caps three times with sample water before collection. Rinse graduated cylinders for measuring acid preservative with a small amount of acid before measuring.

Wrench all bottle caps tight after being filled. The jaws of the pliers used to tighten and loosen bottle caps must be covered with a few plastic gloves. Take care not to rip holes in these gloves.

An area upon which to place clean objects can be created by placing plastic gloves on a flat surface. This technique is especially useful when working alone.

Unless collecting a rain sample, sampling during a precipitation event should be avoided. Although rain and snow can have relatively low trace metal concentrations, rain and melted snow tend to collect on people and equipment. Drops of precipitation may subsequently splash into and contaminate samples.

Clean Technique: Theory vs. Practice

The clean techniques described above are ideal procedures to be employed whenever collecting trace metal samples. Extreme field conditions are occasionally encountered while sampling (*e.g.* high winds, low temperatures). So, the techniques used to collect samples may only approach this ideal. For this reason it is vital to keep detailed notes when collecting trace metal samples. Compromises made during collection may correlate with unusual sample results.

10 BIOLOGICAL MONITORING.

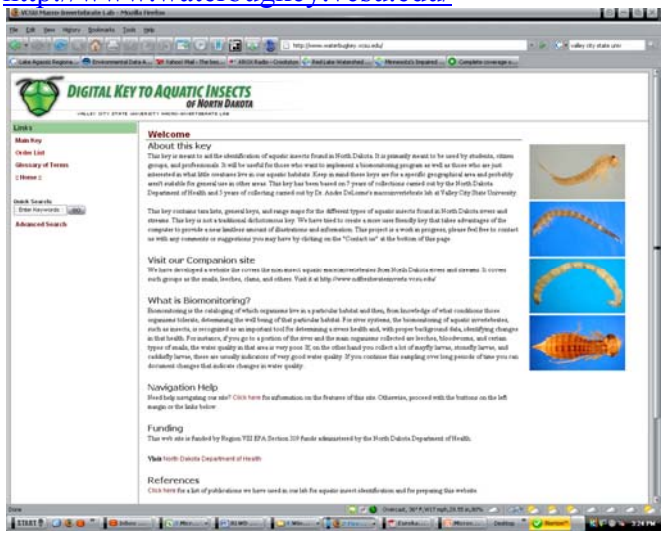
In addition to physical and chemical monitoring of our waters, it is also important to conduct biologic monitoring. Biologic indicator species can help us identify the evidence of an aquatic life impairment that can be missed by a water quality monitoring program. An Index of Biotic Integrity is an overall assessment of the health of a waterbody based upon a variety of biometrics. There are different types of biologic assessments that can be conducted including:

- Fish index of biotic
- Macroinvertebrate metrics (Hilsenhoff Index, #Diptera, %EPT)
- Macroinvertebrate index of biotic integrity
- Lake benthic macroinvertebrate studies
- Zooplankton studies

There also are different sampling methods that can be used, including:

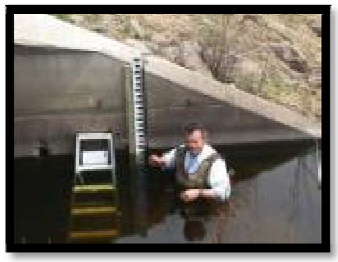
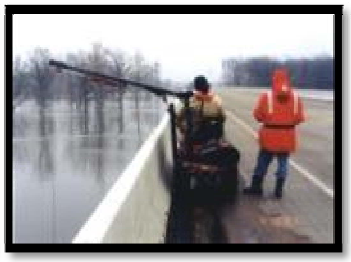
- Kick nets
- D-frame dip nets
- Benthic grabs
- Core samplers
- Electrofishing

Valley City State Digital Key to Aquatic Insects
http://www.waterbugkey.vcsu.edu/



- Surber stream bottom sampler
- Plankton nets
- Snag net
- Hester-Dendy Samplers

The protocol used by the Red Lake Watershed District is the U.S. Environmental Protection Agency's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.* This document and its appendices are available for viewing, printing, and downloading at http://www.epa.gov/owow/monitoring/rbp/. A training module is available at http://www.epa.gov/owow/watershed/wacademy/acad2000/rbp/index.html.

11 MEASURING STAGE AND DISCHARGE.

11.1 MEASURING STAGE

Stage Measurement

Stage is a general term for a measurement of the water level in a river or stream. River or stream stage is a measure of the elevation of the water surface relative to an established plane (datum or gauge-zero). The datum may be a mean sea level elevation or may be based on the assumed elevation of a benchmark or reference point. Many sites have established gage datum and have a staff gage, wire weight gage, and/or a continuous data recorder. Where a stage reading can be taken with one of these methods (increasing water level = a higher number), the stage reading can be referred to as *gage height.* Stage measurements are a quick way of measuring the elevation of the water surface without using survey equipment.

While continuous stage records obtained from an automated stage recording system (stilling well and data logger) will provide the most accurate measurements of stream stage this system is sometimes cost prohibitive. Stream stage is also measured with manual observations based on staff gauges, wire weight gauges, or measure down readings. If a rating curve has been developed, use these measurements to estimate flow as well.

The accuracy of stream discharge estimates using the staff gage method is largely dependent upon the frequency of stage measurements taken. Take measurements more frequently for higher accuracy in discharge estimates, particularly during storm events and spring runoff. Measure the stream's stage whenever water quality samples are collected.

If you are unsure of where the reference point or gage is located, measure down from the upstream side of the crossing, over the center of the thalweg, and describe your measure-down point in the comments section of your field data sheet.

11.1.1 Establishing Reference Points

A stable reference mark (RM) also known as a reference point (RP) may be used to measure down to the water surface. This reference point, known as a tape-down (TD) or bridge to water (BTW) is located on the bridge or culvert above the water surface. A weighted tape is used to measure the distance from this point to the water surface. A staff gage, or a continuous data recorder may also be installed. More commonly, a combination of these processes is used. Because free standing staff gages may move and the accuracy of a continuous stage recorder may change, a series of permanent stable reference points must be established to ensure accuracy of these stage recorders.

When setting up a new reference point, locate the point in the thalweg (deepest portion of the stream). It should be located away from bridge abutments or other obstacles that deflect flow (affect stage) and accumulate woody debris (that can impact stage). Reference points should be located where people can safely obtain accurate measurements. Marks that require a person to crawl between bridge rails or bend significantly over the top rail can be difficult to read accurately and can be unsafe in some circumstances.

Permanently mark the RP location with paint or a chiseled open-ended square on concrete (open end is the edge of the concrete) structures. Take care not to chip the outside edge of the concrete. Three saw marks are used as the reference point for a metal railed bridge. If a vertical metal support beam (see photo) is not present, the top of a bolt or a metal plate may be used. Use orange marking paint (cans with inverted tips work the best) to mark the RP. This mark will be used to repeatedly measure to the water surface so it must be easily located and must provide accurate measurements.

The “sharper” the edge of the RP is, the more accurate the measurements will be. A metal railing like the one pictured on this page works very well. Using the bottom edge of a beveled bridge curb/rail allows for more accurate tape-downs than using the top surface of a beveled bridge curb/rail. If the top surface of a beveled concrete structure has already been established as the RP, you can still get a very accurate reading by using a rigid, flat object or a ruler to extend the plane of that surface out to your tape. It is also possible to calculate the elevation of the bevel’s bottom edge if the elevation of the top surface is known. Just measure the vertical distance between the two (planes) and subtract that from the top surface elevation (extending the top surface plane with a ruler would help with this. Wooden bridges still exist in some places. If the curb and rails of a wooden bridge are weathered wood, a board can be attached to the outside of the curb so that the top of the board is even

with the top of the curb. That will provide a "sharper" spot for more accurate measurements. A metal plate or a bolt could also be used as an RP on a wooden bridge.

It's not a bad idea to document the relationship between a RP and a staff gauge just in case something happens to the staff gauge. Staff gages can be moved or damaged by ice and debris. Ideally, an assumed elevation and/or mean sea level (MSL) elevation is established for each RP.

There are situations in which more than one RP may exist at a site. This can happen when an organization moves its RP or when multiple programs are collecting data at a site over time. When this happens, coordination among local resource agencies and organizations should take place to determine who is actively monitoring a site and which RP is the best. Any parties that are collecting data at the site should agree to use the best RP or the site. The "official" RP for the site should then be selected or created and all the other marks are surveyed in relation to the permanent RP and described. The reference points that are "retired" should be painted over with a color that best matches the bridge surface. Past data should be corrected in relation to the "official" RP.

Here are some more tips to consider when establishing a reference point:

- Narrower streams are better for creating rating curves
- Use the downstream side of the bridge/culvert if there is a chance that debris will accumulate on the upstream side. Debris or ice build-up can interfere with or damage equipment, especially if the equipment is mounted on the bridge or culvert. Debris may also affect the stage reading or make collecting a stage reading impossible.
- The DNR recommends using the bottom of the bevel on beveled bridge curbs.
    - Paint/mark an arrow pointing down to the bottom edge of the bevel.
- Three saw marks are used to mark an RP on a steel rail.
- A good reason for surveying the elevation of RPs is that you can determine the water's actual elevation using a measure-down stage reading. Time-series graphs showing water level readings make much more sense than graphs of measure-down readings. Simply subtract your tape-down measurement from the RP elevation.
    - RP Elevation – Tape Down = Water Surface Elevation (1,159.54 – 8.60 = 1,150.94)
- Because bridges and culverts are occasionally replaced, it is a good idea to survey the elevation of each RP. Two or more additional benchmarks should then be established nearby so that the elevation of the RP on the new bridge can be established. If the flow rating curve is based upon the elevation of the water and you are able to accomplish this surveying, the rating curve will continue to be valid for the site.
- Describe the location of the RP in as many places as possible (field notes, SAP, QAPP, online database, spreadsheets).
    - Example description: Measure down point is the lower beveled edge at chiseled square painted orange, located on the downstream (north) cement bridge barrier. Located 50 feet west of right bank (east) end of bridge, between 10^{th} and 11^{th} verticals.

11.1.2 Staff gauge.

Staff gauges are permanent (depending on what they are mounted to) gauges demarcated in tenths and/or hundredths of feet. The standard Geological Survey vertical staff gage consists of porcelain-enameled iron sections that are four inches wide, 3.4 feet long, and graduated every 0.02 feet. Some older gauges are made of wood alone and are not as durable. Mount this plate on a piece of lumber for support, such as a 2" X 6" board. The gauge datum point is often referred to as "gauge zero." This point is usually set at or below the elevation of zero flow on a natural channel.

Mount staff gages on a permanent structure in the water such as a bridge or dam if possible (with permission), or mount them on a steel fencepost in the water. A permanent structure is preferred as it will provide more reliable elevations from year to year and will generally only need to be surveyed one time until it needs to be replaced. Mount gauges at a height and location where the range of levels on the gauge will cover as much variation in water level as possible. Yearly surveying is necessary for gauges mounted on fence posts since the push and pull effect of ice can change the gauge datum (zero point) elevations for the gauges.

1. To determine a gauge zero by surveying, first take fore sight reading of the benchmark and the water surface. If possible, take a fore sight reading of the top of the gauge itself. This measurement is useful if the top of the gauge is a definite number and it is possible to rest the base of the survey rod on this point.

2. Record the gauge reading at the time of surveying.

3. Calculate elevations. If the elevation of the benchmark used is unknown, use 100 feet as the benchmark elevation. A benchmark may be a certain point on a bridge/culvert, or a nail in a telephone pole/tree. In your survey book, determine the elevations of the other points based upon the benchmark elevation of 100 feet. The difference between survey rod readings and the difference between elevations of the benchmark and the water surface should be equal.

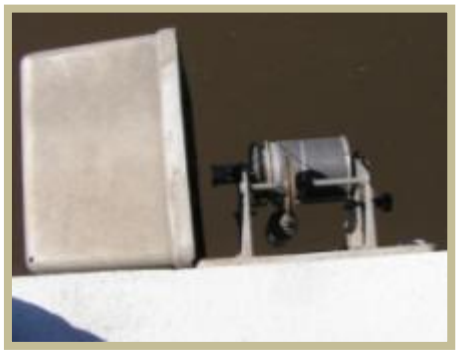
4. If you took a survey rod reading for the top of the gauge and also took a gauge reading, decide which the most accurate number is. If there were a lot of waves, making the gauge hard to read, then the elevation of the top of the gauge may be the most reliable number. If the water surface was calm and it was difficult to accurately set the base of the survey rod at the topmost number on the gauge (metal staff gauge plates are usually cut off right at a certain whole number such as 4.00), then the gauge reading may be the more accurate of the two measurements. If the staff gauge reading is the most accurate, subtract the gauge reading at the water surface from the water surface elevation. This is the elevation of the gauge zero. If the reading at the top of the

gauge was the most accurate number of the two, subtract the reading at the top of the gauge from the elevation of the top of the gauge to find the gauge zero.

5. Once the gauge zero elevation is found, add this number to future staff gauge readings to determine the water surface elevation.

When installing any type of gauge or changing stream gauge methods, correlation between old and new gauge readings may be necessary. This is one of the reasons why documenting the relationship between staff gauge measurements and the benchmark is very important.

11.1.3 Wire weight.



Wire weight gauges consist of a bronze weight attached to a stainless steel cable wound around a steel drum that is used to record the equivalent of a staff gauge/USGS gauge house reading from the top of the bridge. These are usually located on large bridges and co-located with actual staff gauges and/or USGS gauge houses.

Because wire-weight gages are usually mounted on bridges, changes in gage datum can result from the settling of bridge abutments or piers, or from changes in the deflection of the bridges resulting either from differences in traffic loading at the times of observation or from seasonal changes in air temperature. Erroneous readings of the type A wire-weight gage may also be caused by slippage of the graduated disc. Slippage may be detected if a reading of the gage height of the horizontal check-bar is always made prior to lowering the weight to the water surface.

Because of these possible changes, the datum of the wire-weight gage should periodically be checked by surveying the check-bar elevation to a known reference mark. The correct wire weight elevation should read on the counter when the bottom of the wire weight is resting flat on the check-bar. Adjustments to the gage elevation are made by loosening the graduated disc, rotating the disc to the true gage height of the bottom of the weight as determined from surveying, and then retightening the disc screws. Reliable observations can be difficult to obtain by wire-weight gage when the water surface is disturbed by waves, if the water surface is calm or if strong wind is present. A median elevation should be recorded between the waves during turbulent conditions. When observations are made on windy days, the wire that supports the weight may bow rather than hang vertically, thereby causing the gage to under register the stage. The ideal condition for sensing the water surface occurs during low velocity water current with calm wind conditions.

Another source of error (that increases with height above the water surface) is created by the tendency of the weight to rotate about its vertical axis as the weight is being lowered. As the wire twists, the wire may shorten and the weight ascends; likewise, while untwisting, the wire lengthens. A gage height reading of the water surface should not be made until the weight has ceased to rotate.

1. To take a wire weight measurement from a bridge equipped with one of these gauges, first locate the box on the bridge, usually mounted on the outside of the upstream guardrail.

2. Unlock the box and open it (make sure you have obtained a key from the agency that installed the wire weight gauge beforehand).

3. While holding onto the pulley handle, crank the weight up a touch in order to release the latch that stops the pulley from spinning. Flip this mechanism back and out of the way so that you may lower the weight. Lower the weight slowly until the base of the weight is at the water surface.

4. Record the gauge reading from the click meter (Veeder counter) and a graduated disc on the left hand side of the pulley. The click meter will show the whole number and an arrow will be pointing to the hundredths reading on the left-hand side of the pulley. For example, if the click meter reads 003 and the arrow is pointing to .55, then the gauge reading is 3.55.

5. Crank the weight back up into the box and flip the latch forward to keep the pulley from spinning and the weight from falling. When you are finished, close the box and lock it.

11.1.4 Measure down (tape down) from a reference point.

Also referred to as a tape-down reading, a measure down reading is simply measuring down to the water surface from a reference point (RP) or a benchmark (BP) on a bridge or culvert using a weighted tape or a survey rod. This method of water level measurement is the inverse of gage height. Measure down values will decrease as water level increases. Reference points often have an elevation (surveyed or assumed). Subtract the tape down reading from the RP elevation to get the actual elevation of the water surface.

In order to begin taking tape down measurements, one must first identify a reference point (RP) on the bridge or culvert over the stream. The best spot from which to take these readings is an existing benchmark on a bridge. A painted line or other permanent marking near the center of the bridge's guardrail/curb/barrier will often mark the location of a benchmark if one exists.

Perform tape-down measurements when no other, more permanent gauges are currently installed at the site. If other gauges are present, rating curves developed for that site will most likely refer to stage readings from the permanent gauge. Consult other local monitoring organizations and agencies to see if an elevation has been established for an existing RP.

Take tape-down measurements with a weighted measuring tape that has feet marked to the 100th. Attaching a weight to the end of the tape helps it hang straight down and reduces error from wind. These measurements must be taken from exactly the same location each time they are recorded. Lower the tape to the water surface. When the tape is straight and the weight is just barely touching the water surface, the measurement at the RP is recorded. Wind can cause some error in the tape down measurement. If the site is windy, and effecting the measurement, get the best measurement possible and note on the field data sheet that wind may have influenced the tape down measurement. If using a weight such as a padlock on the end of a tape, make sure to adjust the reading to compensate for the distance that the weight hangs down below the zero point on the end of the tape by adding this distance to the tape reading at the RP. Note: You add the length that the weight adds to the tape, not necessarily the length of the weight. If the bridge is close enough to the water surface, a survey rod works better than a tape because it provides a rigid, straight measurement from the RP down to the water surface.

11.2 MEASURING DISCHARGE.

Summary

When monitoring streams, a complete range of flow readings is necessary for the computation of an accurate stage/discharge relationship (Section 10.4). Collect flow readings at or near the peak flows as well as during low flows. Create this relationship as soon as the field data becomes available to avoid the potential for missing values. Record stage measurements whenever a sample is collected (Section 10.1). Gather this information to track the stage of the stream and utilize it along with a stream hydrograph to estimate discharge and loads for water quality parameters.

Careful selection of sampling sites can greatly reduce the amount of work required to get accurate discharge measurements. When choosing a location for this work, look for a bridge that spans a relatively straight portion of the stream. There also should be a significant relationship between stage and discharge at the site. In other words, an increase in stage (increasing depth at the site) should result in an increase in discharge. Avoid sites that are affected by backwater from another river, a man-made dam or a water control structure, Sites immediately downstream of a dam or another control structure should be ruled out. Ideal sites to look for are; weirs, bridges, box and round culverts. The advantages of these sites are that even during flood conditions, flow measurements are possible through a relatively

narrow space. These structures also act as "controls" and there will be minimal change to the flow rating curve over time. When none of the above situations exist and the stream is small enough a temporary weir can be created to aid in collecting flow measurements, but only in places where fish passage is not a concern. Rock riffles can also act as more natural "controls."

AquaCalc 5000 Digital Readout

Collect velocity readings from the same location throughout the study period. If for some reason the location is moved, even just a short distance, the new location must be noted. Enter the reasons as to why it was moved on your log sheet. The measurement site must be a fairly clean reach of the channel with uniform flow (without much vegetation, rocks or other debris). Locate the site away from turbulent areas upstream or downstream of the structures (weirs, bridges, etc.). The turbulence will cause inaccuracy of the measurements. Still, make sure the site is near enough to the structure to include additional water entering the stream before the structure and exclude water entering the stream after the structure, e.g., from a small stream or overland flow.

Measurements during low flow can require some extra thought in order to get an actual value for the measurement. Pools likely won't have enough velocity to spin the meter during low flows. When you arrive at a site, look for a location where the water is visibly flowing. If the water is pooled, there may or may not be a shallower point (riffle) at the downstream end of the pool. Basically, you want to find a spot with measurable velocity, even during low flow.

<u>Calculating Stream Discharge with a Wading Rod</u>

Use this method for wadeable streams with an open stream bed with a depth of less than four feet.

Price, Type AA current meter

Equipment:

- Flexible tape measure (long enough to reach across the stream)
- Current meter
  - Pygmy current meter for velocities of .05 feet per second to 3.0 feet per second
  - Price AA current meter for velocities of .1 feet per second to 20.0 feet per second
  - Acoustic Doppler current meter
- Means of reading and recording velocity
  - Manual (becoming less common)
    - Headphones
    - Stopwatch
    - Calculator
    - Current meter rating tables
    - Flow measurement field data sheets

    - Digital (recommended)
        - AquaCalc 5000, or
        - AquaCount
            - Flow measurement field data sheets
            - Calculator
- Electric wire or cable to connect to the current meter;
- Wading rod.
    - The normal length is 4 feet
    - 8 foot wading rods are sometimes used for collecting measurements from culverts during high flows.
- Flow Measurement Field Data Sheet and pencil.
- Stakes to hold the tape.

Pygmy current meter with digital (optical) head

A digital readout for current meters, if available, will replace the stopwatch and headphones listed above. The RLWD uses AquaCount and an AquaCalc 5000 digital readouts, which are made by JBL Instruments and distributed by Rickly Hydrological and Gurley Precision Instruments.

The AquaCount is simple to use, but velocity, depth, and width data must be written down. There also is an added step of calculating flows manually or entering data into a spreadsheet that is used to calculate flows. These are recommendable steps for someone who is learning how to measure flow. The extra steps can be time consuming and there are times (although not recommended by the safety SOP section) when there is only one person doing the monitoring. Recording velocities and calculating flows by hand also introduces the possibility of human error. There is an instrument available to improve the efficiency and accuracy of flow measurements. The AquaCalc 5000 stores data (depth, distance, velocity, etc) and calculates flow volumes. It is a complex instrument with more complex instructions and capabilities than the basics that are provided in this document. AquaCalc users must utilize AquaCalc manual or receive training to become familiar with its use.

<u>Discharge measurement procedure using a wading rod, flow measurement data sheet, and mid-point velocity area flow measurement method.</u>

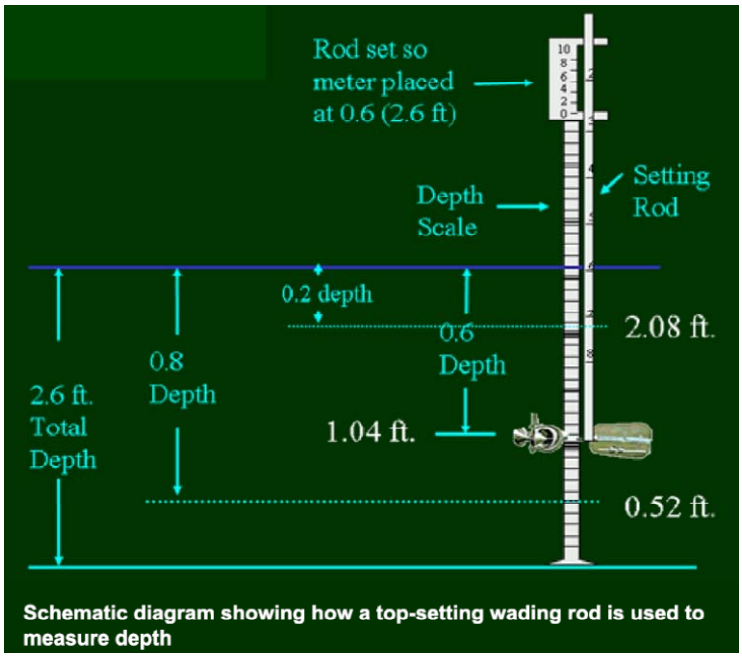
1. If using a pygmy meter, exchange the brass traveling pin for the measuring pivot and assemble the wading rod and pygmy meter. If using an AA meter, loosen the propeller by turning the brass raising nut (part # 15) completely clockwise to allow the bucket wheel to spin on the pin.
2. Record the beginning stage measurement on the flow measurement field data sheet.
3. Drive a stake into the near stream bank to anchor the tape and secure the tape at the far shore, perpendicular to the stream-flow with another stake. Stretch the tape across the stream tight enough to prevent it from dragging in the current. Take note of the total width of the stream in order to plan the number and width of intervals. Plan for 10-20 intervals, dependent upon the width of the stream. More intervals should equal greater accuracy. Take velocity measurements at the mid-point of each interval.
4. Enter the water downstream of the tape so as not to disturb the flow of water to be measured by the current meter. Note: Face into the current with the wading rod upstream of your position

5. Make note of the measuring tape reading at the edge of the water. This distance is the width of the first section, for which depth, velocity, area, and flow will be zero.
6. Place your wading rod at the mid-point of the second interval (which is the first actual interval within the stream). Record this distance and the width of the interval.
7. Measure the water depth using the wading rod.
8. Adjust the current meter to 0.6 of the total stream depth below the water surface using the scale at the top of the wading rod. For example, if the depth is 1.6 feet, adjust the rod so that the line on the round, movable rod labeled 1 is level with the line labeled 6 on the handle. On the flow measurement field data sheet, record the distance from the initial point on the tape in the first column. Then record the stream section width in the second column, the depth in feet in the third column, and the angle of the stream compared to the structure in the fourth column.
9. Set up the digital readout unit with the proper model of velocity meter selected (pygmy, AA1, or AA5), set it to SAE standards, and set it to run for at least 40 seconds before it reaches a final average velocity.
10. Slowly pivot the current meter in the water so that it is pointed directly against the direction of flow.
11. Then start the stopwatch and count the number of revolutions of the current meter during a time period no shorter than 40 seconds and no longer than 70 seconds. If using a digital readout unit and the words <Press Start> are displayed, press Start and wait until it stops before recording the velocity.
12. Record the velocity, number of revolutions, ant time (between 40 an 70 seconds) in the fifth column of the flow measurement field data sheet and the number of seconds in the sixth column.
    - If a digital readout is used, simply write the velocity in the appropriate blank
    - The velocity for the pygmy meter model number 612 can be computed through the equation V = 0.951R + 0.056
        i. R = Revolutions/Seconds.
    - The Model A-612 Pigmy Current Meter Rating Table is Figure 7.3.1 for easy use in rounded numbers along with the velocity equation. A digital readout for current meters will display velocity and will allow you to bypass the calculations in this step.

Measuring water depth on the wading rod

Discharge measurements can be made through the ice by drilling a transect of holes. Under-ice flow rating curves will differ from open water rating curves due to friction from the ice.

13. Record the computed velocity of each measurement in the seventh column. If the depth is <u>less</u> than 2.5 feet for water quality projects or 3.5 feet for engineering projects then record the lone velocity computation in the **mean** column.
14. If the total stream depth is <u>greater</u> than 2.5 feet for water quality projects and 3.5 feet for engineering projects, take the second reading (i.e., the velocity reading obtained at 0.2 of total stream depth) and record on the second line of the flow measurement field data sheet before moving along to the next point on the transect.

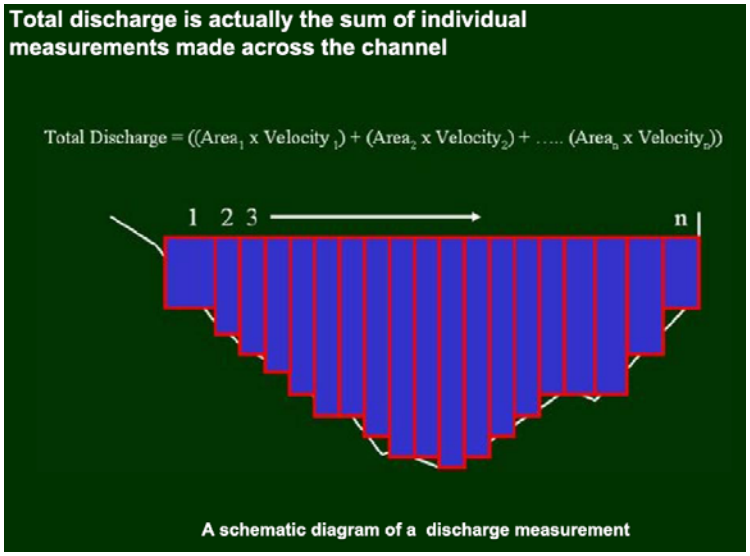


Schematic diagram showing how a top-setting wading rod is used to measure depth

- Take stream flow velocity readings at .2 of the total depth and .8 of the total depth below the water surface.
- To get an approximation of the 0.8 depth point, set the wading rod to ½ the total depth of the water (e.g. if the depth is 4.0 feet, set the rod at 2.0 feet). The meter will be at about 0.8*depth below the surface).
- To approximate the 0.2 depth-point set the wading rod to twice or double the total depth of the water (e.g. if the total depth is 4.0 feet, set the rod at 8 feet, the meter will be at .2*depth below the surface).
- Record two velocity computations, one in each line of the (0.8 and 0.2) **point** column. Then add these two velocity computations and divide by two. Record this resulting number in the **mean** velocity column.

15. Move your wading rod to the mid-point of the next section.
16. Take the second stream velocity reading and subsequent velocity meter readings in the same manner in the increments you determined in Step 3 until the opposite bank is reached.
    - To record subsequent readings with the digital readout unit, press Select. The old velocity reading will clear and <Press Start> will reappear. You can then press Start to begin recording once again. The final depth reading should be zero (0).
    - Distances between current meter readings should never exceed one foot, with some exceptions. Narrower streams may need smaller increments as narrow as three inches in order to get enough measurements for an accurate flow calculation.
    - For wider streams, adjust the increment width so about 25 measurements of approximately equal velocity will be taken.
    - For streams of consistent velocity, fewer measurements and/or wider increments may still produce accurate results.
    - For any stream, the greater the number of readings taken, the higher the accuracy of the total discharge calculation will be.
17. At the completion of the stream flow measurements, take an ending stage measurement. Calculate the average stage using the "before" and "after" stage readings.

18. All data necessary for calculations will be recorded on site.
19. If the angle of the tape or the angles of the points of the velocity measurements differ from 90 degrees to the stream then an adjusted angle computation is necessary.
    - Make this computation by multiplying the uncorrected velocity by the cosine of the angle-difference to determine the stream velocity component normal to the measuring section.
    - Equation: (Cosine of Angle) x (mean velocity) = corrected velocity (Example: If the angle to the stream is 105 degrees, multiply the mean uncorrected velocity by the cosine of 15 degrees or by 0.96593).
20. The next task (column 10) is computing the stream cross sectional area. Multiply the section width (second column) by the depth (third column). Finally, find the discharge by multiplying the area (tenth column) by the mean velocity (eighth column) and record this number in the last column
21. Add all the areas and record this sum at the bottom, marked **AREA**.
22. Add all the discharges and record this total number at the bottom marked **DISCHARGE**. At the bottom of the Stream Discharge Measurement Sheet take the total discharge, in cubic feet per second, and divide it by the total area, in square feet. The resulting number is recorded as the average stream velocity in feet per second. Both persons performing stream gauging are to check the entire data form to determine if stage and flow computations are reasonable. Once the calculations are complete, place the brass traveling pin in the pivot hole of the velocity meter and disassemble the wading rod, pygmy meter and other equipment. For the AA meter, turn the raising nut completely counter-clockwise in order to raise the bucket wheel off the pin and keep it from spinning before putting the meter back in its case.



