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Surface Water Quality Monitoring Procedures, Volume 1:

Physical and Chemical Monitoring Methods

Water Quality Planning Division

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Physical and Chemical Monitoring Methods

Prepared by
Monitoring and Assessment Section
Water Quality Planning Division
Texas Commission on Environmental Quality

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CHAPTER 1

INTRODUCTION

Purpose

This publication serves as a comprehensive source of information on procedures for monitoring surface water quality in Texas. These procedures on surface water quality monitoring (SWQM) are generated and used by the SWQM Program of the Texas Commission on Environmental Quality. The purpose of this document is to help ensure that these procedures are standardized across the state and between the TCEQ's regional offices and the various internal and external monitoring programs that submit water quality data to the TCEQ. The detailed procedures outlined in this manual also help ensure that sampling precision, accuracy, representativeness, comparability and completeness of the data are achieved and documented. Ensuring the comparability of data between various entities is a primary quality objective of the SWQM Program.

The procedures in this manual are to be used by all surface water quality data collection programs within the TCEQ unless a program's data-collection activities are specifically covered by a separate Quality Assurance Project Plan. In addition to TCEQ water quality programs, the procedures in this manual are also used by the Texas Clean Rivers Program partner agencies and other contractors collecting water quality data for the TCEQ. Working together, these programs gather the data our state needs to ensure the quality of surface water in Texas.

SWQM and Clean Rivers Programs

The SWQM Program and the CRP allow for an integrated evaluation of physical, chemical, and biological characteristics of aquatic systems in relation to human health concerns, ecological conditions, and designated uses. In order to balance the needs of multiple programs, monitoring is divided among the following categories:

- routine monitoring
- special-project monitoring
- permit-support monitoring
- systematic watershed monitoring

See Chapter 2 for details on these categories.

How SWQM Procedures Are Used

The guidelines outlined in *SWQM Procedures* are important because they document the quality-assurance procedures that must be used to demonstrate that SWQM data collected by monitoring personnel are of known and comparable quality across the state.

The SWQM Program and the CRP are the programs primarily responsible for the collection of data that accurately describe the physical, chemical, and biological characteristics of state waters. Data collected as part of the statewide monitoring program and for special projects are used to achieve the following goals:

- Characterize existing water quality and emerging problems.
- Define long-term trends.
- Determine compliance with water quality standards.
- Describe seasonal variation and frequency of occurrence of selected water quality constituents.
- Produce the *State of Texas Integrated Report*, which is required by Sections 305(b) and 303(d) of the federal Clean Water Act. This assessment enables the public, local governments, state agencies, the Texas Legislature, the U.S. Environmental Protection Agency, and Congress to make decisions about water quality management.

Legal Authority

Texas law requires monitoring personnel who collect and analyze water samples for the SWQM Program to follow procedures outlined in two TCEQ manuals on SWQM. The rule is in Title 30 of the Texas Administrative Code (TAC), Section 307.9.

This revision to Volume 1 of the manual is to be used with the companion publication, *Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data* (TCEQ publication RG-416).

Contact Information

For questions or comments about this manual or SWQM, you can contact the SWQM Program at the TCEQ. A list of substantive changes to this manual will be proposed and discussed, as needed, at the TCEQ's annual SWQM workshop.

You can reach the SWQM Team in the following ways—

By e-mail:	swqm@tceq.texas.gov
By mail:	SWQM Program, MC 234 TCEQ PO Box 13087 Austin TX 78711-3087
By fax:	512-239-4410
On the Web:	Go to <www.tceq.texas.gov/waterquality/monitoring>

Getting Resources

Volumes 1 and 2 of the *SWQM Procedures* are available both in print and electronically. To order a printed copy, call TCEQ Publications at 512-239-0028, or fax your request to 512-239-4488. These manuals and other SWQM publications and resources, including those that are referenced later in this document can be found at the TCEQ website (see Appendix A).

CHAPTER 2

GENERAL MONITORING GUIDELINES

Monitoring Categories

The SWQM Program and the CRP facilitate an integrated evaluation of physical, chemical, and biological characteristics of aquatic systems in relation to human-health concerns, ecological conditions, and designated uses. In order to balance the needs of multiple programs, monitoring is divided into the following categories:

- routine monitoring
- special-project monitoring
- permit-support monitoring
- systematic monitoring

Routine Monitoring

The routine-monitoring network collects physicochemical, biological, and hydrological data at varying frequencies from most of the 367 classified stream, reservoir, and estuary segments across Texas, as well as the Gulf of Mexico. Smaller unclassified water bodies are also monitored to evaluate and define water quality and to respond to perceived risk for pollution. This monitoring is also conducted on impaired water bodies that do not support the water quality standards.

- Monitoring should continue for at least two years.
- For all streams, quarterly monitoring is preferred; monitoring at least twice a year is required. Quarterly monitoring consists of four seasonal monitoring events (winter, spring, summer, and fall). Samples collected twice a year should include both summer and winter, representing both warm and cool seasons.
- Routine monitoring includes, at a minimum:
  - field measurements—dissolved oxygen (DO), pH, specific conductance, temperature, Secchi depth
  - conventional chemical parameter samples (for example, nutrients, chlorophyll *a*, chloride, sulfate)
  - bacterial measurements
  - flow measurements (or flow obtained from a USGS or an IBWC gauge)
- Routine monitoring may include the following (generally performed at least twice per year):
  - aquatic-life monitoring (ALM)
  - routine monitoring for toxics (metals or organics) in water or sediment
  - routine 24-hour measurements
  - monitoring at representative sites in each ecoregion (“ecoregion monitoring”)
- Routine monitoring does not include:

- ambient toxicity (biomonitoring)
- toxics (metals or organics) in fish tissue
- monitoring to characterize the degree or extent of an impairment

- For reservoirs and estuaries, the preferred monitoring frequency is four times per year, once in each season. Additional data are needed both to develop water quality criteria, and to adequately assess seasonal and long-term conditions in reservoirs and estuaries. Quarterly data collection is particularly useful at monitoring stations listed in Appendix F of the 2010 Texas Surface Water Quality Standards (TSWQS), adopted by the TCEQ on June 30, 2010.

  Where quarterly sampling is not feasible, discuss the possibility of two measurements per year (winter and summer) at annual coordinated monitoring meetings.

- The hierarchy for selecting unclassified waters for routine monitoring is as follows:
  1. perennial streams
  2. reservoirs and bays with high public use
  3. public water supply reservoirs unmonitored by the water supplier or other organization or authority
  4. intermittent streams with permanent pools that are in high public use or contain significant aquatic life

Coordinated Monitoring Schedule and Planning

The coordinated monitoring schedule (CMS) increases the efficiency of surface water data collection and analysis by the SWQM Program and its participating organizations. Coordinated statewide monitoring reduces the duplication of effort and improves spatial coverage of monitoring sites and consistency of data collection. Access the CMS online at <cms.lcra.org/>.

The TCEQ distributes guidelines for revising the routine monitoring schedule annually, before coordinated-monitoring meetings. This information is also available on the Web (see Appendix A).

Planning and development of the CMS takes place in January through May of the preceding fiscal year. The meetings are held in each major river basin and are hosted by the CRP basin planning agency. The schedule is continually updated during the annual planning process with a final version available on September 1 of each fiscal year. The Web-based CMS also allows for changes to be made during the year so the schedule is kept current. Those participating include the TCEQ SWQM and CRP staff, CRP partners, and other state, federal, county, and city agencies. All groups that collect SWQM data and commit to comply with TCEQ requirements for collecting quality-assured data are invited to participate in the meetings.

Special attention is focused on spatial gaps in station locations and gaps in various data needs. New sites are added, existing sites may be relocated, and monitored parameters may be changed based on the discussions at the meetings.

Routine Monitoring During Extended Drought

To ensure continuity of statewide routine SWQM activities during extended periods of

drought, the program has developed a guide to fulfilling the monitoring plan outlined in the CMS, available online (see Appendix A).

Special-Project Monitoring

Special-project monitoring involves data collection to better characterize nonattainment of water quality standards, the loading contributions of nonpoint sources of pollution in a watershed, and stakeholder concerns. Special projects are developed in consultation with other basin monitoring entities and TCEQ coordinators for the SWQM, Clean Rivers, Water Quality Standards (WQS), and TMDL programs.

Special projects improve the TCEQ's understanding of sources, distribution, and fates of particular constituents in selected reaches of water bodies. Special-project monitoring is used to assess toxicity in surface waters and impacts of point and nonpoint source discharges and to develop water quality controls and assess improvements after enforcement actions or implementation of controls. Special-project monitoring is also used to develop new or revised sampling and assessment procedures, to describe impacts of habitat modification on water quality, and to describe water quality in intermittent streams and unclassified streams.

- Monitoring usually continues for at least two years.
- Special-project monitoring is often performed to better characterize impairments and therefore takes place at or near sites where previous sampling identified impairment or concerns.
- Special-project monitoring may include:
  - TMDL project-support monitoring
  - independent 24-hour DO or sediment study (not in conjunction with routine monitoring)
  - independent one-time or multi-year fish-tissue studies
  - ambient toxicity sampling (the SWQM Program produces an annual statewide schedule)
  - monitoring effectiveness of best management practices
  - monitoring to identify and characterize nonpoint source pollution

Sediment Sampling for Metals and Organics

Independent sediment sampling is generally conducted as part of a special project. The sampling plan should specify the generation of at least four samples in 1–2 years. At a minimum, samples are collected twice each year for two years. The data is screened using SWQM Program–derived 85th percentiles and NOAA probable effects levels. If no secondary concerns are identified after four samples are collected, sampling is to be terminated at the site and a new one selected the following year. If secondary concerns are identified, sediment sampling is continued and the other components of the sediment sampling triad approach (toxicity testing and benthic macroinvertebrate sampling) are conducted to determine if the aquatic-life use is impaired by contaminated sediment. Guidelines for sediment sampling appear in Chapter 6.

Fish-Tissue Sampling

Fish-tissue sampling is considered a special project. The project plan outlines sampling to generate at least four composite samples (to assess ecological health) and four individual fillets (to assess human-health risk) in 1–2 years. Collect fillet and composite samples twice each year for two years, or all four samples within one year. Evaluate the fillet data according to human health–based screening levels in the 305(b) guidance. If no secondary concerns are identified after four samples are collected, sampling is terminated at the site and a new one selected the following year. If any secondary concerns are identified in the fillet samples, the TCEQ will notify the Texas Department of State Health Services, and request of the DSHS a more in-depth special study to determine human-heath risk and whether a consumption advisory or aquatic-life closure is warranted. The TCEQ will be developing predator-protection levels for screening whole-fish composite-sample data.

Sediment samples are generally collected from the same water bodies as part of a fish-tissue special study designed to address pollution by toxic contaminants. Details for sampling fish tissue, including target species, appear in Chapter 7.

Where to Collect Samples

Give priority to sites where previous assessments have failed criteria for acute or chronic criteria or human-health criteria, or shown biological impairment. When selecting a site, consider placement where there is a perceived risk of contamination with metals or organic substances. Also consider sites downstream from domestic or industrial discharges, hazardous-waste sites, metropolitan areas, or areas experiencing high nonpoint source loads. Samples are not collected in areas where the DSHS has issued consumption advisories or aquatic-life closures or where it has previously sampled and determined the fish to be safe for human consumption. However, if an advisory is more than eight years old, sampling may be considered with an emphasis on contaminants of concern to determine if the DSHS should revise the advisory.

Sampling Considerations

Field sampling with a boat-mounted electrofisher, gill nets, or trawls should normally be conducted in the summer to early fall when lipid content is generally highest in fish and water levels are low.

Permit-Support Monitoring

Permit-support monitoring is conducted to directly support a TCEQ wastewater-discharge permit action. The TCEQ identifies specific water bodies where permitting programs would benefit from additional information on water quality and quantity. This type of monitoring generally supports the development or modification of effluent limits by determining the appropriate aquatic-life use. Table 2.1 summarizes the objectives.

Use-attainability analyses (UAAs) are assessments of the physical, chemical, and biological factors affecting attainment of a use. UAAs are used to determine if existing criteria and uses described in the TSWQS are appropriate and are being maintained, or to determine causes of use or criteria not being attained. Receiving-water assessments (RWAs) are special-purpose UAAs to assess characteristics on unclassified streams, primarily to obtain data so that appropriate aquatic life uses can be assigned. Procedures for conducting UAAs, RWAs, and other biological and habitat monitoring are described

Table 2.1. Objectives for permit-support monitoring.

General Objective	Approach	Prioritizing Resources
UAA. Determine if existing designated uses and criteria are appropriate and, if not, develop designated-use or criteria-adjustment information.	Collect chemical, biological, and habitat information following prescribed protocols (TCEQ publication RG-416).	Scheduled by the WQS Development Team after review of recent monitoring data.
RWA. Determine appropriate aquatic-life use and criteria for unclassified water bodies receiving permitted discharges.	Collect biological and habitat information following prescribed protocols (TCEQ publication RG-416).	Scheduled by the WQS Implementation Team in response to permit requests.
IS. Evaluate loading from wastewater discharges.	Collect hydraulic and water quality information under low-flow conditions.	Requested by TCEQ water quality modelers.

in *SWQM Procedures, Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data* (TCEQ publication RG-416). The manual and other associated biological monitoring documents and forms are available at the TCEQ website (see Appendix A).

Intensive Surveys are short-term studies where specific hydraulic and water quality measurements (primarily dissolved oxygen) are made under low-flow conditions over several days. These are used by the TCEQ to evaluate loading from wastewater discharges, verify TSWQS, address existing or potential special water quality problems, and document water quality after controls are implemented.

Systematic Watershed Monitoring

Systematic watershed monitoring is similar to routine monitoring but with a shorter duration (1 to 2 years) and is designed to screen waters that are not routinely monitored. Systematic monitoring has several common objectives including:

- Screening waters that would not normally be included in the routine monitoring program.
- Monitoring at sites to check the status of water bodies (improvements or concerns).
- Investigating areas of potential concern.

This type of monitoring, primarily used by CRP partner agencies, can follow either a rotating-watershed approach or an intensive watershed evaluation. Additional information on this monitoring approach appears in Task 3 of the CRP Guidance (see Appendix A). Table 2.2 summarizes systematic watershed monitoring objectives.

Selecting a Monitoring Site

It is important to consider monitoring sites that will best characterize water quality, especially when selecting sites for routine ambient fixed-station monitoring.

Special projects may include nonambient sites. Keep in mind that some types of special study data (data collected during stormwater runoff, inside the mixing zone of a wastewater discharge, during a single low-flow period, or from a single season) may be limited to very specific uses.

Table 2.2. Objectives for systematic watershed monitoring.

General Objective	Approach	Prioritizing Resources
Impairment characterization—for water bodies on the 303(d) List.	Continue monitoring to develop an adequate data set to define geographic extent and severity of the impairment.	State agencies and local stakeholders assist in determining priority.
Develop ecoregion-specific background data.	Develop an ecoregion-specific monitoring plan.	Plan developed by the TCEQ and TPWD biological workgroup.
Aquatic-life assessment. Confirm support or nonsupport of presumed aquatic-life use and criteria for unclassified water bodies not included in Appendix D of the TSWQS; identify appropriate aquatic-life use and dissolved-oxygen criteria.	Collect chemical, biological, and habitat information following prescribed protocols.	State agencies and local stakeholders assist in determining priority.
Determine statewide percentages for use support and concerns—reports to the Texas legislature and EPA.	Comprehensive probability-based or watershed monitoring plan.	10 to 30 percent of total resources for all routinely monitored parameters.
Determine the quality trend for a water body.	Develop a water body– and parameter-specific plan or continue some of the monitoring already under way.	State agencies and local stakeholders assist in determining priority.
Determine pollutant sources.	Develop watershed and parameter specific plan.	Local interest determines priority at this time *or* as part of a TMDL-initiated investigation.
Determine if existing point source controls are effective.	Conduct compliance monitoring of effluents and receiving waters.	A plan is developed from results of the assessment, compliance history, grant commitments, and relative risk to the environment.
Verify effectiveness of BMPs.	Develop a watershed- and parameter-specific plan.	As required by TMDL-implementation plans.

Site Access

Select sites where sampling can be conducted safely during most expected flow conditions.

Historical Sites

Consider historical water quality data—very useful in assessing use attainment, impairment, and the analysis of trends. Consider continued sample collection at sites that are on current or past monitoring schedules.

Water Quality

Establish more than one station for segments with very different water quality or pollution potential. This allows representative data to be collected for all parts of the segment—even for small segments.

Designated Uses

Designated uses are assigned to specific water bodies in Appendix A or D of the TSWQS. Typical designated uses include public water supply, aquatic life, contact recreation (such as swimming or wading), and human health. Consider designated uses for a segment before monitoring. For example, if attainment of the aquatic-life use is to be assessed, choose a site suitable for collecting representative fish or benthic macroinvertebrate samples. Access the TSWQS (30 TAC 307) at the TCEQ website (see Appendix A).

Note: Collect bacteriological samples at all routine monitoring sites and under all flow conditions.

Locating Representative Sites

Spatial Considerations

To evaluate compliance with the TSWQS, water quality data are reviewed station by station within classified and unclassified waters to estimate the geographical extent of use and criteria support, and to identify water quality concerns, based on the following:

- a review of existing data
- the spatial distribution of monitoring sites having the required minimum number of samples
- known sources of pollution
- the influence of tributaries and hydrological modifications
- the best professional judgment of personnel from the TCEQ and CRP partner agencies
- the intent of data collection

Streams are measured in miles, reservoirs in acres, and estuaries and oceans in square miles. A single monitoring site is considered to be representative of:

- no more than 25 miles in freshwater and tidal streams
- no more than 25 percent of the total reservoir acres or estuary square miles
- not more than 5,120 acres or 8 square miles

Major hydrological features, such as the confluence of a major tributary or an instream dam, may also limit the spatial extent of an assessment based on one station.