23. At the end of each day, clean, dry, and oil the meter according to the standard operating procedures for oiling and cleaning found in the appendix.
24. Record all usage, maintenance and repairs in the meter log. After every five days of usage the pygmy meter shall be inspected and spin tested. For additional maintenance and usage information, see Appendix C.

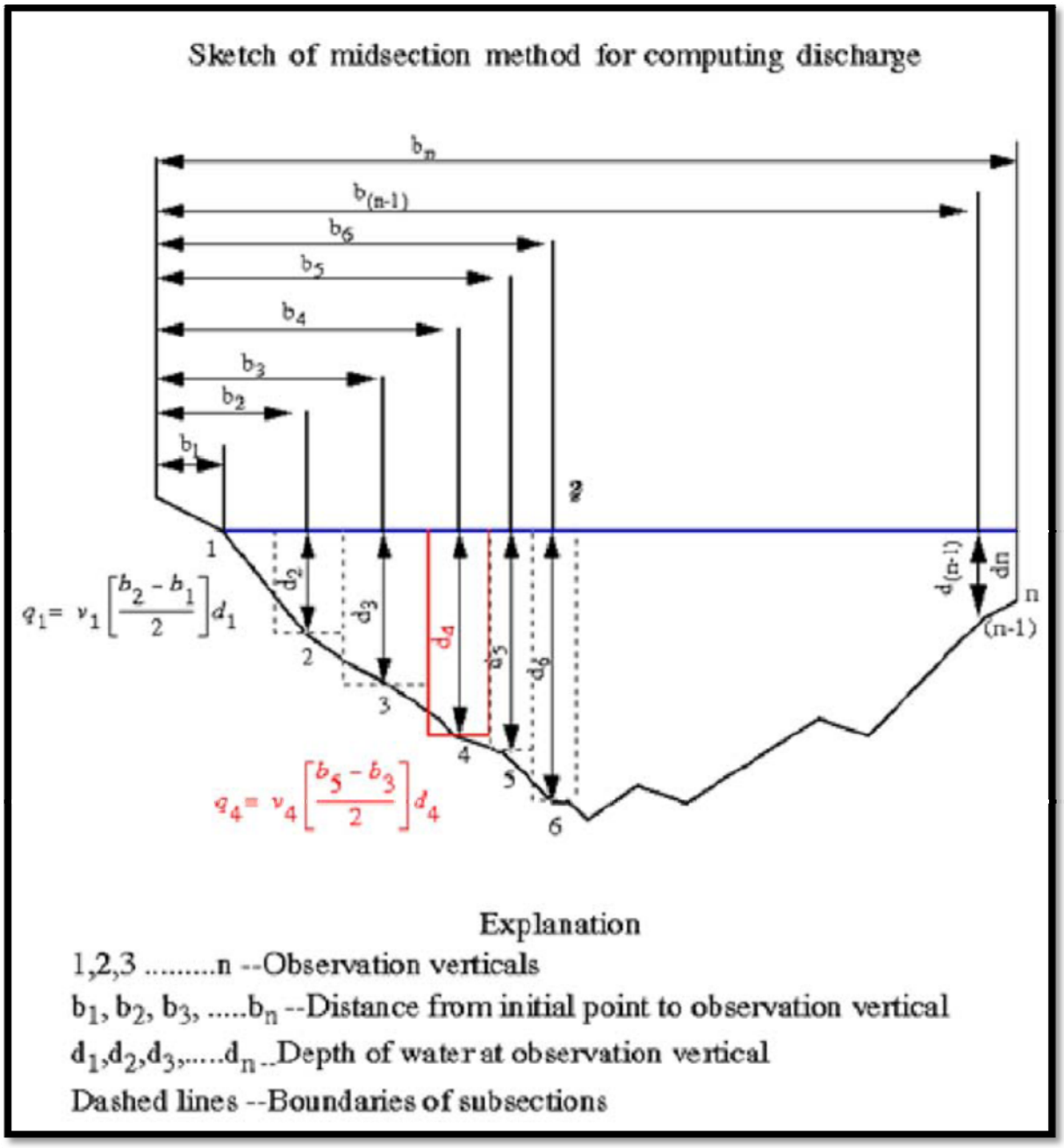


Figure 13. Flow measurement cross-section using the mid-section velocity area discharge measurement method.

Discharge measurement procedure using wading rod and AquaCalc 5000

1. If using a pygmy meter, exchange the brass traveling pin for the measuring pivot and assemble the wading rod and pygmy meter. If using an AA meter, loosen the propeller by turning the brass raising nut (part # 15) completely clockwise to allow the bucket wheel to spin on the pin.
2. Turn on the AquaCalc.
3. Make sure the date and time are correct. Edit if necessary.
4. Press **Enter** twice to get to the most recently used transect.

5. Press **Go to Transect #** and select an unused transect.
6. Make sure that the transect is on observation
7. Press **Menu, 1, and** 1 to get to the ID and Hdwr Info program to store the beginning stage measurement, site number, user ID #, and current meter type. Use the **Enter** button to move from entry to entry and the **Insert/Delete** button to edit an entry
8. Exit the transect information mode and get back to the transect data by pressing **Menu (0)** twice.
9. Drive a stake into the near stream bank to anchor the tape and secure the tape at the far shore, perpendicular to the stream-flow with another stake. Stretch the tape across the stream tight enough to prevent it from dragging in the current. Take note of the total width of the stream in order to plan the number and width of intervals. Try to get at least 10-15 measurements in the cross-section, with a maximum of approximately 25. Collect measurements at smaller increments in areas of greater flow velocity.
10. Enter the water downstream of the tape so as not to disturb the flow of water to be measured by the velocity meter. Note: Face into the current with the wading rod upstream of your position
11. The first measurement of the transect will be the zero point of the tape, so distance and depth will be zero for the first observation on the transect.
12. Press **Next Observation**
13. Record the distance along the tape at the water's edge by using the **Set Distance** button. Depth and velocity for this point will both be zero.
14. Press **Next Observation**
15. Move your wading rod to your first increment. For Aquacalc 5000 readings, measurements will simply be taken at regular intervals across the stream (at the edges of the sections). So, there is no need to figure out the midpoint of the section. If you plan for 1 foot increments, simply move your wading rod to the next even foot line.
16. Input the distance into the AquaCalc using the **Set Distance** button.
17. Measure the depth of the water using the wading rod.
18. Input the depth into the AquaCalc using the **Set Depth** button.
    - The default depth of the AquaCalc is the 6/10 of the depth.
    - Take stream flow velocity readings at .2 of the total depth and .8 of the total depth below the water surface.
    - If the depth is greater than 2.5 feet (for water quality projects), or 3.5 feet (for engineering projects), measure velocity at two depths.
    - Input the meter depth using the **Observe Depth** key. The AquaCalc will tell you how to set the rod to get the current meter to the correct depth for the measurement.
    - Each of these two measurements is recorded in the AquaCalc as a separate observation. They will have the same distance and water depth information.
    - The differences will be the measurement depths and velocities.
19. Set the wading rod to the correct depth using the scale at the top of the rod.
20. Make sure that the current meter is pointed straight against the direction of flow.
21. Press the **Measure** button to start the measurement
22. Go to the next observation and repeat steps 15 – 21 until you reach the opposite bank of the river.
23. Enter distance at the water's edge on the other side of the river as the second to last observation. The depth and velocity of this observation will be zero.
24. The last observation will be an "imaginary" measurement that has a distance equal to several feet beyond the distance at the water's edge (from Step 23), a depth of zero, and a velocity of zero.
25. Record an "ending" stage reading.

26. Press the **Calculate Discharge** button to calculate the flow in cubic feet per second.
27. This data can be uploaded to a computer, but it is good practice to record the mean stage and the discharge measurement on a field data sheet as a "back-up" to the information stored in the AquaCalc.

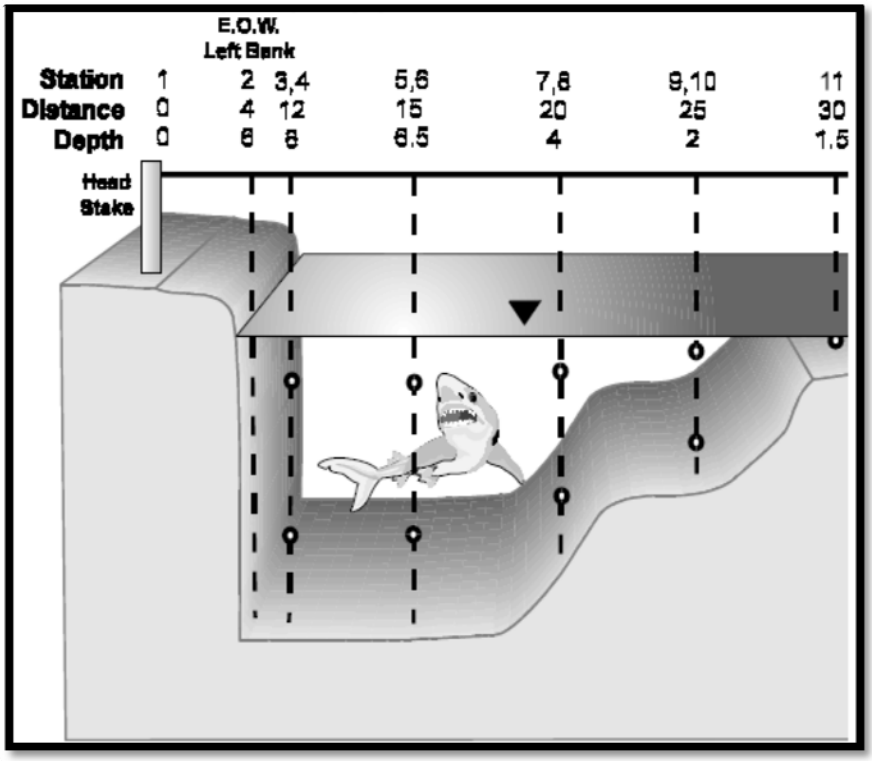


Figure 14. Sample transect for the AquaCalc digital readout from the AquaCalc 5000 manual.

Bridge Crane Discharge Measurements

These are generally used for stream discharge measurements for streams with average velocities above 2.5 feet/second or streams with depths greater than 4 feet.

Equipment:

- A current meter and a weight large enough to keep the current meter from moving.
- A hang cable with headphones. The cable should be marked off in feet to permit suspending the velocity meter at desired depths.
- Flow Measurement Field Data Sheet and pencil.
- A bridge sampler, if necessary, to hold the meter and hang cable.

- Stop watch.
- (Calculator (preferably HP 32 S calculator with programmed depth procedures)
- A digital readout for current meters, if available, will replace the stopwatch and headphones listed above. Set up the readout with the proper model of velocity meter selected (pygmy, AA1, or AA5), set it to SAE standards, and set it to run for at least 40 seconds before it reaches a final average velocity. Commonly used models include the AquaCount and AquaCalc 5000.
- A lumber crayon for making non-permanent markings on the bridge.

Procedure: To get accurate stream discharge estimates, measurements should be made from a bridge, culvert or other structure.

1. Mark off the bridge (or culvert) into increments using a lumber crayon, i.e. 1-foot increments, before beginning the discharge measurement. You may also keep track of distance by laying out a measuring tape. Plan for at least 15 measurements across the stream transect. The "zero distance" point of the transect should be on shore.
2. Assemble the current meter, hang cable, headphones/digital readout, reel, and bridge crane according to the Appendix found in the back of this manual. Lower the raising nut on the current meter shaft from the traveling position to the bottom or measuring position.
3. Record a staff gauge measurement at the beginning and at the end of the stream gauging process. Record the beginning stage measurement.
4. At the first current velocity measurement increment, one foot away from the initial or zero starting point at the water's edge, lower the current meter and weight by letting out the hang cable until the weight touches the water surface.
5. Set this as the zero on the bridge sampler cable meter or record the level of the hang cable at the top of the bridge. Make sure you "zero out" the dial as the first step at each measurement point along the transect.
6. If using an AquaCalc digital readout,
    a. Find an empty transect.
    b. Enter the transect information, including initial stage, site #, staff ID, etc.
    c. Enter the distance (0) and depth (0) for the on-shore beginning of the transect as the first point of the transect.
    d. Enter the edge of water distance and depth (0) as the second point of the transect.
7. Lower the meter until the weight hits the stream bottom and record the depth in the Depth column on the Stream Gauge/Discharge Measurement Sheet.
8. Enter the depth into the AquaCalc 5000.
9. Pick the depth at which you will be measuring (.2, .6, or .8)
    a. If the depth is greater than 3 feet, calculate the 0.2 depth and the 0.8 depth measurements. If you are using the AquaCalc 5000, the instrument will calculate these depths for you.
10. Set the meter to the measurement depth by using the winch.
11. Lower the current meter to 0.8 of total stream depth on the cable meter. If the digital readout

for current meters is used, move on to step (i). When using the headphones and stopwatch, start the stopwatch and count the number of revolutions of the current meter (ticks in the headphones) for a time period between 40 and 70 seconds. Note: The 622 current meter Rating Table is shown in Table 10-2. The current velocity equation is V = 2.2172R + 0.0267, where R = Revolutions/Seconds, for calculating velocity. This equation is valid for measurements involving 5 or more revolutions counted over a measuring period of 40 to 70 seconds. If fewer than 5 revolutions occur during the 40 to 70 second measuring period use the Rating Table in Table 10-2.

12. Record the velocity reading from the current meter after it has stopped calculating the velocity. If using the headphones and stopwatch, record the number of revolutions and measurement time in seconds on the Stream Gauge/Discharge Measurement Sheet.
13. Set the meter at the 0.2 of total stream depth and repeat steps (h) and (i).
14. Repeat steps (d) – (j) for each one-foot increment on the bridge or culvert.
15. Make sure the hub is raised off the needle bearing anytime the velocity meter is not being used.
16. Complete all calculations at the end of the stream flow measurement while personnel are still on site. Follow the steps (j) – (l), under "Procedure," for the measurement of small streams with depths of less than 4 feet.
17. At the end of each day clean, dry, and oil the current meter.
18. Record all usage, maintenance and repairs in the 622 current meter log. After every five days of usage, inspect the current meter and perform a spin test.

Table 9. Example of the stream gauge discharge measurement sheet.

Watercourse: Clearwater River	Gauge # or Location: #52 Clearwater Dam	Date: 7/13/99
Gauge Type: Vert. Staff, (Wire WT), Elec. Tape Automatic Stream Gauge		Readers Names: GL/GA
Gauge Reading: Before Measurement: 3.48 After Measurement: 3.48		Time: Beg. 12:30 A.M. End. 1:55 (P.M.)
Measurement using: Pygmy Meter, ~~Glick Meter (622)~~, Wading Rod, Hang Cable, (Bridge Crane)		Ice Cond.: UPSTM/DNSTM Edges/Flowing
Stream Width: 51 ft	Measurement taken (Upstream) / Downstream	Initial starting point: East Bank (Dist. from culvert, weir, or bench mark)

Dist. From Initial Point	Section Width	Depth	Angle	Revol-utions	Time in Secs.	Velocity Point	Velocity Mean	Adj. for Ang.	Area	Discharge (cfs)
4.5'	9'	2.3'		30	44	1.68	1.68		20.70	34.78
12'	6'	5.0'		30	51	1.32	1.54		30.00	46.20
				40	51	1.75				
18'	6'	6.2'		30	44	1.53	1.57		37.20	58.40
				30	42	1.60				
24'	6'	6.0'		30	50	1.35	1.44		36.00	51.84
				30	44	1.53				
30'	6'	3.7'		30	55	1.23	1.20		22.20	26.64
				30	53	1.27				
36'	6'	2.4'		20	48	.95	.95		14.40	13.68
45'	12'	2.3'		20	41	1.10	1.10		27.60	30.36
261.90		188.10		1.392				Totals:	Area	Discharge
Total cfs	/	Total Area	=	Average Velocity					188.10	261.90

Revised 8/31/99.

Table 10. Rating table for the number A-612 pygmy current meter

DEPARTMENT OF INTERIOR – GEOLOGICAL SURVEY – W — PYGMY CURRENT METER NO. A-612

EQUATION V = 0.951R + .056 R = REV/SEC — SUSPENSION – ROD — CONDITION

ACTUAL RATING LIMITS 0.25 TO 3.0 FEET/SECOND — GULF COAST HYDROSCIENCE CENTER – RATED 01-

Sec	Revolutions															Sec
	3	5	7	10	15	20	25	30	40	50	60	80	100	150	200	
40	0.127	0.175	0.222	0.294	0.413	0.532	0.650	0.769	1.01	1.24	1.48	1.96	2.43	3.62	4.81	40
41	0.126	0.172	0.218	0.288	0.404	0.520	0.636	0.752	0.984	1.22	1.45	1.91	2.38	3.54	4.70	41
42	0.124	0.169	0.215	0.282	0.396	0.509	0.622	0.735	0.962	1.19	1.41	1.87	2.32	3.45	4.58	42
43	0.122	0.167	0.211	0.277	0.388	0.498	0.609	0.719	0.941	1.16	1.38	1.83	2.27	3.37	4.48	43
44	0.121	0.164	0.207	0.272	0.380	0.488	0.596	0.704	0.921	1.14	1.35	1.79	2.22	3.30	4.38	44
45	0.119	0.162	0.204	0.267	0.373	0.479	0.584	0.690	0.901	1.11	1.32	1.75	2.17	3.23	4.28	45
46	0.118	0.159	0.201	0.263	0.366	0.469	0.573	0.676	0.883	1.09	1.30	1.71	2.12	3.16	4.19	46
47	0.117	0.157	0.198	0.258	0.360	0.461	0.562	0.663	0.865	1.07	1.27	1.67	2.08	3.09	4.10	47
48	0.115	0.155	0.195	0.254	0.353	0.452	0.551	0.650	0.849	1.05	1.24	1.64	2.04	3.03	4.02	48
49	0.114	0.153	0.192	0.250	0.347	0.444	0.541	0.638	0.832	1.03	1.22	1.61	2.00	2.97	3.94	49
50	0.113	0.151	0.189	0.246	0.341	0.436	0.532	0.627	0.817	1.01	1.20	1.58	1.96	2.91	3.86	50
51	0.112	0.149	0.187	0.242	0.336	0.429	0.522	0.615	0.802	0.988	1.17	1.55	1.92	2.85	3.79	51
52	0.111	0.147	0.184	0.239	0.330	0.422	0.513	0.605	0.788	0.970	1.15	1.52	1.88	2.80	3.71	52
53	0.110	0.146	0.182	0.235	0.325	0.415	0.505	0.594	0.774	0.953	1.13	1.49	1.85	2.75	3.64	53
54	0.109	0.144	0.179	0.232	0.320	0.408	0.496	0.584	0.760	0.937	1.11	1.46	1.82	2.70	3.58	54
55	0.108	0.142	0.177	0.229	0.315	0.402	0.488	0.575	0.748	0.921	1.09	1.44	1.79	2.65	3.51	55
56	0.107	0.141	0.175	0.226	0.311	0.396	0.481	0.565	0.735	0.905	1.07	1.41	1.75	2.60	3.45	56
57	0.106	0.139	0.173	0.223	0.306	0.390	0.473	0.557	0.723	0.890	1.06	1.39	1.72	2.56	3.39	57
58	0.105	0.138	0.171	0.220	0.302	0.384	0.466	0.548	0.712	0.876	1.04	1.37	1.70	2.52	3.34	58
59	0.104	0.137	0.169	0.217	0.298	0.378	0.459	0.540	0.701	0.862	1.02	1.35	1.67	2.47	3.28	59
60	0.104	0.135	0.167	0.215	0.294	0.373	0.452	0.532	0.690	0.849	1.01	1.32	1.64	2.43	3.23	60
61	0.103	0.134	0.165	0.212	0.290	0.368	0.446	0.524	0.680	0.836	0.991	1.30	1.62	2.39	3.17	61
62	0.102	0.133	0.163	0.209	0.286	0.363	0.439	0.516	0.670	0.823	0.976	1.28	1.59	2.36	3.12	62
63	0.101	0.131	0.162	0.207	0.282	0.358	0.433	0.509	0.660	0.811	0.962	1.26	1.57	2.32	3.08	63
64	0.101	0.130	0.160	0.205	0.279	0.353	0.427	0.502	0.650	0.799	0.948	1.24	1.54	2.28	3.03	64
65	0.100	0.129	0.158	0.202	0.275	0.349	0.422	0.495	0.641	0.788	0.934	1.23	1.52	2.25	2.98	65
66	0.099	0.128	0.157	0.200	0.272	0.344	0.416	0.488	0.632	0.776	0.921	1.21	1.50	2.22	2.94	66
67	0.099	0.127	0.155	0.198	0.269	0.340	0.411	0.482	0.624	0.766	0.908	1.19	1.48	2.19	2.89	67
68	0.098	0.126	0.154	0.196	0.266	0.336	0.406	0.476	0.615	0.755	0.895	1.17	1.45	2.15	2.85	68
69	0.097	0.125	0.152	0.194	0.263	0.332	0.401	0.469	0.607	0.745	0.883	1.16	1.43	2.12	2.81	69
70	0.097	0.124	0.151	0.192	0.260	0.328	0.396	0.464	0.599	0.735	0.871	1.14	1.41	2.09	2.77	70

Copied from RLWD files on 8/30/1999

Table 11. Rating table for the 622 (Price) current meter

This table applies when measurements are made with meter suspended by cable.
When measurements are made with meter suspended by rod, reduce the tabular velocities by 2%.
V = 2.2172 (REV/SEC) + 0.026 Note: Equation is not valid for revolution measurements below 5 revolutions.

Time in Seconds	VELOCITY IN FEET PER SECOND — Revolutions																Time in Seconds
	1	2	3	5	10	20	30	40	50	60	70	80	90	100	150	200	
40	0.09	0.15	0.21	0.30	0.56	1.14	1.69	2.24	2.80	3.35	3.91	4.46	5.02	5.57	8.34	11.11	40
41	0.09	0.15	0.20	0.30	0.57	1.11	1.65	2.19	2.73	3.27	3.81	4.35	4.89	5.43	8.14	10.84	41
42	0.09	0.14	0.20	0.29	0.55	1.08	1.61	2.14	2.67	3.19	3.72	4.25	4.78	5.31	7.95	10.58	42
43	0.09	0.14	0.20	0.28	0.54	1.06	1.57	2.09	2.60	3.12	3.64	4.15	4.67	5.18	7.76	10.34	43
44	0.09	0.14	0.19	0.28	0.53	1.03	1.54	2.04	2.55	3.05	3.55	4.06	4.56	5.07	7.59	10.10	44
45	0.09	0.14	0.19	0.27	0.52	1.01	1.50	2.00	2.49	2.96	3.48	3.97	4.46	4.95	7.42	9.88	45
46	0.09	0.14	0.19	0.27	0.51	0.99	1.47	1.95	2.44	2.92	3.40	3.88	4.36	4.85	7.26	9.67	46
47	0.08	0.14	0.18	0.26	0.50	0.97	1.44	1.91	2.39	2.86	3.33	3.80	4.27	4.74	7.10	9.46	47
48	0.08	0.14	0.18	0.26	0.49	0.95	1.41	1.87	2.34	2.80	3.26	3.72	4.18	4.65	6.96	9.27	48
49	0.08	0.13	0.18	0.25	0.48	0.93	1.38	1.84	2.29	2.74	3.19	3.65	4.10	4.55	6.81	9.08	49
50	0.08	0.13	0.17	0.25	0.47	0.91	1.36	1.80	2.24	2.69	3.13	3.57	4.02	4.46	6.68	8.90	50
51		0.13	0.17	0.24	0.46	0.90	1.33	1.77	2.20	2.64	3.07	3.50	3.94	4.37	6.55	8.72	51
52		0.13	0.17	0.24	0.45	0.88	1.31	1.73	2.16	2.59	3.01	3.44	3.86	4.29	6.42	8.55	52
53		0.13	0.16	0.24	0.45	0.86	1.28	1.70	2.12	2.54	2.96	3.37	3.79	4.21	6.30	8.39	53
54		0.13	0.16	0.23	0.44	0.85	1.26	1.67	2.08	2.49	2.90	3.31	3.72	4.13	6.19	8.24	54
55		0.13	0.16	0.23	0.43	0.83	1.24	1.64	2.04	2.45	2.85	3.25	3.65	4.06	6.07	8.09	55
56		0.12	0.16	0.22	0.42	0.82	1.21	1.61	2.01	2.40	2.80	3.19	3.59	3.99	5.97	7.95	56
57		0.12	0.16	0.22	0.42	0.80	1.19	1.58	1.97	2.36	2.75	3.14	3.53	3.92	5.86	7.81	57
58		0.12	0.15	0.22	0.41	0.79	1.17	1.56	1.94	2.32	2.70	3.08	3.47	3.85	5.76	7.67	58
59		0.12	0.15	0.21	0.40	0.78	1.15	1.53	1.91	2.28	2.66	3.03	3.41	3.78	5.66	7.54	59
60		0.12	0.15	0.21	0.40	0.77	1.14	1.50	1.87	2.24	2.61	2.98	3.35	3.72	5.57	7.42	60
61		0.12	0.15	0.21	0.39	0.75	1.12	1.48	1.84	2.21	2.57	2.93	3.30	3.66	5.48	7.30	61
62		0.11	0.15	0.21	0.38	0.74	1.10	1.46	1.81	2.17	2.53	2.89	3.25	3.60	5.39	7.18	62
63		0.11	0.14	0.20	0.38	0.73	1.08	1.43	1.79	2.14	2.49	2.84	3.19	3.55	5.31	7.07	63
64		0.11	0.14	0.20	0.37	0.72	1.07	1.41	1.76	2.11	2.45	2.80	3.14	3.49	5.22	6.96	64
65		0.11	0.14	0.20	0.37	0.71	1.05	1.39	1.73	2.07	2.41	2.76	3.10	3.44	5.14	6.85	65
66		0.11	0.14	0.19	0.36	0.70	1.03	1.37	1.71	2.04	2.38	2.71	3.05	3.39	5.07	6.75	66
67		0.11	0.14	0.19	0.36	0.69	1.02	1.35	1.68	2.01	2.34	2.67	3.01	3.34	4.99	6.65	67
68		0.11	0.14	0.19	0.35	0.68	1.00	1.33	1.66	1.98	2.31	2.64	2.96	3.29	4.92	6.55	68
69		0.11	0.13	0.19	0.35	0.67	0.99	1.31	1.63	1.95	2.28	2.60	2.92	3.24	4.85	6.45	69
70		0.11	0.13	0.19	0.34	0.66	0.98	1.29	1.61	1.93	2.24	2.56	2.88	3.19	4.78	6.36	70

4118-3-71-100 Teledyne Gurley, Troy, N.Y.

Table 12. Example of the current meter log sheets.

PYGMY METER 612 LOG SHEET

DATE	# STREAMS MEASURED	OILED, CLEANING	SPIN TEST/ INSPECTION	REPAIR

Table 13. Example data from an AquaCalc 5000.

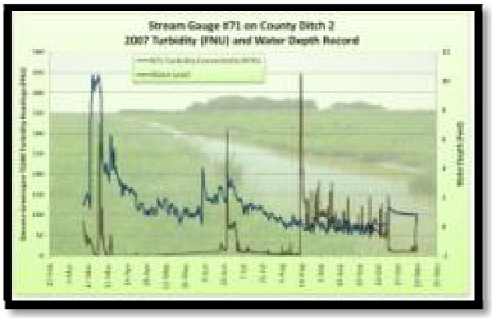
AquaCalc 5000 (tm) by JBS Instruments

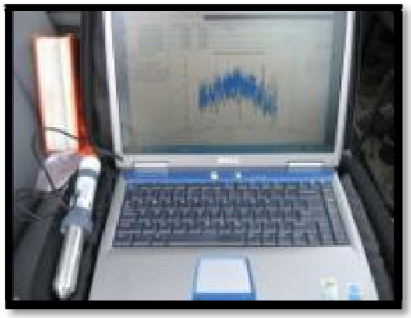
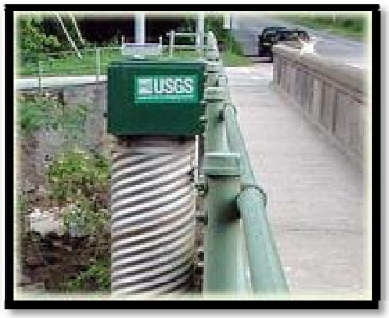
Firmware Version AQCUSH8c (Use with GURLY optical meters) (c)1995-2000

GAGE ID#	160 JD21	METER CONST. C3	2.17		
DATE	3/30/2010	METER CONST. C4	0.03		
TRANSECT	5	METER CONST. C5	2.2		
USER ID#	Corey Hanson	MEASUREMENT TIME	40		
SH BEGIN	0	MEAS. SYSTEM	SAE		
SH END	0	PERCENT SLOPE	0		
GH BEGIN	6.76	TOTAL VERTICALS	20		
GH END	6.76	TOTAL STATIONS	20		
EST. DISCHARGE	0	TOTAL WIDTH	16.9		
EST. Q (ADJ)	24.1	TOTAL AREA	18.1		
METER ID#	0	TOTAL DISCHARGE	24.1	CFS	
AQUACALC ID#	0	PCT DIFFERENCE	0		
SOUNDING WT.	0	MEAN VELOCITY	1.33		
START MEAS. AT	LEW	WETTED PERIMETER	17.47		
METER TYPE	Price AA 1:1 ST1	HYDRAULIC RADIUS	1.04		
METER CONST. C1	2.18	MANNING FACTOR	0		
METER CONST. C2	0.02				

OB	DIST	DEPTH	ICE	REVS	TIME	COS:VF	LOC	COEF	CLOCK	VEL	AREA	FLOW(Q)	FLAGS
1	0	0	0	0	0	1	6	1	15:49	0	0	0	
2	2.1	0	0	0	0	1	6	1	15:49	0	0	0	
3	3	0.4	0	0	0	1	6	1	0:00	0	0.38	0	34
4	4	1.2	0	7	45	1	6	1	15:50	0.359	1.2	0.431	3
5	5	1.3	0	22	40.8	1	6	1	15:51	1.195	1.3	1.554	1 3
6	6	1.35	0	27	40.4	1	6	1	15:53	1.477	1.35	1.994	1 3
7	7	1.3	0	29	41	1	6	1	15:54	1.562	1.3	2.031	1 3
8	8	1.2	0	34	40.1	1	6	1	15:55	1.868	1.2	2.242	1 3
9	9	1.2	0	35	40.3	1	6	1	15:56	1.913	1.2	2.296	1 3
10	10	1.3	0	33	40.8	1	6	1	15:58	1.783	1.3	2.318	1 3
11	11	1.3	0	32	40	1	6	1	15:59	1.764	1.3	2.293	1 3
12	12	1.3	0	30	40.6	1	6	1	16:00	1.631	1.3	2.12	1 3
13	13	1.25	0	27	40.2	1	6	1	16:01	1.484	1.25	1.855	1 3
14	14	1.25	0	28	40.4	1	6	1	16:02	1.531	1.25	1.914	1 3
15	15	1.25	0	25	41	1	6	1	16:03	1.349	1.25	1.686	1 3
16	16	1.15	0	13	41.7	1	6	1	16:05	0.7	1.15	0.805	3
17	17	0.9	0	10	43.2	1	6	1	16:06	0.524	0.9	0.472	3
18	18	0.5	0	5	43	1	6	1	16:07	0.273	0.5	0.137	3
19	19	0	0	0	0	1	6	1	0:00	0	0	0	
20	25	0	0	0	0	1	6	1	0:00	0	0	0	

1. USER EXCEEDED SINGLE SUBSECTION 05% EST. Q.
2. THE PRODUCT OF VELOCITY AND DEPTH EXCEEDED THE SELECTED SOUNDING WEIGHT.
3. INCORRECT METER USED FOR DEPTH OF STREAM.
4. INCORRECT METER USED FOR VELOCITY OF STREAM.
5. ABNORMAL VELOCITY PROFILE CALCULATED.
6. DEPTH ESTIMATED BY USER.
7. VELOCITY ESTIMATED BY USER.
8. TURBULENT VELOCITY MEASURED



11.3 MEASURING STREAM STAGE USING AN AUTOMATED STREAM STAGE RECORDER.

Summary

Continuous stream stage records are essential for estimating nutrient, sediment and/or hydraulic loading and can be important when assessing the effectiveness of best management practice (BMP) implementation. To calculate loads, a stage/discharge relationship needs to be developed. First of all, check with the USGS (http://waterdata.usgs.gov/nwis/rt) to see if there is a real time gauging station at your monitoring site. Next, check with local agencies to see if they have done any flow monitoring at the monitoring site. If insufficient data is being collected, you will have to find a way to collect this data yourself. To accomplish this, utilize an electronic steam stage recorder to record stage height at three-hour intervals or less throughout the monitoring period. The USGS uses a 15 minute time step. This time step is good for catching pulses in water level during storm events, but can generate a large dataset that may be difficult for some software/computer systems to handle. A 30-minute time step will still provide a good record of flow, but will generate a dataset of a more manageable size. Use a stage/discharge relationship to convert continuous stage data into a continuous flow record. To calibrate water quality models, reduce the stage data to average daily stage and flow.