Sample locations in streams, and in open water bodies such as reservoirs and estuaries, should be characteristic of the main water mass or distinct hydrologic areas.

The following criteria may be considered in determining where sampling sites are needed to characterize water quality:

- All classified segments (including reservoirs) should have at least one routine monitoring site that adequately characterizes the water body.
- Segments that have very different hydrologic conditions or water quality in specific areas should have more than one station so that representative data are collected in each distinct part of a segment—even for small segments.
- Very long segments may require more stations. As a rule, stream segments from 25 through 50 miles long require two stations; those longer than 50 miles require three or

more, depending on the presence or absence of areas with significantly different sources of contamination or potential water quality concerns.

- In reservoirs, there should be stations in the major arms and near the dam and, for estuaries, in secondary and tertiary bays.
- Sites should be accessible. When possible, stream sites should have a USGS or IBWC streamflow gauge. If not, it should be possible to measure flow during routine visits.
- Because historical water quality data can be very useful in assessing use attainment, select sites that are on current or former monitoring schedules.
- The site should provide representative samples. On large rivers, specific conductance can be measured from bank to bank to determine if the stream is homogeneous and well-mixed at a proposed site. The site should also be free of backwater effects.
- At impaired sites, monitoring should take place at historical sites that best represent the impaired portion of the water body.

Type of Water Body

Select monitoring sites that best represent water quality conditions of an entire water body based on its type. A water body with varying water quality—due to things such as wastewater treatment plant discharges, significant tributary inflow, spring flow, and stormwater runoff—may require additional sites.

Rivers and streams. Locate sites so that samples can be safely collected from the centroid of flow. If few sites are available for a stream segment, choose one that would best represent the water body, and not an unusual condition or contaminant source. The *centroid* is defined as the midpoint of that portion of stream width which contains 50 percent of the total flow. Avoid backwater areas or eddies when selecting a stream site. For freshwater streams and rivers, sites must either have a streamflow gauge or be suitable for conducting flow measurement. Exceptions may be made for special studies.

Reservoirs. At a minimum, locate sites near the dam and in the major arms. Larger reservoirs might also include stations in the middle and upper (riverine) areas. Select sites that best represent the water body by avoiding coves and backwater areas.

Bays and estuaries. Locate sites that represent the segment. Stations located near freshwater inflow (rivers, streams), a connecting water body, or close to shoreline activities, or discharges from wastewater treatment plants, would not represent true conditions in a bay or estuary.

Select coastal stations so that a representative sample can be collected, regardless of the tidal cycle. Where water masses are likely to change over the tidal cycle (inlets, lower portion of tidal rivers and streams), collect samples during an outgoing tide, or just before the tide turns back. If consistently collection of representative samples at a site is not possible, then consider a new station.

Mixing Zones

A *mixing zone* is defined as the area adjacent to a wastewater discharge point where effluent mixes with the ambient surface water (TSWQS, 2010). In selecting a monitoring site, be aware that locations below effluent discharges may not accurately represent water-quality conditions of a water body and must be located outside the mixing zone.

For a specific delineation of mixing-zone boundaries, see Table 2.3.

Monitoring Below Dams

Water quality conditions created by a dam release are generally not characteristic of a water body. Monitoring sites should be located far enough downstream to be outside any area influenced by a dam release. The acceptable location will vary depending on the size of the stream and release. A low-water dam may cause turbulence only for a short distance, whereas the release from a major reservoir may influence the receiving stream for a kilometer or more. Also keep in mind whether the release is from the top or bottom of the dam. Water released from the bottom (*hypolimnion*) of a reservoir will have lower levels of dissolved oxygen (DO) than water released from the top (*epilimnion*).

Temporal Considerations

Sampling data used to characterize water quality and evaluate compliance with water quality standards must be representative of the range of temperature and flow conditions in the water body. Samples are distributed over at least two seasons (to include *inter-seasonal* variation) and over two years (to include *inter-year* variation), with some collected during the index period, March 15–Oct. 15.

Unattended 24-hour DO sampling can be year-round. The data set should not be biased toward unusual flow conditions, e.g., from drought, runoff, or season. One way to ensure temporally representative data is to collect the data routinely with the same time intervals between sampling events. Detailed information on conducting 24-hour DO monitoring appears in Chapter 3.

Requirements for biological monitoring are located in *SWQM Procedures, Volume 2* (TCEQ publication RG-416).

Data used for determining standards compliance on perennial streams must be collected when the stream is flowing above the seven-day, two-year low flow (7Q2), except when applying the acute criteria for aquatic-life use. The TSWQS define the 7Q2 as the seven-day, two-year low flow, or the lowest average streamflow for seven consecutive days with a recurrence interval of two years, as statistically determined from historical data. Samples collected on perennial streams at flow less than the 7Q2 cannot be used for assessment purposes. However, extreme low-flow sampling results contribute to the understanding of water quality changes during drought conditions and aid in long-term water-resource planning. The 7Q2 values for many stream locations are published in the TSWQS, 30 TAC 307. See "Flow Conditions for Collecting Samples," below, for additional information.

Table 2.3. Mixing-zone boundaries.

Type of Water Body	**Location of Mixing Zone**	
Perennial stream or river	30.5 m (100 ft) upstream of a discharge	91 m (300 ft) downstream of a discharge
Lake, reservoir	The typical mixing-zone radius is no greater than 30.5 m (100 ft) or half the width of the receiving water at the discharge point	
Bay, estuary, or tidal rivers—greater than 122 m (400 ft) across	The typical mixing-zone radius is no greater than 61 m (200 ft) or half the width of the receiving water at the discharge point	

Details on temporal considerations can be found in the most current version of *Guidance for Assessing and Reporting Surface Water Quality in Texas* (see Appendix A).

Generating New Monitoring Stations

Procedures for generating a new monitoring station are found in Chapter 3 of the *SWQM Data Management Reference Guide* (*SWQM DMRG*), available online (see Appendix A).

Check the list of existing stations before submitting a station location form for a new Station ID. The SLOC form and a list of existing stations, arranged by basin, can be found online—see Appendix A.

Note: Station ID numbers are not assigned sequentially. A review of the entire list may be necessary. Unclassified water bodies appear first on the list.

The *SWQM DMRG* contains detailed instructions and information necessary to complete a SLOC form. SLOC forms can be found in the *SWQM DMRG* or online (see Appendix A).

Flow Conditions for Collecting Samples

Baseline water-chemistry monitoring includes samples collected over a range of flow conditions (except metals in water). When samples are collected during abnormally high or low flow, record with each sampling any abnormal conditions in field notes and enter them as an observation when submitting the data.

Metals-in-Water Samples

Metals-in-water samples for status monitoring are not collected during periods of abnormally high turbidity. Samples collected during high turbidity are unstable with regard to soluble metals and are seldom representative. See Chapter 5 for details on monitoring metals in water.

Sediment and Tissue Samples

Methods for sediment and tissue collection generally require normal to lower flow.

Flow Data Requirements

It is important to record measured instantaneous flow, flow severity, and days since last significant rainfall for each sampling event. This information is very useful for interpreting historical data and assessing compliance with the TSWQS. For example, some standards do not apply when evaluating data taken at extremely low flows (below the 7Q2), and in some water bodies DO criteria require a discrete flow value for their determination.

The 7Q2 restrictions apply only to freshwater streams. Reservoirs, bays, estuaries, tidal streams, coastal ship channels, and the Gulf of Mexico are not subject to 7Q2 restrictions.

Flow must be measured at all routine freshwater stream–monitoring sites. A flow measurement is also required for each 24-hour DO-monitoring event and for any biological or habitat assessment activities. See Chapter 3 for detailed flow-measurement methods.

Flow estimates should not be reported in place of an actual instantaneous flow

measurement. However, flow-estimate methods may be used if no other means of flow measurement are available. Use the appropriate parameter code to report flow-estimate data. See Chapter 3 for detailed information on flow-measurement methods.

Required Equipment

See Chapter 9 for the list of basic SWQM equipment.

SWQM Internet Resources

A web page titled "Surface Water Quality Monitoring" <www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/mtr/> serves as a single access point for SWQM guidance documents, data-reporting forms, and data management. In addition to these essential SWQM resources there are additional reference materials available on the web. See Appendix A for Monitoring Resources on the Web.

Guidance Documents

Guidance documents include:

- *SWQM Procedures Manual, Volume 1* (TCEQ publication RG-415)
- *SWQM Procedures Manual, Volume 2* (TCEQ publication RG-416)
- *SWQM Quality Assurance Project Plan* (QAPP)
- *SWQM Data Management Reference Guide (DMRG)*

See the References for full citations.

Forms Online

The SWQM page contains links—in PDF and Word formats—to all SWQM forms used for collecting and managing surface water quality monitoring data, and guidance references for their use. The forms available include:

- biological data forms (benthic-macroinvertebrate, fish and habitat-assessment)
- field data forms and log sheets
- data-management forms and checklists

Quality Control

Various quality-control measures are required for collecting SWQM data. Specific requirements for field measurements are detailed in Chapter 3, for multiprobe instrument calibration in Chapter 8, and for water-sample collection in Chapter 5.

General QC information and SWQM-CRP requirements are outlined in Chapter 10.

Interim Method Changes

A complete revision of the SWQM manuals is done every three to five years. The looseleaf format facilitates the insertion of interim updates between full revisions. A process is in place to facilitate minor and major revisions to the manuals. Details can be found in *Procedures for Making Interim Changes to the SWQM Procedures Manuals* (see Appendix A).

Alternate SWQM Sample Collection Methods

The methods contained in this manual are required for all routinely collected surface

water quality data. Proposed changes or variations to these methods must be submitted to the TCEQ for approval. Once approved the method must be included in an approved quality assurance project plan prior to implementation. At a minimum there must be documentation showing that the revised method yields data comparable to the existing method.

Data Reporting

Appropriate procedures and parameter codes necessary for submitting data are discussed in the *SWQM DMRG*.

Minimum Data Requirements for the Assessment of Surface Waters

Information on the minimum data requirements for use in the water quality assessment required by Section 305(b) of the CWA can be found in the most current version of *Guidance for Assessing and Reporting Surface Water Quality in Texas* (see Appendix A).

CHAPTER 3

FIELD MEASUREMENTS

This chapter describes the methods necessary to record and collect field data. The field parameters *water temperature, pH, dissolved oxygen, and specific conductance* are measured using multiprobe instruments. Additional details on calibration, maintenance, and performance of instruments used to measure these parameters are outlined in Chapter 8 of this manual. The measurement of flow, an important parameter in interpreting data, is also detailed in this chapter.

Recording Field Data

For each sampling trip, record field measurements and observations in a field data logbook or on a field data sheet. This manual does not prescribe any particular system for recording field data. Any mention of a "field data logbook" or "field data sheet" in this document does not refer to a specific document or form. The format for recording field data is left up to the staff responsible for monitoring or as specified in a program or project QAPP.

Field data (bound or loose-leaf sheets) must be maintained on file for a minimum of five years or as defined in a project or program QAPP. It is important to maintain these records since the logbook or data sheets may be the only written record of field measurements. Field-data records are reviewed during the annual technical systems audit or monitoring systems audit.

A good safety precaution against lost field data is to photocopy or electronically scan current data upon returning from the field, keeping these pages on file at the office. The entries discussed below are recorded at each sampling site.

For each visit to an **individual station** where field measurements and samples are collected, record the following:

- station ID
- sampling date
- location
- sampling depth
- sampling time
- sample-collector name(s)
- all measured field parameters and their respective values
- observations

Field physicochemical parameters include part or all of the following:

- dissolved oxygen
- temperature
- specific conductance
- pH

- salinity (tidal waters only)
- Secchi-disk transparency
- days since last precipitation (significant enough to influence water quality)
- flow severity (freshwater streams and rivers)
- stream discharge (freshwater streams and rivers)
- method of stream-discharge measurement (freshwater streams and rivers)

Recording Field Observations

Upon arrival at a sampling site, record observations on the general appearance and condition of the water (for example, color, odor, presence of algae, foam) and other information related to water quality and water use (for example, for fishing or swimming).

Left-bank and right-bank orientation. To be consistent and to help orient others to the location of observations, the convention *left bank–right bank* is used. "Left" and "right" refer to the banks to those sides of an observer when facing downstream.

General Observations

Record field observations to aid in the interpretation of water quality information. Here are some common examples.

Water appearance. General observations on water might include color or an unusual amount of suspended matter, debris, or foam.

Weather. Recent meteorological events that may have affected water quality include heavy rains, a cold front, or very dry or very wet conditions.

Biological activity. Record excessive macrophyte, phytoplankton, or periphyton growth. The observation of water color and excessive algal growth is very important in explaining high chlorophyll *a* or low DO values. Note unusual activities or presence of other aquatic life.

Unusual odors. Examples include hydrogen sulfide, mustiness, sewage, petroleum, chemicals, or chlorine.

Watershed or instream activities. Record instream or drainage-basin activities or events that may affect water quality—for example, bridge construction, shoreline mowing, or livestock watering upstream.

Observations related to water quality and stream uses. If the water quality conditions are exceptionally poor, note that standards are not met in the observations—for example, dissolved oxygen is below minimum criteria. Uses may include swimming, wading, boating, fishing, irrigation pumps, or navigation. This type of information may be used in evaluating compliance with standards.

Specific sample information. Specific information about the sample, such as number of sediment grabs, or type and number of fish in a tissue sample, is required for these sample types. If the sample was collected as part of a complaint or a fish-kill investigation, make a note of this in the *observation* section and use appropriate program codes defined in the *SWQM DMRG*.

Missing parameters. If a scheduled parameter or group of parameters is not collected, note this in the comments.

Other Information Recorded

Water and Sediment Samples

Examples of the general types of chemical samples collected include routine water chemistry, metals in water, metals in sediment, organics and pesticides in water, and organics and pesticides in sediment. Record the method of preservation for each chemical sample. Record the unique tag number for each sample type (water, sediment, or tissue) you submit to the laboratory. The sample tag number is important when contacting the laboratory about a sample. See Chapters 5 and 6 for details on water and sediment collection.

Tissue Samples

Record a description of the general sample habitat where tissue samples were collected. This gives monitoring personnel a reference when sampling similar habitats in following years and at different stations. Also record the species, number of fish per sample, and tag number for each sample submitted to the laboratory. See Chapter 7 for details on tissue collection.

Biological Samples

Procedures for conducting biological and habitat monitoring are outlined in *Surface Water Quality Monitoring Procedures, Volume 2* (TCEQ publication RG-416). See also Appendix A.

Field Measurements

Water samples (including bacteriological) are generally collected before field measurements are taken. If meeting hold times for associated water and bacteriological samples is an issue, field measurements (including flow) may be taken first. Keep in mind that the water samples must be collected from an undisturbed area, and multiprobe instruments must be allowed to stabilize. See Chapters 4 and 5 for details on collecting bacteriological and water quality samples. See Chapter 8 for details on calibration and maintenance of multiprobe instruments. Chapter 9 provides a list of required equipment.

Where to Collect Field Measurements

For freshwater-stream samples, the centroid of flow should be accessible for sampling physicochemical parameters—by bridge, boat, or wading. Field measurements should be taken as close to the centroid of flow as possible when the stream appears to be completely mixed from shore to shore. **The *centroid* is defined as the midpoint of a portion of the stream width which contains 50 percent of the total flow**. In streams, measurements are generally taken upstream of a bridge. This is to avoid any influence runoff from the bridge might have on getting a representative measurement.

Field measurements in reservoirs, estuaries, and bays are generally collected by boat. In tidally influenced portions of streams and rivers, samples are generally collected from the channel midpoint by bridge or boat. Most tidal streams are too deep for wading to the channel midpoint. Sampling from the shoreline of any water body is the least acceptable method. If shoreline sampling is the only option, the TCEQ recommends moving to a more accessible location.

Depth of Field Measurements

Streams and Shallow Rivers

Less than 0.50 m. If the water depth of a stream or shallow river is less than 0.50 m, take field measurements at a depth equal to one-third of the water depth measured from the surface. Report the actual measured depth.

Greater than 0.50 m but less than 1.5 m. If the water depth at the sampling point of a shallow stream or river is greater than 0.50 m, but less than 1.5 m, for dissolved oxygen, temperature, pH, and specific conductance measure at a depth of 0.30 m below the surface.

1.5 m or greater. If the sampling point of a shallow stream or river is 1.5 m deep or deeper, make a vertical profile for dissolved oxygen, temperature, pH, and specific conductance using a multiprobe instrument. If a vertical profile is not practical, report those measurements from a depth of 0.30 m. The measurement depth is more accurately determined from the depth sensor on a multiprobe instrument rather than depth labels on the cable. See Chapter 8 for details on "Calibrating the Depth Sensor."

Vertical Profiles in Rivers, Reservoirs, Bays, and Estuaries

Procedures for measuring depth or vertical profiles in reservoirs, deep rivers, bays, and barge and ship channels greater than 1.5 m in depth are outlined below. See the *SWQM DMRG* for detailed information on data reporting. Take measurements at specific depths to determine if a water body is stratified—if so, certain criteria apply to the mixed surface layer. In the absence of profile data, a single surface sample (0.30 m) is adequate.

For information on the *mixed surface layer,* refer to the most recent revision of the TCEQ's *Guidance for Assessing and Reporting Surface Water Quality in Texas*. See Appendix A.

Reservoirs, inland streams, bays, and barge channels with depths 1.5 to < 3.0 meters. In reservoirs, inland streams, bays, and barge channels (for example, the Intracoastal Waterway) which are 1.5 to < 3.0 m deep, record measurements at 0.30 m below the surface, at mid-depth, and at 0.3 m above the bottom.