Stage Recording Equipment

Stage recording apparatus may consist of the following:

1. A stilling well or a metal post and flange; and
2. A pressure transducer and electronic data logger. Note: There are many makes and models of automated stream recording equipment. Model-specific operation procedures may differ somewhat from what is described below.
    a. There are systems in which the transducer, data logger, and battery are separate components. While the data loggers for these systems are more flexible (can collect other types of data along with stage), the systems are more expensive and are more prone to damage by vandalism, animals, and flooding.
    b. Newer technology combines the water level sensor, data logger, and a 5-10 year battery all within a smaller bullet-shaped instrument. There are some of these that still require a vented cable to the surface, but there are others that do not require this. Those that can be installed without vent cables need a corresponding atmospheric barometric pressure record to correct the water level record.
    c. There are other more complicated systems that can be purchased
        - Telemetry (telephone line or cell phone) remote access data retrieval systems.
        - Bubbler systems

- Ultrasonic and radar stage sensors that can be mounted above the water surface
- Acoustic Doppler flow sensors

General Methods for Field Installation, Maintenance, and Calibration

1. Check the data logger a minimum of once every two weeks to ensure that it is functioning properly.
    a. Checking the time step is important to make sure you collect just the amount of data you need. If the time step is too small, the data logger could run out of memory and you will have a lot of data points for a small window of time.
2. Download data stored in the data logger at least once per month to prevent data loss.
3. Check and calibrate the transducer monthly to ensure accuracy. Perform calibration checks using the stream water and a graduated cylinder at a minimum depth of 0.1 inch and at a maximum depth approximating the total depth likely to be measured.
4. Bring fresh packets of desiccant with you for equipment that uses a vent tube.
5. Armor data and vent-tube cables with conduit.
6. Make sure that external data loggers and ends of vent tubes are above the flood-prone elevation.
7. Protect the water level sensor by suspending it within a stilling well.
    a. In addition to protection, the stilling wells create a still, flat water surface for more accurate stage readings.
    b. Stilling wells can be made easily using PVC pipe (or metal pipe for more permanent installations).
    c. They can be custom made for the site and equipment requirements.
8. Make sure the water level sensor can be returned to the same elevation after maintenance.
    a. Suspend the water level sensor by its attached, vented cable. Suspend HOBO/Diver style level loggers (no vent tubes) within a stilling well using thin steel cable. Steel cable is used because it won't stretch.
9. Collection of manual measurements of stage (water level elevation) is mandatory for correlating water level logger data to stage data. The flow rating curve or table for the site can be used to convert the stage record into a flow record.
    a. Collect manual measurements at each site visit:
        - Each deployment of water level logger
        - Each retrieval of water level logger
        - During the deployment period.
10. Keep your equipment manual(s) and this SOP on hand, especially in the field.
11. Take precautions to prevent vandalism
    a. Deter the lazy criminals by placing equipment in places that aren't easily reachable.
        - Autonomous equipment has the advantage of being installed without any connection to shore. Criminals generally won't go through the effort of wading into the water to get to your equipment.
        - Place solar panels in a location that is difficult to reach without conspicuous effort
    b. Use locks on any on-shore equipment such as data logger boxes.
12. Install the level logger in a pool and/or the deepest part of the stream to make sure the sensor doesn't go dry before flow ceases at the site. Don't stray too far away from your stage

measurement location. Make sure your equipment will be measuring the same water that is measured at your stage measurement point for the site. Stay upstream of inflows that are not accounted for at the manual stage measurement point.

11.3.1 Vented Transducer with On-shore Data Recorder.

Summary

In low flow areas, attach the transducer to a post that is driven into the ground. Place this transducer upstream near a structure such as a weir or culvert, which may be used to compute discharge. Listed below are some basic installation, data transfer and maintenance procedures. Thoroughly review the manual(s) that are specific to the make and model of your equipment. Bring continuous monitoring equipment

Equipment and Supplies

1. Data recorder box
2. Spare fuses
3. Cables
4. Terminal box(es)
5. Pressure transducer
6. Set of small screwdrivers
7. Supplies for securing/suspending the transducer within the water column.
    a. Stilling well materials
        - PVC pipe
        - PVC pipe caps
        - Hose clamps large enough to fit around pipe and post
    b. Hardware for mounting the probe at a stationary point in the water column (metal flange or L-bracket that can be attached to a fence post or other stationary object within the stream).
8. Lockable, weatherproof, solid box of metal, wood, or other sturdy material for securing data recorder and battery, with a hole for cable entry.
9. 12v battery
10. Post pounder
11. Steel post
12. Plastic tie straps

Installation Procedure

1. Drive a steel fencepost into the streambed near your manual stage measurement reference point. Install the transducer in a pool and/or the deepest part of the stream to make sure the sensor doesn't go dry before flow ceases at the site. Install the post in a relatively calm area of the stream. Make sure the post is driven solidly into the streambed and will not tip over. Try to find a spot where vegetation and turbulence will not affect the transducer.
2. Attach the mounting/suspending hardware to the fence post

a. Mounting directly to post
    - Bolt the flange to the post and place the transducer on the flange running the plastic straps through the holes in the flange and tighten around transducer.

b. Stilling well
    - Cut the pipe to the desired length.
    - Drill a pattern of holes in the PVC pipe
    - Attach well screen to the bottom of metal pipe
    - Secure the pipe to the steel fence post with hose clamps that wrap around the fence post and the pipe. Or, secure it to another stationary object in a similar fashion.
    - The stilling well pipe may also be angled toward shore to make retrieval easier. Keep in mind that this may also make vandalism easier.
    - The hose clamps will do a great job of holding the pipe in place within the water column. Bolting or screwing the pipe to a stationary object, in addition to the clamps, will provide added insurance that the pipe will remain at the same level within the water column.
    - Provide a point from which to hang the transducer. This method will vary dependent upon the equipment being used. If a hanger is attached to the instrument's cable, you can bolt a hook onto the inside of the pipe that will be used for hanging the transducer. The cable can strung through and attached to the cap as well. Just make sure your method of transducer suspension can be repeated each time the sensor is retrieved and deployed so that the sensor is always suspended at the same elevation.

3. Place the weatherproof security box in an area near the stream but out of the flood plain so it will not be affected by water. If the length of the transducer cable is not sufficient to get the box far enough out of the flood plain, place the box on an elevated surface (or post) where it will be safe from floodwater and, if possible, hidden in order to minimize the potential of vandalism.
4. String the transducer cable through the hole in the security box. Connect the transducer wires to the data logger. A terminal box may be needed to make this connection. The terminal box also may contain desiccant that will keep moisture from clogging the vent tube.
5. First making sure the switch on the data recorder is turned OFF, place the battery in the security box and attach the alligator clamps to the battery.
    - If the switch on the data recorder box is not turned OFF when the alligator clamps are attached, the fuse will blow.
    - Also, never take the alligator clamps off the battery while the data recorder switch is still turned on or the fuse will also blow.
6. Turn on the data recorder box and follow instructions contained in its manual. If the fuse blows, first turn OFF the switch and then replace the fuse before turning the switch back on.

Cleaning and Maintenance

The first section of the cleaning and maintenance procedures is for maintenance needing to be performed every two weeks and the second is for maintenance and cleaning to be performed once every four weeks. Be sure to record the proper information on the automatic stream gauge log.

Equipment and Supplies

Every Two Weeks:

1. Desiccant packs.
2. Plastic straps for transducer (if applicable).
3. Charged batteries, have a few on hand.
4. Volt/ohm meter, with alligator clamps on the end of the cables.
5. Proper sized screwdriver for terminal screws in the terminal box.
6. Keys for the padlock on the security box(es).

Every Four Weeks:

1. All the equipment listed above in the Every Two Weeks section.
2. A bottle of Simple Green all-purpose cleaner.
3. A plastic pail, large enough to wash the transducer.
4. Rag for scrubbing.
5. Pair of snips for cutting the plastic straps (if applicable).

Procedures

1. Two-Week Procedures.

    a. Begin filling out the Automatic Stream Gauge Log (date, site, initials).
    b. Take a manual measurement of stream stage and record the measurement and current time in the Automatic Stream Gauge Log.
    c. After opening the security box, check the color of all the desiccant packets that are being used. If a desiccant packet is pink, exchange it for a fresh one. Record findings and action on the Automatic Stream Gauge Log.
    d. Check the current water level reading displayed by the data logger and then record this number and the current time in the Automatic Stream Gauge Log.
    e. Make sure the current water level is realistic relative to the actual water level above the logger.
    f. Check the battery voltage with the volt/ohm meter or by using the data logger. If the battery is below 11.5 volts exchange the battery with a charged battery. Record the voltage and battery ID on the Automatic Stream Gauge Log.
    g. Check current setting to make sure the box is actively logging at the correct time step interval. Record the time step in the Automatic Stream Gauge Log.
    h. Download data from the data logger to a computer, data shuttle, data card, or other data storage method. Follow the specific instructions in the manual for your data logger and its software. Examine the data to see that the data box was logging properly. If it was not logging properly, re-check the data box and setup. Consult the troubleshooting sections of the data logger's manual.
2. Four-Week Procedures.

    a. Go through the steps for the two-week procedures.

b. Remove the transducer from the water. **Be careful; do not alter any of the mounting and/or suspension components.** This would change the elevation of the transducer when it is returned to the water, which would result in water level records that are inconsistent with other deployment periods.
c. Wash the transducer by rubbing it with a rag and spraying the Simple Green cleaner on the body of the transducer. Collect some water in the plastic pail and submerge the transducer, add more simple green to the water.
d. **Do not place a rag or any solid object in the transducer's sensor. This is factory calibrated and it may ruin the calibration of the transducer.**
e. Carefully scrub the cap of the transducer, making sure all the holes are free of debris.
f. Re-install the transducer in the water so that it is in the exact same place that it was before you removed it.
g. Collect manual measurement of stage, recording it and the time it was taken in the Automatic Stream Gauge Log.
h. Record the current water level reading on the data recorder and current time in the Automatic Stream Gauge Log. Check to make sure the water level reading is correct by comparing re-deployment water level readings (data recorder and manual measurements) to retrieval water level readings. If the stage of the stream hasn't changed, the data recorder reading at re-deployment should be the same as it was before retrieval.

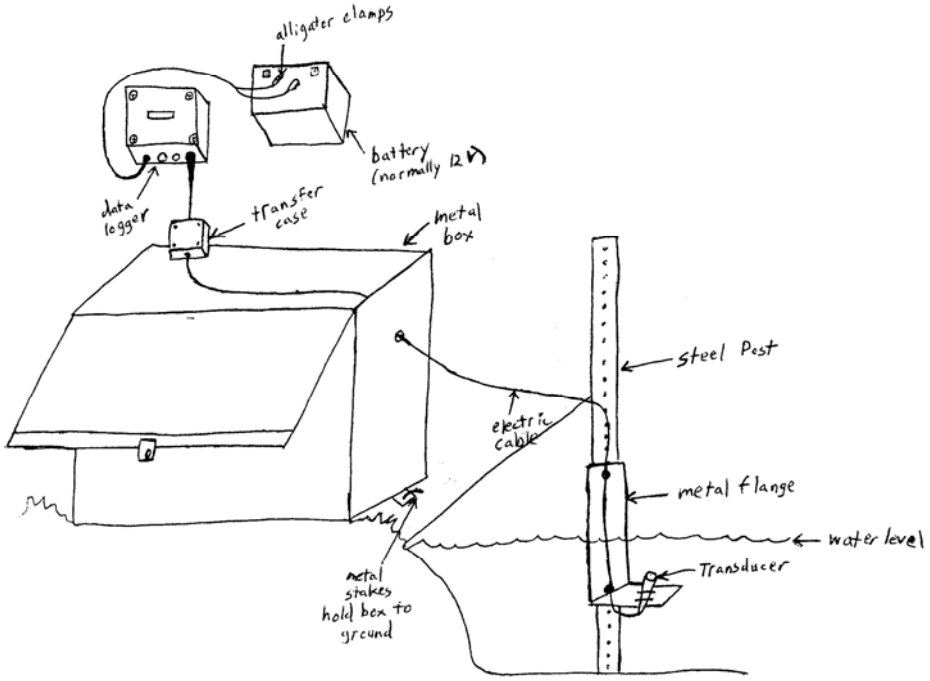


Figure 15. Diagram of a Stevens AXSYS automatic stage recording apparatus

11.3.2 Water level logger with internal battery and memory.

There are alternatives to the setup described in the previous section that are less expensive and more reliable. These water level logging devices have internal memory and internal batteries. The internal memory means that there is no need for an onshore data logger that will be subject to vandalism and flooding. The internal data logging also eliminates the need for any easily damaged cables. The internal battery power means you don't have to lug around 12 volt batteries or worry about your solar panel battery maintainer being stolen or vandalized.

There are several companies producing this type of equipment, including Onset (HOBO), Solinst, and In-Situ. These bullet shaped instruments usually feature a removable cap that protects infrared communication connections. Data is transferred to a computer via these connections and a shuttle device. Some still have vent tubes to the surface, but others have eliminated the need for vent tubes and desiccant. These only need a barometric pressure record from nearby that is used to improve the accuracy of the water level data. A level logger suspended in the air is a good way to collect this barometric pressure record.

While these water level loggers are fairly easy to use, diligence is still a necessity for the collection of a complete data record.

Before installing a water level logger, determine how the logger will be installed at the site. This style of logger works great for installations in stilling wells of varying configurations. The installation and stilling well construction strategy may differ with site characteristics. The wells may be made of PVC or metal. PVC is cheaper and easier to use. Metal is, of course, more durable and can be used in more permanent installations. Stilling wells may be designed to allow access from a bridge. They may be installed vertically (attached to a fence post) in the middle of a stream. They might also be installed at an angle along one of the banks of the river. The most important consideration is how you are going to install the level logger so that it can be returned to the same elevation in the water column after maintenance and data retrieval.

Equipment Needs

1. Water Level Logger
2. Accessories needed to connect the water level logger to a computer for data retrieval and programming. (data shuttle or USB base station)
3. Laptop computer
4. Stilling well installation materials and hardware.
5. Spray bottle with soapy water
6. Wire rope and wire rope clips (1/16")
7. Automatic Stream Gauge Log data sheet
8. Jug of clean water
9. Paper towels

Deployment

1. Install the software provided by the manufacturer
2. Decide the measurement interval needed by your monitoring program.
    - Do you want to capture storm events? You may miss peak flows if your measurements are too far apart.
    - Are you just looking for daily average flows for modeling loads? Measurements taken at a small time step will generate an unnecessarily large and unwieldy set of data.
    - The USGS uses a 15 minute measurement interval
    - The RLWD uses 15 minute measurement intervals when capturing peak flows and storm hydrographs is important.
    - The RLWD uses a 30 minute interval when a more general record of flow is needed (for calculating daily averages).
3. At the site, begin filling in the Automatic Stream Gauge Log with the date, site, and staff initials.
4. Use the software to program the level logger with the desired time step and name of the site.
5. Synchronize the clocks of all your level loggers (to the same computer) if possible.
6. Record the time step in the Automatic Stream Gauge Log.
7. Calculate the number of days of data points the logger will store. Don't allow the logger to stop logging because the memory is full. Schedule a day to reset the memory, if necessary, before the day the memory is filled).
8. Double-check the water level logger programming settings.
9. For loggers that require a barometric pressure record, install barometric pressure loggers first and download their data last. This will ensure that there will be a barometric pressure reading for every water level reading.
10. Continue to collect stage measurements, often, in the traditional manner for each site. Level loggers measure the depth of water above the sensor. This depth needs to be translated into stage. This is done by correlating physical measurements of stage and automated records of water level that are collected at the same time.
11. After deploying the water level logger, collect a manual measurement of stage and record it in the Automatic Stream Gauge Log

Maintenance

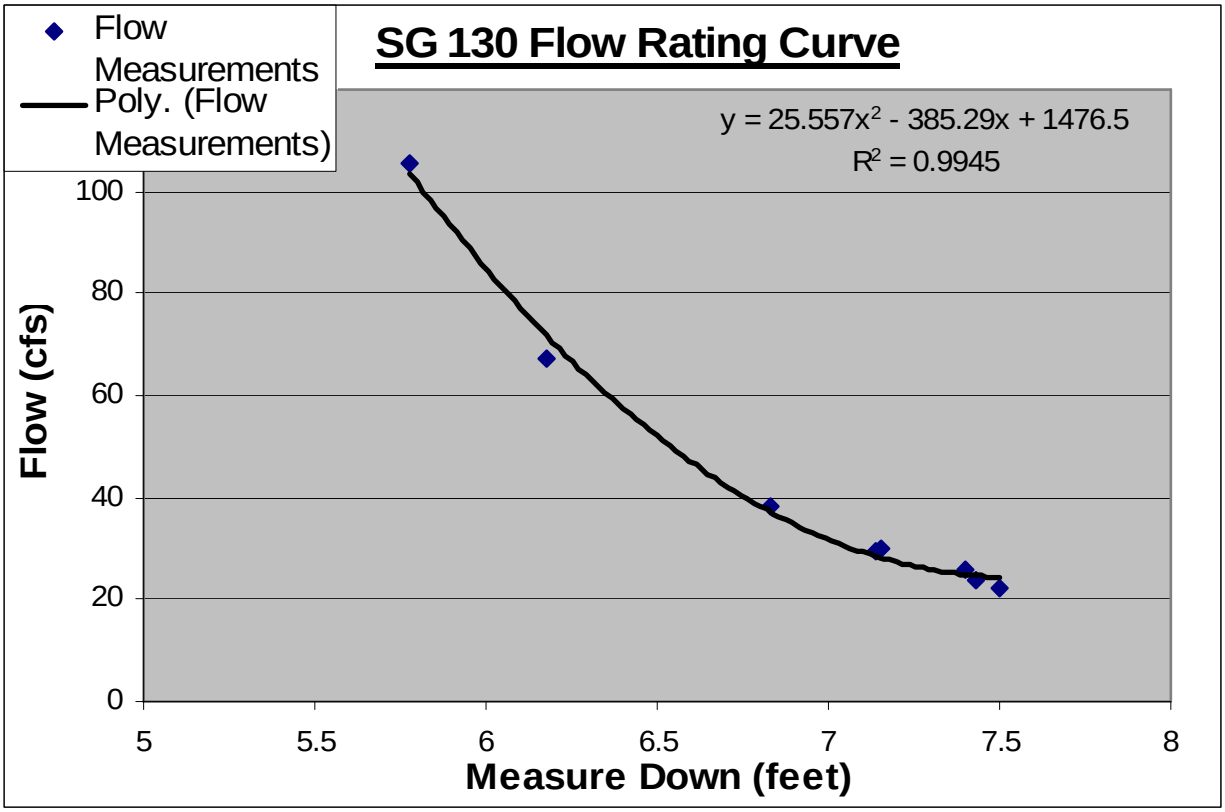
1. At the site, begin filling in the Automatic Stream Gauge Log with the date, site, and staff initials.
2. Check the time. Make sure the water level logger won't be out of the water when its next measurement is scheduled.
3. Manually measure stage using the standard method for the site. Record this measurement and the time it was taken in the Automatic Stream Gauge Log. Ideally, this measurement will be made at the same time the data logger is collecting a measurement to accurately convert the logger data to a usable stage and/or flow record.
4. When you are reasonably sure the logger won't be collecting another measurement for several minutes, remove the logger from the water.
5. Clean and dry the logger. Don't use solid objects to clean out the hole on the sensor end of the water level logger. Use a spray bottle of soapy water to clean this out. Rinse with clean water. If you are monitoring water quality as well, you will likely have a jug of distilled water in your vehicle that will work well for this.

6. Open the software program.
7. Connect the logger to the computer.
8. Follow software instructions for downloading data
    a. For Onset HOBO Water Level Loggers, you will have to choose whether or not to stop logging. In most cases, you can download the data without stopping the logging. You should stop the logger and re-launch it in the middle of the monitoring season (by August) if you are using a 15-minute time step.
9. Re-deploy the water level logger in the stream.
10. Examine the data. Make sure readings are realistic.
11. Find the last measurement that was collected and record it, its time, and the last battery voltage reading on the Automatic Stream Gauge Log. Make sure this reading seems realistic compared to the actual water depth above the sensor.
12. In your log book, find the last time the site was visited. In the dataset, find the first reading the level logger collected after re-deployment during the last site visit. Record this measurement and its time in the **Data Recorder Reading (re-deployment)** and **Time of Data Recorder Reading (re-deployment)** columns of the last site visit record in the Automatic Stream gauge Log.
13. Collect a manual stage reading and record it and its time in the Automatic Stream Gauge Log.
14. Finish filling out the Automatic Stream Gauge Log with comments, etc.

Table 14. Automatic Stream Gauge Log

Automatic Stream Gauge Log														
Date (mm/dd/yyyy)														
Initials														
Site ID														
Time Step (15 min., 30 min., etc.)														
Data Recorder Reading (Retrieval)														
Time of Data Recorder Reading (Retrieval)														
Manual Stage Reading														
Time of Manual Reading														
Current Battery Voltage														
Battery Change (Yes/No)														
Cleaned Transducer (Yes/No)														
Data Retrieved from Logger? (Yes/No)														
Desiccant Changed? (Yes/No)														
Data Recorder Reading (re-deployment)														
Time of Data Recorder Reading (re-deployment)														
Manual Stage Reading (re-deployment)														
Time of Manual Stage Reading (re-deployment)														
Comments														

11.4 CREATING RATING CURVES.



- When coupled with discharge measurements, stage measurements can be used to create rating curves. Rating curves are created using a range of paired stage and discharge measurements.

- Basically, to create a rating curve, plot the measurements by using graph paper, or by using spreadsheet software such as Microsoft Excel to create an X–Y plot of the stage and discharge data.

- In Microsoft Excel, create a trendline through the points by right-clicking on the data points on the chart and then clicking on "add trendline." When adding the trendline, click on the options tab and check the box to display the equation on the chart and check the box to display the R-squared value on the chart.

- Adjust the type of curve by changing the level of polynomial equation in order to get the R-squared value as close to 1.0 as possible. The closer the R-squared value is to 1, the more accurately the equation will estimate the amount of flow based upon a stage measurement.

- A greater amount of stream gauging records, greater accuracy of stream gauge measurements, and the removal of outliers will all improve the accuracy of a rating curve. The resulting equation can be incorporated into databases to calculate flow based upon stage measurement data.

12 CONTINUOUS WATER QUALIITY MONITORING

Studies, especially for impaired waters, are more often requiring continuous monitoring data to better understand water quality problems. Continuous monitoring can record important water quality information that is very difficult to collect with periodic spot check monitoring. Because of the diurnal fluctuation of dissolved oxygen levels, daily minimums (upon which the Minnesota State water quality standard is based) occur in the early morning, usually before monitoring personnel begin collecting their first measurements of the day. Summer storms often occur in the evening, when monitoring personnel are at home. Monitoring can be also be dangerous during thunderstorms. Peaks in turbidity and stage during these runoff events can be captured by continuous monitoring equipment when monitoring staff can't be there. The technology is becoming more affordable and feasible for most monitoring programs. Grant funds can be used to help pay for the instruments when they are needed. Internal data logging and batteries have helped to make installation of this equipment easier. Equipment can be connected to a laptop, or even a PDA, for data downloads and calibration.

There is, of course, more to the collection of continuous monitoring data than simply throwing the equipment in the river and collecting the data. There are a lot of methods specific to continuous that go beyond the considerations needed for regular water quality monitoring. Two very good manuals are available that provide methods for continuous monitoring:

- *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting, Techniques and Methods 1-D3* by the United States Geological Survey
- *Continuous Water-Quality Sampling Programs: Operating Procedures* by the British Columbia Ministry of Environment.

Both documents are useful. The USGS document provides more in-depth information about water quality equipment, but the data handling procedures are more specific to programs using the USGS's ADAPS software. The British Columbia procedures are written in a more practical style (Layman's terms), including photos of example equipment installations. Repetition of the information in those manuals will not be included in this revision of the SOP document. There are some main points expressed in these documents that, based on experience, need to be stressed in order to ensure the collection of quality data.

- Site selection is very important to collecting an accurate, representative set of data in a safe, feasible manner.
- Choose the equipment that meets your needs.
    - Avoid spending time and money on parameters that you don't need.

    - Determine your equipment needs before you set your budget to avoid having to settle for equipment that doesn't meet all of your needs
    - If you can afford it, purchase an optical dissolved oxygen sensor. They maintain their calibrations much longer than Clark cell (membrane) probes. They can provide more accurate readings throughout the deployment period, even through a certain amount of fouling and in low flow conditions.
- Don't completely rely upon the continuous monitoring equipment for your data record. You will also need to collect regular manual measurements of water quality and stage that can be used to process the continuous monitoring data.
- Equipment maintenance and data retrieval should be conducted at least once every two weeks.
- Data validation procedures should be conducted to determine whether the data collected is usable. The validation process also gives you the data you need to adjust the data, if needed, for analysis. Validation is needed because of calibration and fouling errors that develop during each deployment period. The forms on the following pages are based on those found in the British Columbia Ministry of Environment methods and will help you collect and grade the validation data you will need.
- Software can be purchased to streamline data compilation and correction. For example, the Red Lake Watershed District uses Aquarius software that is sold by Aquatic Informatics.