Reservoirs, inland streams, and bays with depths ≥ 3.0 meters. In reservoirs, inland streams, and bays which are 3.0 meters or greater in depth, record measurements at 0.30 m below the surface and then at 1.0 m and each subsequent 1.0 m interval. For the final measurement, take a reading 0.30 m above the bottom, if possible. If the remaining distance is less than 0.3 m, a final measurement is not required. The intervals may be extended to 3.0 m in reservoirs, if the total depth exceeds 18 m. All of the intervals, however, must be equal—1, 2, or 3 meters—and consistent with intervals used in earlier and subsequent field events. This helps determine compliance with water quality standards.

Coastal ship channels with depths ≥ 3.0 meters. In coastal ship channels which are 3.0 m or greater in depth, record measurements at depths of 0.30 m below the surface and then at 3.0 m and each subsequent 3.0 m interval. For the final measurement, if the distance from the last reading to the bottom is greater than 1.0 m, take a reading at 0.30 m above the bottom. If the distance is equal to or less than 1.0 m, do not take another reading.

Field Parameters

This section summarizes information, guidelines, and minimum requirements that apply to the following field measurements; DO, specific conductance, pH, 24-hour DO, salinity, chlorine residual, and Secchi-disk transparency.

Required Monitoring Equipment

See Chapter 9 for the list of required SWQM equipment.

Water Temperature

Parameter Code 00010

Record the water temperature data to the nearest tenth of a degree Celsius (°C).

Equipment

- A multiprobe instrument (see Chapter 8).

Procedures for Sampling

Measure temperature directly from a water body at one or more depths specified in "Depth of Field Measurements." Allow the sensors to equilibrate for at least 2 minutes before recording the temperature. The temperature sensor does not require routine calibration but must be checked for accuracy during routine instrument maintenance. See Chapter 8, "Temperature Sensor," for additional information on temperature sensor checks.

pH

Parameter Code 00400

Record pH data to the nearest tenth of a standard unit.

Equipment

- A multiprobe instrument, calibrated according to "pH Sensor," Chapter 8.

Procedures for Sampling

Measure pH directly from a water body at one or more depths specified in "Depth of Field Measurements." The pH sensor is calibrated each day of use for multiprobe instruments. See Chapter 8, "Calibrating and Maintaining Multiprobe Instruments." Allow the sensors to equilibrate for at least two minutes before recording pH.

Dissolved Oxygen

Parameter Code 00300

Record dissolved-oxygen data to the nearest tenth of a mg/L.

Equipment

- A multiprobe instrument, calibrated according to "Dissolved Oxygen Sensor," Chapter 8.

Procedures for Sampling

Measure DO directly from a water body at one or more depths specified in "Depth of Field Measurements." The DO sensor is calibrated each day of use for multiprobe instruments. See Chapter 8, "Calibrating and Maintaining Multiprobe Instruments."

The DO probe must be allowed to stabilize for at least two minutes before DO is recorded. Since dissolved oxygen takes the longest to stabilize, record this parameter **after** temperature, specific conductance, and pH. For profile measurements, allow the DO probe to stabilize for at least two minutes before taking the initial reading. For each subsequent depth allow the DO reading to stabilize before recording the measurement.

24-Hour Dissolved Oxygen

Sampling for Compliance with Standards for the Aquatic-Life Use

Parameter Codes 89857 and 89855

Each classified water body in the TSWQS is assigned an aquatic-life use (ALU)—*exceptional, high, intermediate, limited,* or *minimal*—based on physical, chemical, and biological characteristics. To protect these uses, 24-hour average DO criteria and absolute DO minimum criteria are assigned to each ALU category.

For detailed information on DO criteria for classified and unclassified water bodies and on the use of 24-hour DO data in assessing aquatic-life-use support, see the most recent revision of the TCEQ's *Guidance for Assessing and Reporting Surface Water Quality in Texas* (see Appendix A).

Unattended Data Collection—Dissolved Oxygen

Why Collect 24-Hour Data?

Dissolved oxygen sampling for compliance with ALU standards is targeted to water bodies where low instantaneous DO levels indicate only partial support or nonsupport of designated ALUs. This sampling requires intensive monitoring with automated equipment that is preset to record and store field measurements over one 24-hour period.

When to Take Measurements

Twenty-four-hour DO monitoring events can be conducted year-round. To ensure unbiased, seasonally representative data, samples are allocated to various times of the year. Collect one-half to two-thirds of the samples during the *index period* representing warm-weather seasons of the year, March 15–October 15 (Figure 3.1). Of the total allocated to the index period a subset of the samples are to be collected during the *critical period* of the year (July 1–September 30)—when minimum streamflows, maximum temperatures, and minimum DO concentrations typically occur in Texas streams. Collect a minimum of one-fourth to a maximum of one-third of the samples (allocated to the index period) during the critical period. The remainder of the samples can be collected outside the index period. **Approximately one month must separate each 24-hour sampling event. The minimum number of samples collected in a year is two—one within the index period and one within the critical period**.

Note: For specific guidance on data requirements for determining DO standards compliance refer to the most current version of the *Guidance for Assessing and Reporting Surface Water Quality in Texas* (see Appendix A).

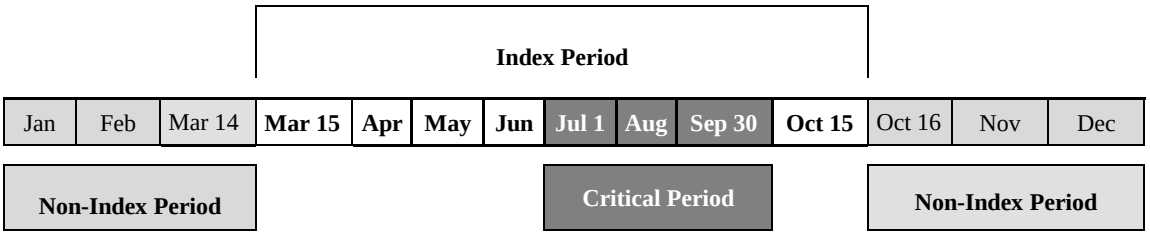


Figure 3.1. Index, non-index, and critical periods.

Stream Discharge Requirements

In flowing freshwater streams and rivers, a *discharge measurement must be taken during the period of deployment, where possible*. If the discharge is less than the 7Q2 in a perennial stream, the DO criterion does not apply, and 24-hour data are not evaluated for compliance with standards. Discharge measurements are not required for tidal streams, reservoirs (including riverine portions), bays, or estuaries. For larger streams, **only** where discharge cannot be measured, a flow-severity value may be submitted.

Equipment

Please refer to Chapter 8 for specific information on instrument setup and calibration.

Frequency of Measurements

The preferred measurement interval is no more than once per 15 minutes, and no less than once per hour. Thus, the minimum total number of measurements over the 24-hour period is 25. Meeting the minimum would require programming an instrument to record data for more than 24 hours. Those leaving instruments out for several days should report the first 24-hour period after initial stabilization. See "Acclimating to Ambient Conditions," below, for additional information.

Sometimes a complete 24-hour data set is not possible. For example, if there are 20 measurements instead of 24, a time-weighted average needs to be calculated.

A TWA is calculated using the following formula:

$$TWA = \left(\frac{T_2 - T_1}{24}\right) \times \left(\frac{DO_1 + DO_2}{2}\right) + \left(\frac{T_3 - T_2}{24}\right) \times \left(\frac{DO_2 + DO_3}{2}\right) + \left(\frac{T_4 - T_3}{24}\right) \times \left(\frac{DO_3 + DO_4}{24}\right) + \ldots$$

DO = DO concentration in mg/L
T = Time interval

Acclimating to Ambient Conditions

Allow the instrument time to acclimate to ambient conditions by setting its start time at least an hour after deployment. Unlike the short warm-up time for instantaneous measurements, extended monitoring takes a little longer so that all measurements are collected under the same conditions. In cases where the instrument begins recording data shortly after deployment, the first measurement should not be included in the data set.

Where to Take Measurements

Shallow streams. For purposes of determining compliance with the 24-hour average criteria, samples collected at the surface (0.3 m) will be considered representative of the mixed surface layer.

Refer to "Depth of Field Measurements" for guidelines on deployment depths.

The placement of the instrument is specific to each sample location. Remember, the main goal is to place the instrument in a location that will best represent conditions of that water body. Avoid backwater areas, stagnant pools, shallow areas, or areas near the bank. Where possible, place instruments away from the bank in flowing water.

Due to the varied conditions encountered in Texas, the following are general guidelines. In general, suspend instruments from cables or chains attached to a bridge piling, or over a hanging tree or some other structure that will allow their suspension at the correct depth. To protect the instrument from damage, place it in a guard (usually a piece of PVC pipe slightly larger than the instrument) with slits or holes that allow water to flow through. Avoid laying instruments on soft stream bottoms where sediment can interfere with the probes. Cinder blocks, boulders, or other stable objects can be used to position an instrument off the bottom in cases where there is no overhanging structure or the bottom is soft (see Figure 3.2).

Deep streams, reservoirs, and bays. Deploy instruments in the *mixed surface layer*. Determine the location of that layer by taking profile measurements (refer to "Vertical Profile Depth").

Deploy a multiprobe instrument between a depth of 0.3 m (from the surface) and half the depth of the mixed surface layer. For example, if the mixed surface layer is 3 m deep, deploy the instrument between 0.3 m and 1.5 m. This is only required when the water body is stratified.

Figure 3.2. Deploying an instrument for 24-hour monitoring.

For additional information on the *mixed surface layer* see the most recent revision of the TCEQ's *Guidance for Assessing and Reporting Surface Water Quality in Texas* (see Appendix A).

Suspend instruments from buoys, pilings, or structures that allow their placement at the correct depth. In pools, reservoirs, bays, or estuaries, sample the central water mass, rather than side channels, backwater areas, or shallow areas near the bank.

When to Collect Other Routine Samples

Collect other routine field measurements and water samples either deployment or when retrieving a multiprobe instrument that is recording 24-hour data.

Priority for Scheduling 24-Hour Sampling Events

When prioritizing 24-hour sampling events, consider the following:

- water bodies on the 303(d) List
- water bodies with concerns for low DO (too few samples available for full-use assessment)
- occurrence of low or very high DO concentrations during the day
- water bodies with trends that indicate declining DO concentrations
- water bodies contributing to an ecoregion data set

Data Reporting

24-hour data. Data submitted for a 24-hour DO event include:

- minimum value
- maximum value
- 24-hour average
- number of measurements

Reporting other field measurements—water temperature, specific conductance, pH, and salinity —collected as part of the 24-hour deployment is optional. See the *SWQM DMRG* for a list of parameter codes and detailed information on reporting these parameters.

Non–24-hour data. All grab-sample data or instantaneous measurements associated with a 24-hour event must be reported separately. **They are not composites and therefore cannot be considered part of a 24-hour event.** Examples include Secchi-disk transparency; instantaneous DO, temperature, pH, and specific-conductance measurements; stream discharge, routine water chemistry, and bacteria data, or simply everything that was not downloaded from the multiprobe instrument.

QC Checks

It is important to collect accurate 24-hour DO data. These data are used for assessing standards compliance and whether a water body is capable of supporting the designated or presumed ALU. **Calibration and post calibration checks must be done with each 24-hour deployment. The difference between the calibration and post calibration for DO must be within ± 0.5 mg/L or ± 6 percent saturation.** Post-calibration error limits for optional 24-hour parameters are listed in Chapter 8.

The time between calibration and the post-calibration check may vary. Some instruments are left out for 48 hours. In other cases, one instrument may be used for several 24-hour samplings before the post-calibration check. This is not the preferred method but is acceptable as long as the instrument passes the post-calibration check. The risk of expanding the time between calibration and the post-calibration check is the loss of data if the instrument fails the QC checks.

Specific Conductance

Parameter Code 00094

Record specific conductance measurements in microsiemens per centimeter (µS/cm); to three significant figures if the value is greater than 100 µS/cm and to two significant figures if the value is less than 100.

Equipment

- A multiprobe instrument, calibrated according to "Conductivity Sensor," Chapter 8.

Procedures for Sampling

The specific conductance function is calibrated each day of use for multiprobe instruments. See Chapter 8, "Calibrating and Maintaining Multiprobe Instruments." Measure specific conductance, like other field parameters, directly from a water body at depth(s) specified in "Depth of Field Measurements." Allow the conductivity probe to equilibrate for at least two minutes before recording specific conductance.

A common physical problem in using a specific-conductance probe is trapping of air bubbles. Air in the probe is indicated by unstable specific conductance values fluctuating up to ±100 µS/cm, which can be minimized by slowly, carefully placing the probe into the water and, when the probe is completely submerged, quickly moving it through the water to release any air bubbles.

Salinity

Parameter Code 00480

In 1978, oceanographers redefined salinity in the *Practical Salinity Scale* as the conductivity ratio of a seawater sample to a standard KCl solution. PSS is a ratio with no units but is expressed in ppth which is approximately *grams of salt per kilogram of solution* (Stewart, 2008). Salinity is calculated from specific conductance and temperature. Multiprobe instruments compute salinity from specific conductance and temperature based on Standard Method 2520b, 18th edition, 1989. The method detection limit for the equation used by field instruments is 2.0–42.0 parts per thousand (ppth).

Equipment

- Multiprobe instrument, calibrated according to "Conductivity Sensor," Chapter 8.

Procedures for Sampling

In estuarine waters, salinity is a relevant and meaningful parameter. Often, salinity may be low, approaching that of freshwater. Nevertheless, this is useful information. Determine if a station is estuarine from historical records (cases where salinity is ≥ 2.0 ppth) and always report salinity at this station, regardless of the salinity during periods of high flow. Measure salinity, like other field parameters, directly in situ at the depths specified in "Field Measurements." Record salinity data in parts per thousand, to the nearest 0.1 ppth, for tidal streams, estuaries, or bays. Report values less than 2.0 ppth as "< 2.0 ppth" rather than the actual value.

Do not report salinity from freshwater or inland (brine) locations. These values are not comparable to salinity measurements in marine or tidally influenced locations. They include other salts depending on the underlying geography. In the absence of salinity data, the staff can calculate salinity by using temperature and specific conductance.

Field Measurements from a Bucket

If it is not possible or unsafe to measure *in situ*, use a container (for example, a Nalgene or plastic bucket) to measure DO, water temperature, pH, and specific conductance. Take care to ensure a measurement representative of in-stream conditions.

When taking field measurements with a multiprobe instrument, remember to place the sonde directly in the water body to be sampled and then allow it to equilibrate while water samples are collected. Only use a multiprobe instrument and bucket to measure field parameters in atypical circumstances.

- Do not use a bucket if the multiprobe instrument can be put directly into a water body. Use a bucket in atypical situations when such insertion is not practical (extreme high flows, a bridge too high for the cable, lack of safety).
- Choose a bucket that is large enough to allow full immersion of the probe.
- Before filling, bring the temperature of the bucket to the same temperature as the water.
- Place the probe in the bucket immediately, before the temperature changes.
- Protect the bucket from direct sunlight and strong breezes before and during field measurements.
- Allow the probe to equilibrate for at least two minutes before recording field parameters (DO, water temperature, specific conductance, and pH).
- For details on collecting water samples from a bucket, see Chapter 5.

Secchi-Disk Transparency

Parameter Code 00078

Importance of Secchi-Disk Transparency Data

Secchi-disk transparency remains an important secondary parameter for assessing *eutrophication*—the natural aging process in reservoirs and lakes—and for determining trends in water clarity. Eutrophication is accelerated by human activities that add nutrients to lakes, reservoirs, and the surrounding watersheds. Section 314 of the federal Clean Water Act of 1987 requires all states to classify lakes and reservoirs according to the trophic state. The TCEQ evaluates and ranks major Texas reservoirs and lakes using Carlson's trophic-state index (TSI). The TSI was developed to compare among reservoirs, Secchi-disk depths, chlorophyll *a* and total phosphorus concentrations obtained during routine reservoir monitoring (Carlson 1977). Although chlorophyll *a* is the most direct measure of algal biomass, Carlson's TSI uses Secchi-disk depth as the primary factor. Carlson's TSI is a useful tool for assessing the current condition of a reservoir or lake and monitoring it for change over time. It is important to pair nutrient sampling with Secchi-disk transparency whenever possible. For additional information see the "Nutrient Sample Collection" section in Chapter 5. Secchi-disk measurements in streams are also important for interpreting nutrient data. For bays and estuaries the Secchi disk is the preferred method. For shallow streams and rivers the Secchi tube is the preferred method.

Equipment

- Secchi disk, 20 cm in diameter attached to a calibrated line (calibrated in metric increments) or fixed pole

- Secchi tube (optional)
- measuring tape (metric)

Procedures for Sampling

Measure Secchi-disk transparency directly in the water body wherever conditions allow. The Secchi disk should be clean, weighted and suspended on a metric-calibrated chain, wire, or Dacron line (not nylon or cotton because stretching may cause erroneous readings). A standard Secchi disk is 20cm in diameter and divided into four sections alternating black and white (see Figure 3.3). Another option is to attach the Secchi disk to a PVC pole calibrated in metric units. A Secchi disk mounted on a pole is beneficial for stations affected by wind and waves that make reading a traditional Secchi disk difficult. Record the Secchi-disk transparency in meters. Remove sunglasses before making a measurement.

Normal Turbidity

Following are procedures for measuring Secchi-disk transparency under normal conditions:

- Lower the Secchi disk vertically in a location shielded from direct sunlight. Glare from the water's surface will affect the accuracy of the measurement. Don't wear sunglasses.
- Slowly lower the disk until it disappears from view. The viewer should maintain an eye level of less than 2 meters above the water's surface. Note the depth from the surface at which the disk disappears from view.
- Slowly raise the disk until it becomes visible. Note the depth at which the disk reappears.
- Compute the average (mean) of the two depths noted and record the value in the field logbook. The recorded average value is the Secchi-disk transparency.