Table 15. Continuous monitoring equipment maintenance, calibration, and data validation log

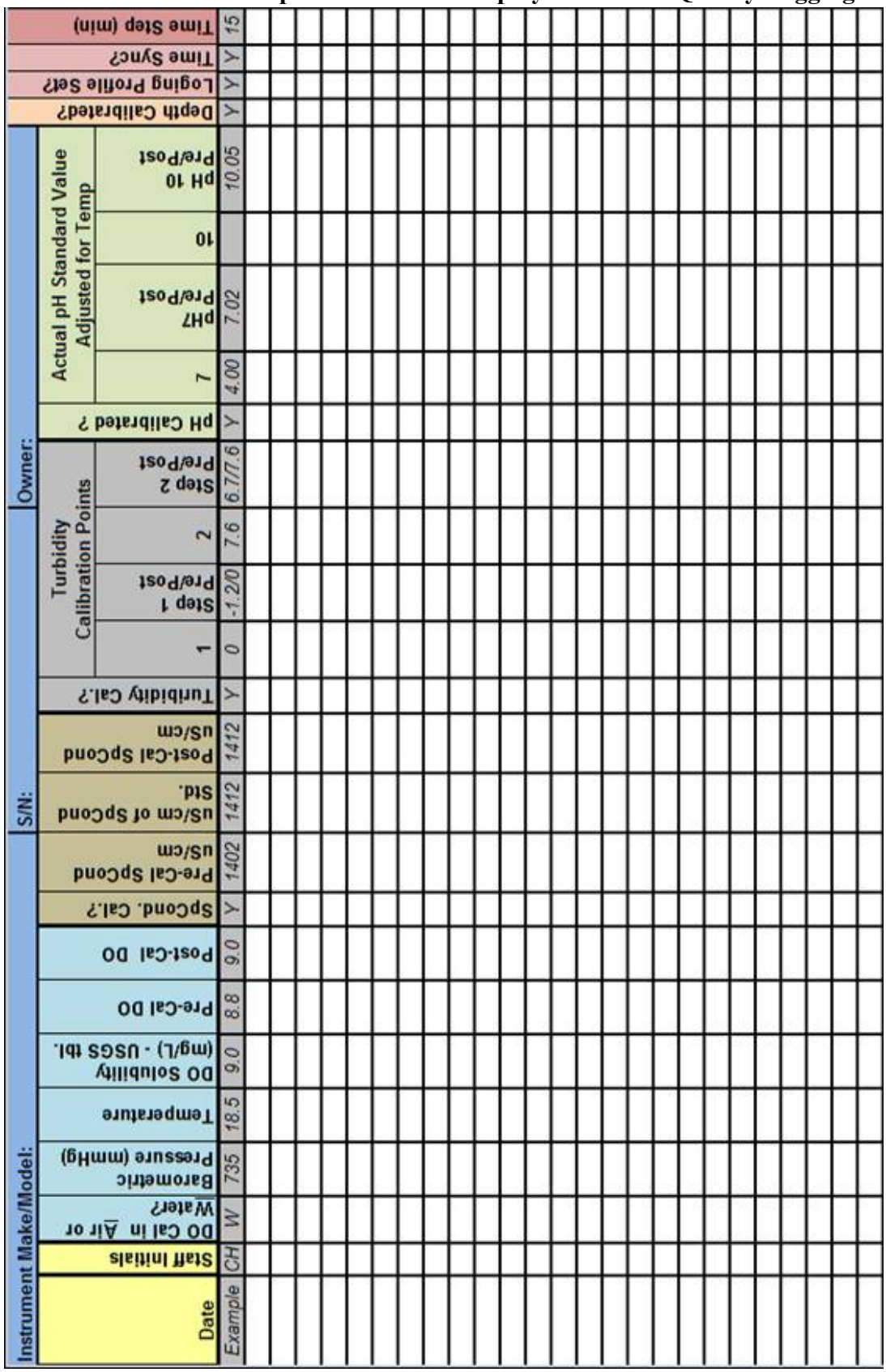
CONTINUOUS MONITORING MAINTENANCE, CALIBRATION AND DATA VALIDATION LOG								Pre Cleaning Data		Difference Between Deployed and Portable	Pre-Cleaning Data	Post Cleaning/Pre-Calibration Data		Difference Between Deployed and Portable	Post-Cleaning Data	Re-Deployment/Post Calibration Data		Difference Between Deployed and Portable	Post-Cal. Data Grade
								Deployed	Portable			Deployed	Portable			Deployed	Portable		
Deployed Sonde ID	Site Name	Portable Sonde ID	Beginning Time	End Time	Parameter	Date	Staff	Bucket of Stream Water				Bucket of Stream Water				Bucket of Stream Water			

Table 16. Data grades and sensor error (from British Columbia Ministry of Environment *Continuous Water-Quality Sampling Programs: Operating Procedures*).

Parameter	Data Grade Criteria				
	Excellent	**Very Good**	**Good**	**Fair**	**Poor**
Temperature	≤ ± 0.2 °C	> ± 0.2 to 0.4 °C	> ± 0.4 to 0.6 °C	> ± 0.6 to 0.8 °C	> ± 0.8 °C
Specific conductance (≤ 100 µS/cm)	≤ ± 3µS/cm	> ± 3 to 6 µS/cm	> ± 6 to 9 µS/cm	> ± 9 to 12 µS/cm	> ± 12 µS/cm
Specific conductance (> 100 µS/cm)	≤ ± 3% of reading	> ± 3 to 6% of reading	> ± 6 to 9 % of reading	> ± 9 to 12 % of reading	> ± 12 % of reading
pH	≤ ± 0.2 pH units	> ± 0.2 to 0.4 pH units	> ± 0.4 to 0.6 pH units	> ± 0.6 to 0.8 pH units	> ± 0.8 pH units
Turbidity (≤ 40 NTU)	≤ ± 2 NTU	> ± 2 to 4 NTU	> ± 4 to 6 NTU	> ± 6 to 8 NTU	> ± 8 NTU
Turbidity (> 40 NTU)	≤ ± 5 % of reading	> ± 5 to 10% of reading	> ± 10 to 15% of reading	> ± 15 to 20% of reading	> ± 20% of reading
Dissolved oxygen (≤ 4 mg/l)	≤ ± 0.2 mg/L	> ± 0.2 to 0.4 mg/L	> ± 0.4 to 0.6 mg/L	> ± 0.6 to 0.8 mg/L	> ± 0.8 mg/L
Dissolved oxygen (> 4 mg/l)*	≤ ± 5 % of reading	> ± 5 to 10% of reading	> ± 10 to 15% of reading	> ± 15 to 20% of reading	> ± 20% of reading

* The sensors may be less accurate for values > 20 mg/l.

Table 17. Calibration and Setup Worksheet for Deployable Water Quality Logging Sondes.



13 PHOTO DOCUMENTATION

Photographs provide a qualitative, visual record of conditions in a water body. Photographs can be used to document general conditions during monitoring, identify pollutant sources, assess resource conditions over time, and document temporal progress of restoration efforts. Digital photography allows us to inexpensively compile visual records of water resource conditions.

Some monitoring programs require upstream and downstream photographs during each sampling event. These photos should be taken from the same position (photo point), at the same bearing, and at the same vertical angle. Try to include some landscape features that are unlikely to change over several years (buildings, structures, rocky landscape features, and large trees).

What to record in your field notes or other form of documentation:

- Photo number/file name
- Date and time
- Direction of the photo
    - Upstream (US)
    - Downstream (DS)
    - Bearing
- Site ID
- Overlay an arrow showing flow direction

Photos should be organized and labeled soon after the sampling trip, while your memory is fresh. Photos of the bridge and the reference point are helpful to have in your files. Also, take pictures of anything else that might be affecting water quality:

- Erosion
- Plumes of sediment, muddy inflows
- Flooding
- Illicit discharge
- Stormwater discharge
- Livestock in or near the stream
- Beaver dams

14 HEALTH AND SAFETY.

Water quality monitoring is not without its safety risks. The following are some situations in which extra caution is needed to avoid injury or worse.

1) Monitor with a partner and/or always let someone else know where you are, when you intend to return, and what to do if you don't come back at the appointed time.
2) Develop a safety plan. Find out the location and telephone number of the nearest medical center and determine directions on how to get from that center to your site so that you can direct emergency personnel. Have other members of the sampling team complete a medical form that includes emergency contacts, insurance information, and pertinent health information such as allergies, diabetes, epilepsy, etc.
3) Put your wallet and keys in a safe place so they don't end up in the water.
4) Boating
    a) A Coast Guard approved personal flotation device for each person in the boat is necessary. If there is a person riding in the boat that is not a strong swimmer, the person should be wearing his or her flotation device at all times while riding in the boat. Everyone in the boat should wear flotation devices during times when the water temperature is cold. Even strong swimmers can drown in these conditions.
    b) Use caution when collecting the sample as to not tip the boat over or fall into the lake.
    c) Make sure the drain plug is in place before putting the boat into the water.
    d) Exercise caution when loading and unloading a boat from its trailer. Standing on the tongue of the trailer to push a boat off or pull a boat onto the trailer can be dangerous since the tongue is narrow and often slippery. Molded plastic trailer walk ramps with non-slip surfaces can increase the safety of unloading and loading a boat.
    e) Comply with all other boating safety rules and regulations for the area in which you are sampling.
5) Use caution when taking samples through ice. Make sure that the ice is thick enough to support your weight. Wear insulated rubber gloves to protect your hands from cold water.
6) Be very careful when walking in the stream itself.
    a) Rocky-bottom streams can be very slippery and can contain deep pools.
    b) Muddy bottom streams might also prove treacherous in areas where mud, silt or sand has accumulated in sink holes.
    c) If you must cross the stream, use a walking stick to steady yourself and to probe for deep water or muck, especially if you can't see the bottom in murky water.
    d) When wading in a river or stream to obtain a sample, do not enter water that is moving too swiftly.
    e) When walking in relatively swift current, walk (cautiously) so that your body is facing perpendicular to the direction of flow. If the stream flow rate (ft/sec) X stream depth (ft) is greater than 10 ft^2/second, do not attempt to wade.
    f) Wear waders and rubber gloves in streams that are cold and in streams that are suspected of having significant pollution problems.
7) Chemical Use (preservatives such as sulfuric acid)
    a) Latex gloves can be used as a safety precaution to avoid contact with skin when using sulfuric acid to preserve samples.

b) Avoid contact between chemical reagents and anyone's skin, eyes, nose and mouth. Sulfuric acid will also eat holes in clothing, even when diluted. Before pouring sulfuric acid into the sample bottle, make sure there is enough room in the bottle for the acid so that it does not spill over the lip of the bottle and onto the bottle's surface. Also, use caution while pouring the acid. If using vials from a lab, only touch the outside of the vial. After pouring, rinse your hands thoroughly with water. Safety goggles can add increased protection from chemical reagents as well. These precautions will decrease the chance of you or your clothes coming into contact with the acid.
c) Store chemicals and preservatives in a safe place, away from small children. Do not store chemicals where they will be subject to temperature extremes or long-term direct sunlight.
d) When using pre-measured preservative vials from a lab, dispose of the empty vials in a plastic bag (empty bags that used to contain vials work well) and return them to the laboratory.

Safety Data for Sulfuric Acid

Danger.... Liquid and mist cause severe burns to all body tissue. May be fatal if swallowed. Harmful if inhaled. DO NOT get in eyes, on skin or clothing. Do not breathe mist. Wash thoroughly after handling. Always keep container closed when not in immediate use. Always add the acid to water, never add water to acid.

Inhalation
If inhaled, move to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.

Ingestion
If swallowed, DO NOT induce vomiting. Give large quantities of water or milk if available. Call a physician immediately. Never give anything by mouth to an unconscious person.

Skin Exposure
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing. Call a physician if itchiness and/or burning sensations persist.

Eye Exposure
Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

8) Use caution when sampling from bridges and along roads to avoid being in the path of oncoming traffic. Make sure that your vehicle doesn't prevent the flow of traffic or create a hazard for other drivers.

   a) Park your vehicle behind or alongside where you will be working so you won't be caught between your vehicle and traffic.
   b) Use a flasher/beacon on the top of your vehicle to signal the presence of a worker to oncoming traffic.
   c) Place orange traffic cones on the oncoming-traffic side of where you will be working. Cones should be placed by you and behind the vehicle to catch the attention of oncoming motorists.
   d) Keep as much of your body on the road side of the bridge rail as possible. Don't lean to far over, straddle, or sit on the bridge rail.
   e) If feasible, sweep your sampling site. Sweep to the side or in the direction of the road; don't sweep sediment into the water you will be sampling. Loose sand and gravel at your bridge sampling site can not only provide a potential source of sample contamination, but also can make you lose your footing if you lean too far over the bridge rail.

9) Never cross private property without permission from the landowner.
10) Have a first aid kit available.
11) Listen to weather reports. Never sample during severe weather. Stay off lakes if severe weather is imminent or occurring.

12) Be wary of natural hazards such as poison ivy, poison oak, burning nettle, other vegetation that will cause rashes and irritation, hornets and yellow-jackets, unfriendly domestic animals, wildlife such as skunks, and others.
13) Try to keep the equipment safe.
    a) Lower, don't drop, sondes into the water.
    b) Use caution when sampling on dams
    c) Use caution in swift currents
    d) Instruments may be swinging when brought out of the water. Don't allow them to swing into the bridge. Use caution and patience.
14) Maintain your physical fitness. Collecting water quality data often requires working in hot weather, wearing waders, climbing up and down steep banks, walking on land and in water, etc. Being in good physical shape can help you avoid injury when doing field work.
15) Use proper footwear.
16) When working outdoors, wear sunglasses to protect your eyes from ultraviolet radiation. Sunglasses aren't just for bright sunny days. Harmful UV rays still damage your eyes on cloudy days and in the winter.
17) Wear sunscreen and a hat to protect you from sunburn.
18) Never drink the water in the stream. Even if the water appears clear and clean, it may still contain bacteria or other pollutants that can make you sick. Assume it is unsafe to drink, and bring your own water from home. After monitoring, wash your hands with antibacterial soap.
19) Do not monitor if the stream is posted as unsafe for body contact. If the water appears to be severely polluted, contact your program coordinator.

River conditions can be unsafe for equipment.

20) Do not walk on unstable stream banks. Disturbing these banks can accelerate erosion and might prove dangerous if a bank collapses. Disturb streamside vegetation as little as possible.
21) **<u>Be aware of your surroundings and traffic</u>. If at any time you feel uncomfortable about the condition of the stream or your surroundings stop monitoring and leave the site. Your safety is more important than the data. Trust your instincts – if it doesn't feel right, it probably isn't.**

15 SITE LOCATION

Making sure you are monitoring the correct sites is a basic essential of a successful monitoring program. Monitoring the correct sites can have different meanings. When first creating a monitoring plan, choosing the correct sites means choosing sites at which the data collected will be most useful. When an individual monitors existing monitoring sites for the first time, it is important that the individual can easily find the sites so that data is collected from the right place.

Choosing sites for a monitoring program can be influenced by the goals of the monitoring program, monitoring budget, ease of access, site location relative to the watershed/subwatershed being monitored, locations of flow (USGS) monitoring stations, location of known or suspected impaired reaches, and other strategic factors.

Site location should be documented with sufficient detail so that an individual can find the site without aid from someone that has monitored the site in the past. If it is possible for someone to be shown sites and trained by another staff member, this should be done. However, there are cases where there is a complete changeover in monitoring staff or monitoring sites are abandoned for a period of time where an individual cannot be shown the site and will have to rely on site descriptions. A site description sheet should be kept on file. This should include such information as site name/ID, name of waterbody being sampled, township, range, section, latitude, longitude, benchmark location, and a description of exact location where sample is taken (from benchmark on the upstream side of the bridge). GPS points should be created for each sampling site as well, if GPS equipment is available. This is especially important for lake sampling. Being able to locate the sampling site with a GPS unit is much easier and more accurate than trying to find the site by guesswork or by using a depth finder.

16 PERSONNEL QUALIFICATIONS.

Field personnel must satisfactorily demonstrate, to experienced personnel, proficiency in documenting field activities, sampling, sample preservation, etc. Knowledge of spreadsheet/database software is necessary for managing data. Field personnel should also be in good physical condition to avoid fatigue and injury and to be able to perform some heavy lifting. Staff should attend training courses whenever possible/applicable. Monitoring staff in the Red River Basin (Minnesota side) should attend the Annual Red River Basin Water Quality Monitoring Training workshops on an annual basis.

17 DATA COORDINATION STANDARD OPERATING PROCEDURES.

Data coordination is essential for any successful water quality program. Data coordination begins with each project manager. Each project manager should be responsible for maintaining water quality files on spreadsheets or a database that may be easily transferred from one agency or person to another. All water quality analyses are to be performed by laboratories certified by the Minnesota Department of Health.

Profiles of each site are to be kept and maintained by both cooperating agencies/persons. The data recorded for each site should include:

1) Site name
2) Site description (location)
3) GPS Coordinates
4) Map of the site
5) Township, range, section
6) List of others that monitor the same site
7) STORET ID
8) Parameters measured at the site
9) Stage measurement technique
10) Location of water quality sampling reference point

A map of all watershed sites will also be included in this book along with the GPS location. Each agency or organizational entity within the watershed also needs to keep that portion of this book that contains their specific monitoring sites. Any new sites that are added are to be maintained in this fashion.

Develop a naming/numbering system for your sites. For example, the RLWD assigns a sequential "stream gauge" number to most new sampling sites. Other methods include using the combination of an abbreviation (river, county, and organization) and a number. The RRBMN, another example, uses the initials of the watershed along with a number (RL1, SH1). Other sites simply use the name of the bridge on which they are located (Broadway Bridge, Murray Bridge, and Sorlie Bridge). For lakes, the number will correspond to the MPCA identification number. The water quality monitoring project manager also has the responsibility of sending this information to the Minnesota Pollution Control Agency (MPCA) who assigns a STORET number to each site. The STORET number is included with each site profile.

The entry of data into a communal database is essential for the sharing and utilization of data. The EPA STORET database is currently used by the MPCA for statewide water quality assessments. In order for data to make it into this database, it must be collected by a monitoring program that uses a Minnesota Department of Health certified laboratory and a set of standard operating procedures (this document). The data must also pass a data review before being finalized. Here are some tips for a successful submission of data to the STORET database.

- For most Minnesota monitoring programs, data and establishment forms are submitted to the Minnesota Pollution Control Agency (MPCA).

- Make sure all lab, project, and site establishment forms have been completed and submitted before the beginning of the sampling season.
- Update the project establishment form(s) for your project(s) with any changes in staff, sites, etc.
- Submit new data for STORET entry by December 1st of each year.
- Include the STORET Project Code (CWPREDLK, THIEFSED, etc) and STORET Site ID (e.g. S002-123) with each data record that is submitted.
- Use the most recent MPCA STORET data entry template, available at http://www.pca.state.mn.us/water/storet.html.
- Make sure you consistently use correct site names. If you establish a site with the name RR-1 (in the Field Code line of the Station Establishment Form), make sure you use that same label on data sheets and in data entry.
- Check your dataset for outliers. Make sure that, for example, a pH of 78 wasn't entered where it should be 7.8. If a number is correct that might look odd at first glance, mark it as such. This will eliminate the need of a confirmation phone call or email from MPCA STORET entry staff.
- Review your data by checking 10% of your records against lab results and field data sheets.

There also are localized water quality databases that are accessible through the internet.

- The RLWD website (www.redlakewatershed.org) provides online access to the data that has been collected by the RLWD water quality monitoring program
- The Red River Basin Monitoring Network and the University of Minnesota have created an online data storage and analysis tool (http://riverwatch.umn.edu/) for data collected throughout the Red River Basin. Its primary use is for the simplification of submittal, storage, review, and analysis of River Watch data. It is not limited to River Watch groups and other monitoring groups can submit data to this database and utilize the data analysis tools.
- RMB Environmental Laboratories' Lakes Monitoring Database (http://www.rmbel.info/Reports/Reports.aspx) can be used to view lake water quality data, analyze lake water quality data, and create maps of lakes.

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Appendix A

Summarized Water Quality Multi-parameter (Sonde) Methods

Calibration of YSI QS 600 Series Sonde w/ 650 MDS Handheld

Getting Ready To Calibrate – Calibration Tips:

1. If you use the calibration cup for dissolved oxygen (DO) calibration, make certain to loosen the seal to allow pressure equilibration before calibration. The DO calibration is a water-saturated air calibration.

2. The key to successful calibration is to insure that the sensors are completely submersed when calibration values are entered. Set calibration standards out ahead of time in room where calibration is to occur for temperature stability.

3. For maximum accuracy, use previously used calibration solution to pre-rinse the sonde. You may wish to save used or expired calibration standards for this purpose.

4. Fill a bucket or sink with ambient temperature tap water to rinse the sonde between calibration solutions.

5. Have several clean, absorbent paper towels or cotton cloths available to dry the sonde between rinses and calibration solutions. Shake excess rinse water off the sonde, especially when the probe guard is installed. Dry off the outside of the sonde and probe guard. Drying the sonde reduces carry-over contamination of calibrator solutions and increases calibration accuracy.

6. Remove the stainless steel weight from the sonde bottom by turning the weight counterclockwise. When the weight is removed, the calibration solutions have access to the sensors without displacing a lot of fluid. This also reduces the amount of liquid that is carried between calibrations.

7. Make certain that port plugs are installed in all ports where probes are not installed. It is extremely important to keep these electrical connectors dry.

YSI handheld and sonde equipment set-up prior to calibration and sampling

Once this set-up is initially done, it will not be necessary to go through these set-up procedures each time calibration is done:

1. Press the **Power** (Green "⏻") button to turn the YSI 650 MDS handheld on.
2. From the "650 Main Menu" select **Sonde menu**.
3. From the "Main" menu screen scroll down and select **Advanced**.
4. From the "Advanced Menu" scroll down and select **Setup**.
5. From the "Advanced Setup" menu ensure that **Auto sleep RS232** and **Auto sleep SD112** are not enabled. It is also suggested that **Power up to Run** be selected in this screen.
6. Press **Escape** twice to return to "Main" menu and select **Report**.
7. From the "Report setup" menu scroll through and minimally enable by selecting the following: Temp C; SpCond uS/cm; DOsat %; DO mg/l; DO Charge; pH; and pH mV. Enable other options as per your instrument capabilities and your monitoring program reporting needs.
8. While selecting **SpCond** in the "Report setup" menu, select "SpCond uS/cm" as the unit to display.

9. Press **Escape** and turn power off or begin calibration process. The sonde is now set up for calibration and sampling.

CALIBRATION TIPS - DISSOLVED OXYGEN

DISCRETE MONITORING (Spot Sampling) PREPARATION

Preparing to calibrate Dissolved Oxygen:

Inspect the DO probe anodes; recondition using the 6035 reconditioning kit if they are darkened or gray in color. (see instructions on pg. 90 of YSI Environmental Operations Manual). If you have resurfaced your DO sensor, it is recommended to run the probe continuously for 15-30 minutes or until good stability is realized. After a membrane change only, run the probe continuously for 3-4 minutes or until good stability is realized.

It is recommended to change DO membranes every 30 days. Also inspect O-ring and replace if not providing a tight seal. (See DO membrane installation procedure) After installing a new membrane, make sure that it is tightly stretched and wrinkle free. Note: DO membranes will be slightly unstable during the first 3 to 6 hours after they are installed; it is suggested that the final calibration of the DO sensor take place after this time period.

BAROMETRIC PRESSURE (BP) NOTE: If your YSI handheld does not have BP built into it you will need to obtain a local BP reading from a local source. If you get BP from a weather service it is often in inches Hg and also corrected to sea level. First you need to convert it to mm Hg by multiplying the inches Hg by 25.4. Then to "uncorrect" for sea level use the following formula:

True BP in mm Hg = [Corrected BP in mm Hg] – [2.5 * (Local Altitude/100)]

Dissolved Oxygen Calibration:

1. **Note:** Calibration should occur on-site in the atmospheric conditions which sampling will occur. Carefully remove the sensor guard, remove the weight, and inspect the membrane to ensure that no water droplets are on the membrane—as needed, wash off with wash bottle or gently dab with Kimwipe or other lens tissue to absorb the water droplets. Also dry the silver thermistor (temperature sensor) for accurate temperature measurements. Remove the sponge from the storage/calibration bottle. Carefully replace the sensor guard (without the weight) and place the sonde in the calibration bottle with approximately 1/8 inch of water or you may use the wet towel method if you prefer. Do not allow water to touch the membrane and make sure no water droplets are on the membrane. If using the calibration bottle, unscrew the cap slightly to relieve pressure, allowing equilibrium to be reached with atmospheric pressure. The sonde must now sit in this saturated environment for at least 10 minutes before the DO calibration can begin—both the DO reading and the temperature need to stabilize before starting the calibration sequence. It is suggested to put the sonde in the "Run" mode (see step 2 below) during this time to allow monitoring stabilization of the DO % saturation and temperature. While monitoring stabilization of these readings, the DO sensor output countdown check in step 2 below can be performed and results recorded.

2. From the "Main" menu, select **Sonde run** (you may need to then select **Discrete Sample**, then **Start Sampling** if the meter doesn't initially start in run mode. The sonde should be in the discrete run mode at a 4 second rate). Immediately watch the DO% display. Observe and/or write down the first 10 DO % numbers. The numbers must start at a high number and drop with each four second sample, example: 110, 105, 102, 101.5, 101.1, 101.0, 100.8, 100.4, 100.3, and 100.1. It does not matter if the numbers do not reach 100% or they are below 100%, or that they do not drop each time—it is only important that they have a high to low trend. (**Note**: Initial power-up can make the first two DO % samples read low, disregard low numbers in this position.) Should the output display a negative value or start at a low number and climb up to the calibration point, check Reject on the calibration worksheet and examine the probe anodes, membrane, or other possible errors—do not deploy the probe. If the display declines as it should, check Accept on the calibration worksheet. After this check, while still in the Run mode, allow the sonde to continue to warm up/run for a total of 10 minutes or longer while the DO% and temperature readings stabilize, then proceed with calibration.

3. When DO % saturation and temperature readings are stable, press **Escape** to get back to the "650 Main Menu." Scroll to and select **Sonde menu**.

4. From the "Main" menu scroll to and select **Calibrate**.

5. From the "Calibrate" menu scroll to and select **Dissolved Oxy**.

6. The next "DO calibration" menu will offer you the option of calibrating in percent saturation or mg/l—calibrating either of the choices will automatically calibrate the other. Select **DO %** saturation.

7. The next "DO Calibration" menu will require barometric pressure to be entered. If your handheld does not have barometric pressure built into it, be sure to enter your local barometric pressure in mm Hg as explained above. If your handheld does have barometric pressure built in, it will be displayed. Record the barometric pressure on your calibration worksheet. Press **Enter**, and then monitor the stabilization of the DO % readings. After no changes occur for approximately 30 seconds, record the Pre-Calibration DO% on the calibration worksheet.

8. Press **Enter** to confirm the calibration. Then record the Post-Calibration DO% value and the DO Charge on the calibration worksheet. Press **Enter** again to return to the "DO calibration" menu. Press **Escape** twice to return to the "Main" menu.

9. From the "Main" menu scroll down to the bottom and select **Advanced**.

10. From the "Advanced" menu select "**Cal constants**" and record the DO Gain on the calibration worksheet. The gain should be 1.0 with a Range of -0.3 to +0.5. The probe should now be successfully calibrated and ready for discrete sampling. Press **Escape** twice to get back to the "Main" menu or turn the power off until ready to use. As with the other parameters any warning messages displayed by the sonde during the calibration are a cause for concern and must be investigated before deploying the sonde.

11. **End of Day Calibration Check:** It is recommended that at the end of your sample run to perform a DO calibration check. Carefully remove the sensor guard and inspect the DO membrane to ensure that no water droplets are on the membrane—as needed, wash off with wash bottle or gently dab with lens tissue to absorb the water droplets. Also dry the silver thermistor (temperature sensor). Carefully replace the sensor guard and place the sonde in the calibration bottle with the wet sponge or wrap in the wet towel if using this method. If using the calibration bottle, unscrew the cap slightly to allow equilibrium to be reached with atmospheric pressure. Put in **Run** mode and when readings stabilize, record the DO% on your calibration worksheet as "End of Day D.O. calibration check."

Dissolved Oxygen Discrete Sampling Tips:

1. Always prepare the equipment the day before the expected field study. Membrane changes should be done the day prior to the study to minimize any drift.

2. For YSI Model 6820 or similar sondes that have a separate sensor guard, the transfer of the sonde from the storage/calibration cup to the sensor guard puts the sonde and sensors at risk during the process. Usually, this is when most accidents occur, so it is best to avoid removing the protective sensor guard when in the field. A recommended procedure is to carry the sonde in a 5 gallon pail with the sonde wrapped in a wet white towel that covers the entire unit. The towel being wrapped around the sonde will protect it during transport from shock and vibration and will keep the sonde in the perfect saturated environment for pre and post calibration checks as needed.

3. When arriving on site, turn on the sonde and allow it to warm up for approximately 4 to 5 minutes. Next, check the DO output. It should measure saturation in your local environment or barometric pressure setting, plus or minus the instrument's tolerance of 2 percent. If you should find that the DO has drifted, then simply recalibrate on the spot and record the amount of drift that was witnessed.

4. The sonde will then be deployed and the measurements automatically taken. Remember to allow the sonde a few minutes to equilibrate to the water temperature before taking the reading. Once the data has been collected, wrap the sonde again in the wet towel and perform a dissolved oxygen post calibration. Again, the sonde should return to saturation, plus or minus the tolerance of 2 percent, within a few minutes.

If you are logging the information, it is recommended that you store this pre- and post-calibration data in the actual site data file. Otherwise, if you are manually recording the data, record the information in your log sheet. This assures anyone who might look at the records at a later time that the sonde was indeed calibrated and working correctly. The additions of these steps add very little time to the collection process and can actually save time when unexpected results are witnessed.

CALIBRATION TIPS - CONDUCTIVITY

Calibrate conductivity first to avoid contamination of the standard.

For maximum accuracy, the conductivity standard you choose should be within the same conductivity range as the water you are preparing to sample. However, it is not recommended to calibrate with conductivity standards that are less than 1.0 millisiemens/cm (mS/cm) [which is equal to 1,000 microsiemens (µS/cm)]. These low standards are easily contaminated and can be interfered with by outside noise sources (RF, etc.)

TIP: During calibration for conductivity and pH, you may remove the stainless steel weight from the bottom of the sonde by unscrewing the weight counterclockwise. When the weight is removed, the calibration solutions have access to the sensors while displacing less fluid. This also reduces the amount of liquid that is potentially carried between calibrations.

1. Remove the sponge from the calibration bottle and pour 1-2 inches of conductivity calibration solution into the bottle. If you have used conductivity solution saved from your last calibration, you can use it for this rinsing process.
   Put the sonde in the bottle, screw the cap on firmly and shake the solution around to rinse the sonde and bottle. Unscrew the bottle and pour out the solution. Repeat this rinse process once more and then do a third rinse with fresh conductivity calibration solution.

2. Fill the calibration bottle about ¾ full with fresh conductivity calibration solution. Insert the sonde back in the bottle. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell. The conductivity port in the side of the sonde must be completely submerged in calibration solution and not have any trapped bubbles in the opening.

3. Allow at least one minute for temperature equilibrium before proceeding.

4. With the YSI 650 MDS Handheld on, scroll to "**Sonde menu"** and press the **Enter** key.

5. The handheld will make a sound that indicates you are actively connected to the sonde and its menus. From the displayed screen, scroll to "**Calibrate"** and press the **Enter** key.

6. Scroll to "**Conductivity"** and press **Enter** to access the Conductivity calibration procedure.

7. From the next "Cond Calibration" screen scroll to **SpCond** and press **Enter** to access the specific conductance calibration procedure. Then enter the calibration value of the standard you are using. **Note:** The sonde requires the input in milliSiemens (mS/cm). 1,000 microsiemens (µS/cm) = 1 millisiemen thus when using a 1,000 microSiemen/cm standard, enter **1.000.** Record the conductivity of the standard being used on the calibration work sheet. Press **Enter**. The current value of all enabled sensors will appear on the screen and will change with time as they stabilize.

8. If the sonde should report **"Out Of Range"**, investigate the cause. Never override a calibration error message without fully understanding the cause. Typical causes for error messages are incorrect

entries, for example, entering 1000 microSiemens instead of 1.0 milliSiemens. Low fluid level and/or air bubbles in the sonde conductivity port are other error causes.

9. Observe the readings under Specific Conductance or Conductivity and when they show no significant change for approximately 30 seconds; record the temperature and conductivity value being displayed as the "pre-calibration conductivity" on the calibration work sheet, then press **Enter**. The top of the screen will show "Calibrated" which indicates that the calibration has been accepted. Record the conductivity value being displayed as the "post-calibration conductivity" on the calibration worksheet, then press **Enter** again to continue and return to the Calibrate menu.