High Turbidity

(Muddy Water)

To measure Secchi-disk transparency in highly turbid water:

- If necessary, use a bucket to measure Secchi-disk transparency in streams with very high turbidity and high velocity. Fill the bucket from the centroid of flow, being careful not to disturb the substrate.

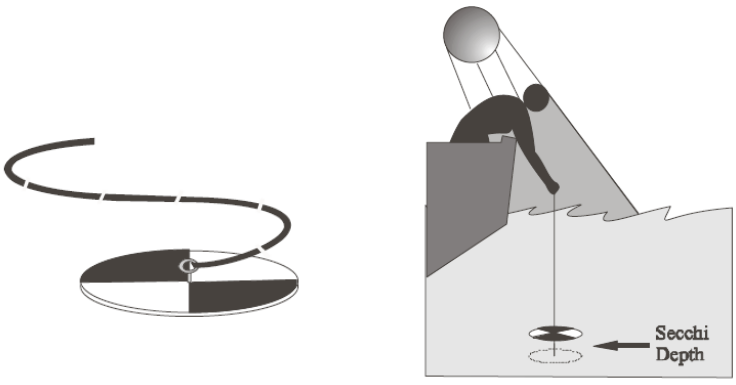


Figure 3.3. Secchi disk (Ministry of the Environment, Ontario, Canada, 2003).

- Follow the steps above for measuring the Secchi-disk depth within 30 seconds after raising the filled bucket from the water surface. If the solids settle resuspend by stirring and then quickly take the measurement.
- Record Secchi-disk transparency measurements in meters to two significant figures.

Low Turbidity
(Clear Water)

To measure Secchi-disk transparency under very clear water with low turbidity:

- Some bodies of water will be so clear and shallow that it will not be possible to lower the Secchi disk until it disappears from view.
- Measure and record the depth at the deepest point accessible.
- Report Secchi-disk transparency as greater than the deepest depth measured.

Example of low turbidity: South Fork Rocky Creek is a small (< 1 ft^3/s flow) clear stream. The stream in the vicinity of the sampling site is less than 1 meter deep and the bottom is clearly visible everywhere. However, a pool is located in the stream next to a bridge. The maximum depth of the pool is 2.6 meters, at which depth the Secchi disk is still visible. Therefore, Secchi-disk transparency for South Fork Rocky Creek is recorded as > 2.6 m.

Secchi Tube

Stream transparency can be measured with either a Secchi disk or Secchi tube. The tube varies in length and is made of narrow clear plastic, with a release valve at the bottom (see Figure 3.4). The bottom end of the tube has a small Secchi-disk symbol. The standard dimensions of a Secchi tube for SWQM in Texas are 120 cm long × 4 cm in diameter.

1. Fill the tube with sample water just until the image at the bottom of the tube is no longer visible when looking directly through the water column at the image—having taken care to take readings in open but shaded conditions. Avoid direct sunlight by turning your back to the sun. Remove sunglasses before making a measurement.
2. Look down into the tube and release water through the valve until the symbol is just visible.
3. Read the turbidity on the column at the bottom of the meniscus (bottom of the curve in the water surface).
4. Record the depth of the water in meters. If the symbol is visible when the tube is full, the transparency reading is greater than 0.60 meters (see Figure 3.4).

Figure 3.4. Secchi tube.

Note: If you have the type of Secchi tube that includes a string for lowering and raising the disk, average the measurements taken where the disk disappears and then reappears.

Chlorine Residual

Chlorine has an effect on bacteria, BOD, cyanide, semivolatile organics, pesticide, and herbicide samples. Chlorine residual should be analyzed from samples collected downstream of chlorinated effluent discharges or in areas where the presence of chlorine is suspected when these types of samples are collected. If chlorine is present and these samples are to be analyzed for bacteria, BOD, semivolatile organics, pesticides, and herbicides, the samples must be treated with sodium thiosulfate ($Na_2S_2O_3$) to remove the chlorine. Cyanide samples are treated with ascorbic acid to remove chlorine. See Chapters 4 and 5 for details on the treatment of samples in the presence of chlorine. Test strips or a standard chlorine residual test may be used as a way to determine the presence or absence of residual chlorine in the field.

Field Data Reporting

Values must be in final form before reporting to the TCEQ central office (see Table 3.11). See the *SWQM DMRG* for detailed information on data reporting.

General Rounding Rules

Every measurement has a degree of uncertainty, so field measurements are rounded before being submitted to the TCEQ SWQMIS database. Round numbers by dropping digits that are not significant, according to *Standard Methods* (APHA, et al. 2005). In decimals, if the digit *6, 7, 8,* or *9* is dropped, increase the preceding digit by one unit. For example, *6.68* rounds to *6.7*. If *0, 1, 2 3,* or *4* is dropped, do not change the preceding digit. For example, *6.62* rounds to *6.6.* If *5* is dropped, round off the preceding digit to the nearest even number. For example, *2.25* rounds down to *2.2*; *2.35* rounds up to *2.4*. See Table 3.1.

Other Field Observations

Days Since Last Significant Precipitation

Parameter Code 72053

"Significant" precipitation is defined as any amount that visibly influences water quality. Water quality in small to medium streams and in the headwaters of many reservoirs is influenced by runoff during and immediately after rainfall. This influence is

site specific and poorly studied. To understand and regulate the adverse effects of runoff, the SWQM Program would like to associate recent rains or melted snow with ambient water quality, using *days since last significant precipitation*, which can also be used to indicate periods of insufficient rainfall and long-term drought.

Using your best professional judgment, record the number of days—rounded to the nearest whole number—since a rainfall that may have influenced water quality. Here are some guidelines:

- If it is raining when the sample is collected, or has rained within the last 24 hours, report a value of *< 1*.

- If it has been a long time since a significant rain, record either the actual number of days, if known, or a 'greater than' value—for example, *> 60 days*.
- If your confidence about the recent history of precipitation is low, don't report a value. See the *SWQM DMRG* for detailed information on data reporting.

Flow Severity

Parameter Code 01351

Record a flow-severity value for each SWQM visit to freshwater streams or rivers (**nontidally influenced**) and report the value to the TCEQ central office. Do not report flow severity for reservoirs, lakes, bays or tidal streams. It should be recorded even if it was not possible to measure flow on a specific sampling visit. See the *SWQM DMRG* for detailed information on data reporting.

No numerical guidelines are associated with flow severity, an observational measurement that is highly dependent on the water body and the knowledge of monitoring personnel. It is a simple but useful piece of information when assessing water quality data. For example, a bacteria value of 10,000 with a flow severity of *1* would represent something entirely different than the same value with a flow severity of *5*. See Table 3.2 for detailed descriptions of flow-severity values.

Real-time flow data for U.S. Geological Survey sites statewide and International Boundary and Water Commission sites in the Rio Grande Basin are available on the Web (see Appendix A). This is useful information in determining actual flow, flow conditions before sampling, and flow severity. Flow severity in streams with managed flows—especially seasonal, for irrigation—can be difficult to determine. Flow severity in these streams should not be based on seasonal norms. For example, flow due to irrigation demands creates a "normal" flow of 500 cfs during the summer months and a "normal" flow of 50 cfs during the winter months where irrigation flows stop. This information would be difficult to interpret.

Table 3.1. Final format for reporting field data (rounding, significant figures).

Parameter	Parameter Code	Final Form for Field Data (Rounding, Significant Figures)
Water temperature (˚C)	00010	Report temperature to the nearest tenth in degrees Celcius. (example: *25.94* to *25.9*, or *26.97* to *27.0*)
pH (s.u.)	00400	Report pH to the nearest tenth in pH standard units. (example: *7.94* to *7.9*, or *7.97* to *8.0*)
DO (mg/L)	00300	Report dissolved oxygen to the nearest tenth in mg/L. (example: *5.94* to *5.9*, or *6.97* to *7.0*)
Specific conductance (µS/cm)	00094	Report specific conductance to only three significant figures if the value exceeds 100—for example: *1532* to *1530*. Do not report ORP, which is displayed by some multiprobe instruments. For values < 100µS/cm follow standard rounding rules and report the nearest whole number. For example, report *88.7* as *88 µS/cm*.
Salinity (ppth)	00480	Report salinity values above 2.0 ppth to the nearest tenth in parts per thousand. Do not report salinity from freshwater or inland (brine) locations. In estuarine waters report the actual values displayed by the instrument above 2.0 ppt, and values less than 2.0 as *< 2.0* (examples: *0.85* to *< 2.0*; *1.5* to *< 2.0*). Determine if a station is estuarine (experiencing periods where salinity is > 2.0 ppth), and always report salinity at this station, regardless of salinity during periods of high flow. In the absence of salinity data, use specific conductance and temperature to calculate salinity.
Secchi disk (meters)	00078	Report Secchi-depth transparency in meters to two significant figures (examples: *0.35 m* or *1.3 m*).
Days since last significant precipitation (days)	72053	Report whole numbers. If it is raining when the sample is collected, or has rained within the last 24 hours, report a value of *< 1*. Otherwise report the actual number, if known, or a 'greater than' value.
E. coli (MPN/100 mL)	31699	First step: round the result to the nearest whole number to remove decimals. Second step: round to two significant figures (example: *347.1* to *347* to *350*). Adjust < and > results based on dilution. Do not report "zero" but *< 1*.
Enterococci (MPN/100 mL)	31701	*First step:* round the result to the nearest whole number to remove decimals. *Second step:* round to two significant figures (example: *347.1* to *347* to *350*; *9.7* to *10*). Adjust < and > results based on dilution. Do not report "zero" but *< 1*.
Fecal coliform (colonies/100 mL)	31616	Always report fecal coliform densities as a whole number. If no colonies are detected, report a less than value based on the volume filtered. For example: report *< 1* (100 mL filtered), *< 4* (25 mL filtered), or *< 10* (10 mL filtered). For concentrations > 100, report two significant figures. Do not record "TNTC" or "0/100 mL."
Flow (**Stream Discharge)** (ft^3/s)	00061	Report instantaneous flow **values less than 10 but greater than 0.1 ft^3/s** to the nearest tenth (example: *9.35* to *9.4*). Report flow **values greater than 10 ft^3/s** to the nearest whole number (example: *20.62* to *21*). Actual flow **values less than 0.1 ft^3/s but greater than or equal to 0.01 ft^3/s** are reported and not subject to rounding (example: report *0.07* as *0.07*). Report flow **values < 0.01 ft^3/s** as *< 0.01*. When there is **no flow** (pools), report 00061 as *0.0*. When there is no water, do not report a value for 00061.
Flow severity (1—No Flow, 2—Low, 3—Normal, 4—Flood, 5—High, 6—Dry)	01351	Report flow severity for freshwater streams and rivers only. When there is no flow (pools), report a flow severity of *1*, and the instantaneous flow (00061) as *0.0 ft^3/s*. If the stream is dry, record only the flow-severity value of *6*.
Note: For details on reporting final data sets to the TCEQ, see the *SWQM DMRG*.		

Table 3.2. Flow-severity values.

Severity Value		Description
1		**No Flow.** When a flow severity of ***1*** is recorded for a sampling visit, record a flow value of 0 ft^3/s (using parameter code 00061) for that sampling visit. A flow severity of *1* describes situations where the stream has water visible in isolated pools. There should be no obvious shallow subsurface flow in sand or gravel beds between isolated pools. "No flow" not only applies to streams with pools, but also to long reaches of streams that have water from bank to bank but no detectable flow.
2		**Low Flow.** When streamflow is considered low, record a flow-severity value of ***2*** for the visit, along with the corresponding flow measurement (parameter code 00061). In streams too shallow for a flow measurement where water movement is detected, record a value of < 0.10 ft^3/s. In general, at low flow the stream would be characterized by flows that don't fill the normal stream channel. Water would not reach the base of both banks. Portions of the stream channel might be dry. Flow might be confined to one side of the stream channel. ***Note:*** Use a stick or other light object to verify the direction of water movement. Make sure the movement is downstream and not the effect of wind.
3		**Normal Flow.** When streamflow is considered normal, record a flow severity value of ***3*** for the visit, along with the corresponding flow measurement (parameter code 00061). What is normal is highly dependent on the stream. Normality is characterized by flow that stays within the confines of the normal stream channel. Water generally reaches the base of each bank.
4		**Flood Flow.** Flow-severity values for high and flood flows have long been established by the EPA and are not sequential. Flood flow is reported as a flow severity of ***4***. Flood flows are those that leave the confines of the normal stream channel and move out onto the floodplain (either side of the stream).
5		**High Flow.** High flows are reported as a flow severity of ***5***. High flow would be characterized by flows that leave the normal stream channel but stay within the stream banks.
6		**Dry.** When the stream is dry, record a flow-severity value of ***6*** for the sampling visit. In this case the flow (parameter code 00061) is not reported, indicating that the stream is completely dry with no visible pools.

Pool Characteristics (Flow Severity = 1)

Parameter Codes 89864, 89865, 89869, and 89870

Data collection as part of routine water quality monitoring is conducted under all flow conditions including intermittent streams with pools (flow severity = 1). When sampling in a pool it is important to record basic information about its size, to better define attainable and beneficial uses for aquatic life and contact recreation. Pool characteristics (other than size) are also needed to determine the aquatic-life use supported by pools of different sizes and persistence. A pool is defined as anything greater than or equal to 10 meters in length and greater than or equal to 0.4 m in depth.

To aid in defining pools, record and report the following information for the main pool sampled:

- maximum pool width (meters)
- maximum pool depth (meters)
- pool length (meters)

To determine the percent pool coverage, check a reach that extends a total of 500–800 meters upstream and downstream of the monitoring site. Report the percent pool coverage in a 500 m–800 m reach.

Reporting the Flow-Measurement Method

Parameter Code 89835

The method (or instrument) used to measure flow is noted by reporting a method category number.

1—flow-gauge station (USGS, IBWC)

2—electronic (example, Marsh-McBirney)

3—mechanical (example, pygmy meter)

4—weir or flume

5—Doppler (example, FlowTracker)

Flow

Parameter Code 00061

Flow is required at all routine freshwater stream monitoring sites. Always measure flow, read a USGS (or IBWC on the Rio Grande) flow gauge, or obtain a flow value at a later date from the USGS or IBWC. Flow from gauging stations may only be reported with data collected immediately adjacent to that site, unless a case can be made that no major tributary or wastewater discharge is located between the gauge station and monitoring site.

Report flow values in cubic feet per second (ft^3/s). Flow values must be in final form before they are reported to the TCEQ central office (see Table 3.1). See the *SWQM DMRG* for detailed information on data reporting.

Considerations when Measuring Flow

When measuring flow there are two things to keep in mind. Consider measuring flow first in order to delay collection of chemical and biological water samples with limited holding

times. If flow is measured first, take care not to deploy a multiprobe instrument or to collect water samples in the area disturbed during flow measurement.

Exceptions to Flow-Reporting Requirements

There are two exceptions to the flow-reporting requirements:

No flow and pools. If there is no flow at a stream site, and accessible, isolated pools remain in the stream bed, collect and report the required field data and laboratory samples from the pools and report instantaneous flow. Under these conditions, report flow (ft^3/s) as zero (parameter code 00061 = 0.0). The reported flow severity value should be 1 (parameter code 01351 = 1). Pools may represent natural low-flow conditions in Texas streams, and the chemistry of these pools will reveal natural background conditions.

Dry. If the stream bed holds no water, no sampling is required. Report that the stream was "dry" in the observations and record a value of *6* (meaning 'dry') for flow severity (parameter code 01351 = 6). No value is reported for flow (parameter code 00061) since there is no water. A data record must be sent to the TCEQ central office if the site is on the routine monitoring schedule.

Methods for Measuring Flow

Instantaneous Flow Measurement

Instantaneous flow must be measured at water quality monitoring visits to sites where there are no nearby flow gauges. The method described in this manual is based on the U.S. Geological Survey's method for streamflow measurement (Rantz 1982).

Equipment

Flow Meter

One of the following or an equivalent:

- Marsh-McBirney electronic meter
- Son-Tek FlowTracker (Doppler, handheld)

Additional Equipment

- top-setting wading rod (measured in tenths of feet)
- tape measure (with gradations every tenth of a foot)

Procedure for Measuring Flow

1. Site Selection

The key to successful flow measurement is site selection. Select a stream reach with the following characteristics (see Figure 3.5):

- Find a straight reach with laminar flow (parallel threads of velocity) that extends from bank to bank. The depth and velocity should be relatively uniform. This is typically found in unobstructed riffles, runs or glides.