10. When the calibration has been accepted check the conductivity cell constant which can be found by pressing **Escape** three times to return to the sonde's "Main Menu." Scroll to **Advanced** at the bottom and press **Enter**. Press **"Cal Constants"** and record the conductivity cell constant value on the calibration work sheet. The acceptable range is 5.0 +/- 0.5. Numbers outside of this range usually indicate a problem in the calibration process or a contaminated standard was used. If cell constant is out of range or is significantly different than its historic range, clean and recalibrate.

At this point rinse the sonde with tap water and turn the **Power** off or press **Escape** two times to return to the "Main" menu and select "**Calibrate**" to proceed with calibration for other variables as needed or replace sponge and silver weight and screw on calibration bottle for transport or storage.

Note: Recommend using small brush from YSI maintenance kit to clean sensors in conductivity ports at the end of each sampling day, especially in high turbidity waters.

CALIBRATION TIPS - pH

If initial set-up has not been done, go to the sondes report menu and turn on the pH mv output. This will allow the sonde to display the millivolts or the probes raw output, as well as the pH units during the calibration process.

Note: In most cases, a two point calibration using pH buffers 7 and 10 will be used to cover conditions generally found in the Red River Basin.

If not already done, remove the sponge from the calibration bottle and the silver weight from the bottom of the sonde. Pour 1-2 inches of pH 7 buffer solution into the bottle. If you have used pH 7 buffer solution saved from your last calibration, you can use it for this rinsing process.
Put the sonde in the bottle, screw the cap on firmly and shake the solution around to rinse the sonde and bottle. Unscrew the bottle and pour out the solution. Repeat this rinse process once more and then do a third rinse with fresh pH 7 buffer solution.

Fill the calibration bottle about ½ full with fresh pH 7 buffer solution. Place the sonde in the bottle and screw the cap back on. Gently rotate and/or move the sonde up and down to remove any bubbles from the sensors. Ensure that the pH reference and glass sensor as well as the temperature sensor are completely submerged in solution.

With the YSI 650 MDS Handheld on, scroll to "**Sonde menu"** and press the **Enter** key.

From the displayed "Main" menu screen, scroll to "**Calibrate"** and press **Enter**.

Scroll to "**ISE1 pH"** and press **Enter** to access the pH calibration menu.

From the "pH calibration" screen scroll to **2 point** and press **Enter** to access the screen to enter your first pH buffer value. Enter **7.00** (or the proper pH value adjusted to the temperature of the calibration standard if other than 25°C) and press **Enter**. Record the temperature and pH value of the pH Buffer 7 that you entered on the calibration worksheet in the "Cal. Standard" section.

Watch for the pH value and temperature to stabilize. When stable, record the pH and mV meter readings as the pH Buffer 7 "Pre-Calibration" values on the calibration worksheet.

Press **Enter** and record the pH and mV meter readings as the pH Buffer 7 "Post-Calibration" values on the calibration worksheet. Press **Enter** again and screen will prompt you to "Enter 2nd pH." At this time, remove sonde from calibration bottle and pour out the pH 7 buffer. [Note: Consider pouring into a container marked "used pH 7 buffer" which can be used as the pre-rinse for the next time pH calibration is done.]

Enter **10.00** for the 2nd pH value (or the proper pH value adjusted to the temperature of the calibration standard if other than 25°C) and press **Enter**. Pre-rinse the calibration bottle and sonde with used and fresh pH 10 buffer as you did for the pH 7 buffer. Watch the pH display to see if it responds and rises quickly to near the pH 10 level which is an indicator that the pH sensors are in good condition.

Discard and then pour enough of the pH 10 buffer into the pre-rinsed calibration cup to cover the pH sensors.

Fill the calibration bottle about ½ full with fresh pH 10 buffer solution. Place the sonde in the bottle and screw the cap back on. Gently rotate and/or move the sonde up and down to remove any bubbles from the sensors. Insure that the pH reference and glass sensor as well as the temperature sensor are completely submerged in solution.

Record the temperature and pH value of the pH Buffer 10 that you entered on the calibration worksheet in the "Cal. Standard" section.

Watch for the pH value and temperature to stabilize. When stable, record the pH and mV meter readings as the pH Buffer 10 "Pre-Calibration" values on the calibration worksheet.

Press **Enter** and record the pH and mV meter readings as the pH Buffer 10 "Post-Calibration" values on the calibration worksheet.

Remove sonde from calibration bottle and pour out pH 10 buffer. [Note: Consider pouring into a container marked "used pH 10 buffer" which can be used as the pre-rinse for the next time pH calibration is done.] Rinse calibration bottle and sonde with tap water and store sonde in bottle with wet sponge or place sonde in wet towel for short-term storage and transport. Assess slope as per discussion below.

After recording the pH millivolts for the calibration points, you must determine the slope of the sensor. This is done by determining the difference between the two calibration points that were used, for example, if buffer 7 was +3 mV and buffer 10 was –177mV, the slope would be 180.

The millivolts help tell us the present status of the probe; a good set of numbers to use are as follows:

Buffer 4 = + 180 +/- 50 mv
Buffer 7 = 0 +/- 50 mv
Buffer 10 = - 180 +/- 50 mv

The ideal numbers when a probe is new are between 0 and 180, but as the probe begins to age, the numbers will move and shift to the higher side of the tolerance. The acceptable range for the slope is 165 to 180. Once the slope drops below a span of 165, the sensor should be taken out of service. Recondition the probe if a slow response in the field has been reported. The procedure can be found in the YSI sonde manual under the "**Sonde Care and Maintenance Section**".

Never override any calibration errors or warnings without fully understanding the reason for the message. Proper storage of the sensor when not in service will greatly extend the life of the probe.

Calibration Worksheet

Date of Calibration: _____ Handpad SN: _____ Sonde SN: _____ Technician: _____

Conductivity Calibration Record: Date: _____ Sonde SN: _____ Technician: _____

Conductivity Std.	Conductivity Standard °C	Pre-Calibration Conductivity (µS/cm)	Post-Calibration Conductivity (µS/cm)	Conductivity Cell Constant (Range 5.0 +/- .5)
1.000 µS/cm	_____	_____	_____	_____

NOTES: (when calibrating for "specific conductance," no temperature adjustments for the conductivity standard are needed)

pH Calibration Record: Date: _____ Sonde SN: _____ Technician: _____

	Cal. Standard °C	Adj. pH	Pre-Calibration pH	mV	Post-Calibration pH	mV	
pH Buffer 7	___	_____	_____	_____	_____	_____	Range 0 MV ± 50 MV
pH Buffer 10	___	_____	_____	_____	_____	_____	Range -180 ± 50 MV
Milli-volt span between pH 7 and 10 should be ≈ 165 to 180 MV						_____	

The ideal numbers when a probe is new are between 0 and 180, but as the probe begins to age, the numbers will move and shift to the higher side of the tolerance. The acceptable range for the slope is a span of 165 to 180. Once the slope drops below a span of 165, the sensor should be taken out of service if maintenance cannot bring it back into range.

NOTES:

Dissolved Oxygen Calib. Record: Date: _____ Sonde SN: _____ Technician: _____

DO membrane changed? Y N Note: After membrane change, should wait 6 to 8 hours before final DO calibration, run sensor for 15 minutes in Discrete Run to accelerate burn-in.

Corrected* Barometric Pressure (Inches/Hg)	x 25.4 =	Corrected Bar. Pres. mm/Hg	- [2.5*(Altitude/100)]	[Sea level correction] Local	True =Bar.Pres.	Pre-Calib. D.O. %	Post-Calib D.O.%	DO Charge (Range: 50 ± 25)	DO Gain (Range: 1.0 - 3 to + 5)
_____	x 25.4 = _____		- _____		= _____	_____	_____	_____	_____

DISSOLVED OXYGEN SENSOR OUTPUT TEST (after DO calibration probe in saturated air)

After calibration, did the DO % output display the proper declining high to low trend? If so, check _____ ACCEPT

ACCEPT. Should the output display a negative number or start at a low number and climb up to the calibration point, check REJECT and do not deploy the probe. _____ REJECT

NOTES: (End of Day D.O. calibration check: _____)

*Generally weather service barometric pressure readings are corrected to sea level, and cannot be used until they are "uncorrected."

CALIBRATION WORK SHEET – DISSOLVED OXYGEN

Dissolved Oxygen Calib. Record: Date: _____ Sonde SN: _____ Technician: _____

DO membrane changed? Y N Note: After membrane change, should wait 6 to 8 hours before final DO calibration, run sensor for 15 minutes in Discrete Run to accelerate burn-in.

Corrected* Barometric Pressure (Inches/Hg)	x 25.4 =	Corrected Bar. Pres. mm/Hg	- [Sea level correction] [2.5*(Altitude/100)]	Local True =Bar.Pres.	Pre-Calib. D.O. %	Post-Calib D.O.%	DO Charge (Range: -50 +25)	DO Gain (Range: 1.0 -.3 to +.5)
_____	x 25.4 = _____		- _____	= _____	_____	_____	_____	_____

DISSOLVED OXYGEN SENSOR OUTPUT TEST (after DO calibration probe in saturated air)

After calibration, did the DO % output display the proper declining high to low trend? If so, check ACCEPT. Should the output display a negative number or start at a low number and climb up to the calibration point, check REJECT and do not deploy the probe. _____ ACCEPT _____ REJECT

NOTES: (End of Day D.O. calibration check: _____)

*Generally weather service barometric pressure readings are corrected to sea level, and cannot be used until they are "uncorrected."

Dissolved Oxygen Calib. Record: Date: _____ Sonde SN: _____ Technician: _____

DO membrane changed? Y N Note: After membrane change, should wait 6 to 8 hours before final DO calibration, run sensor for 15 minutes in Discrete Run to accelerate burn-in.

Corrected* Barometric Pressure (Inches/Hg)	x 25.4 =	Corrected Bar. Pres. mm/Hg	- [Sea level correction] [2.5*(Altitude/100)]	Local True =Bar.Pres.	Pre-Calib. D.O. %	Post-Calib D.O.%	DO Charge (Range: -50 +25)	DO Gain (Range: 1.0 -.3 to +.5)
_____	x 25.4 = _____		- _____	= _____	_____	_____	_____	_____

DISSOLVED OXYGEN SENSOR OUTPUT TEST (after DO calibration probe in saturated air)

After calibration, did the DO % output display the proper declining high to low trend? If so, check ACCEPT. Should the output display a negative number or start at a low number and climb up to the calibration point, check REJECT and do not deploy the probe. _____ ACCEPT _____ REJECT

NOTES: (End of Day D.O. calibration check: _____)

*Generally weather service barometric pressure readings are corrected to sea level, and cannot be used until they are "uncorrected."

Dissolved Oxygen Calib. Record: Date: _____ Sonde SN: _____ Technician: _____

DO membrane changed? Y N Note: After membrane change, should wait 6 to 8 hours before final DO calibration, run sensor for 15 minutes in Discrete Run to accelerate burn-in.

Corrected* Barometric Pressure (Inches/Hg)	x 25.4 =	Corrected Bar. Pres. mm/Hg	- [Sea level correction] [2.5*(Altitude/100)]	Local True =Bar.Pres.	Pre-Calib. D.O. %	Post-Calib D.O.%	DO Charge (Range: -50 +25)	DO Gain (Range: 1.0 -.3 to +.5)
_____	x 25.4 = _____		- _____	= _____	_____	_____	_____	_____

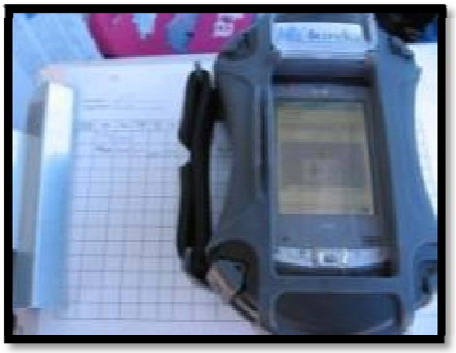
DISSOLVED OXYGEN SENSOR OUTPUT TEST (after DO calibration probe in saturated air)

After calibration, did the DO % output display the proper declining high to low trend? If so, check ACCEPT. Should the output display a negative number or start at a low number and climb up to the calibration point, check REJECT and do not deploy the probe. _____ ACCEPT _____ REJECT

NOTES: (End of Day D.O. calibration check: _____)

*Generally weather service barometric pressure readings are corrected to sea level, and cannot be used until they are "uncorrected."





Calibration Methods for Eureka Manta Multi-parameter Sondes

These procedures are designed specifically for portable Manta multi-parameter sondes with Amphibian hand pads. These instruments are made by Eureka Environmental Engineering, Inc. While there are some details specific to Eureka, the basics of the procedure are universal for many multi-parameter sondes with field replaceable probes. These probes can be equipped with Clark cell dissolved oxygen, optical dissolved oxygen, pH, specific conductivity, turbidity, and temperature probes.

Clark Cell Dissolved Oxygen Probe Membrane Replacement

1. Make sure you have all the equipment you will need
    a. Package of fresh dissolved oxygen membranes
    b. Fresh bottle of DO electrolyte solution. Double-check the bottles label to make sure it is DO electrolyte solution and to make sure the solution's expiration date has not been passed.
    c. Small, sharp scissors or knife for trimming the membrane. Avoid using a dull scissors or knife as it will pull or tug on the membrane instead of cutting it cleanly.
    d. Fresh o-rings, if needed
    e. Ring Stand with a clamp that will hold your instrument.
2. Rinse the probes to make sure they are clean.
3. Remove the old membrane and o-ring.
4. Gently shake the instrument and lightly tap the probe to remove solution that may be adhering to the inside of the probe.
5. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.
6. Carefully fill the probe with fresh dissolved oxygen electrolyte solution. Fill it until a convex meniscus (miniature dome of water cause by water molecules' attraction to each other) forms on the top of the probe.
7. Tap the sides of the DO probe to make sure that there are no air bubbles inside of it.
8. Carefully remove a fresh membrane from its package, holding it by its edges. Place the membrane on top of the meniscus without trapping any air bubbles under the membrane.


a. If there are any air bubbles under the membrane, top off with more DO electrolyte, and replace the membrane.

9. Carefully place the DO probe cap on top of the membrane, directly over the top of the probe.
10. Apply even pressure around the o-ring and make sure that no air bubbles are trapped under the membrane. Also make sure there are no wrinkles in the membrane.
    a. If there are any air bubbles under the membrane or wrinkles under the membrane, repeat steps 3 through 10 until you are successful
11. Condition the membrane by storing it overnight with tap water.
12. The following day, drain the tap water from the storage cup and examine the dissolved oxygen probe.
    a. If you see any air bubbles under the membrane, membrane wrinkles, or membrane tears, repeat steps 3 through 12.
    b. If the membrane looks like it has been properly changed (no air bubbles, wrinkles, or tears), proceed to calibration of the probe.

Clark Cell Dissolved Oxygen Probe Calibration

1. Turn on the instrument and give the Amphibian hand pad time to connect to the Manta. The circulator will turn on briefly when the connection is made.
2. Begin filling out a record for this calibration in the calibration log book.
3. Make sure the circulator (if installed) is turned off.
4. Rinse probes, and make sure the dissolved oxygen membrane is clean.
5. Dry the dissolved oxygen probe and membrane with Kim Wipes.
6. Screw the calibration cup cylinder, without its cap, onto the instrument.
7. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.

8. Carefully pour tap water into the calibration cup without getting any water on the dissolved oxygen membrane. Fill the calibration cup to a point just under the o-ring of the dissolved oxygen sensor.
9. Using a Kim Wipe, remove any drops of water that may have fallen upon the dissolved oxygen membrane.
10. Place the cap of the calibration cup on top of the open end of the cup without screwing it on. This will allow the creation of a water-saturated-air environment within the cup and around the end of the sensor while also allowing equilibration of barometric pressure.
11. Allow dissolved oxygen readings to stabilize for at least six minutes. Make sure the readings are stable before continuing.
12. Record the dissolved oxygen reading before calibration (in %Sat). This reading will likely be slightly off from 100%.
13. Record the current barometric pressure in mm HG.
    a. Use a digital barometer

b. If you get BP from a weather service it is often in inches Hg and also corrected to sea level. First you need to convert it to mm Hg by multiplying the inches Hg by 25.4. Then to "uncorrect" for sea level use the following formula: **True BP in mm Hg = [Corrected BP in mm Hg] – [2.5 * (Local Altitude/100)]**

14. Use the Amphibian hand pad to complete the calibration process.
    a. **Probe**
    b. **Calibration**
    c. **DO %Sat.**
    d. **Enter the current barometric pressure in mmHg**
    e. Proceed with the calibration process. The Amphibian will allow the sensor to stabilize for approximately 1 minute before giving you a message that the calibration is complete
15. Exit the calibration window to get back to the main screen that displays current probe readings
16. Record the post-calibration dissolved oxygen concentration (%Sat). This reading should be almost exactly 100%.

Optical Dissolved Oxygen Calibration

There doesn't yet seem to be one standard method for this type of calibration yet. The optical dissolved oxygen sensor on the Eureka Manta multi-parameter sonde faces to the side, so it can't be calibrated in the same way as the Clark cell probe (on which the membrane faces up). These probes can be calibrated with a water-vapor-saturated-air calibration, air-saturated-water calibration, and a zero oxygen solution (not recommended by the manufacturer). Since the Eureka Manta manual does not provide detailed instructions for calibration of the optical dissolved oxygen probe, the methods from the USGS *National Field Manual for the Collection of Water-Quality Data* will be used. While the wet towel water-vapor-saturated air method seems to be the easiest method, the air-saturated water method seems to be the most accepted and recommended of the two types of calibrations.

Water-Vapor-Saturated Air Calibration for the Eureka Manta Optical Dissolved Oxygen Sensor

When the regular method of dissolved oxygen calibration (probes facing upwards in a half-filled calibration cup and a lid set on top to trap water vapor) will not work for instruments such as the Eureka Manta (side facing) optical dissolved oxygen probe, an alternative method may be used.

A wet towel can facilitate the water-saturated air calibration of the DO sensor as follows:

1. Wrap the sensor guard with a white towel wetted in field (or room) temperature water, forming an enclosed moist environment around the instrument sensor guard and sonde body.
2. Allow time for the air inside the sensor guard and wet towel to become saturated with water vapor (10-15 minutes)
3. Calibrate using a normal 1-point DO %Sat calibration.

Air-Saturated Water Calibration for the Eureka Manta Optical Dissolved Oxygen Sensor

Calibration will be done in mg/L instead of %Sat

1. To create an air-saturated water bath, one method is to fill a 1-5 gallon bucket with distilled water and aerate the water using a mid-sized aquarium pump with air stone. Check the manufacturer's recommendations. Some manufacturers have developed their own bath aeration system to help avoid effects from variance of temperature and hydrostatic pressure on the calibration.
   - The air-saturated water method is faster and guarantees temperature equilibration of the optical DO sensor and calibration medium.
   - If the water bath is kept air-saturated and ready to use, calibration time can be reduced, as there is no need to wait for a calibration cup or wet towel to saturate the air.
2. Aerate the water for at least 1 hour prior to use.
3. When measuring in low DO environments or after replacing a luminescent-sensor membrane, a two point DO calibration and/or a zero DO check is needed or required.
   - Purchase a zero DO calibration solution from Eureka Environmental
   - Calibrate the saturated and zero DO levels, starting with the saturated level.
   - After calibrating the sensor with the zero-percent solution, take extra care in rinsing the sensor thoroughly to remove any residue of the solution. Inadequate rinsing will cause negatively biased DO readings and can result in cross contamination, possibly causing fault SC or pH readings. The thee-time tap water or DIW rinse recommended for other calibration procedures may not be sufficient. One manufacturer recommends rinsing the sensor under running tap water for at least 10 minutes.
4. Observe the readings for DO; when there is no appreciable change for approximately 30 seconds; lock in the reading by proceeding with the calibration steps (steps differ with software options).
5. Use water that has been stored at a constant temperature so the temperature will be stable.
   - If possible, use water that has the same temperature and conductivity of the water to be measured.
   - If working in a laboratory, obtain about 1 L of distilled or deionized water. The benefit to this is that the µS/cm will be as close to zero as possible so the salinity correction will not be a factor (factor = 1 at 0 µS/cm).
6. Place the DO sensor into the air-saturated water bath. Avoid placing the instrument in the stream of air bubbles.
   - Allow the sensor to come to thermal equilibrium with the water temperature
   - Shield the beaker or container from direct sunlight and wind (perform the calibration inside a lab or vehicle) to minimize temperature variations.
7. Read the ambient atmospheric pressure to the nearest 1 mm of mercury using your digital barometer.
8. Read the temperature of the calibration water to the nearest 0.1 °C.
9. Using oxygen solubility table 6.2-6 of the USGS *National Field Manual for the Collection of Water-Quality Data,* determine the DO saturation value at the measured temperature and atmospheric pressure of the calibration water.
10. Following the manufacturer's instrument calibration instruction, verify that the instrument reading is within ± 0.2 mg/L of the computed saturation that reflects study data-quality requirements.) The luminescent (optical) sensor instrument is now calibrated and ready for use.

Specific Conductivity Calibration

Eureka uses a one-point calibration. The first point is a zero point and the second should be somewhere near the maximum levels that you will be measuring in the field. The specific conductivity is measured between two sensors that face each other across the hollowed out portion of the probe. The "zero" point is established when there is nothing between the sensors to provide conductance (probe is dry). Make sure you have enough specific conductivity calibration standard solution to rinse the probes and enough fresh solution to complete the rinsing process and fill the calibration cup for calibration.

1. Begin filling out a line of the calibration log book.
2. Turn on the instrument. Make sure the circulator (if installed) is turned off.
3. Rinse the probes with distilled water to make sure they are clean.
4. Triple rinse the probes with the specific conductivity standard solution.
5. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.
6. Fill the calibration cup to a point just above the dissolved oxygen probe membrane.
7. Allow the conductivity readings to stabilize for at least 3 minutes.
8. Use the Amphibian hand pad to complete the calibration process
    a. **Probe**
    b. **Calibration**
    c. **Sp.Cond**.
    d. Check the µS/cm value that is shown in the calibration description to make sure it matches the solution you will be using. Edit if necessary. Use solutions with consistent µS/cm concentrations for consistency in your measurements and calibrations.
    e. **Calibrate**
    f. Overwrite the previous calibration? **Yes**
    g. Allow the stabilization process to be completed.
9. Tap the **OK** button on the pop-up window and the top right corner when the calibration is completed to return to the main screen that displays current probe readings.
10. Record the post-calibration Sp.Cond. reading in the calibration log book.
11. Triple rinse the probes with distilled water to make sure they are clean and residual specific conductivity calibration solution has been removed.

pH Calibration

Make sure you have sufficient pH calibration solution for triple-rinsing the probes and enough fresh buffer solution in, at least two levels (pH 7 and pH 10) to fill the calibration cup for the calibration.

1. Fill out the date and staff portions of the calibration log book.
2. Make sure the probes have been triple rinsed with distilled water to remove contamination from previous (sp. cond.) calibration procedures and/or field use.
3. Make sure your Amphibian hand pad is connected to the Manta and turned on.
4. Triple rinse the probes with pH 7 buffer solution.
5. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.
6. Fill the calibration cup with fresh ph7 calibration solution to a point just above the dissolved oxygen probe membrane.
7. Allow the probes readings to stabilize for at least 3 minutes
8. While the instrument is stabilizing, calculate the temperature-corrected pH values for the pH 7 and pH 10 buffer solutions. Store the ph buffer solution in the same location where the temperatures will be stable and the equal among separate bottles.
9. Record the temperature-corrected pH of the buffer solutions in the calibration log book.
10. Record a pre-calibration pH reading in the calibration log book.
11. Use the Amphibian hand pad to conduct the first step of the calibration process.
    a. **Probe**
    b. **Calibration**
    c. Select **pH** from the drop-down menu.
    d. Edit the calibration points to match your current temperature-corrected values.
    e. **Calibrate**
    f. Overwrite previous calibration? **Yes**
    g. Step 1 of 2 pop-up window: Tap **Ok**
    h. Allow the stabilization process to complete and the Step 2 of 2 pop-up window to appear.
12. Triple rinse the probes with distilled water.
13. Triple rinse the probes with pH 10 buffer solution.
14. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.
15. Fill the calibration cup with fresh ph10 calibration solution to a point just above the dissolved oxygen probe membrane.
16. Allow the probes readings to stabilize for at least 3 minutes
17. Use the Amphibian hand pad to conduct the second step of the calibration process.
    a. Tap **Ok** in the Step 2 of 2 pop-up window.
    b. Allow the stabilization process to complete.
    c. Tap **Ok** in the pop-up window that appears and then the one in the upper right hand corner of the calibration screen to return to the view that shows the current probe readings.
18. Perform a post-calibration check of the pH level while the solution is still in the calibration cup. Record this value in the calibration log book. The value should be a pH of 10, or very close to the value of the standard.
19. Discard used pH 10 solution or save for the first rinse in the next pH 10 calibration.
20. Triple rinse probes with distilled water to remove residual pH buffer solution.

Turbidity Probe Calibration

Make sure you have sufficient turbidity calibration solution for triple-rinsing the probes filling the calibration cup for the calibration. At this time, a maximum of two calibration points can be used for a Eureka Manta turbidity probe calibration. The first point is a turbidity of 0 NTU. A 0 NTU calibration solution can be purchased or you can use distilled water. Distilled water is much cheaper and, because the water is more expendable, it can be used more liberally in rinses than an expensive calibration standard. The steps listed below will use distilled water as the 0 NTU calibration point. The second point should be near the maximum levels commonly measured in the field. Polymer bead turbidity standard solution sold by Eureka Environmental Engineering should be used for Eureka Manta turbidity probe calibrations. Eureka offers solutions in 0 NTU, 7.6 NTU, 77 NTU, 313 NTU, and 673 NTU concentrations.

1. Make sure the date and staff portions of the calibration log worksheet are filled in.
2. Record the concentrations of solutions that you will be using for the calibrations on the calibration log worksheet.
3. Make sure your Amphibian hand pad is connected to the Manta and turned on.
4. Turbidity calibrations are conducted using either the storage cup of the sonde as it is somewhat opaque to block the effect of fluorescent lighting upon the probe's readings and it has a dark bottom.
5. Triple rinse the probes with distilled water by filling the calibration cup (which should be attached to the sonde) and swirling the water within the cup, around, and through the probes. Check the cup for any visible particulates after the third rinse. If you can still see some specks of dirt, rinse again with fresh distilled water until the cup is clean.
6. When the probes and calibration cup are clean, attach it to the sonde, and clamp the sonde onto the ring stand so the probes are facing up. Fill the calibration cup with distilled water to a point that is at least one inch above the turbidity sensor. Make sure there aren't any air bubbles on the end of the turbidity probe. Leave the end of the cup open.
7. Allow the probe's readings to stabilize for at least 3 minutes
8. Record a pre-calibration turbidity reading in the calibration log book.
9. Use the Amphibian hand pad to conduct the first step of the calibration process.
    a. Tap **Probe**
    b. Tap **Calibration**
    c. Select **turbidity** from the drop-down menu.
    d. Edit the calibration points to match the solutions you will be using.
    e. Tap **Calibrate**
    f. Overwrite previous calibration? **Yes**
    g. Follow the instructions of the pop-up windows until the Amphibian hand pad.
10. When the pop up window asks for the second solution, discard the distilled water that is in the calibration cup.
11. Triple rinse the calibration cup and sensors with your second solution (e.g. 7.6 NTU). Used solution may be used only for the first two rinses. Fresh solution must be used for the third rinse.
12. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.
13. Fill the calibration cup with fresh turbidity calibration solution to a point that is at least one inch above the end of the turbidity sensor. Make sure that there aren't any air bubbles or particles of

dirt on the end of the turbidity probe or floating around in the solution that could affect the accuracy of the calibration.

14. Allow the probes readings to stabilize for at least 3 minutes
    a. Tap **OK** on the pop-up window (the one asking for the second solution), and allow the Amphibian to continue with the calibration.
    b. You should be able to get a pre-calibration reading in this solution by watching the concentration shown in the pop-up widow before and during stabilization.
    c. The amphibian will stabilize for a minute, "think" for a few seconds, and return to the main turbidity calibration window.
15. Click OK in the upper right corner of the window to return to the real-time reading display.
16. Record a post-calibration turbidity reading in the calibration log worksheet.
17. Empty the turbidity solution from the calibration cup into a container used to save the solution for rinsing during the next calibration.
18. Rinse the probes with distilled or tap water to remove any residual calibration solution.

Summarized Methods for Calibration of In-Situ TROLL 9000 Sondes

In-Situ TROLL 9000/9500 multi-parameter sondes are calibrated similarly to other sondes with field replaceable probes. There are some differences in DO membrane replacement and software options.

Dissolved Oxygen Probe Membrane Module Replacement

Replace the membrane when it has become fouled, ripped, torn, developed air bubbles, or has become damaged in some other way. Ideally the membrane will be replaced monthly. The rate may also vary dependent upon the project budget, monitoring objectives, and the water being tested. These probes are capable of producing reliable readings in long-term deployment throughout the monitoring season with only one or two membrane module changes.

1. Begin filling out a record for the membrane replacement in the calibration log book.
2. Gather the supplies that you will need.
   - Fresh dissolved oxygen membrane module(s)
   - Dissolved oxygen electrolyte solution
3. Make sure he probes are free of dirt and moisture
4. Remove and discard the used membrane module
5. Inspect and clean the sensor as needed.
6. Remove the soft protective cap from a new membrane module
7. Fill a new membrane module with electrolyte and attach it to end of the sensor.
   - Insert the sensor into the open end of the membrane module. To minimize air, some of the electrolyte should overflow from the open end as the sensor is inserted.
   - Thread the membrane module onto the D.O. sensor.
8. Condition the sensor and membrane.
   - Put a small amount of clean water in the clean Cal Cup and attach it loosely to the instrument. Do not seal the Cal Cup; it should be at ambient pressure. The sensor membrane can be submerged or above the water level.
   - Connect the MP TROLL 8000 to a PC and establish a connection in Win-Situ or Pocket-Situ
   - Select the MP TROLL 9000 I the Navigation tree. All installed sensors will be displayed.
   - Powering of the DO sensor begins as soon as the software recognizes the DO sensor and displays it in the Navigation tree. This starts the conditioning process.
9. Allow the sensor to condition overnight before calibrating.