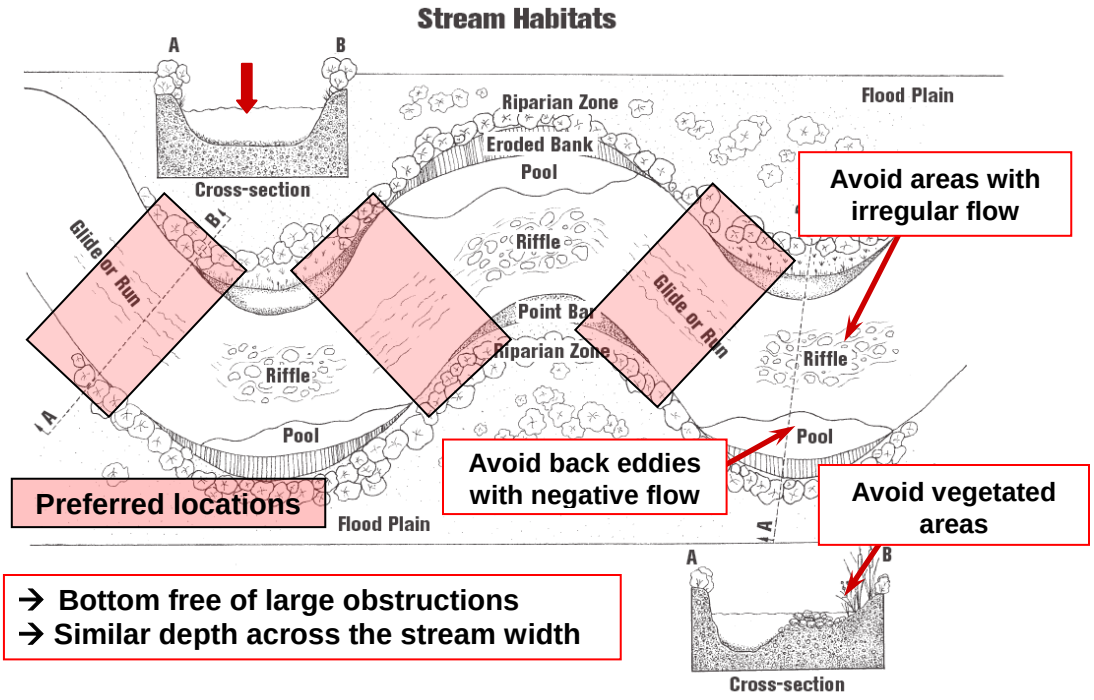


Figure 3.5. Selecting a stream reach.

- Find an even streambed free of large rocks, weeds, and protruding obstructions that create turbulence. Flow should be uniform and free of eddies, dead water near banks, excessive turbulence, and aquatic vegetation.
- Avoid measuring flow in areas with back eddies. However, this cannot always be avoided. Measure the negative flows in areas with back eddies. Include these negative values in the final flow calculation.

2. Recording Flow Data

Record the following information on a flow measurement form:

- the station location and ID
- the date
- the time the measurement is initiated and ended
- the names of persons measuring flow
- the total stream width and the width of each measurement section
- the midpoint, section depth, and flow velocity for each cross-section

See Tables 3.3 to 3.5 for examples of completed flow-measurement forms. See Table 3.6 for a blank form.

3. Cross-Section Profile

Stretch the measuring tape across the stream at right angles to the direction of flow. When an electronic flow meter is used, the tape does not have to be exactly perpendicular to the bank (direction of flow). If necessary, on smaller, low-flow streams, the cross-section can be modified—by building dikes to cut off dead water and shallow flows and removing rocks, weeds, and debris in the reach of stream 1 to 2 meters upstream from the

measurement cross-section. After modifying a streambed, allow the flow to stabilize before starting the measurement.

4. Measuring the Stream Width

Measure and record the stream width between the points where the tape is stretched (water's edge to water's edge). See Figure 3.6.

5. Determining the Number of Flow Cross-Sections

Determine the spacing and location of flow measurement cross-sections. Some judgment is required, depending on the shape of the streambed. Measurements must represent the velocity within the cross-section. Fewer measurements are needed if the stream banks are straight, the depth nearly constant, the bottom free of large obstructions, and the flow homogeneous over a large section. Flow-measurement sections should be of equal width, unless an obstacle or other obstruction prevents an accurate velocity measurement at that point. **No single cross-section should have more than 10 percent of the total flow.** Take the majority of flow measurements in cross-sections of equal width; they will be a constant value in the flow calculation.

Stream width* less than *5 feet. If the stream width is less than 5 feet, cross-section widths are 0.5 ft. See Table 3.5.

Stream width* greater than *5 feet but* less than or equal to *10 feet. If the stream is wider than 5 ft, the minimum number of cross-sections is 10.

Stream width* greater than *10 feet. If the stream is wider than 10 ft, the preferred number of cross-sections is 20 to 30.

Note: Figures 3.6 through 3.15 illustrate an example using a stream that is 10 feet wide.

6. Determining the Midpoint of the Cross-Section

Divide the cross-section width in half to find the midpoint of the cross-section (see Figure 3.7).

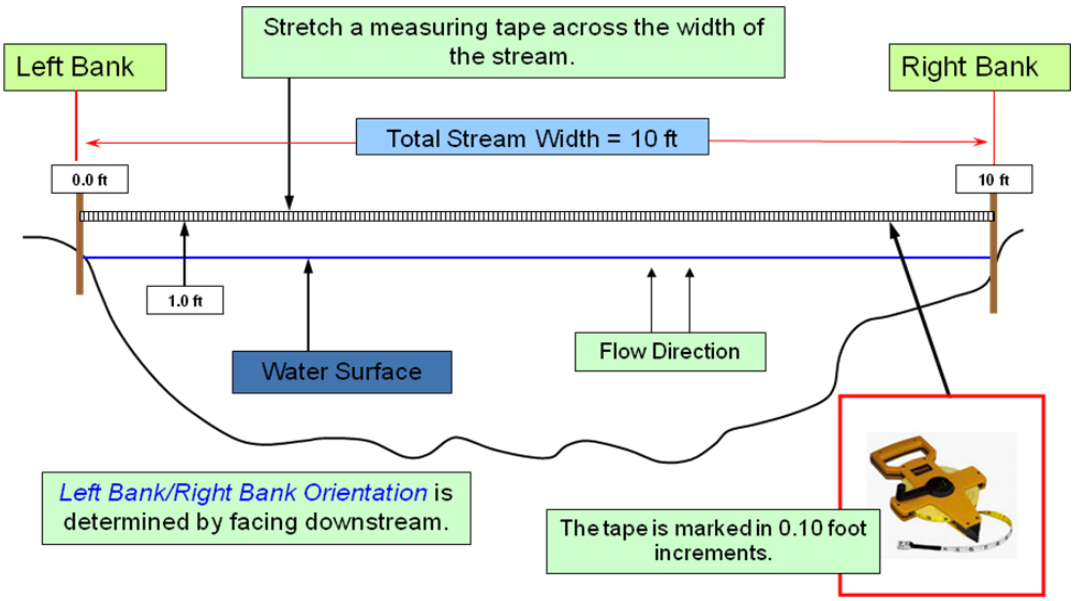


Figure 3.6. Measuring the stream width.

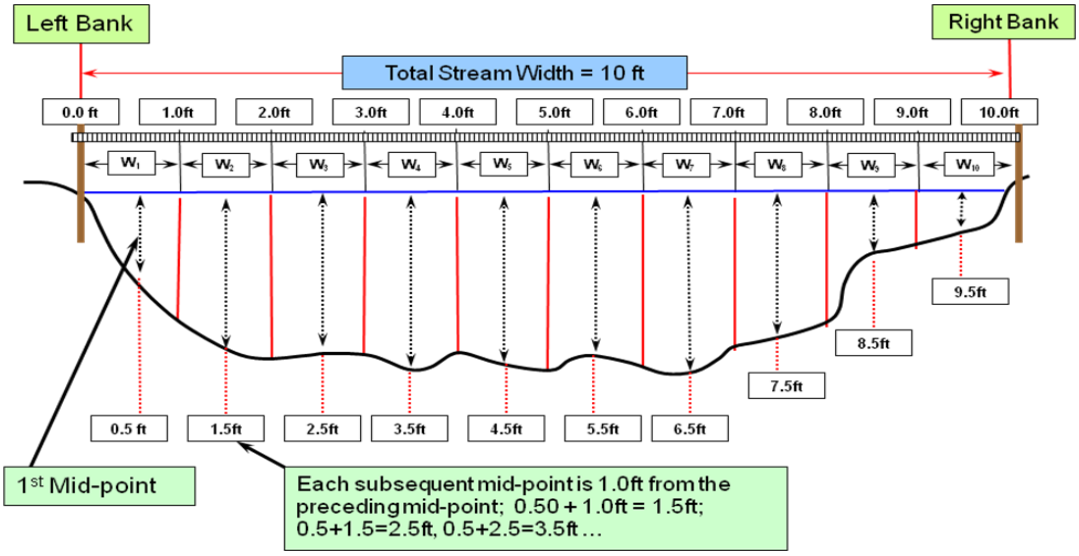


Figure 3.7. Determining the midpoint of the cross-section.

7. Determining the Cross-Section Depth

Using a top-setting wading rod measure the depth at the midpoint of the first cross-section and record to the nearest 0.01 ft. See Figure 3.8.

Measure the total depth at each cross-section with the *depth gauge rod*. Each single mark represents 0.10 ft; each double mark, 0.50 ft; and each triple mark, 1.00 ft (see Figure 3.9).

8. Adjusting the Sensor Depth at a Cross-Section

Adjust the position of the sensor to the correct depth at each midpoint. The top setting wading rod is designed so the user to can easily set the sensor at 20, 60, and 80 percent of the total depth. See Figure 3.10.

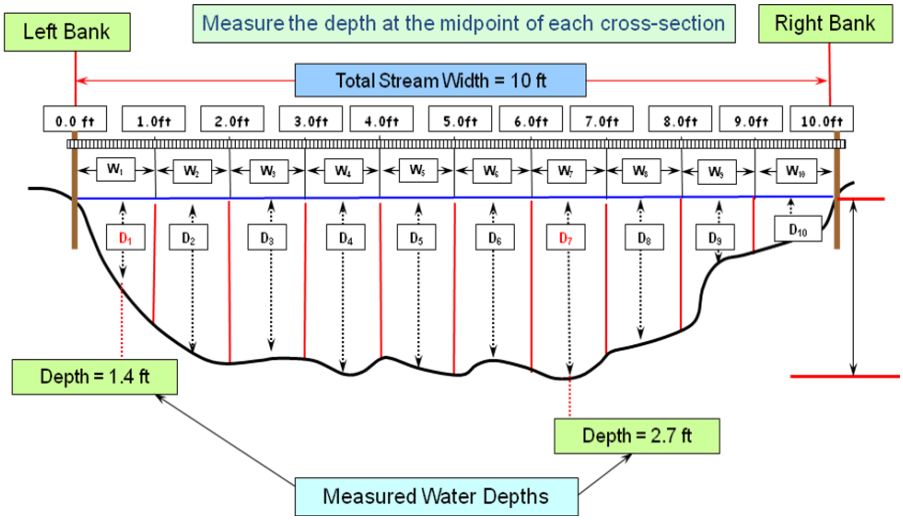


Figure 3.8. Measuring the depth at each midpoint.

For depths ≤2.5 feet. If the depth is 2.5 ft or less, only one velocity measurement is required at each cross-section. To set the sensor at 60 percent of the depth, simply line up the foot scale on the *sliding rod* with the *tenth scale*, located at the top of the depth gauge

rod. If, for example, the total depth is 1.4 ft, then line up the *1* on the feet scale with the *4* on the tenths scale. See Figure 3.11.

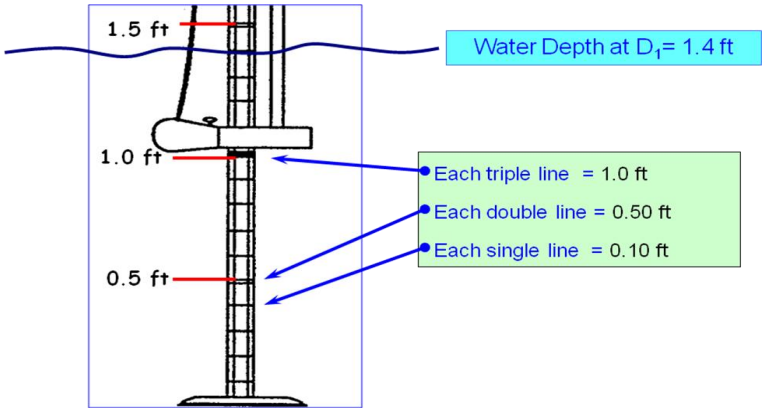


Figure 3.9. Measuring the depth using a top-setting wading rod.

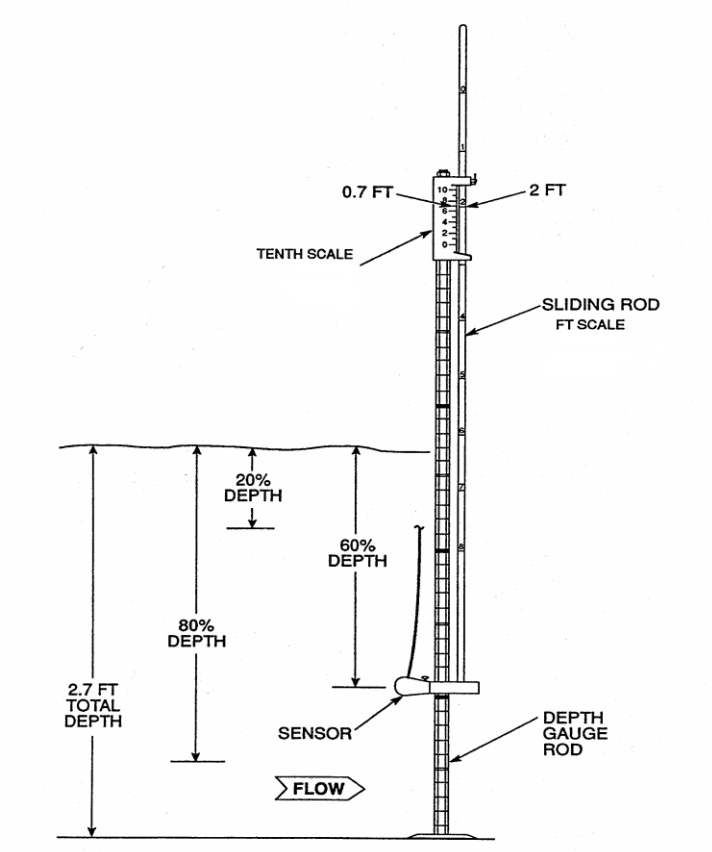


Figure 3.10. Top-setting wading rod.

For depths > 2.5 feet. If the depth is greater than 2.5 ft, take two velocity measurements, at 20 and 80 percent of the total depth. Never set the wading rod at the actual depth. In this case, it would not be set at 2.7 ft.

- ***20 percent of the depth.*** Multiply the total depth by 2. If the total depth is 2.7 ft, the rod would be set at 5.4 ft (2.7 × 2). Line up the *5* on the sliding rod with the *4* on the tenths scale (Figure 3.12). Take a velocity measurement.

■ ***80 percent of the depth***. To set the sensor at 80 percent of the depth, divide the total depth by two. For example, the total depth is 2.7 ft and the rod is set at 1.35 ft (2.7⁄2). Line up the *1* on the sliding rod between the *3* and *4* on the tenths scale (Figure 3.12). Take a velocity measurement. The average of the two velocity measurements is used in the flow calculation.

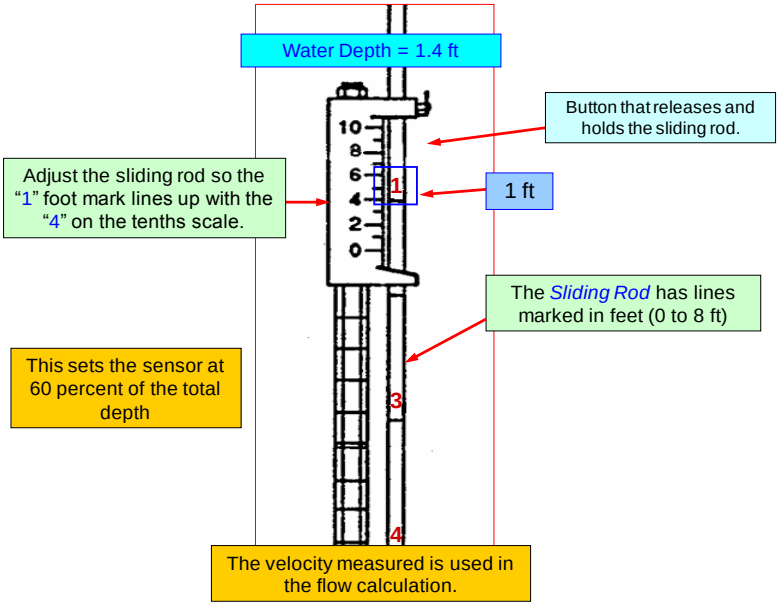


Figure 3.11. Setting the flow sensor at depths ≤ 2.5 feet.

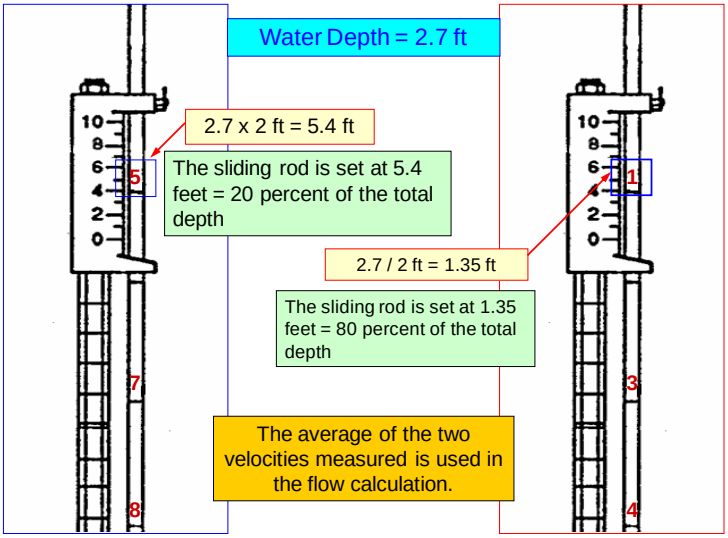


Figure 3.12. Setting the flow sensor at depths > 2.5 feet.