Dissolved Oxygen Calibration

This calibration can be performed using the water-vapor-saturated air method used by other multi-parameter probes, the main difference being in the software operation. The instrument manual also says that it may be calibrated with an air-saturated water method. The standard method described here will be for the water-vapor-saturated air method. Calibration should be performed every 2-4 weeks.

1. Begin filling out a record for this calibration in the calibration log book.
2. Rinse the probes in clean water to remove contaminants.
3. Dry the DO sensor membrane with Kim Wipes
4. Thread a clean Cal Cup onto the MP TROLL 9000.
5. Invert the TROLL with Cal Cup attached and remove the black end cap from the Cal Cup
6. Gently fill the Cal Cup with clean water until the temperature sensor is completely covered, while making sure that the membrane at the tip of the DO sensor remains in air.
7. Remove any moisture that may have splashed onto the membrane using a Kim Wipe.
8. Loosely attach the black end cap of the Cal Cup. For proper venting, the small holes in the threads of the cap should still be visible.
9. Connect the TROLL to a PC and establish a connection in Win-Situ or Pocket-Situ.
10. Select the TROLL in the Navigation tree
11. Select Dissolved Oxygen in the Parameters list.
12. Select **Read** to get the pre-calibration dissolved oxygen reading and record it in the calibration log book entry for this calibration.
13. Select **Calibrate**
14. A pop-up window will ask you how to handle barometric pressure. You can choose to do this manually (obtain the methods in Section 3.2.4 of this SOP), or allow the instrument to obtain the barometric pressure reading itself (if equipped with a vented cable).
15. Record the barometric pressure in the calibration log book entry for this calibration.
16. The DO Calibration Wizard starts.
17. Set the number of calibration points to 1.
18. Select the membrane type (stamped on membrane module)
19. Select the medium for the first calibration point (Air).
20. Select the stimulus at saturation (Default)
21. Select **Next** to continue to the next screen.
22. Select **Run** to begin stabilization for the first calibration point.
23. Pay attention to the Status indicator
    - **NOT TESTED** displayed until you begin the calibration by selecting Run
    - **UNSTABLE** indicates the sensor response does not meet the criteria for a valid calibration point.
    - **NOMINAL** indicates the sensor deviation meets early stabilization criteria.
    - **STABLE** is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen
24. When stable, the final screen is displayed. The calculated sensor slope and offset are shown.
25. Select **Finish** to program the sensor with the new calibration coefficients.
26. Choose to save the calibration record. Create a folder for each instrument's calibration records.
27. Select Dissolved Oxygen in the Parameters list.
28. Select **Read** to get the post-calibration DO reading and record it in the calibration log book.

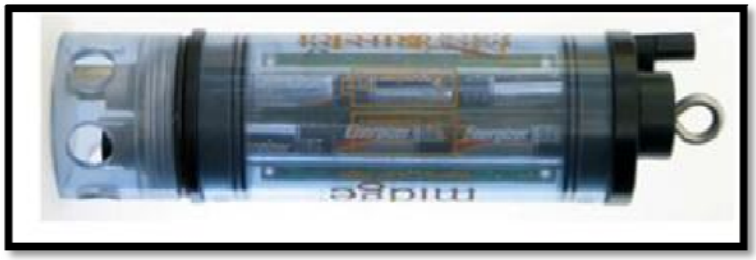
Specific Conductivity Calibration

Although the TROLL manual states that the specific conductivity sensor only needs to be calibrated once every 2-3 months, perform this calibration monthly. Use a standard solution that is greater than 1000 µS/cm (1412 µS/cm). Make sure that you have at least one pint of solution to perform the rinsing and calibration procedures.

1. Begin filling out a record for this calibration in the calibration log book.
2. Rinse the probes to remove contaminants. Use a swab or Kim wipe to gently clean the electrodes.
3. Thread the Cal Cup onto the TROLL
4. Triple-rinse the probes with conductivity standard solution
5. Remove the Cal Cup
6. Fill the Cal Cup with the selected calibration solution up to the upper line on the cup
7. Thread the Cal Cup back onto the TROLL
8. Connect the TROLL to a PC and establish a connection in Win-Situ or Pocket-Situ
9. Select the TROLL in the Navigation tree
10. Select **conductivity** in the Parameters list.
11. Select **Calibrate**
12. Select the calibration solution the sensor is soaking in, or input a custom value.
13. Select **Next** to continue.
14. In the next screen, select **Run** to begin the stabilization.
15. Pay attention to the Status Indicator
    - **NOT TESTED** displayed until you begin the calibration by selecting Run
    - **UNSTABLE** indicates the sensor response does not meet the criteria for a valid calibration point.
    - **NOMINAL** indicates the sensor deviation meets early stabilization criteria.
    - **STABLE** is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen
16. The final screen shows the new cell constant (Kcell) calculated for the selected range during the calibration process.
17. Choose to save the calibration record. Create a folder for each instrument's calibration records.

pH Calibration

1. Begin filling out a record for this calibration in the calibration log book.
2. Triple-rinse the probes with distilled water to remove contaminants. Use a swab or Kim Wipe to clean the pH sensor bulb.
3. Thread the Cal Cup onto the TROLL
4. Triple-rinse the probes with pH 7 buffer solution.
5. Remove the Cal Cup from the TROLL
6. Fill the Cal Cup to the upper line with pH7 buffer solution.
7. Insert the front end of the TROLL into the open end of the Cal Cup and Thread the Cal Cup onto the body, but do not over-tighten.
8. Connect the TROLL to a PC and establish a connection in Win-Situ or Pocket-Situ.
9. Select the TROLL in the Navigation tree
10. Click to select **Temperature** in the **Parameters** list.
11. Note the temperature reading and use it to calculate the temperature corrected pH values of your pH 7 and pH 10 buffer solutions.
12. Record these temperature corrected values in the calibration log book.
13. Click to select **pH** in the **Parameters** list.
14. Select **Read** to get a pre-calibration ph reading and write it down in the calibration log book entry for this calibration.
15. Select **Calibrate**
16. Select the number of calibration points for this calibration, and enter the temperature-corrected the pH value of the buffer solution for each point.
17. Select **Next** to continue
18. In the next screen, select **Run** to begin the stabilization.
19. Pay attention to the Status Indicator.
    - **NOT TESTED** displayed until you begin the calibration by selecting Run
    - **UNSTABLE** indicates the sensor response doesn't meet the criteria for a valid calibration point.
    - **NOMINAL** indicates the sensor deviation meets early stabilization criteria.
    - **STABLE** is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen
20. When the calibration process has proceeded to the next screen, discard the first solution (you may want to save this solution for the first rinses of future calibrations).
21. Triple-rinse the probes and Cal Cup with distilled water.
22. Triple-rinse the probes with pH 10 solution.
23. Remove the Cal Cup.
24. Fill the Cal Cup with pH 10 solution up to the upper line.
25. Select **Run** to begin the stabilization for the second calibration point. Status indicators and controls are the same as for the first calibration point.
26. The final screen shows the sensor slope and offset calculated during the calibration process. For a 3-point calibration, 2 sets of calculated coefficients will be shown.
27. Select **Finish** to program the sensor with the newly calculated calibration coefficients.
28. Select **Read** to get a post-calibration ph reading and write it down in the calibration log book. The reading in the pH 10 solution should be equal to the temperature corrected value for the solution.
29. Discard the pH s10 solution (you may save this solution for rinsing during future calibrations).
30. Triple-rinse the probes and Cal Cup with distilled water to remove residual calibration solution.



Summarized Methods for Calibration of Eureka Midge Dissolved Oxygen Probes

Dissolved Oxygen Probe Membrane Replacement

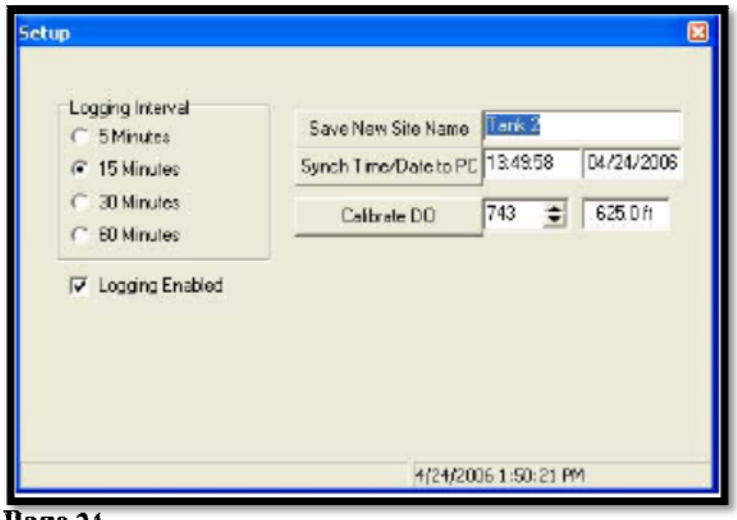
1. Make sure you have all the equipment you will need
    a. Package of fresh dissolved oxygen membranes
    b. Fresh bottle of DO electrolyte solution. Double-check the bottles label to make sure it is DO electrolyte solution and to make sure the solution's expiration date has not been passed.
    c. Small, sharp scissors for trimming the membrane
    d. Ring Stand with a clamp that will hold your instrument.
2. Rinse the probes to make sure they are clean.
3. Remove the cap by pulling up on it.
4. Discard the old membrane.
5. Remove the old electrolyte solution. Gently shake the instrument and lightly tap the probe to allow all of the old electrolyte solution to
6. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling.
7. Carefully fill the probe with fresh dissolved oxygen electrolyte solution. Fill it until a convex meniscus (miniature dome of water cause by water molecules' attraction to each other) forms on the top of the probe.
8. Tap the sides of the DO probe to make sure that there are no air bubbles inside of it.
9. Carefully remove a fresh membrane from its package, holding it by its edges. Place the membrane on top of the meniscus without trapping any air bubbles under the membrane.
    a. If there are any air bubbles under the membrane, top off with more DO electrolyte, and replace the membrane.
10. Carefully place the DO probe cap on top of the membrane, directly over the top of the probe. Make sure the o-ring inside the cap is at the top.
11. Press the cap down onto the probe until it snaps into place. Make sure that no air bubbles are trapped under the membrane. Also make sure there are no wrinkles in the membrane.
    a. The o-ring will grab the top of the membrane and stretch it uniformly.
    b. If there are any air bubbles under the membrane or wrinkles under the membrane, repeat steps 3 through 10 until you are successful

12. Trim any excess membrane material with a sharp knife or a sharp pair of scissors.
13. Place a few teaspoons of water in the storage cup and secure it to the sonde
14. Condition the freshly prepared dissolved oxygen probe by allowing it to age for 24 hours within it moist storage cup environment before calibrating. As it ages, the probe's sensitivity decreases, with most of the decrease occurring in the first 12 hours. After about 24 hours, the sensitivity of the probe becomes very stable. It is extra important to make sure these probes are well aged before they are calibrated because they will be used for continuous monitoring in which they might be deployed in a stream for up to two weeks without re-calibration.
15. The following day, drain the tap water from the storage cup and examine the dissolved oxygen probe.
    a. If you see any air bubbles under the membrane, membrane wrinkles, or membrane tears, repeat steps 1 through 15.
    b. If the membrane looks like it has been properly changed (no air bubbles, wrinkles, or tears), proceed to calibration of the probe.

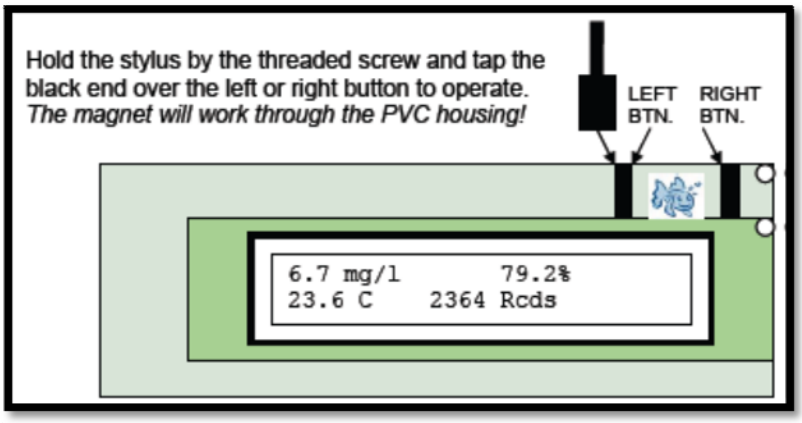
<u>Dissolved Oxygen Calibration</u>

Calibration is conducted with the 100% air saturated with water method.

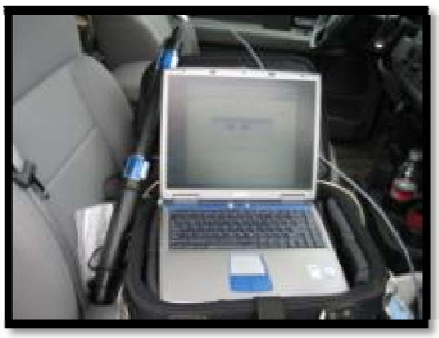
1. Turn on the instrument and/or connect it to a computer.
2. If you are connecting the instrument to a computer, establish the connection by opening the MidgeMinder software program.
3. Rinse probes, and make sure the dissolved oxygen membrane is clean, free of wrinkles, and free of air bubbles.
4. Dry the dissolved oxygen probe and membrane with Kim Wipes.
5. Screw the calibration cup cylinder, only, onto the instrument.
6. Place the probe in a ring stand clamp with the probes pointing up toward the ceiling. Do not clamp the instrument too tightly – avoid deforming the housing.
7. Carefully pour tap water into the calibration cup without getting any water on the dissolved oxygen membrane. Fill the calibration cup to a point just under the o-ring of the dissolved oxygen sensor.
8. Using a Kim Wipe, remove any drops of water that may have fallen upon the dissolved oxygen membrane.
9. Gently place the lid upside down on the cal cup.
10. Watch the data on either the LD screen or the MidgeMinder software to determine when the data has stabilized.
11. Allow dissolved oxygen readings to stabilize for at least five minutes. Make sure the readings are stable before continuing.



12. Record the dissolved oxygen reading before calibration (in %Sat if possible)
13. Record the current barometric pressure in mm HG.
    a. Use a digital barometer
    b. If you get BP from a weather service it is often in inches Hg and also corrected to sea level. First you need to convert it to mm Hg by multiplying the inches Hg by 25.4. Then to "uncorrect" for sea level use the following formula: **True BP in mm Hg = [Corrected BP in mm Hg] – [2.5 * (Local Altitude/100)]**



14. Input the current barometric pressure by using the probe's LCD screen or by using the MidgeMinder software.
15. From the Setup screen on the MidgeMinder software, press calibrate. Or, from the LCD data screen on the Midge, use the stylus to press and hold the right-hand button for 5 seconds. This will calibrate the dissolved oxygen sensor.
16. Record the post-calibration dissolved oxygen concentration (in %Sat if possible).


Methods for Calibration of Stevens TS300 Turbidity Sensors/Loggers

Measurement Overview

The Greenspan Turbidity Sensor utilizes a high gain infrared optical system to detect the back scatter intensity of suspended particles.

The optical system transmits a beam of 860nm wavelength. The effective working area around the sensor is approximately 300mm forward and 50mm circumference, however this is dependent on the calibrated range.

The Sensor is packaged in a 316-grade stainless steel or Delrin tube, with O ring sealed Delrin end fittings. This design is rugged and well proven and can withstand the harsh conditions found in any field environment.

The external optical surface is coated with a special polymer which resists fouling from algae growth. It does not eliminate the problem but increases the time between cleaning.

Advanced digital filtering techniques are used to achieve a high level of rejection of ambient light and stray signals from the measurement of data. Standard RS232 output is provided.

Sensor Maintenance

Protection of the lens surface is vital to maintain the accuracy of the calibration. Note that regular cleaning of the lens will, in time, remove the polymer coating applied during manufacture. Please contact Greenspan if you wish new coatings to be applied. The lens can be cleaned using a wash bottle filled with a warm detergent solution. Be very careful not to scratch the lens, use only soft materials combined with gentle rubbing.

Calibration Introduction

Simple calibration checking can be performed in the field by using calibration reference cups, **Model TR100** available from Greenspan. These are easily slid over the optics of the sensor and an indication is given immediately if calibration has changed or how much adjustment is required to correct it.

A **re-calibration** method for field and laboratory is also provided using the TR100 and SmartCom.

Standardization is the process of setting the zero of the instrument. A simple method is to immerse the optics of the sensor in a darkened vessel of pure filtered water.

Calibration adjustment compensates for such things as component characteristic changes or re-calibration of the range. Calibration is carried out by comparing known NTU values to the displayed reading of the instrument. New values if required are then entered in SmartCom.

Output of the sensor is calibrated in terms of NTU (Nephelometric Turbidity Units).

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Output of the sensor is calibrated in terms of NTU (Nephelometric Turbidity Units).

Re-Calibration using TR100

1. Ensure the Turbidity head is clean and the sensor is connected to power and a computer.
2. Ensure that the sensor turn on time is not set more than 6 seconds while taking a reading.
3. In SmartCom for Windows, select User Cal from Logger Control menu.
4. Select the Turbidity Channel.
5. Select 1 Decimal Places.
6. Select 2 point Span Calibration
7. The screen should display a window to allow entry of the new low value.
8. Use the same method for checking the low value cup reading as previously described.
9. Type in the new value to be read by the Smart Sensor as the low point, e.g.: (00000.0) click OK.
10. The screen now displays a window to allow entry of the new high value.
11. Use the same method for checking the high value cup reading as previously described.
12. Type in the new value to be read by the Smart Sensor for full scale, e.g.: (00092.0, for 100NTUrange), click OK.
13. The Smart Sensor will calculate a new calibration curve based on this data.
14. Thoroughly clean the sensor with water. The Turbidity channel is now recalibrated and ready for use.

Calibration of Turbidity Cups

Function

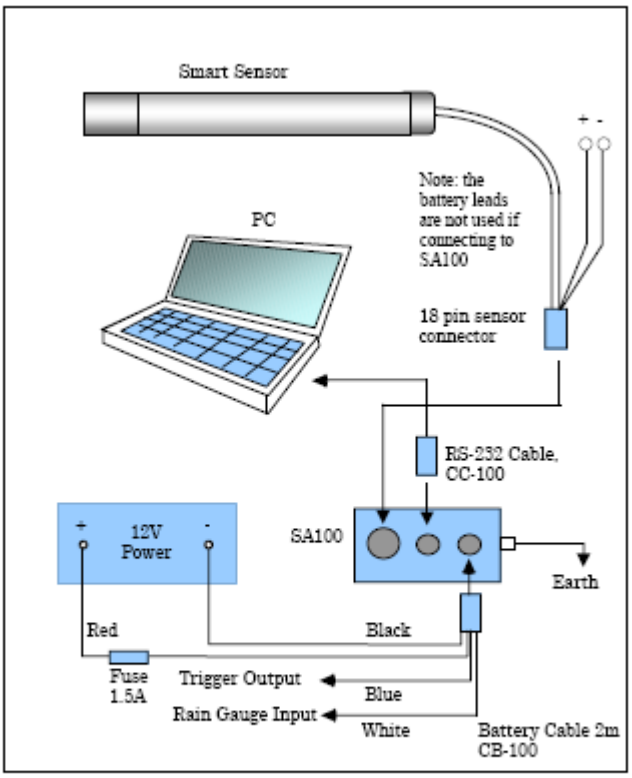
Each cup and sensor must be matched prior to use in checking. If this was not done at the factory, then the matching can be performed by the customer on the bench using the following procedure. Note that this assumes that the sensor is accurately calibrated. Once matched the pair should remain stable indefinitely.

Method

1. Gently remove any debris which may have accumulated on the sensor head with a moist soft cloth, avoid scratching the turbidity lens. Dry the lens.
2. Ensure that the sensor has been accurately calibrated, if not, refer to the Re-Calibration section of this document.
3. Engrave a permanent alignment mark laterally, anywhere along the sensor head. Be careful not to scratch the sensor lens.
4. Clean and dry the sensor head with a soft cloth.
5. Remove the protective cap on the high and low turbidity calibration cups and pour 2.5mL or ½ teaspoon of silicone oil into each and allow them to form a level, bubble free layer over the calibration suspension in the base of the cups.
6. Slide the low value turbidity calibration cup over the sensor head until it reaches the bottom, (some silicone oil may overflow). Rotate the cup while keeping firm contact on the bottom, to line up the alignment mark on the cup with the mark on the sensor head.
7. Once the cup and sensor are in place and aligned, remove your hands from the sensor and allow the assembly to stand in a vertical position (with the cup on the bottom) while taking the reading.

NOTE: Air bubbles trapped between the sensor lens and the calibration suspension will cause high and erratic readings. Be sure to use an adequate amount of silicone oil to prevent this from occurring and ensure no air bubbles are present prior to installing the cup. is also important not to break contact with the interface prior to reading the calibration point.

8. Note the reading in SmartCom Monitor Current Values mode and record the reading of the sensor onto the Turbidity Reference Table in the calibrator kit, using a waterproof pen. Also, record the serial numbers of the turbidity sensor and turbidity cup. These may be changed or removed later with mentholated spirits if the calibration is redone.
9. Repeat steps 5-8 for the full scale calibrator cup. Remove the cup and wipe the sensor head clean of oil with a soft cloth. Note that the same cup may be used on different sensors of the same range with correspondingly different readings being obtained. Each reading is valid for that particular sensor and all are recorded on the Turbidity Reference Table provided in the TR100 kit.



For further details on all pin connections please refer to Application Notes supplied with Interface Adaptors.

Appendix B

Forms

RMB Environmental Laboratories, Inc.

22796 County Highway 6, Detroit Lakes, MN 56501 • *phone & fax:* 218-846-1465 • rmbel@eot.com • www.rmbel.info

CHAIN OF CUSTODY RECORD

Client:

Project Name: P.O.#:

Samplers: (print) Phone #:

Samplers: (signature) Fax #:

Analyses Requested

Lab Code	Sample Description	Date	Time	# of Bottles	Collection: Composite / Grab / Integrated	Matrix: See Below	Sample Comments: (Collection, Filtration, Preservation)

Relinquished By: (Signature) Date/Time

Received by Lab: (Signature) Date/Time

_____(Initial) In the event that samples are received by the lab at a temperature greater than 6° Celsius, I hereby authorize RMB Environmental laboratories to process the samples as received.

_____(Initial) In the event that samples are received by the lab at a temperature greater than 6° Celsius, please contact client at ph #_____before processing samples.

Report To:

Bill To:

❑ Rvcd in acceptable condition

❑ Does not meet proper sample storage and transporation guidelines

Explain:_____

❑ Rcvd at Room Temp ❑ Rcvd on Ice

❑ Temp Blank NA

❑ Temp Blank _____ °C

❑ Samples Rcvd Same Day as Collection

❑ Evidence Tape:

❑ Intact ❑ Not Intact ❑ NA

Sample Matrix Options: DW—Drinking Water GW—Ground Water SW—Surface Water WW—Waste Water FB—Field Blank SL—Sludge S—Solid

Distribution: White—Accompanies Shipment & Analytical Results Yellow—RMBEL Project File Pink--Client Copy

RED RIVER BASIN MONITORING NETWORK / STREAM FIELD SHEET

Individual Observers-First and Last Names :

Sonde S/N: _____

Handpad S/N: _____

Turbidimeter S/N: _____

FIELD INFO.	A	B	C	D	E	F	G	H	I	J
SITE ID										
DATE										
TIME (military)										
Depth to Bottom*										
STAGE: Surface*										
Stream Water Depth*										
Sample Depth Goal*: 50% of water depth										
Actual Sample Depth*										
GAGE TYPE*										
Appearance: 1A-clear; 1B-tea-colored; 2-cloudy; 3-muddy; 4-green; 5-muddy & green										
Appearance:										
Recreation Suitability: 1-Beautiful; 2-Excellent body contact; 3-Body contact impaired; 4-no swim/boating OK; 5-recreation nearly impossible										
Recreation Suitability:										
StreamCondition* H-N-L or NoFlow										
Rain Event (Y/N)*										
T-Tube Reading 60 cm : First / Final AVG	/	/	/	/	/	/	/	/	/	/
*(Circle which tube used if it is greater than 60cm)	100/120	100/120	100/120	100/120	100/120	100/120	100/120	100/120	100/120	100/120
Water Temp °C										
Conductivity (uS/cm)										
DO (% Saturation)										
DO (mg/l)										
pH										
Turbidity (NTUs) Hach 2100P *										
Turbidity (FNUs) YSI Sonde *										
SAMPLE DEVICE* (Van Dorn / or see instructions)										
SAMPLE TYPE* (Grab)										
QA* (Field Dup)										

Observer(s):_____ **Date:** _____

FIELD NOTES: station name/location, vegetation status(leaf out, cropping, harvest), land use, erosion, wildlife, general phenology, wind, cloud cover, recent precipitation, ice condition, picture #, GPS coordinates, etc. **Also record here if NO FLOW.**

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	

WATER QUALITY MONITORING FIELD DATA SHEET

Individual Observers-First and Last Names : _____

Sonde S/N: _____

Handpad S/N: _____

Turbidimeter S/N: _____

SITE ID & INFO:	**Site ID**_____ **Location Description**_____									
FIELD INFO.	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
DATE										
TIME (military)										
Sample #										
STAGE: Staff Gage										
Measure Down from Upstream RP (ft)										
Measure Down from Downstream RP (ft)										
When using a tape with a weight that hangs below the tape's zero point, make sure that the measure-down result includes the length of the weight (measure down = tape reading + wt. length). Measure and record the length of the weight in each column below as a reminder.										
Length that weight adds										
Sample Bottles used										
Actual Sample Depth*										
GAGE TYPE*										
Appearance: 1A-clear; **1B**-tea-colored; **2**-cloudy; **3**-muddy; **4**-green; **5**-muddy & green										
Appearance:										
Recreation Suitability: 1-Beautiful; **2**-Excellent body contact; **3**-Body contact impaired; **4**-no swim/boating OK; **5**-recreation nearly impossible										
Recreation Suitability:										
StreamCondition* H-N-L-NF-Z-D-I										
Rain Event (Y/N)*										
Water Temp °C										
Conductivity (uS/cm)										
DO (mg/l)										
pH										
Turbidity (NTUs) Hach 2100P *										
Turbidity (FNUs) Eureka Manta Sonde *										
T-Tube Reading 60 cm : First / Final AVG	___/___	___/___	___/___	___/___	___/___	___/___	___/___	___/___	___/___	___/___
SAMPLE DEVICE* (**V**an **D**orn / Dip)										
SAMPLE TYPE* (**G**rab/**I**ntegrated)										
QA* (**F**ield **D**up)										

Observer(s):_____ **Date:** _____

FIELD NOTES: station name/location, vegetation status (leaf out, cropping, harvest), land use, erosion, wildlife, general phenology, wind, cloud cover, recent precipitation, ice condition, picture #, foam, any floating or suspended matter in sample or stream, etc.
Also record here if NO FLOW.

A	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
B	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
C	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
D	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
E	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
F	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
G	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
H	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
I	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):
J	Sonde Removed?_____ Sonde Deployed?_____ Time of removal/deployment?_____ Sonde ID#_____ Comments (weather, wildlife, other observations):

ADDITIONAL INSTRUCTIONS

PROJECT NAME
Write down project this data is being collected for: for river watch enter: **REDRWTCH** (Other examples: Red River Conditon, FDR , etc…)

SAMPLE TYPE	ABBREVIATION	DEFINITION
Grab	G	Sampling vessel or bottle filled at one point in water column and cross section of a waterbody
Composite-F	CF	Flow-weighted with auto-sampler
Composite-M	CM	Samples from multiple locations on a waterbody, combined w/churn splitter (describe in comments)
Composite-O	CO	Composite – Other (describe in comments)

FIELD CODE OR STREAM NAME
If this is an unestablished site and you want the site established and data entered in STORET, please supply GPS coordinates and station description/location. Note these in the field observation section.

QA
FD = Field Duplicate, SB = Sampler Blank, TB = Trip Blank, BB = Bottle Blank, RB = Reagent Blank

STAGE (feet):
Stage is a measurement of the elevation or level of the water surface. It is determined by reading a staff gage, recording gage, wire-weight gage, or by subtracting a tape down measurement to water level from a fixed measuring point elevation or reference point (RP). The gage type abbreviation below should be entered into the front of the field sheet under Gage Type. Note in "field observations", any unusual conditions that affect the measurement (debris around the staff, wind catching the tape, standing waves, etc.) **Depth to Bottom:** is the measurement from the RP to the stream bottom. **Stream Water Depth:** depth to Bottom minus Stage. **Sample Depth Goal:** half or 50% of the stream water depth. **Actual Sample Depth:** is the depth at which the sample was actually collected.

GAGE TYPE	ABBREVIATION	DEFINITION
USGS Staff or Wire Weight	U-R	USGS outside reference gage, such as staff or wire-weight, at an active gage
Tape-down from RP Tape-down from known Elevation	TD	Measured distance to water level from established reference point (RP) on bridge or other structure. Tape-down to water level subtracted from established measuring point elevation (describe in comments)
Other Staff or Wire Weight	R	Outside reference gage, such as staff or wire-weight, that is maintained by a non-USGS agency (describe in comments)

STREAM CONDITION
This refers to the relative amount of water flowing in the stream channel.

L = Low:	Water covers 1/3 or less of the distance from the stream bottom to the top of the bank.
N = Normal:	Water covers 1/3 to 2/3 of the distance from the stream bottom to the top of the bank.
H = High:	Water covers 2/3 or more of the distance from the stream bottom to the top of the bank.
NF = No Flow	Water is not flowing. May be dry or water present in pool. Water quality readings may or may not be taken.
Z = No Flow	Disconnected stagnant pools/puddles without observable flow
D = Dry	No visible standing water in channel
I = Interstitial	Flowing, but with some reaches beneath substrate

RAIN EVENT (Y/N)
Put a "Y" in the "Rain event" column if you are sampling in response to a significant rainfall event (over 1" in previous 24 hour period; an "N" if you are taking your weekly or monthly stream measurements.