9. Measuring Velocity

To measure velocity:

■ Position the flow sensor at the midpoint of the cross-section as described above in "Adjusting the Sensor Depth at a Cross-Section" (see also Figure 3.13). Measure and record the velocity and depth. While measuring velocity with an electronic flow meter, keep the wading rod vertical and the flow sensor perpendicular to the tape, rather than perpendicular to the flow.

- Allow the sensor to adjust to the current for a few seconds. Measure the velocity for a minimum of 20 seconds
- When measuring the flow by wading, stand in the position that least affects the velocity of the water passing the current meter. Stand a minimum of 1.5 ft downstream and off to the side of the flow sensor.

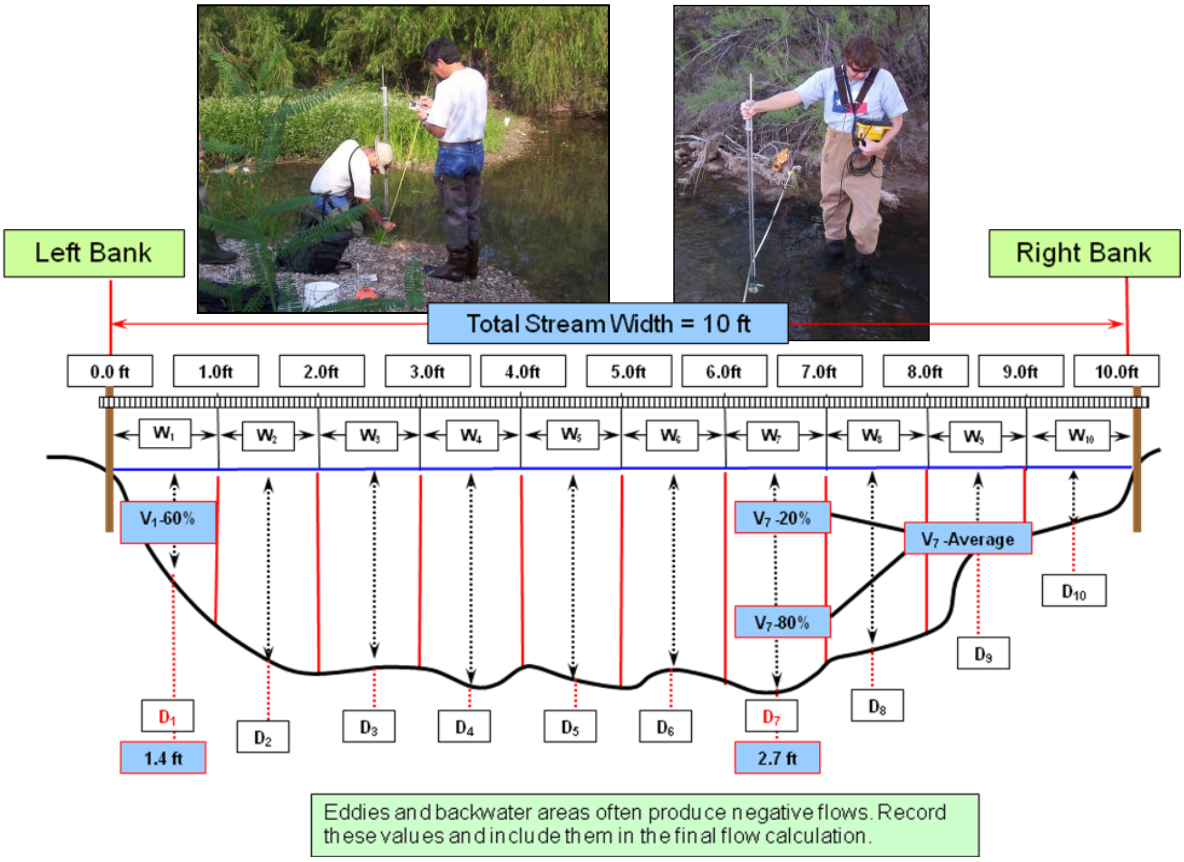


Figure 3.13. Measuring velocity.

10. Recording Flow

Do not round values (other than the final value) when recording flow data. For example, if the velocity is 1.99, do not round to 2.0. Rounding each value on the worksheet will introduce an error in the final value. Record negative velocity values. See Figure 3.14.

Stream Width = 10 ft; Cross Section Width (W) = 1.0 ft						
Cross–Section No. (see Figure 3.12)	Section Midpoint (ft)	Section Depth (D) (ft)	Sensor Depth	Velocity (V)		Discharge (Q) (ft^3/s) Q = (W)(D)(V)
				At Point (ft/sec)	Average (ft/sec)	
1	0.5	1.4	1.4		0.85	
2	1.5	2.0	2.0	60%	1.0	
3	2.5	1.9	1.9		1.3	
4	3.5	2.2	2.2		1.7	
5	4.5	2.1	2.1	20%	1.8	
6	5.5	2.5	2.5		1.8	
7	6.5	2.7	5.4	1.8	1.9	
			1.35	2.0		
8	7.5	1.7	1.7	80%	1.1	
9	8.5	1.0	1.0		0.75	
10	9.5	0.5	0.5		-0.45	

Figure 3.14. Recording flow data.

11. Calculating Flow

After measuring and recording the velocity and depth at each cross-section, follow these steps to calculate flow:

Calculate flow at each cross-section by multiplying the width (W) × depth (D) × velocity (V) to determine flow in cubic feet per second (cfs or ft^3/sec). See Figure 3.15.

Q = Total Flow (or discharge), W = Width, D = Depth, V = Velocity

$$Q = (W_1 \times D_1 \times V_1) + (W_2 \times D_2 \times V_2) + \ldots (W_n \times Dn \times V_n)$$

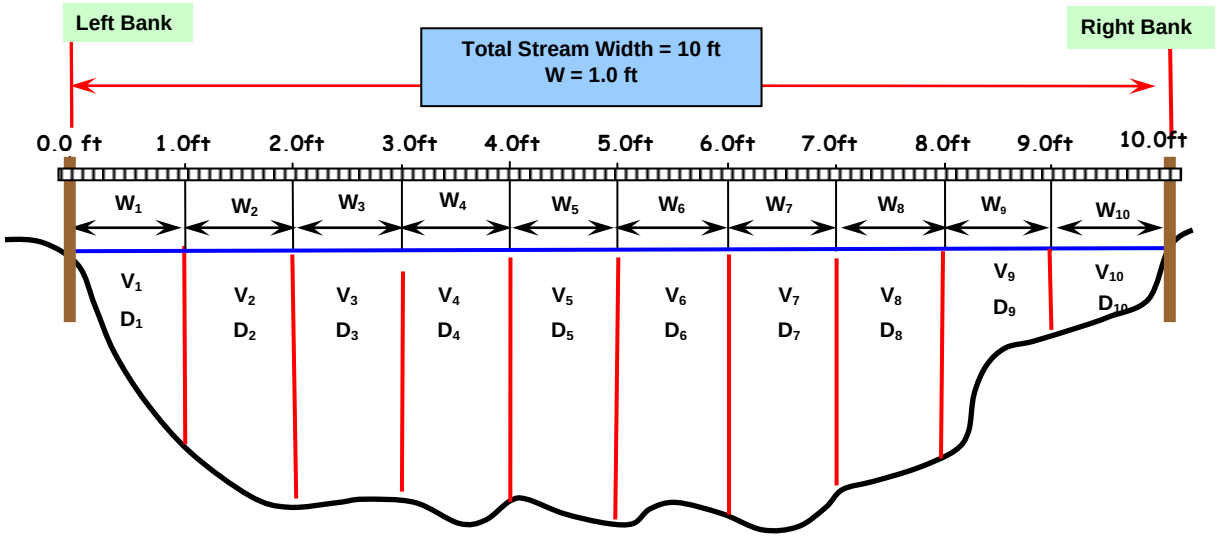
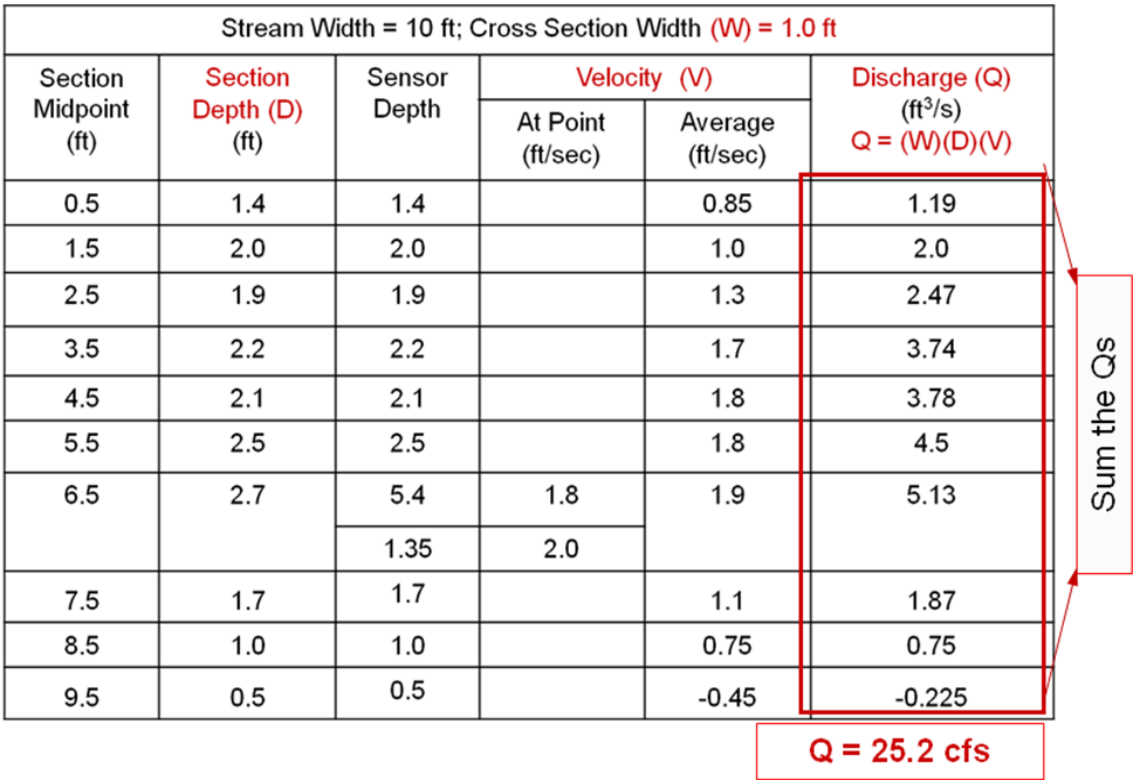


Figure 3.15. Streamflow (discharge) measurement.

- For each individual cross-section flow, **do not** round values. For example, if the calculated flow for a cross-section is 1.23956, do not round. Rounding each value on the worksheet could introduce an error in the final value.
- After calculating the flow for each cross-section, add them together for the total streamflow. See Figure 3.16.



Stream Width = 10 ft; Cross Section Width (W) = 1.0 ft					
Section Midpoint (ft)	Section Depth (D) (ft)	Sensor Depth	Velocity (V)		Discharge (Q) (ft^3/s) Q = (W)(D)(V)
			At Point (ft/sec)	Average (ft/sec)	
0.5	1.4	1.4		0.85	1.19
1.5	2.0	2.0		1.0	2.0
2.5	1.9	1.9		1.3	2.47
3.5	2.2	2.2		1.7	3.74
4.5	2.1	2.1		1.8	3.78
5.5	2.5	2.5		1.8	4.5
6.5	2.7	5.4	1.8	1.9	5.13
		1.35	2.0		
7.5	1.7	1.7		1.1	1.87
8.5	1.0	1.0		0.75	0.75
9.5	0.5	0.5		-0.45	-0.225

Figure 3.16. Calculating streamflow (discharge).

12. What to Do with Negative Values

Do not treat cross-sections with negative flow values as zeros. Negative values obtained from areas with back eddies should be subtracted during the summation of the flow for a site.

13. Reporting Final Flow Values

Report instantaneous flow as follows:

- Report values **< 10 but > 0.1 cfs** to the nearest tenth (for example, *9.35* to *9.4*).
- Report values **> 10 cfs** to the nearest whole number (for example, *20.62* to *21*).
- Report actual values **< 0.1 cfs but ≥ 0.01 cfs**. These values should not be rounded (for example, report *0.07* as "0.07").
- Report **flow values < 0.01 cfs** as *< 0.01*. See Table 3.1.

Examples

See Tables 3.3, 3.4, and 3.5 for examples of completed flow-measurement forms.

Flow-Gauging Stations

Many SWQM stations are sampled at sites where the USGS or the IBWC maintains flow-gauging equipment. A **USGS or IBWC flow-gauging station represents a quarter mile of stream.** A longer distance may apply if it can be shown that no contributions or reductions in flow occur between the gauge and sampling station. USGS gauge stations are statewide; IBWC gauges are located in the Rio Grande Basin. Flow data for these gauging stations can be found on the Web—see Appendix A.

Table 3.3. *Example 1:* Streamflow measurement in a small stream < 5 feet wide and ≤ 2.5 feet deep

Streamflow Measurement

Stream: **OAK CREEK** Date: **5/29/2010**
Station Description: **Oak Creek at US Hwy 90A**
Time Begin: **1545** Time End: **1630** Meter Type: **Marsh-McBirney**
Observers: **BK/MK Total** Stream Width: **5 ft** Section Width (W): **0.5 ft**
Observations:_____

Section Midpoint (ft)	Section Depth (ft) (D)	Sensor Depth (ft)	Velocity (V)		Discharge (Q) (ft^3/s) Q = (W)(D)(V)
			At Point (ft/s)	Average (ft/s)	
0.25	0.55			–0.05	–0.01375
0.75	0.80	Nothing is recorded in these columns when the top-setting wading rod is set at 60% of the total depth. The velocity value is recorded in the "Velocity Average" column.		0.11	0.0444
1.25	0.85			0.27	0.11475
1.75	0.90			0.49	0.2205
2.25	1.10			0.58	0.319
2.75	1.50			0.72	0.540
3.25	1.20			0.76	0.456
3.75	0.90			0.76	0.342
4.25	0.75			0.44	0.165
4.75	0.30			–0.25	–0.0375
			Total Flow (Discharge)		**2.16415 ≈ 2.2**

Table 3.4. *Example 2:* Streamflow measurement in a larger stream > 5 feet wide and ≤ 2.5 feet deep.

Streamflow Measurement

Stream: **RED RIVER** Date: **5/28/2010**
Station Description: **Post Oak Creek 40 m Below Sherman WWTP Outfall**
Time Begin: **1542** Time End: **1601** Meter Type: **Marsh-McBirney**
Observers: **CM, EW, DO Total** Stream Width: **26 ft** Section Width (W): **1.3 ft**
Observations:_____

Section Midpoint (ft)	**Section Depth (ft) (D)**	**Sensor Depth (ft)**	**Velocity (V)**		**Discharge (Q) (ft^3/s) Q = (W)(D)(V)**
			At Point (ft/s)	**Average (ft/s)**	
0.65	0.55			2.03	1.45145
1.95	0.40			2.04	1.0608
3.25	0.42	Nothing is recorded in these columns when the top-setting wading rod is set at 60% of the total depth. The velocity value is recorded in the "Velocity Average" column.		2.02	1.10292
4.55	0.38			1.77	0.87438
5.25	0.40			1.75	0.910
7.15	0.42			1.93	1.05378
8.45	0.40			1.99	1.0348
9.75	0.37			1.92	0.92352
11.05	0.37			1.56	0.75036
12.35	0.43			1.32	0.73788
13.65	0.40			1.36	0.7072
14.95	0.42			1.33	0.72618
16.25	0.40			1.35	0.702
17.55	0.45			1.64	0.9594
18.85	0.48			1.70	1.0608
20.15	0.48			2.00	1.248
21.45	0.50			1.95	1.2675
22.75	0.40			2.18	1.1336
24.05	0.48			1.71	1.06704
25.35	0.50			0.60	0.390
			Total Flow (Discharge)		**19.16161 ≈ 19.2**

Table 3.5. *Example 3:* Streamflow measurement in a larger stream > 5 feet wide and > 2.5 feet deep.

Streamflow Measurement

Stream: **ARROYO COLORADO** Date: **6/16/2010**
Station Description: **Downstream of Harlingen WWTP**
Time Begin: **1400** Time End: **1445** Meter Type: **Marsh-McBirney**
Observers: **JD, CK Total** Stream Width: **47.5 ft** Section Width (W): **2.375 ft**
Observations: Note that the starting point is at 3.5 ft on the measuring tape and not zero.

Section Midpoint (ft)	Section Depth (ft) (D)	Sensor Depth (ft)		Velocity (V) At Point (ft/sec)	Velocity (V) Average (ft/sec)	Discharge (Q) (ft^3/s) Q = (W)(D)(V)
4.70	0.73				0.65	1.1269375
7.08	1.10				1.08	2.8215
9.45	1.85				0.90	3.954375
11.83	2.20				1.05	5.48625
14.20	2.20				1.44	7.524
16.58	2.45				1.09	6.3424375
18.95	2.55	20	5.1	1.75	1.76	10.659
		80	1.27	1.76		
21.33	2.60	20	5.2	1.79	1.56	9.633
		80	1.3	1.32		
23.70	2.70	20	5.4	1.63	1.45	9.298125
		80	1.35	1.26		
26.10	3.05	20	6.1	1.68	1.42	10.286125
		80	1.525	1.15		
28.48	3.10	20	6.2	1.23	0.96	7.068
		80	1.55	0.69		
30.85	2.90	20	5.8	1.22	1.06	7.30075
		80	1.45	0.89		
33.23	2.84	20	5.67	0.60	0.49	3.30505
		80	1.42	0.37		
35.60	2.65	20	5.3	0.80	0.51	3.2098125
		80	1.325	0.21		
37.98	2.65	20	5.3	0.85	0.91	5.7273125
		80	1.325	0.96		
40.35	2.20				0.28	1.463
42.73	2.30				0.16	0.874
45.10	2.05				0.51	2.4830625
47.48	1.10				0.49	1.280125
49.86	0.65				0.62	0.957125
				Total Flow (Discharge)		**100.8 ≈ 101**

Table 3.6. Streamflow (discharge) measurement form.

Streamflow (Discharge) Measurement Form

Stream:_____Date:_____
Station _____
Description:_____
Time Begin:_____ Time End: _____Meter Type:_____
Observers: _____Total Stream Width: _____Section Width (W):_____
Observations:_____

Section Midpoint (ft)	Section Depth (ft) (D)	Sensor Depth (ft)	Velocity (V)		Flow (Q) (ft^3/s) Q = (W)(D)(V)
			At Point (ft/s)	Average (ft/s)	
$m^3/s \times 35.3 = ft^3/s$			**Total Flow (Discharge)**		

TCEQ-20117 (Rev. 04-22-2004)

Guidelines for Using a SonTek FlowTracker (Acoustic Doppler Velocimeter)

This section summarizes the use of the SonTek FlowTracker for flow measurement. While this section provides information on the basic use of this instrument it does not contain the level of detail found in the *FlowTracker Handheld ADV® Operation Manual*. Periodically, check the SonTek Web site for manual and firmware upgrades (see Appendix A). If using a similar instrument (e.g., the OTT Hydrometry Acoustic Digital Current Meter) refer to the manufacturer's operations manual. Follow the flow-measurement method described in that manual.

Under appropriate conditions the FlowTracker can be used in place of electronic and mechanical flow meters; it is also mounted on a top-setting wading rod. The same procedures outlined for use with electronic or mechanical flow meters apply to the FlowTracker. The main difference is that the FlowTracker records all of the data and calculates the flow.

Note: When using the FlowTracker in saltwater, a sacrificial zinc anode should be installed on the probe for corrosion protection.

Follow steps 1 through 9 in the preceding section, "Procedures for Measuring Flow." In brief, the flow-measurement site should be within a relatively straight reach. The streambed should be relatively uniform, with few boulders, and free of debris and heavy aquatic growth. The flow should be relatively uniform and free of eddies, slack water, and excessive turbulence.

The stream width is measured and divided into the appropriate number of cross-sections. For detailed information on the cross-section profile, see the preceding sections "Measuring the Stream Width," "Determining the Number of Flow Cross-Sections," "Determining the Midpoint of the Cross-Section," "Determining the Cross-Section Depth," and "Adjusting the Sensor Depth at a Cross-Section."

Getting Started with the Equipment

Hold the *On/Off* key for "1" second. This will display the firmware version and the current date and time from the internal clock (see Figure 3.17). Press *Enter* to display the *Main Menu*.

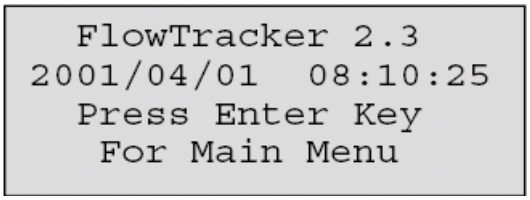


Figure 3.17. Start-up screen.

Important note: Always return to the *Main Menu* before turning the system off to ensure all data are properly saved.

Setup Parameters Menu

For more detailed instructions, see the FlowTracker operations manual, Section 2.4, "Setup Parameters Menu."

From the *Main Menu*, press "1" to access the Setup Parameters Menu, which contains the parameters that determine how the FlowTracker collects data. These parameters are generally set once and do not need to be reset with each use (see Figure 3.18).

```
     Main Menu
1: Setup Parameters
2: System Functions
3: Start Data Run
```

Figure 3.18. Main Menu screen.

Units

The output needs to be in *English* units. To set the units to English, press "1" from the Setup Parameters Menu and then press "1."

Average Time

The average time (*Avg Time*) specifies the amount of data to be collected at each cross-section (Figure 3.18). Average time is specified in 1-second intervals from 10 to 100 seconds. Measure the velocity for a minimum of 40 seconds at each cross-section. Press "2" from the Setup Parameters Menu and set the *Avg Time* by typing in "40" seconds.

```
1: Units (English)
2: Avg Time (40 s)
3: Mode (Discharge)
ENTER: More Options
```

Figure 3.19. Setup parameters—Average Time and Discharge Mode screen.

Data-Collection Mode

The *Mode* option determines the procedure for collecting at a series of cross-sections. **Flow is measured in the discharge mode.** To set the *Data-Collection Mode*, press "3" from the Setup Parameters Menu and press "1" for *Discharge Mode* (Figure 3.19). Discharge Mode allows a sequence of measurements needed to calculated streamflow (Figure 3.20).

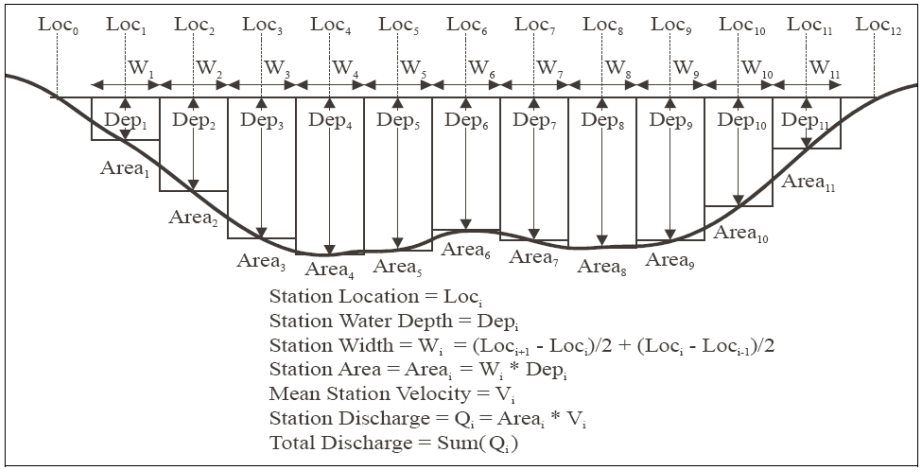


Figure 3.20. Streamflow-measurement method.

Salinity

Since salinity affects the speed of sound, FlowTracker uses a constant to measure velocity. Freshwater has a salinity of "0," which is the default salinity-parameter setting.

System Functions Menu

The *System Functions* menu provides access to items that should be checked periodically, but are not directly related to data collection. To view the menu, press "2" on the Main Menu screen (see Figure 3.17). For additional information, refer to the FlowTracker operation manual, Section 2.5. Figure 3.21 gives a list of system functions.

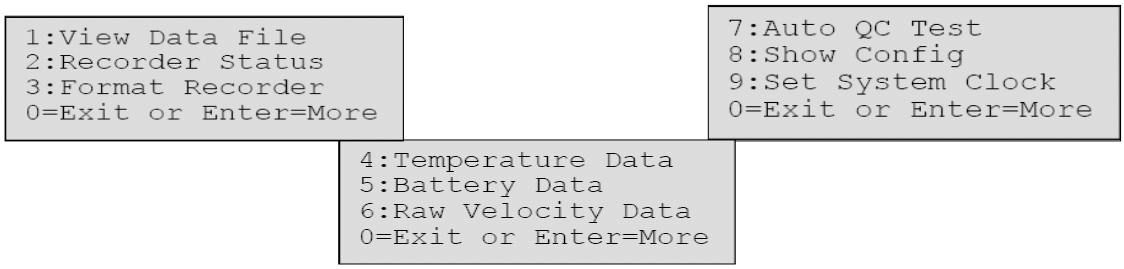


Figure 3.21. System Function screens.

Starting Data Collection in the Discharge Mode

The following steps describe the data collection sequence in Discharge Mode. For more detailed information, refer to the FlowTracker operation manual, Section 5.3.

1. Venting the Handheld Controller

The FlowTracker is completely sealed, which can cause problems. Changes in temperature or barometric pressure can result in a difference between the device's internal pressure and atmospheric pressure that can affect the keypad and operating system. To avoid those problems, the handheld controller must be vented before every data-collection run.

To vent the keypad, loosen the small silver cap next to the communication cable. The pressure will equalize in a few seconds. When finished, tighten the cap. When storing or shipping a handheld controller, leave the silver cap loose to let the system acclimate to pressure changes.

Keypad

For detailed information on the keypad functions, refer to the FlowTracker operation manual, Section 2.2. Figure 3.22 depicts the keypad for Firmware version 3.0 or higher.

Figure 3.22. FlowTracker keypad.

2. Entering the Data File Name

From the Main Menu, press "3" to *Start Data Run*. This will display the *Data File Name* menu. Press "1" to enter a file name. This is required. The file, a maximum of 8 characters, can be either letters or numbers. For example, use the Station ID *13208* (see Figure 3.23).

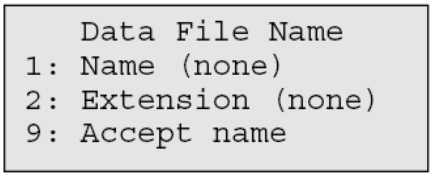


Figure 3.23. Data File Name menu.

To enter a number, simply type it. To enter a letter, type the number on the key pad and use the *ABC+* and *ABC–* keys to scroll through the alphabet (see Figure 3.22). After the letter is displayed, type any number to enter the next letter and continue to use the *ABC* keys. Press *Enter* to complete the file name, which will appear in parentheses on the screen. Press "9" to *Accept Name* when ready to start data collection. The next screen will display starting gauge information.

3. Staff and Gauge Height

A menu allowing for entry of staff and gauge height will be displayed after you have entered the data file name. Staff and gauge height values can be entered by pressing "1" and "4," respectively (see Figure 3.24). These values are used to document the data set but have no effect on operation; they are optional. When ready, press *Next Station* to continue.

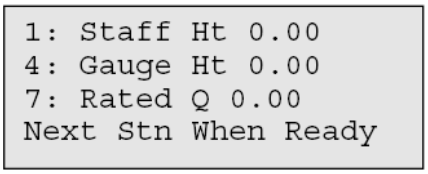


Figure 3.24. Staff and Gauge Height menu.

4. Set the Starting Edge

Next, set the starting-edge information. When *Next Station* is pressed in the previous step the *Starting Edge* screen will be displayed (Figure 3.25). On the keypad (Figure 3.22), press the *Set Location* key to set the starting edge of the water, *Loc* (see Figure 3.22). This is usually zero and will also be station zero (*Stn 0*). Press the *Set Depth* key to set the starting edge of the water depth, *Dep*, also usually zero. Next, press either the *LEW* or *REW* key.

The *LEW* (left edge of water) and *REW* (right edge of water) keys are used to specify the starting or ending edge of the water. LEW and REW are used to document the data set and have no impact on calculations. Do not press *Measure* at Station 0, the starting edge. When done, press *Next Station* to continue. The starting-edge information is complete.

5. Set Location

The next screen (Figure 3.26) will allow entry of the station information. Press *Set Location* to set the first station location, *Loc 1*. The first location (*Loc 1*, *Stn 1*) will be

the midpoint of the first cross-section and is based on the stream width and the number of flow cross-sections. See above, "Determining the Number of Flow Cross-Sections" and "Determining the Midpoint of the Cross-Section." For example, if the cross-section width is 1.0 ft and the midpoint of the cross-section is 0.5 ft, set the first location (*Loc 1*, *Stn 1*) at 0.5 ft.

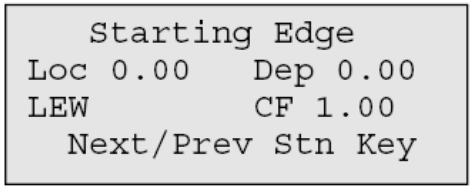


Figure 3.25. Starting Edge screen.

6. Set Depth

Press *Set Depth* to set the water depth. Input the depth of the water column of *Stn 1* as measured with the top-setting wading rod, then press *Enter*. See above, "Determining the Cross-Section Depth," for additional information.

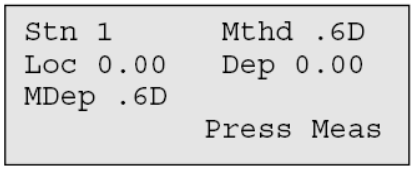


Figure 3.26. Set Location screen.

7. Method Selection

After pressing *Set Depth*, you must select a method for determining velocity. The FlowTracker allows you to choose among several methods. These two methods are described above in "Methods for Measuring Flow."

- The *single-point method* measures velocity at 60 percent of the total depth, *Mthd .6D*. This method used when the water depth at a cross-section is less than 2.5 ft.
- The *two-point method* measures the velocity at 20 and 80 percent of the total depth, *Mthd 2/8*. The method needs to be changed when the depth at a cross-section is greater than 2.5 ft. When this method is used, the system requires two measurements before advancing to the next station.
- Once a method is selected, it will be retained by the system unless changed by the user.

For information on using the top-setting wading rod to set the correct sensor depth, see above, "Adjusting the Sensor Depth."

On the keypad (Figure 3.22), scroll through the methods using the *Toggle Method+* and *Toggle Method–* keys. The method selected will appear on the *Station Information* screen (Figure 3.25). Keep in mind that the method will need to be switched between *Mthd .6D* to *Mthd 2/8* when the depth is greater or less than 2.5 ft.

8. Measuring Velocity

After correctly setting the station information and setting the probe at the correct depth, press *Measure* to start the collection of water velocity data.

9. Review Quality-Control Indicators

Review QC indicators and decide whether to accept the station velocity measurement, or the repeat measurement after modifying stream conditions or sensor placement. QC indicators are discussed at length in "Quality-Control Indicators," below.

10. Completing the Station

Press "1" to accept the measurement and move on to the next cross-section, or press "2" to repeat the measurement. See Section 5.3 of the *FlowTracker Operations Manual* for additional information on deleting or repeating a station.

11. Next Station

When a station is complete, the FlowTracker displays the next station. It predicts location, depth, and measurement method for the new station based on the previous input.

At the next station, measure and enter the new depth and station location, then reset the method if necessary. Once the station location increments have been entered twice, the FlowTracker will automatically predict the correct location for the next station. If incorrect, the user should set the location manually. Press *Measure* to start the collection of water velocity data. Repeat this procedure until you have completed all of the cross-sections. Remember to review the QC indicators before moving on to the next station.

Note: At the second location, *Loc 2, Stn 2*, change the width so that the rest of the measurements are done at the correct cross-section width. This change is made after finishing at *Loc 1, Stn 1*. At *Loc 2, Stn 2*, press *Set Location* and enter the value of the midpoint plus the cross-section width. For example, if the cross-section width is 1.0 ft and the first midpoint is 0.5 ft, enter *1.5 ft*. Remember, when this measurement is accepted the FlowTracker will automatically start using 1.0 ft widths.

12. Set the Ending Edge

Press the *End Section* key when all stations are complete. This activates the *Ending-Edge Screen*. Enter the ending-edge information. On the keypad, press the *Set Location* key to set the ending edge of the water. Press the *Set Depth* key to set the ending edge of the water depth, *Dep*. Next, press either the *LEW* or *REW* key, depending on which key you pressed at the starting edge of the water.

Next, press *Calc Disch* to complete the discharge calculation and close the file. After final discharge calculations are complete, five data screens are available (Figure 3.26). Press *Enter* to move between the five screens. When finished viewing the summary data, press "9" to exit and return to the main menu. Hold the *On/Off* key for "1" second.

13. Calculate Discharge

Next, press *Calc Disch* to complete the discharge calculation and close file. After final discharge calculations are complete, five data screens are available (Figure 3.27). Press *Enter* to move between the five screens. When finished viewing the summary data, press "9" to exit and return to the main menu. Hold the *On/Off* key for "1" second.

Important note: Turning off the FlowTracker from any page other than the *Main Menu* will cause data loss. Always return to the *Main Menu* before powering down.

Quality-Control Indicators

The following indicators should not be considered QC criteria but rather information to assist the user in placement of the sensor and identifying existing stream conditions that

may decrease the FlowTracker's ability to measure velocity. When out of range, the user should modify the probe placement or stream conditions to improve values prior to accepting the measurement. If corrective action does not improve the indicator value, the user may look for a more suitable location for flow measurement and start over, or accept the values if no better option is available.

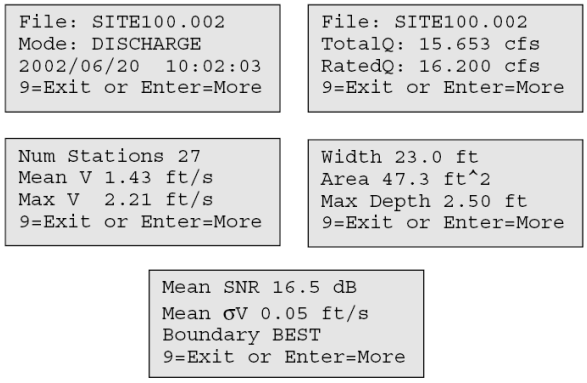


Figure 3.27. Final Discharge Measurement screens.

The first QC indicator, associated with the position of the flow sensor relative to the direction of streamflow, is *Flow Angle*. The ideal measurement occurs when the flow is perpendicular to the measuring tape. A flow angle measurement of 0° means the flow is perpendicular; any angle less than 20° will yield reliable results. Try to position the probe perpendicular to the measuring tape. Keep in mind that a flow angle < 20° may not always be possible (Figure 3.28).