SAMPLING DEVICE

ABBREVIATION	STORET CONFIG ID	NAME
VD		Van Dorn Type Sampler – Bottle type sampler with trip for closing ends.
None		Sample collected directly into sample bottle (hand dip)
SIM	SIMPLE	Simple Open Plastic Bucket
ROD	ROD	Telescoping Rod with Bottle
ICE1	ICE 1	Ice Conditions Water Sampler (straight rod with bottle attached to lower through ice)
DI		Depth Integrating (USGS type)
WB	WEIGHTED	Weighted Bucket with Cover (aka triple sampler, "labline")
AS		Automatic Sampler
Other		Another type of sampler (describe in notes)

Instrument Make/Model:									S/N:						Owner:			
												Turbidity Calibration Points				Actual pH Standard Value Adjusted for Temp		
													2					
Date	Staff Initials	DO?	Barometric Pressure (mmHg)	New DO Membrane?	Pre-Cal DO % Sat	Post-Cal DO % Sat	SpCond. Cal.?	Pre-Cal SpCond uS/cm	uS/cm of SpCond Std.	Post-Cal SpCond uS/cm	Turibidity Cal.?	1st Step NTU	2nd Step NTU	Pre/ Post Cal Step 2	pH Calibrated ?	4	7	10
Example	*CH*	*Y*	*740*	*N*	*96.01*	*99.87*	*Y*	*1410*	*1412*	*1412*	*Y*	*0*	*7.6*		*Y*	*4.00*	*7.02*	*10.05*

Turbidity Calibration/Calibration Check Worksheet

Meter Model	Meter Serial Number	Date & Time	Formazin Calibration Solution Concentrations (every 1-3 mos.)				Target Values and Calibration Check Results from Gelex Standards (At Each Sample Outing)			Difference from Gelex Values at Last Calibration			Percent Difference from Values at Last Calibration (recal. @ ≥5% difference)		
			S0	S1	S2	S3	1-10	0-100	0-1000	1-10	0-100	0-1000	1-10	0-100	0-1000

Continuous Monitoring Maintenance, Calibration and Data Validation Log

Deployed Sonde ID	Site Name	Portable Sonde ID	File Name	Data Looks OK?	Parameter	Date	Staff	Pre Cleaning Data: Deployed (Bucket of Stream Water)	Pre Cleaning Data: Portable (Bucket of Stream Water)	Difference Between Deployed and Portable	Pre-Cleaning Data	Post Cleaning/Pre-Calibration Data: Deployed (Bucket of Stream Water)	Post Cleaning/Pre-Calibration Data: Portable (Bucket of Stream Water)	Difference Between Deployed and Portable	Post-Cleaning Data	Re-Deployment/Post Calibration Data: Deployed (Bucket of Stream Water)	Re-Deployment/Post Calibration Data: Portable (Bucket of Stream Water)	Difference Between Deployed and Portable	Post-Cal. Data

Water Quality Monitoring
Sample Log

Sample #	Lab Code #	Date	Time	Duplicate Log #	Blank Log #	Sample Method (Dip, VD)	Method # 1-10 for each

A set of duplicate samples is collected for every 10th set of samples
Blank samples are collected during every 10th set of samples collected with each different sampling method
(blanks for every 10th set of samples collected by hand dipping, blanks collected for every 10th set collected with Van Dorn)

Appendix C

Calibration and Maintenance of Vertical-Axis Type Current Meters

Assembly and Disassembly of the Current Meter

The procedure in assembling the Current meter may best be followed by referring to the figure below, which shows a sectional view of a type AA meter and the names of the parts.

1) Assemble the two vanes of the tailpiece (10).
2) Insert the tailpiece assembly, with balance weight underneath, into the yoke (8) and tighten the tailpiece set screw (7).
3) Place the bucket wheel (21) onto the bucket-wheel hub (13) with the side marked "S" upward, and with the dowel pin on the hub fitting the notch in the bucket-wheel frame. These parts are held together by means of the bucket-wheel hub nut.
4) Place the bucket-wheel assembly within the arms of the yoke (8) and pass the shaft (12) through the hole in the upper arm of the yoke. Screw the shaft directly into the bucket-wheel hub (13), then insert a pin into the hole in the shaft and use the pin to tighten the shaft in the hub.
5) Loosen the penta gear (6) in the contact chamber (2) by a single turn of the small screw that passes through the adjusting slot of the gear pad. Do not remove this screw completely as it is difficult to replace.
6) Slip the contact chamber, with the cap (1) removed, over the upper end of the shaft and into the hold in the upper limb of the yoke. This should be done with great care in order not to damage either the threaded shaft or the penta gear.
7) A line the contact chamber with the yoke by making the centerline of the yoke bisect the angle formed by the two contact binding posts. Some meters have been provide with grooved marks on the front of the contact chamber and on top of the upper arm of the yoke; making these marks coincide insure the proper alignment.
8) Tighten the yoke set screw (7) to hold the contact chamber in place.
9) Screw the cap (1) onto the contact chamber
10) Insert the pivot (17) through the hole in the lower arm of the yoke after placing a drop of oil in the lower bearing and on the pivot.
11) Adjust the pivot as described in section Adjusting Pivot. This adjustment allows a vertical play of 0.008 inch, the amount of play used when the meter is rated.
12) Return the meter to an upright position, and remove the cap from the contact chamber. Adjust the penta gear to mesh properly with the threads on the shaft and tighten the small (unnumbered) screw which holds the penta gear assembly.
13) Spin the bucket wheel rapidly while watching the action of the penta gear to make sure that there is complete freedom of action between the gear and the threads on the shaft. Then apply oil to the penta gear and to the three bearing surfaces (one drop on the vertical shaft and two on the horizontal shaft that supports the gear).
14) Adjust the contact wires so that these wires touch the edge of the single and penta eccentrics very lightly. Then replace the cap on the contact chamber and listen with a headset for a sharp click.
15) Place the assembled meter on a solid surface with the shaft vertical, and make a spin test.

Disassembly of Current Meters

Disassembly of Current Meter is easy and should provide no problems for the user
The following precautions however should be observed.

1) Removal of the contact chamber for the yoke should be done carefully and without exerting appreciable force, so that the penta gear and shaft will not be damaged.

2) The contact-chamber cap should never be unscrewed when the upper end of the shaft bears forcible against its underside, a condition which exists if the bucket-wheel raising nut has been previously tightened, and if the pivot adjustment has been made so tight that there is no play between the end of the shaft and the underside of the cap.

Maintenance for Current Meters

Rinse Current Meter in clear water as soon as possible after use and dry using a soft cloth, never place a wet Current Meter in its carrying case. Lubricate Current Meter after approximately 8 hours of use, or at least once a week when use is infrequent. Lubricate Pivot and Pivot Bearing and Upper Bearing in Contact Chamber.
The outline below gives a step-by-step procedure for the cleaning and oiling of current meters

Equipment:

1) Screwdrivers of proper size for use on set screws in the yoke and on the pivot-adjusting nut.
2) Large soft cloth that will readily absorb water for wiping the outer surfaces of the meter.
3) Cotton-tipped swabs for cleaning the bearing surfaces.
4) Supply of oil (instrument oil that is available from the Property Maintenance Sections is preferred) in a container with facilities that permit a drop of oil to be applied in places that otherwise are difficult to reach.
    a. Dismantle the current meter as follows:
        i. Release the raising nut
        ii. Release the two set screws in the yoke, holding the contact chamber and the pivot in place with forefinger and thumb
        iii. Remove the contact chamber from the yoke slowly and carefully. Don not remove the cap at this time
        iv. Remove the pivot from the yoke
        Clean the parts as follows:
            a. Pivot bearing
                a. Clean and dry the air pocket and the pivot bearing, using a cotton-tipped swab
                b. Inspect the pivot bearing
            b. Pivot hole in the yoke
                a. Swab the pivot hole in the yoke with a cotton-tipped swab
            c. Shaft
                a. Clean and dry the shaft-particularly the acme threads
            d. Pivot
                a. Wipe the pivot until it is thoroughly dry
            e. Contact Chamber
                a. Remove the cap and shake out any water that may be trapped within the contact chamber. Occasionally clean the chamber with hot water by letting the water flow into it under pressure.
                b. Wipe the interior of the stem of the contact chamber

c. Swab the hole in the bearing lug by means of a cotton-tipped swab inserted through the stem of the contact chamber. Clean the hole from the bottom as to not risk breaking wires

Oil as follows:

1) Shaft
    a. Apply a film of oil to (a) the acme threads (liberally, so that the excess oil will later spread over the penta gear and the penta shaft), (b) the area that enters the bearing lug, and (c) the uppermost end of the shaft.
2) Pivot Bearing
    a. Apply a thin film of oil over all exposed parts of the pivot bearing
3) Pivot hole in yoke
    a. Apply a drop of oil to the sides of the hole through which the pivot passes
4) Pivot
    a. Apply a thin film of oil to the pivot

Reassembly follows:

1) Replace the pivot and tighten the set screw that holds it in place. Make sure that the pivot lock nut bears against the yoke, and that the set screw bears against the flattened part of the pivot.
2) Fit the contact chamber over the end of the shaft and into its hole in the upper arm of the yoke. Do this slowly and carefully without applying much force; otherwise the penta gear or shaft may become damaged.
3) Match the marks on the contact chamber and yoke, and tighten the set screw holding the contact chamber in place.
4) Check the contact wires. The adjustment of both the single and penta contact wires should be examined to be sure that the adjustments are as light as possible without impairing the electrical contact.
5) Replace the cap on contact chamber.
6) Move the bucket-wheel and hub assembly up and down to determine whether the pivot adjustment is correct.
7) Check the operation of the current meter with a spin test
8) Unless the current meter is to be used immediately, raise the pivot bearing off the pivot by means of the bucket-raising nut.

The Pivot and Pivot Bearing of this meter must be protected to insure proper results when using this instrument. A knurled Nut is provided beneath the Bucket Wheel to raise it and provide clearance between the Pivot and Pivot Bearing when the instrument is in transit. The knurled Nut has a left hand thread, rotate the Nut in the direction in which the impeller would rotate in use in water until you feel resistance, and impeller no longer rotates freely. The upper end of the Shaft to which the Bucket Wheel is mounted now bears against the underside of the Contact Chamber Cap, and a separation exists between Pivot and Pivot Bearing. Reverse the above to bring in the Pivot and Pivot Bearing into contact again when preparing to use the meter.

Adjustment of Pivot

Make sure that the meter has been properly oiled: then hold meter in inverted position whit pivot uppermost.
Release keeper screw (42) for pivot adjusting nut (41) and unscrew the nut a few turns.
Release set screw (13) and advance pivot until all vertical play of the hub assembly is eliminated.
Tighten set screw (13) temporality and advance pivot adjusting nut (41) until it touches the yoke.
Release set screw (13) (not to far because the pivot should not revolve) and advance the pivot adjusting not one-fourth turn. Then tighten keeper screw (42).
Push the pivot inward as far as it will go and tighten set screw (13).

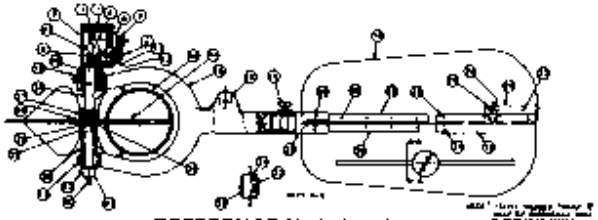
RICKLY HYDROLOGICAL CO.

1700 Joyce Avenue · Columbus, Ohio 43219 · USA
Phone: (614) 297-9877 www.rickly.com
Fax: (614) 297-9878 E-mail: sales@rickly.com

TAKING CARE OF THE CURRENT METER

Rinse Current Meter in clean water as soon as possible after use and dry using a soft cloth. Never place a wet Current Meter in its carrying case. Lubricate Current Meter after approximately 8 hours use or at least once a week when use is infrequent. Lubricate Pivot and Pivot Bearing and Upper Bearing in Contact Chamber.

The Pivot and Pivot Bearing of this meter must be protected to insure proper results when using this instrument. A knurled Nut is provided beneath the Bucket Wheel to raise it and provide clearance between the Pivot and Pivot Bearing when the instrument is in transit. The knurled Nut has a left hand thread; rotate the Nut in the direction in which the Impeller would rotate in use in water until you feel resistance, and Impeller no longer rotates freely. The upper end of the Shaft to which the Bucket Wheel is mounted now bears against the under side of the Contact Chamber Cap, and a separation exists between Pivot and Pivot Bearing. Reverse the above to bring the Pivot and Pivot Bearing into contact again when preparing to use the meter.



REFERENCE NUMBERS

1	CAP	10	PAD	* 19	ANGLE	* 28	LEVER		37	NUT	
2	CHAMBER	11	SCREW	* 20	ANGLE	* 29	RIVET		38	NUT	
* 3	BIND POST	12	WASHER	* 21	ANGLE	* 30	RIVET	*	39	HOUSING	
4	NUT	13	SCREW	* 22	ANGLE	31	WASHER		40	PIVOT	
5	BUSHING	14	SCREW	* 23	CONNECTOR	32	NUT		41	NUT	
* 6	WIRE—SIN	15	YOKE	* 24	RIVET	33	SCREW		42	SCREW	
* 7	WIRE—PEN	16	SCREW		25	PATE CNT	34	SHAFT		43	LUG
8	GEAR	* 17	VANE - HORIZ	* 26	WASHER	35	HUB		* 44	FRAME	
9	AXLE	* 18	VANE - VERT	* 27	PIN	36	KEY		* 45	BUCKET	
									* 46	BEARING	

ADJUSTMENT OF PIVOT

Make sure that the meter has been properly oiled; then hold meter in inverted position with pivot uppermost.

Release keeper screw (42) for pivot adjusting nut (41) and unscrew the nut a few turns.

Release set screw (13) and advance pivot until all vertical play of the hub assembly is eliminated.

Tighten set screw (13) temporarily and advance pivot adjusting nut (41) until it touches the yoke.

Release set screw (13) (not too far because the pivot should not revolve) and advance the pivot adjusting nut one-fourth turn. Then tighten keeper screw (42). Push the pivot inward as far as it will go and tighten set screw (13).

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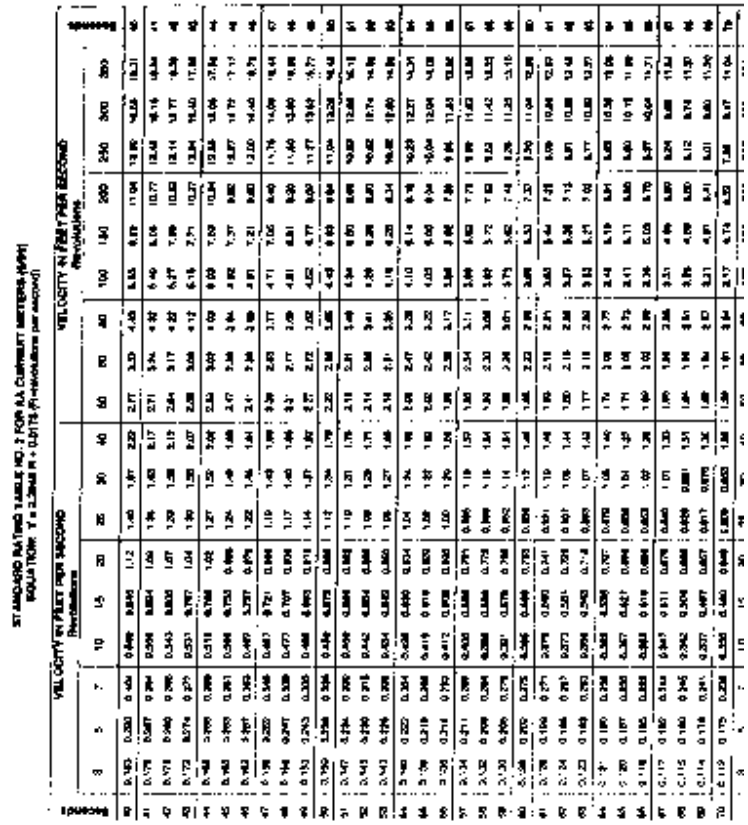
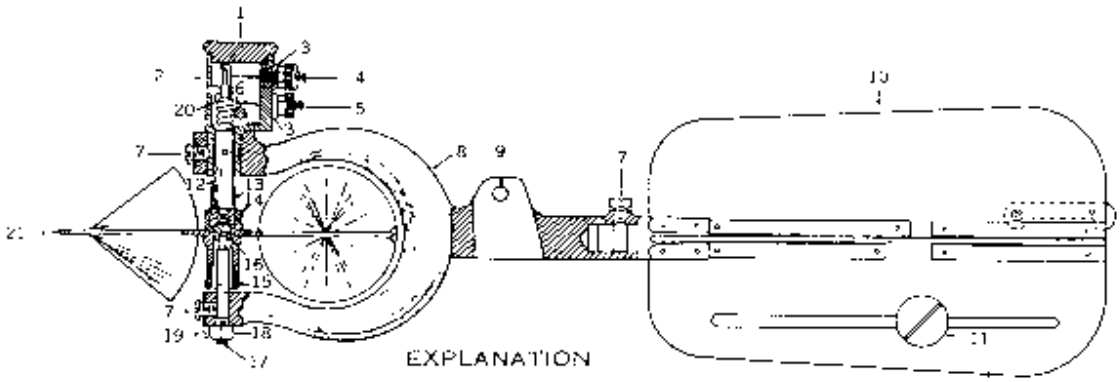




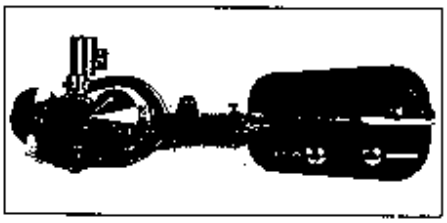
EXPLANATION

1 Cap for contact chamber
2 Contact chamber
3 Insulating bushing for contact binding post
4 Single-contact binding post
5 Penta-contact binding post
6 Penta gear
7 Set screws
8 Yoke
9 Hole for hanger screw
10 Tailpiece
11 Balance weight
12 Shaft
13 Bucket wheel hub
14 Bucket-wheel hub nut
15 Raising nut
16 Pivot bearing
17 Pivot
18 Pivot adjusting nut
19 Keeper screw for pivot adjusting nut
20 Bearing lug
21 Bucket wheel

Figure 3.—Assembly drawing of small Price type AA current meter.

The small Price current meter probably has been used more extensively and has been subjected to more investigation than any other type of current meter. As a result of the extensive investigation and because of the natural advantages afforded by the type, the small Price has been perfected in its details; the type-AA Price meter is now better suited to general use than any other meter. It is light and yet strong, sensitive yet durable. It will measure with a high degree of accuracy velocities ranging from 0.1 foot per second to more than 20 feet per second. It is easily repaired, it can be quickly taken apart for cleaning and oiling, and it can be quickly reassembled without change in rating.

To properly use and care for a current meter, the user must be familiar with all of its parts, as well as with the assembled meter. If any part fails completely because of excessive wear or damage, the condition is usually obvious, but small irregularities that may introduce large percentage errors in velocity determinations are not always readily detected. For this reason the parts of the type-AA meter and their functional characteristics are described, the numbers assigned to the various parts in this description correspond to the numbers used in the assembly diagram of the type-AA current meter shown in figure 2.



Appendix D

Sediment Sampling Hand-Corer Design and Technique

WILDCO HAND CORER

General Description: The Wildco Hand Corer is a simply-designed and low-cost corer sampler particularly interned for shallow water coring in fresh, salt, or brackish waters. It is, because of its simplicity, and excellent corer for student use.
Operating Procedures and Techniques: Using the Wildco Hand Corer to obtain a sample is a simple matter of pushing the corer, by hand, into the sediment to be sampled and then pulling the corer free. A few trials, plus reasonable care in performing the work, will enable the student or researcher to take satisfactory samples.

Here is the procedure:

1) Get in position for the sampling operation, keeping in mind that, if the purpose is to obtain samples containing fauna or stratified sediments, disturbance of the bottom area to be sampled should be avoided.
2) Inspect the core sampler.
    a. Be sure the entire instrument is firmly assembled.
    b. Inspect the core tube and, if one is being use, the tube liner. Be sure it is free of obstruction throughout its length. The penetrating edges of the core tube should be sharp and free of nicks and dents.
    c. Check the flutter valve for ease of movement.
3) Line up the sampler, aim it vertically for the point where the sample is to be taken
4) Push the sampler in a smooth and continuous movement, through the water and into the sediments, increasing the thrust as necessary to obtain the penetration desired.
5) If the corer has not been completely submerged, close the flutter valve by hand and hold it shut while the sample is retrieved.
   With complete submergence, the pull to remove the Wildco Hand Corer from the bottom sediments is normally all that is needed for automatic closure of the flutter value.
6) Lift the core sampler clear of the water, keeping it as nearly vertical as possible, and handle the sample according to the type of core tube and the work in progress.
    a. If a plastic core tube was used and the sample is to be retained in the tube for in situ study:
        i. Cap the bottom of the tube and tape the cap securely in place.
        ii. Release the valve and dismount the core tube from the sampler head.
        iii. Cap the top of the tube, and tape the cap securely in place.
        iv. Scrape any sediment adhering to the tube into a sample jar.
7) Seal all sample jars tightly. Protect cores against drying out by wrapping in several layers of plastic film or by wax coating
8) Label all samples

Hand Corer

- With handles for shallow water coring
- With clevis for deeper water
- Simple automatic flap valve
- Available with or without liners
- Sample by hand or by diver
- Sample by gravity on a line

Wherever you can wade, float or find a dock, you can use the Wildco® hand corer! Here is a low-cost, foolproof sampler especially intended for shallow coring in fresh, salt or brackish waters. Use is simplicity itself: merely push it into bottom sediments using handles on the head assembly. After the corer penetrates the bottom, twist or pull it free to retrieve your sample. In deeper water, you can attach a 5 - 15 foot long extension handle to the head. In deeper water yet, you can drop it by attaching a line to a clevis located on the head assembly between the handles. (If you need more penetration, clamp the auxiliary weight to the core tube.) The hand corer works by creating a partial vacuum which holds the sample in place and helps prevent washout. As the tube is pulled up, the polyurethane flutter valve on the head assembly tightly seals the upper end of the sampler. As long as the bottom end of the tube is 2-3" (50-75 cm) under water, the corers will hold. This device is recommended for student use and comes with or without liners. Carry case and kit components also available separately

Specifications:
- 316 stainless steel head assembly with 2 removable handles, screw pin clevis and polyurethane flutter valve
- Optional extension handle and weights available
- Core tube threaded both ends
- Liner-type includes: 2 nosepieces [2449-A11]; 2 clear CAB liner tubes/caps; 3 eggshell catchers [2449-A13].

What are Core Samplers?
A core, in marine research, is a cylindrical section taken from sediments underlying a water body.

Core samplers, the instruments used to obtain cores, range from the simple to the complex. The variety of corer types reflects the breadth and variety of marine research.

For example, the simplest corers are hand-operated types used in shallow waters to collect sediment cores containing fauna. For biological studies, a core 20-25 cm (8-10”) in length is usually sufficient.

The most complex core samplers are those used in oceanographic research. These are generally large and require winches, power sources and other gear. In extreme cases they can take cores as

long as 25 m (80’). Such cores have provided geological and climatic information through study of the stratified sediments and their contained fossils.

If done properly, core sampling is a reliable method for obtaining basic data for many types of studies pertaining to the water-and-bottom interface of marine bodies. It is often the only practical way - and therefore the best way - to sample underwater strata satisfactorily.

Wildco® core sampling equipment offers dependability, versatility and quality. It ranges from light, hand-operated corers used in shallow water from boats to gravity corers relying on weight such as the K-B™ corer. Interchangeable parts serve as “building blocks” to construct the equipment you need for your particular project. For example, the heads can attach to more than one type of core tube.

The “building block” concept relies on a simple design feature: the uniform use of coarse pipe thread. This thread provides an extremely reliable way to connect core tubes to sampling heads at a low mass-market cost. Because we use straight pipe threads threaded all the way into the head assembly, no pipe wrenches are required - a bonus in the field. While by the very nature of the equipment these threads can become dirty and jam, they can be washed in water to remove debris and easily reattached.

Wildco® hand and Ogeechee™ corers are designed to be lowered on a taut line or cable into the substrate. They are not designed to be dropped because they are top heavy and can easily tip over. While some customers tell us they obtain a good sample by a free drop on a loose line up to 20-30” (7-10 m), to accomplish this you must keep the sampler entirely in water, still and vertical when dropped. This cannot be attempted using bricks or cement blocks as weights due to the need to keep the core tube balanced and vertical.

Maintenance Tips for Wildco Core Samplers: Cleaning Wildco® corer valves:

• Keep valves and seats in corer heads free of dirt, grease and oil to maintain a good air seal. It’s best to clean valve and seat after each sample with 70% ethyl alcohol.
Chemical removal of rust stains from stainless steel:

• Stainless steel parts may show a rust stain, indicating an active corrosion cell area which should be deactivated. These are often caused by scratching or marring the surface.

• Soak the stained area in concentrated HNO3 for a few hours or make a paste to spread over the stain using Vaseline, corn starch or other thickener. Repeat as needed.

• Sand blasting with clean silica sand will remove rust but must be rinsed with strong HNO3 to prevent future damage.

• If left in salt water, stainless steel corrodes quickly. All stainless steel should be rinsed at once with fresh water after removal from salt water.

Appendix E

Glossary

Glossary/Definitions

Accuracy-a measure of how close repeated trials are to the desired target

Acidity-a measure of the number of free hydrogen ions (H^+) in a solution that can chemically react with other substances

Alkalinity-a measure of the quantity of compounds that shift the pH to the alkaline side of neutrality (above 7) or it is a measure of the capacity of water to neutralize acids. The pH of a normal stream usually falls between 6.5 and 8.5.

Ambient-pertaining to the current environmental condition

Ammonia (NH_3) - Ammonia (NH3+) is a colorless gas with a strong pungent odor. It is easily liquefied and solidified and is very soluble in water. Ammonia is toxic to fish and other living organisms in the water. The un-ionized form of ammonia (NH3) should not exceed 0.05 mg/L in order to protect aquatic organisms.

Assemblage-the set of related organisms that represent a portion of a biological community (e.g. benthic macroinvertebrates)

Benthic-pertaining to the bottom (bed) of a water body

Best Management Practices (BMP) - Management practices or techniques used to guide improvements to minimize adverse environmental impacts. Often organized into a list of practices, from which those practices most suited to a specific site can be chosen to halt or offset anticipated problems.

Biological Oxygen Demand (BOD)-a measure of the oxygen in the water that is required by the aerobic organisms. Rivers with high BOD have high nutrient levels in the water. Most of the oxygen is consumed by the organisms. Rivers with low BOD have low nutrient levels; therefore, much of the oxygen remains in the water. Unpolluted, natural waters will have a BOD of 5 mg/L or less.

Biological criteria-numerical values or narrative descriptions that depict the biological integrity of aquatic communities in that state. May be listed in state water quality standards.

Buret-a graduated glass tube used for measuring and releasing small and precise amounts of liquid

Calibration-is the setting or correcting of a measuring device or base level, usually by adjusting it to match or conform to a dependably known and unvarying measure.

Chain of Custody (COC) - an unbroken trail of accountability that ensures the physical security of samples, data and records. This is a sheet or log book that is sent with the samples for analysis with the tests that are to be run and the information that the lab needs to make concise and accurate records.

Channel-the section of the stream that contains the main flow

Channelization-the straightening of a stream; this often is a result of human activity

Chemical constituents-chemical components that are part of a whole

Chemical Oxygen Demand (COD)-the amount of oxygen required to degrade the organic compounds of waste water. The bigger the COD value of waste water, the more oxygen the discharges demand from water bodies.

Chlorophyll-a-the most common type of chlorophyll. Chlorophyll a is measured to estimate the abundance of phytoplankton in the water. More chlorophyll-a indicates that there are more phytoplankton present. Most chlorophyll a is found near the surface of the water because there is less light at depth. Chlorophyll a concentrations are often highest just below the surface, not at the surface of the water.

Conductance (Conductivity)-the amount of ionic material dissolved in the water that can hold an electrical charge. Ionic materials like salts are good conductors. Seawater has a higher conductivity then freshwater.

Cobble-medium-sized rocks (210 inches) that are found in a stream bed

Combined sewer overflow (CSO)-sewer systems in which sanitary waste and stormwater are combined in heavy rains; this is especially common in older cities. The discharge from CSOs is typically untreated

Community-the whole part of the plant and animal population inhabiting a given area

Culvert-man-made construction that diverts the natural flow of water

Dframe net- a fine mesh net that is attached to a pole and used for sampling. It resembles a butterfly net

Deionized water-water that has had all of the ions (atoms and molecules) other then hydrogen and oxygen removed

Designated uses-state-established desirable uses that water should support, such as fishing, swimming, and aquatic life. Listed in state water quality standards

Dissolved Oxygen (DO)-a measure of the amount of oxygen freely available in water. It is commonly expressed as a concentration in terms of milligrams per liter (mg/L) or ppm, or as a percent saturation which is temperature dependent. Oxygen is the single most important gas for most aquatic organisms; free oxygen (O) or DO is needed for respiration. The colder the water, the more oxygen it can hold. DO levels below 3 ppm are stressful to most aquatic organisms. DO levels below 1 ppm will not support fish; levels of 5 to 6 ppm are usually required for most fish.

Distilled water-water that has had most of its impurities removed

Dredge-to remove sediments from the stream bed to deepen or widen the channel

Ecoregion-geographic areas that are distinguished from others by ecological characteristics such as climate, soils, geology.
Effluent-wastewater discharge

Embeddedness-the degree to which rocks in the streambed are surrounded by sediment

Emergent plants-plants rooted underwater, but with their tops extending above the water

Erlenmeyer flask-a flask having a wide bottom and a smaller neck and mouth that is used to mix liquids

Eutrophication-the natural and artificial addition of nutrients to a waterbody, which may lead to depleted oxygen concentrations. Eutrophication is a natural process that is frequently accelerated and intensified by human activities

Fecal Coliform- defined as bacteria that ferment lactose with gas formation and grow on specialized media within 24 hours at 44.5 degrees Celsius. Fecal coliform can be found in populations ranging from 0 to thousands of colonies per milliliter of water. High counts of fecal coliform bacteria in rivers, streams and lakes are caused by contamination from the intestinal tract of humans and other warm-blooded animals. Fecal coliform bacteria are not in themselves harmful, but are associated with other bacteria and viruses which are, such as typhoid fever, hepatitis A, cholera, dysentery.

Field Blank-samples obtained by running deionized water through the sampling equipment and placing in appropriate containers for analysis. The field blank is used to check for contamination from the samplers.

Field Duplicate-independent samples collected in such a manner that they are representative of the population being sampled at a given point in time and space. Sometimes called side-by-side samples.

Floating plants-plants that grow free floating, rather than being attached to the stream bed

Flocculent (floc)-a mass of particles that form into a clump as a result of a chemical reaction

Glide/run-section of a stream with a relatively high velocity and with little or no turbulence on the surface of the water

Graduated cylinder-a cylinder used to measure liquids that is marked in units

Gross morphological features-large obvious identifying physical characteristics of an organism

Headwaters-the origins of a stream

Hypoxia-depletion of dissolved oxygen in an aquatic system

Impairment-degradation

Impoundment-a body of water contained by a barrier, such as a dam

Inert-not chemically or physically active

Integrated Lake Sampler-a PVC pipe with a plug at one end that is used to collect a vertical column of water for Chlorophyll-a samples, Total Phosphorus samples in the middle of a lake. The integrated lake sampler is often used only for depth of 1 meter.

Kick net-a fine mesh net used to collect organisms. Kick nets vary in size, but generally are about three feet long and are attached to two wooden poles at each end

Land uses-activities that take place on the land, such as construction, farming, or tree clearing

Macroinvertebrates-organisms that lack a backbone and can be seen with the naked eye

National Pollutant Discharge Elimination System (NPDES)-a national program in which pollution dischargers such as factories and sewage treatment plants are given permits to discharge. These permits contain limits on the pollutants they are allowed to discharge

Nitrate/Nitrites (NO_2+NO_3)- Nitrates and nitrites are nitrogen-oxygen chemical units which, combine with various organic and inorganic compounds. Once taken into the body, nitrates are converted into nitrites. The greatest use of nitrates is as a fertilizer.

Orthophosphate-inorganic phosphorus dissolved in water

Outfall-the pipe through which industrial facilities and wastewater treatment plants discharge their effluent (wastewater) into a waterbody

Permeable-porous

pH- a measure of acidity and alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality and lower numbers indicate increasing acidity and higher numbers increasing alkalinity and on which each unit of change represents a tenfold change in acidity or alkalinity and that is the negative logarithm of the effective hydrogen-ion concentration or hydrogen-ion activity in gram equivalents per liter of the solution.

Phosphorus-a nutrient that is essential for plants and animals, but in large amounts can damage a waterbody

Photosynthesis-the chemical reaction in plants that utilizes light energy from the sun to convert water and carbon dioxide into simple sugars. This reaction is facilitated by chlorophyll

Pipet-an eyedropper-like instrument that can measure very small amounts of a liquid

Pool-deeper portion of a stream where water flows slower than in neighboring, shallower portions

Precision-a measure of how close repeated trials are to each other

Protocol-defined procedure

Quality Assurance Project Plan (QAPP)-an outline of the project, agencies, tasks and budget to follow. This is usually done before the SAP is started.

Quality Assurance/Quality Control (QA/QC)-standard procedures to follow when in the field to insure proper quality and quantity of the samples collected.

Reagent-a substance or chemical used to indicate the presence of a chemical or to induce a chemical reaction to determine the chemical characteristics of a solution

Riffle-shallow area in a stream where water flows swiftly over gravel and rocks

Riparian-of or pertaining to the banks of a body of water

Riparian zone-the vegetative area on each bank of a body of water

Riprap-rocks used on an embankment to protect against bank erosion

***Run*/glide**-see glide/run

Sampling and Analysis Plan (SAP)-a specific plan for a project listing out all tasks and parties involved.

Saturated-inundated; filled to the point of capacity or beyond

Secchi disk-a disk that is 20 centimeters in diameter and divided into alternating black and white quadrants to enhance visibility and contrast (although some are totally white). This disk is used to measure the turbidity of the water.

Sheen-the glimmering effect that oil has on water as light reflected more sharply off the surface

Sieve bucket-a bucket with a screen bottom that is used to wash macroinvertebrate samples and to removed excess silt and mud

Silviculture-forestry and the commercial farming of trees

Standard Operating Procedures (SOP) - is a set of written instructions that document a routine or repetitive activity followed by an organization. SOPs detail the work processes that are to be conducted or followed within an organization. They document the way activities are to be performed to facilitate consistent conformance to technical and quality system requirements and to support data quality. SOPs are intended to be specific to the organization or facility whose activities are described and assist that organization to maintain their quality control and quality assurance processes and ensure compliance with governmental regulations.

STORET-is EPA's STOrage and RETrieval system for water quality data, this is a computer database that holds all of the water quality data for the whole United States.

Submergent plants-plants that live and grow fully submerged under the water

Substrate-refers to a surface. This includes the material comprising the stream bed or the surfaces to which plants or animals may attach or live upon

Taxon (plural taxa)-a level of classification within a scientific system that categorized living organisms based on their physical characteristics

Taxonomic key-a quick reference guide used to identify organisms. They are available in varying degrees of complexity and detail

Titration-the addition of small, precise quantities of a reagent to a sample until the sample reached a certain endpoint. Reaching the endpoint is usually indicated by a color change

Tolerance-the ability to withstand a particular condition, e.g., pollution-tolerant indicated the ability to live in polluted waters

Total Kjeldahl Nitrogen (TKN)-represents the nitrogen equivalent available from ammonia and organic nitrogen. TKN levels are important for assessing the amount of nitrogen available for biological activities.

Total Phosphorus (TP) - Phosphorus is usually present in river water as phosphates, and is in very small amounts unless there has been human caused enrichment of the water. The natural scarcity of phosphorus can be explained by its attraction to organic matter in soil particles. Generally the lower the total phosphorus value in the water, the better. Total phosphorus includes organic and inorganic phosphate. Organic phosphate is a part of living plants and animals. Inorganic phosphates comprise the ions bonded to soil particles, and phosphates present in laundry detergents (polyphosphates). Phosphorus is considered to be a limiting factor in aquatic systems, meaning that it is not freely available for easy consumption by aquatic organisms.

Total Dissolved Solids (TDS) - The total dissolved solids test measures the amount of particles that are dissolved in the river water. The USEPA standard is 500 mg/L or ppm. The quantity of TDS in a body of water depends on several factors, including: the precipitation contributing to the body of water (Rainwater is almost pure with less than 10 ppm TDS.), the type of soil and rock the water passes over, and human activities.

Total Suspended Solids (TSS)- Suspended solids are pieces of sand, silt and the fine organic matter of leaves, pieces of wood, etc. suspended in a stream or lake. The faster flowing water erodes the banks and because the stream is moving so fast, the suspended solids don't have a chance to settle to the bottom.

Tolerance-the ability to withstand a particular condition, e.g., pollution-tolerant indicated the ability to live in polluted waters

Tributaries-a body of water that drains into another, typically larger, body of water

Turbidity-the measurement of lack of water clarity. Turbidity is the result of suspended solids in the water. Suspended solids are variable, ranging from clay, silt, and plankton, to industrial wastes and sewage. A rough measure of turbidity can be made with a Secchi Disk, but more accurate measurements need to be taken with a turbidimeter, Turbidity is measured in NTUs, the abbreviation for nephelometric turbidity unit.

Volumetric flask-a flask that holds a predetermined amount of liquid

Water quality criteria-maximum concentrations of pollutants that are acceptable, if those waters are to meet water quality standards. Listed in state water quality standards

Water quality standards-written goals for state waters, established by each state and approved by EPA

Watershed-the area of land drained by a particular river or stream system

Appendix F

Water Monitoring Checklists

WATER MONITORING CHECKLISTS

TASKS TO COMPLETE BEFORE THE TRIP

MONITORING PLAN

-Develop Monitoring Plan ___
-If applicable, notify Lab about the seasonal monitoring schedule ___
-Sample site directions and map ___

RESERVATIONS

-Vehicle ___
-Boat and Trailer ___
-Field Monitoring Equipment ___
-Motel/Hotel (if necessary) ___

LAB ARRANGEMENTS

-Order Bottles ___
-Freeze ice packs/cubes ___

QUALITY ASSURANCE

-If necessary, obtain Standard Operating Procedures for Field Methods ___
-Inspect/Test Monitoring Equipment ___
-Develop plan for Field QA Samples ___
-Calibrate meters ___

EQUIPMENT AND SUPPLIES

STREAM MONITORING EQUIPMENT AND SUPPLIES

SONDES AND METERS

-Carrying case ___
-Multiparameter sonde ___
-Probe membranes ___
-Probe filling solutions ___
-Cable (no. of feet __) ___
-Portable turbidimeter (HACH 2100P) ___

SAMPLER KIT

-Sampler (Van Dorn, Kemmerer) ___
-Extra trip head ___
-Extra messenger ___
-Carrying case ___
-Cable (no. of feet ___) ___

STREAM GAGE EQUIPMENT

-Pygmy meter/AA meter ___
-Headset/Stopwatch ___
-Flow recording sheets ___
-Automatic Reader ___
-Long tape, stakes ___
-Wading rods ___
-Bridge crane and weight ___
-Data sheets ___

OTHER EQUIPMENT AND SUPPLIES

-Chain of Custody ___
-Large beaker or bucket ___
-Turbidity meter ___
-Transparency Tubes (60 & 100 cm) ___
-Digital Camera ___
-Cooler and ice packs ___
-Ice Auger (winter conditions) ___
-Weighted tape or Survey Rod ___
-Field data sheets ___
-Watch or other type of a clock ___
-Rubber gloves (in winter) ___
-Latex gloves (in summer) ___
-200 ml bottles ___
-500 ml bottles ___
-1000 ml bottles ___
-Safety equipment ___
-Extra bottles for duplicates and field blanks ___
-Preservatives (H_2SO_4) ___
-Kim-wipes ___
-Distilled water ___
-Pencils and Pens ___
-Shipping labels ___
-Packin-Develop plan for Field QA Samples ___
g tape ___
-Jug of tap water for general cleaning ___
-Other _____ ___

LAKE MONITORING EQUIPMENT AND SUPPLIES

MULTI-PARAMETER SONDE

-Carrying case ___
-Meter with removable cup ___
-Probe membranes ___
-Probe filling solutions ___
-Cable (no. of feet __) ___

SAMPLER KIT

-Sampler body ___
-Extra trip head ___
-Extra messenger ___
-Carrying case ___
-Cable (no. of feet ___) ___

LAKE SAMPLING EQUIPMENT

-Integrated Sampler ___
-Sampler (depth) ___
-Hydrolab ___
-GPS unit ___
-Boat and Trailer ___
-Life jackets ___
-Profile/Lake Sampling sheets ___
-1 liter Amber bottle ___
-500 ml bottle ___
-Extra bottles for duplicates and field blanks ___
-Other _____ ___
-Preservatives (H_2SO_4) ___
-Secchi (in meters) ___

BOAT AND TRAILER

-Boat drain plug ___
-Anchor(s) ___
-Gas for engine ___
-Check straps on boat ___
-Check boat crank tie-down and safety chains ___
-Check trailer hitch/lights ___

ZOOPLANKTON/PHYTOPLANKTON

-Zooplankton net ___
-Clear polyethylene sample bottles ___
-99% Isopropyl alcohol (for preserving ___
-Squirt bottle w/tap water ___
-Labels ___

RIVERWATCH SAMPLING EQUIPMENT

-YSI or Hydrolab/Sonde 4 ___
-Van Dorn or Sampler (depending on school equipment) ___
-Hip boots or waders ___
-Turbidity meter ___
-Kim-wipes ___
-Transparency tubes (60 & 100 cm) ___
-Clipboard and pen ___
-Field data sheets ___
-Cooler and ice (if sending out samples) ___
-Thermometers ___
-Camera for pictures ___
-Tape (for measuring water depth & stream width) ___

OTHER SUPPLIES

VEHICLE

-Adjust mirrors ___
-Check fluid levels (gas, oil, washer fluid, antifreeze) ___
-Check tire inflation levels ___
-Vehicle kit (flares, washer fluid, lug nut wrench, car and boat jacks) ___

SAFETY

-First aid kit ___
-Safety vests ___
-Traffic Cones ___
Roof-top flasher/beacon ___
-Flotation devices (life jackets, throwable device) ___
-Survival kit ___
-Safety boots ___
-Safety eye glasses/goggles ___
-Nitrile gloves ___
-Extra clothes for winter ___
-Check weather conditions ___

MISCELLANEOUS SUPPLIES

-Permanent markers and pencils ___
-Cooler(s) and ice ___
-Lab sheets ___
-Field sheets (waterproof, if necessary) ___
-Field notebook ___
-Clipboard ___
-Compass ___
-GPS ___
-Extra Batteries ___
-Maps (state, county, lake) ___
-Labels (if needed) ___
-Gloves (if needed) ___
-Phosphate-free soap, solvent, and acid (See SOPs for cleaning equip.) ___
-Waste bottles (to collect solvent rinse) ___
-Tool box ___
-Cellular phone ___
-Duct tape ___
-Extra line (rope) ___
-Camera and film or disk (digital) ___
-Waders (hip and chest) ___
-Rain gear ___
-Change of clothes ___
-Sunglasses and hat ___
-Sunscreen ___
-Insect repellent ___
-Kim-wipes ___

TOOLKIT/SUPPLIES for CONTINUOUS MONITORING EQUIPMENT DEPLOYMENT

- -Wire rope cable (1/16", 1/8" etc.) ___
- -Cable clips ___
- -Pressed metal sleeves ___
- -Claw hammer ___
- Sledge hammer ___
- Level ___
- Nylon rope ___
- String ___
- Assorted screws ___
- Assorted bolts ___
- PVC primer and glue ___
- Bolt cutter ___
- Wrenches ___
- Allen wrenches ___
- Tape measure ___
- S-hooks ___
- Turnbuckles ___
- Whisk broom ___
- Wire brush ___
- Hose clamps ___
- Duct tape ___
- Hand saw ___
- Utility knife ___
- Pliers ___
- Paper towels ___
- Padlocks ___
- Work gloves ___
- Permanent marker ___
- Fluorescent marking tape ___
- Chisel (for benchmarks) ___
- Spray bottle with soapy water ___

Appendix G

SOP Comment Sheet

Standard Operating Procedures for Water Quality Monitoring
Comment Sheet

Name:_____
Organization:_____
Phone Number:_____
Email Address:_____

Comments:

Chapter/Section:_____
Comment:_____
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Chapter/Section:_____
Comment:_____
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Chapter/Section:_____
Comment:_____
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_____

Please mail to:

Corey Hanson
Red Lake Watershed District
1000 Pennington Ave S
Thief River Falls, MN 56701

Or email to:

coreyh@wiktel.com

Appendix F

USGS NFM Table A-1 (Turbidity Units)

Attachment 2- NFM Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August 19, 2004.

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
[For decisions on appropriate instrument design refer to figure 6.7-2. For specific instrument specifications, contact manufacturers directly. **Abbreviations**: PCODE, parameter code; N/A, not applicable or unavailable; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity ratio units; BU, backscatter units; AU, attenuation units; NTMU, nephelometric turbidity multi-beam units; FNU, formazin nephelometric units; FNRU, formazin nephelometric ratio units; FBU, formazin backscatter units; FAU, formazin attenuation units; FNMU, formazin nephelometric multibeam units; nm, nanometers; °, degree; USEPA 180.1, United States Environmental Protection Agency method 180.1; ASTM D1899-00, American Society for Testing and Materials method D1899-00; ISO 7027, International Organization for Standardization method 7027; GLI M2, Great Lakes Instruments Company Method 2; >, greater than; ± plus or minus]

Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
White or Broadband (480-680 nm) Light Source, 90° detection angle, one detector.	NTU	Compliant with USEPA 180.1, Hach 10133, and ASTM D1899-00. Primarily for drinking water applications or low turbidity. Measurement should not be >40 NTU.	63675	HACH, sensor model 2100 AN (Ratio OFF), NTU	A	USEPA 180.1	Static	Flow-through accessory provides more dynamic measurement, making readings more stable.
				HACH, sensor model 2100 N (Ratio OFF), NTU	B	USEPA 180.1	Static	Flow-through accessory provides more dynamic measurement, making readings more stable.
				HACH, sensor model 1720 C, NTU	C	USEPA 180.1	Process	
				HACH, sensor model 1720 D, NTU	D	USEPA 180.1	Process	
				HACH, sensor model 1720 E, NTU	E	USEPA 180.1	Process	
				HACH, sensor model Filter Track 660, NTU	F	Hach 10133	Process	
				HACH, sensor model SS6, NTU	G	N/A	Process	Not USEPA 180.1 approved
				HF Scientific, Sensor Model Micro100 (Light source WHITE), NTU	H	USEPA 180.1	Static	
				HF Scientific, Sensor Model Micro200, NTU	I	USEPA 180.1	Process	
				HF Scientific, Sensor Model DRT-15CE, NTU	J	USEPA 180.1	Static (Portable)	
				HF Scientific, Sensor Model Micro 1000 (light source WHITE, Ratio OFF), NTU	K	USEPA 180.1	Static	Flow-through accessory provides more dynamic measurement, making readings more stable. Instrument option allows choice of ratiometric or non-ratiometric mode.
				ICM, Sensor Model 11150, NTU	L	USEPA 180.1	Static	
				ICM, Sensor Model 11152, NTU	M	USEPA 180.1	Static (Portable)	
				LaMotte Instruments Sensor Model 2008, NTU	N	USEPA 180.1	Static	

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
[For decisions on appropriate instrument design refer to figure 6.7-2. For specific instrument specifications, contact manufacturers directly. **Abbreviations**: PCODE, parameter code; N/A, not applicable or unavailable; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity ratio units; BU, backscatter units; AU, attenuation units; NTMU, nephelometric turbidity multi-beam units; FNU, formazin nephelometric units; FNRU, formazin nephelometric ratio units; FBU, formazin backscatter units; FAU, formazin attenuation units; FNMU, formazin nephelometric multibeam units; nm, nanometers; °, degree; USEPA 180.1, United States Environmental Protection Agency method 180.1; ASTM D1899-00, American Society for Testing and Materials method D1899-00; ISO 7027, International Organization for Standardization method 7027; GLI M2, Great Lakes Instruments Company Method 2; >, greater than; ± plus or minus]

Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
White or Broadband (480-680 nm) Light Source, 90° detection angle, one detector. (*continued*)	NTU (*continued*)	Compliant with USEPA 180.1, Hach 10133, and ASTM D1899-00. Primarily for drinking water applications or low turbidity. Measurement should not be >40 NTU.	63675	Orbeco-Hellige, Sensor Model 965-10A, NTU	O	USEPA 180.1	Static	
				Orbeco-Hellige, Sensor Model 966-01, NTU	P	USEPA 180.1	Static (Portable)	
				WTW Measurement Systems, sensor model 550, NTU	Q	USEPA 180.1	Static	
				Turbiquant Sensor Model 1500 T, NTU	R	USEPA 180.1	Static	
				Turbiquant Sensor Model 3000 T (Ratio OFF), NTU	S	USEPA 180.1	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.
White or Broadband (480-680 nm) Light Source, 90° detection angle, multiple detectors with ratio compensation.	NTRU	Compliant with USEPA 180.1 and ASTM D1899-00 for turbidities <40 NTRU. Use Ratio mode on applicable NTU instruments when turbidity >40.	63676	HACH, sensor model 2100 AN (Ratio ON), NTRU	A	USEPA 180.1	Static	
				HACH, sensor model 2100 N (Ratio ON), NTRU	B	USEPA 180.1	Static	
				HACH, sensor model 2100 P, NTU	C	USEPA 180.1	Static (Portable)	
				HF Scientific, Sensor Model Micro 1000 (light source WHITE, Ratio ON), NTRU	D	USEPA 180.1	Static	
				LaMotte Instruments, Sensor model 2020, NTRU	E	USEPA 180.1	Static	
				Turbiquant Sensor Model 3000 T (Ratio ON), NTRU	F	USEPA 180.1	Static	
				WTW Measurement Systems, sensor model 555, NTRU	G	USEPA 180.1	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
[For decisions on appropriate instrument design refer to figure 6.7-2. For specific instrument specifications, contact manufacturers directly. **Abbreviations**: PCODE, parameter code; N/A, not applicable or unavailable; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity ratio units; BU, backscatter units; AU, attenuation units; NTMU, nephelometric turbidity multi-beam units; FNU, formazin nephelometric units; FNRU, formazin nephelometric ratio units; FBU, formazin backscatter units; FAU, formazin attenuation units; FNMU, formazin nephelometric multibeam units; nm, nanometers; °, degree; USEPA 180.1, United States Environmental Protection Agency method 180.1; ASTM D1899-00, American Society for Testing and Materials method D1899-00; ISO 7027, International Organization for Standardization method 7027; GLI M2, Great Lakes Instruments Company Method 2; >, greater than; ± plus or minus]

Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
White or Broadband (480-680 nm) Light Source, 30 ± 15° detection angle (backscatter).	BU	Applicable for high particle densities	63677	HACH, sensor model 2100 AN (light source WHITE, Backscatter ON), BU	X	N/A	Static	
				HF Scientific, Sensor Model Micro 1000 (light source WHITE, Ratio OFF, Backscatter ON), BU	Y	N/A	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.
White or Broadband (480-680 nm) Light Source, 180 ° detection angle (attenuation)	AU	Instrument response negatively correlated with particle density	63678	HACH, sensor model 2100 AN (light source WHITE, Attenuation ON), BU	X	N/A	Static	
				HF Scientific, Sensor Model Micro 1000 (light source WHITE, Ratio OFF, Attenuation ON), AU	Y	N/A	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.
White or Broadband (480-680 nm) Light Source, Multiple light sources. Detectors at 90° and possibly other angles to each beam.	NTMU	Instrument algorithm uses a combination of detector readings, which may differ for values of varying magnitude	63679	Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.

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Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static / Dynamic / Process	Comments
Near Infrared (780-900 nm) or Monochrome light source. 90° detection angle, one detector	FNU	ISO 7027 compliant (at <40 FNU). Compensates for color in sample. Includes most submersible probes used for profiling and continuous monitoring.	63680	Eureka Environmental, Sensor model Trimeter, FNU	A	ISO 7027	Dynamic	
				Forest Technology Systems, Sensor Model DTS-12, FNU	B	ISO 7027	Dynamic	
				Greenspan, sensor model TS 100, FNU	C	ISO 7027	Dynamic	
				Greenspan, sensor model TS 300, FNU	D	ISO 7027	Dynamic	
				Greenspan, sensor model TS 1200, FNU	E	ISO 7027	Dynamic	
				HACH, sensor model 2100 N IS (Ratio OFF), FNU	F	ISO 7027	Static	With Infrared filter installed downstream of white light source
				HACH, sensor model 2100 AN IS (Ratio OFF), FNU	G	ISO 7027	Static	With Infrared filter installed downstream of white light source
				HACH, sensor model 1720 D/L, FNU	H	ISO 7027	Static (Portable)	
				HACH, sensor model Optiquant, FNU	I	ISO 7027	Static	
				HACH, sensor model Pocket Turbidimeter, FNU	J	ISO 7027	Static	
				HF Scientific, Sensor Model Micro TPI, FNU	K	ISO 7027	Static	
				HF Scientific, Sensor Model Micro100 (light source INFRA RED), FNU	L	ISO 7027	Static	
				HF Scientific, Sensor Model Micro 1000 (light source INFRA RED, Ratio OFF), FNU	M	ISO 7027	Static	
				Hydrolab, sensor model Datasonde 4, FNU	N	ISO 7027	Dynamic	
				In-Situ, sensor model MP TROLL 9000, FNU	O	ISO 7027	Dynamic	

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
[For decisions on appropriate instrument design refer to figure 6.7-2. For specific instrument specifications, contact manufacturers directly. **Abbreviations**: PCODE, parameter code; N/A, not applicable or unavailable; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity ratio units; BU, backscatter units; AU, attenuation units; NTMU, nephelometric turbidity multi-beam units; FNU, formazin nephelometric units; FNRU, formazin nephelometric ratio units; FBU, formazin backscatter units; FAU, formazin attenuation units; FNMU, formazin nephelometric multibeam units; nm, nanometers; °, degree; USEPA 180.1, United States Environmental Protection Agency method 180.1; ASTM D1899-00, American Society for Testing and Materials method D1899-00; ISO 7027, International Organization for Standardization method 7027; GLI M2, Great Lakes Instruments Company Method 2; >, greater than; ± plus or minus]

Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
Near Infrared (780-900 nm) or Monochrome light source. 90° detection angle, one detector *(continued)*	FNU *(continued)*	ISO 7027 compliant (at <40 FNU). Compensates for color in sample. Includes most submersible probes used for profiling and continuous monitoring. *(continued)*	63680	McVan, sensor model Analite NEP 160-3 (90 deg), FNU	P	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 195, FNU	Q	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 390, FNU	R	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 391, FNU	S	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 395, FNU	T	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 396, FNU	U	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 495, FNU	V	ISO 7027	Dynamic	
				McVan, sensor model Analite NEP 9000, FNU	W	ISO 7027	Process	
				McVan, sensor model Analite NEP 9500, FNU	X	ISO 7027	Process	
				Orbeco-Hellige, Sensor Model 965-IR, FNU	Y	ISO 7027	Process	
				Orbeco-Hellige, Sensor Model 966-IR, FNU	9	ISO 7027	Process	
				Turbiquant sensor model 1000 IR, FNU	0	ISO 7027	Static	
				Turbiquant sensor model 1500 IR, FNU	1	ISO 7027	Static	
				Turbiquant sensor model 3000 IR (Ratio OFF), FNU	2	ISO 7027	Static	
				YSI Environmental, sensor model 6026, FNU	3	ISO 7027	Dynamic	
				YSI Environmental, sensor model 6026-4000, FNU	4	ISO 7027	Dynamic	YSI 6026 sensor factory adjusted to allow readings and calibration to 4000 FNU

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
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Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
Near Infrared (780-900 nm) or Monochrome light source. 90° detection angle, one detector *(continued)*	FNU *(continued)*	ISO 7027 compliant (at <40 FNU). Compensates for color in sample. Includes most submersible probes used for profiling and continuous monitoring. *(continued)*	63680	YSI Environmental, sensor model 6136, FNU	5	ISO 7027	Dynamic	
				WTW Measurement Systems, sensor model 350 IR, FNU	6	ISO 7027	Static (Portable)	
				WTW Measurement Systems, sensor model 550 IR, FNU	7	ISO 7027	Static	
				WTW Measurement Systems, sensor model VisoTurb 700 IQ, FNU	8	ISO 7027	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.
Near Infrared (780-900 nm) or Monochrome light source. 90° detection angle, multiple detectors, ratio compensation	FNRU	ISO 7027 compliant (at <40 FNU). Compensates for color in sample. Ratio mode provides added color compensation and stability at high particle densities.	63681	HACH, sensor model 2100 AN IS (Ratio ON), FNRU	A	ISO 7027	Static	
				HF Scientific, Sensor Model Micro 1000 (light source INFRA RED, Ratio ON), FNRU	B	ISO 7027	Static	
				Turbiquant sensor model 3000 IR (Ratio ON), FNRU	C	ISO 7027	Static	
				WTW Measurement Systems, sensor model 555 IR, FNRU	D	ISO 7027	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
[For decisions on appropriate instrument design refer to figure 6.7-2. For specific instrument specifications, contact manufacturers directly. **Abbreviations**: PCODE, parameter code; N/A, not applicable or unavailable; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity ratio units; BU, backscatter units; AU, attenuation units; NTMU, nephelometric turbidity multi-beam units; FNU, formazin nephelometric units; FNRU, formazin nephelometric ratio units; FBU, formazin backscatter units; FAU, formazin attenuation units; FNMU, formazin nephelometric multibeam units; nm, nanometers; °, degree; USEPA 180.1, United States Environmental Protection Agency method 180.1; ASTM D1899-00, American Society for Testing and Materials method D1899-00; ISO 7027, International Organization for Standardization method 7027; GLI M2, Great Lakes Instruments Company Method 2; >, greater than; ± plus or minus]

Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
Near Infra-Red (780-900 nm) or Monochrome light source. 30±15° detection angle (Backscatter)	FBU	Applicable for high particle densities where color compensa-tion also is Required.	63682	D-A Instruments Co, Sensor Model OBS-3, FBU	S	N/A	Static	
				D-A Instruments Co, Sensor Model OBS-3A, FBU	T	N/A	Static	
				HACH, sensor model 2100 AN IS (light source INFRA RED, Backscatter ON), FBU	U	N/A	Static	
				HF Scientific, Sensor Model Micro 1000 (light source INFRA RED, Ratio ON, Backscatter ON), FBU	V	N/A	Static	
				McVan, sensor model Analite NEP 160-1 (180 deg), FBU	W	N/A	Static	
				McVan, sensor model Analite NEP 180 (180 deg), FBU	X	N/A	Static	
				McVan, sensor model Analite NEP 185 (180 deg), FBU	Y	N/A	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.
Near Infrared (780-900 nm) or Monochrome light source, 180° detection angle (Attenuation)	FAU	ISO 7027 compliant (at >40 FAU).	63683	HF Scientific, Sensor Model Micro 1000 (light source INFRA RED, Ratio ON, Attenuation ON), FAU	A	ISO 7027	Static	
				Turbiquant sensor model 3000 IR (>40), FAU	B	ISO 7027	Static	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.

Table A-1: Parameter codes and method codes corresponding to instrument designs, reporting units, and currently available instruments, as of August, 2004.
[For decisions on appropriate instrument design refer to figure 6.7-2. For specific instrument specifications, contact manufacturers directly. **Abbreviations**: PCODE, parameter code; N/A, not applicable or unavailable; NTU, nephelometric turbidity units; NTRU, nephelometric turbidity ratio units; BU, backscatter units; AU, attenuation units; NTMU, nephelometric turbidity multi-beam units; FNU, formazin nephelometric units; FNRU, formazin nephelometric ratio units; FBU, formazin backscatter units; FAU, formazin attenuation units; FNMU, formazin nephelometric multibeam units; nm, nanometers; °, degree; USEPA 180.1, United States Environmental Protection Agency method 180.1; ASTM D1899-00, American Society for Testing and Materials method D1899-00; ISO 7027, International Organization for Standardization method 7027; GLI M2, Great Lakes Instruments Company Method 2; >, greater than; ± plus or minus]

Instrument Design	Reporting Unit	Method Comments	PCODE	Method (Instrument Name, mandatory)	Method Code	Method Source	Static/ Dynamic/ Process	Comments
Near Infrared (780-900 nm) or Monochrome light source, Multiple light sources. Detectors at 90° and possibly other angles to each beam.	**FNMU**	**Instrument algorithm uses a combination of detector readings, which may differ for values of varying magnitude.**	63684	Great Lakes Instruments, Sensor 95 T, FNMU	V	GLI M2	Static	
				Great Lakes Instruments, Sensor Accu4, FNMU	W	GLI M2	Static	
				Hydrolab, sensor model 4a, FNMU	X	GLI M2	Dynamic	
				Hydrolab, sensor model Quanta 4-beam, FNMU	Y	GLI M2	Dynamic	
				Other, unspecified	Z	N/A	N/A	Only for interim storage while method codes are being generated for new instruments.