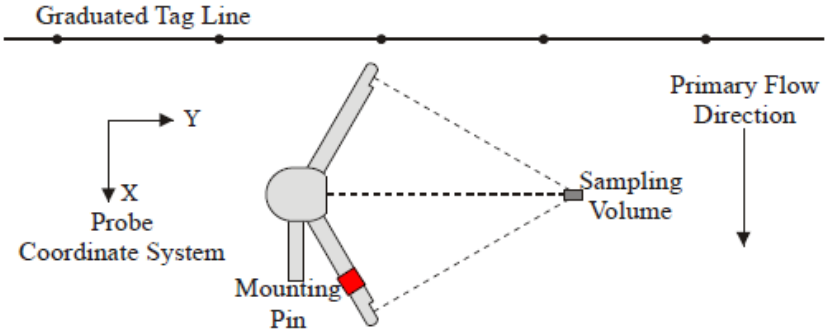


Figure 3.28. FlowTracker probe orientation relative to streamflow.

While a measurement is being made, an updating display shows the velocity and *signal-to-noise ratio* (*SNR*) (Figure 3.29). For best operating conditions the SNR should be greater than 10 decibels. The FlowTracker will display a warning at the end of the measurement if the SNR is less than 4 dB. A low SNR indicates a lack of suspended material in the water. A low SNR can be improved by stirring the sediment upstream of the flow-measurement point.

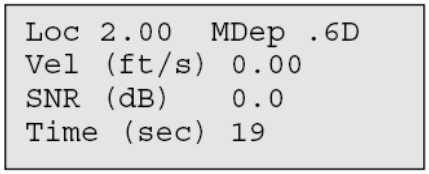


Figure 3.29. Updating-display screen.

When the velocity measurement is complete, a summary of velocity and quality control data is displayed (see Figure 3.30). In addition to SNR and Flow Angle a *standard error of velocity* (σV) is calculated as an accuracy measure of the velocity data, based on the variability of individual velocities measured during the averaging time.

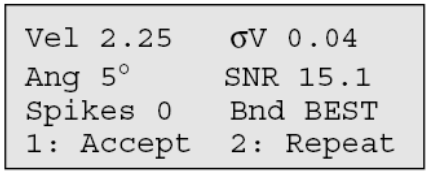


Figure 3.30. Velocity and QC Data screen.

Boundary adjustment or *Boundary QC* is an indicator of interference from underwater objects. The FlowTracker works best away from underwater obstructions. Select a site free of large objects. The FlowTracker records changes required to avoid acoustic interference as *Boundary QC* or *Bnd* (see Figure 3.30). *Boundary QC* describes the effect (if any) of boundary adjustments on the system's performance—automatically determined by the FlowTracker and quantitatively reported as *(0) Best, (1) Good, (2) Fair, or (3) Poor*. The most common are *Best* and *Good*. If Boundary QC is *Fair* or *Poor*, attempt to move away from any instream obstruction.

Spikes are unusually high velocity measurements compared to the average, usually the result of large particles or bubbles. A spike measurement is determined automatically and filtered from the data set by the FlowTracker. The number of spikes, typically *0* or *1*, is displayed on the Velocity and QC Data Screen (see Figure 3.30).

For more details, refer to Section 1.4 of the FlowTracker operations manual.

FlowTracker Software

Software is used to start programs for all major FlowTracker functions. The most commonly used applications are *SonUtils* for downloading data and *FlowTracker* for viewing binary data. Instructions on downloading data using FlowTracker software are provided below. The user may refer to the FlowTracker operations manual for guidance regarding SonUtils. For more details, see Sections 6.0 to 6.4 of the manual. Links to the FlowTracker user manuals are available in the software.

Downloading Data Files

To download data files:

- Connect the power-communication cable from the FlowTracker to COM1 of the PC.
- It is not necessary to turn the FlowTracker on manually (using the keypad) to download data via the PC; however, batteries must be installed.

- Start the FlowTracker software by clicking on the desktop icon or via *Start | Programs | SonTek Software | FlowTracker*.
- From the FlowTracker Main Screen (Figure 3.31), click the *Connect to a FlowTracker* icon to establish communication with the FlowTracker and retrieve the recorder directory. Establishing the connection may take a few minutes. Once the device is connected, the keypad will display "FlowTracker Under External Control."
- Use the *Recorder* button to locate the file to be downloaded from the FlowTracker, and browse to the location on the PC (*Download File Directory Location*) where you want to save the file (*.WAD). The *Recorder* becomes available once the PC is successfully connected to a FlowTracker.
- Select one or more files from the download recorder directory (see Figure 3. 31).
- Click *Download* to retrieve the files from the FlowTracker and download them to the PC. The downloaded files will have the file extension **.WAD*.

For detailed instructions, see Section 6.4 of the FlowTracker operation manual.

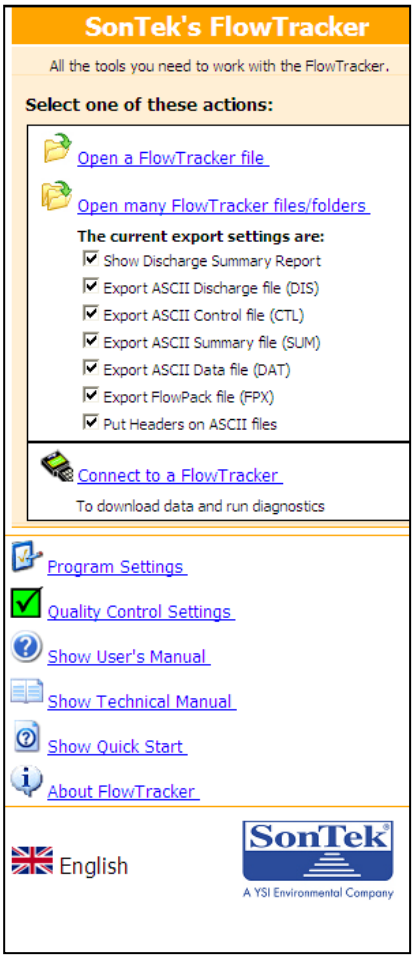


Figure 3.31. FlowTracker main screen.

View Data Reports

FlowTracker files are recorded in a compact binary format. To assess these reports FlowTracker software is used to view the information in the *.WAD file. After downloading data from the FlowTracker open the *.WAD file using the following steps:

- Start the FlowTracker software by clicking on the desktop icon or via *Start | Programs | SonTek Software | FlowTracker*.
- From the FlowTracker main menu, click the *Program Settings* button to specify output in *English Units* and the file download directory—typically the *Same Directory as Data File* (see Figure 3.32). Specifying the directory is optional, and only used if you intend to download to the same directory every time.
- Click the *Open a FlowTracker File* button to navigate to the *.WAD file. Click *Open* once the file is selected.
- Once selected and opened, the *.WAD file will load in a few moments.

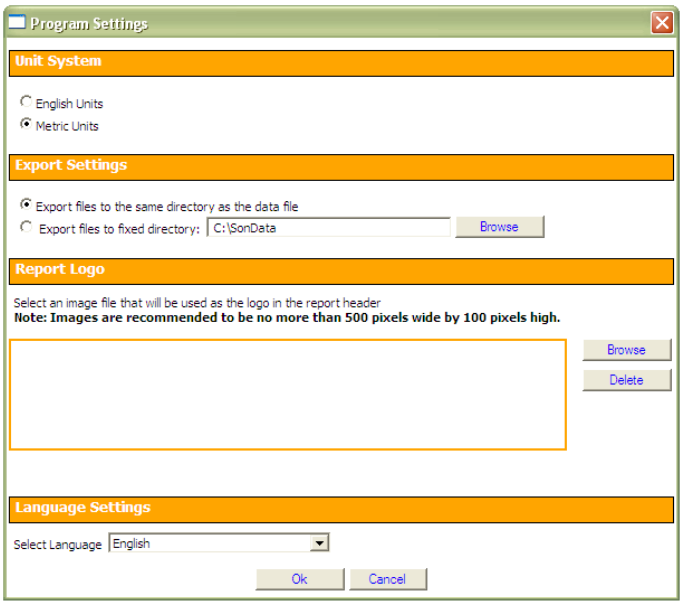
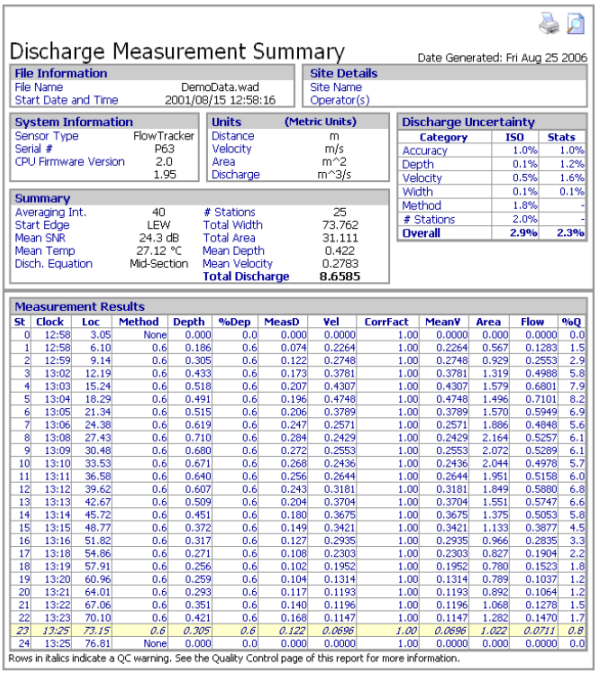


Figure 3.32. FlowExporter options window.

- FlowTracker processes information in the *.WAD file and generates various output reports;
  - Discharge Measurement Summary (see Figure 3.33)
  - Quality Control Summary (see Figures 3.34)
- All output reports can be loaded onto the screen. It is possible to copy and paste the report information into Notepad or Excel. You may also print or save the reports as a PDF for your records.
- Press *Disconnect* when finished.
- For more detailed instructions, refer to Section 6.5 of the FlowTracker operation manual.

Data Retention

The downloaded files are saved for QA purposes under the same retention schedule specified for other field data records. Make a note of the file names in the field record for that sampling.



Discharge Measurement Summary

Date Generated: Fri Aug 25 2006

File Information

File Name	DemoData.wad
Start Date and Time	2001/08/15 12:58:16

Site Details

Site Name	
Operator(s)	

System Information

Sensor Type	FlowTracker
Serial #	P63
CPU Firmware Version	2.0 1.95

Units (Metric Units)

Distance	m
Velocity	m/s
Area	m^2
Discharge	m^3/s

Discharge Uncertainty

Category	ISO	Stats
Accuracy	1.0%	1.0%
Depth	0.1%	1.2%
Velocity	0.5%	1.6%
Width	0.1%	0.1%
Method	1.8%	-
# Stations	2.0%	-
Overall	**2.9%**	**2.3%**

Summary

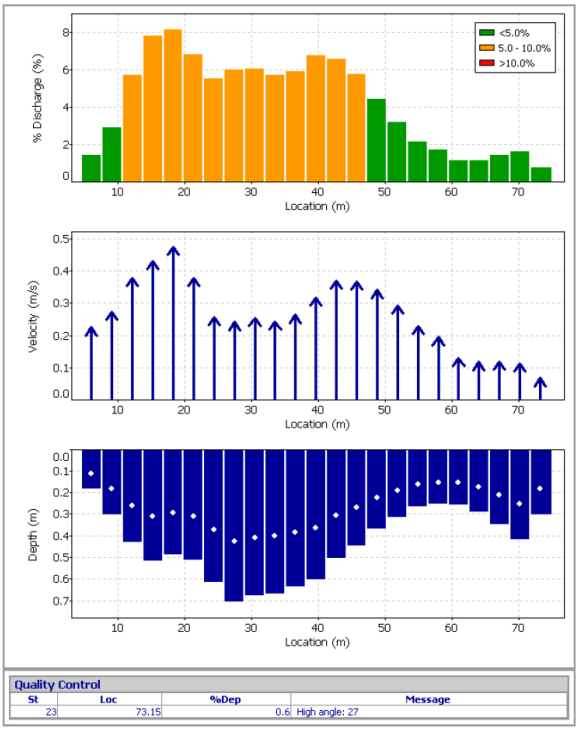
Averaging Int.	40	# Stations	25
Start Edge	LEW	Total Width	73.762
Mean SNR	24.3 dB	Total Area	31.111
Mean Temp	27.12 °C	Mean Depth	0.422
Disch. Equation	Mid-Section	Mean Velocity	0.2783
		Total Discharge	**8.6585**

Measurement Results

St	Clock	Loc	Method	Depth	%Dep	MeasD	Vel	CorrFact	MeanV	Area	Flow	%Q
0	12:58	3.05	None	0.000	0.0	0.000	0.0000	1.00	0.0000	0.000	0.0000	0.0
1	12:58	6.10	0.6	0.186	0.6	0.074	0.2264	1.00	0.2264	0.567	0.1283	1.5
2	12:59	9.14	0.6	0.305	0.6	0.122	0.2748	1.00	0.2748	0.929	0.2553	2.9
3	13:02	12.19	0.6	0.433	0.6	0.173	0.3781	1.00	0.3781	1.319	0.4988	5.8
4	13:03	15.24	0.6	0.518	0.6	0.207	0.4307	1.00	0.4307	1.579	0.6801	7.9
5	13:04	18.29	0.6	0.491	0.6	0.196	0.4748	1.00	0.4748	1.496	0.7101	8.2
6	13:05	21.34	0.6	0.515	0.6	0.206	0.3789	1.00	0.3789	1.570	0.5949	6.9
7	13:06	24.38	0.6	0.619	0.6	0.247	0.2571	1.00	0.2571	1.886	0.4848	5.6
8	13:08	27.43	0.6	0.710	0.6	0.284	0.2429	1.00	0.2429	2.164	0.5257	6.1
9	13:09	30.48	0.6	0.680	0.6	0.272	0.2553	1.00	0.2553	2.072	0.5289	6.1
10	13:10	33.53	0.6	0.671	0.6	0.268	0.2436	1.00	0.2436	2.044	0.4978	5.7
11	13:11	36.58	0.6	0.640	0.6	0.256	0.2644	1.00	0.2644	1.951	0.5158	6.0
12	13:12	39.62	0.6	0.607	0.6	0.243	0.3181	1.00	0.3181	1.849	0.5880	6.8
13	13:13	42.67	0.6	0.509	0.6	0.204	0.3704	1.00	0.3704	1.551	0.5747	6.6
14	13:14	45.72	0.6	0.451	0.6	0.180	0.3675	1.00	0.3675	1.375	0.5053	5.8
15	13:15	48.77	0.6	0.372	0.6	0.149	0.3421	1.00	0.3421	1.133	0.3877	4.5
16	13:16	51.82	0.6	0.317	0.6	0.127	0.2935	1.00	0.2935	0.966	0.2835	3.3
17	13:18	54.86	0.6	0.271	0.6	0.108	0.2303	1.00	0.2303	0.827	0.1904	2.2
18	13:19	57.91	0.6	0.256	0.6	0.102	0.1952	1.00	0.1952	0.780	0.1523	1.8
19	13:20	60.96	0.6	0.259	0.6	0.104	0.1314	1.00	0.1314	0.789	0.1037	1.2
20	13:21	64.01	0.6	0.293	0.6	0.117	0.1193	1.00	0.1193	0.892	0.1064	1.2
21	13:22	67.06	0.6	0.351	0.6	0.140	0.1196	1.00	0.1196	1.068	0.1278	1.5
22	13:23	70.10	0.6	0.421	0.6	0.168	0.1147	1.00	0.1147	1.282	0.1470	1.7
23	*13:25*	*73.15*	*0.6*	*0.305*	*0.6*	*0.122*	*0.0696*	*1.00*	*0.0696*	*1.022*	*0.0711*	*0.8*
24	13:25	76.81	None	0.000	0.0	0.000	0.0000	1.00	0.0000	0.000	0.0000	0.0

Rows in italics indicate a QC warning. See the Quality Control page of this report for more information.

Figure 3.33. Discharge Measurement Summary report.



Quality Control

St	Loc	%Dep	Message
23	73.15	0.6	High angle: 27

Figure 3.34. Quality Control Summary report.

Portable Cutthroat Flume

A portable stainless steel cutthroat flume can be used to measure flow in very narrow and shallow streams where flow meters are not effective (see Figure 3.35). In general, this method channels all of the flow through the flume and a measurement is made from a staff gauge. The staff gauge value is converted to a flow value (ft^3/s) using a cutthroat-flume table (see Table 3.7). A cutthroat flume is used in situations where the expected flow is less than 2 ft^3/s and the maximum flow through the flume is 0.74 ft. The throat of the flume can be adjusted to widths of 1, 2, 4, or 8 in depending on the expected flow. For routine monitoring, the 2 in and 4 in widths are generally the most appropriate (see Figure 3.35).

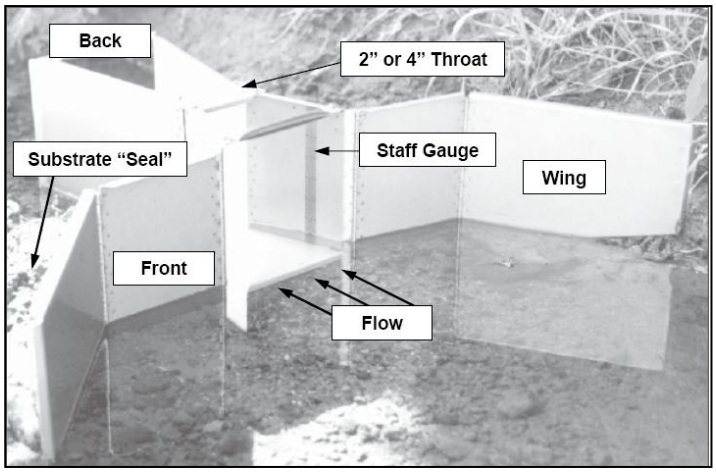


Figure 3.35. Portable cutthroat flume (Baski, Inc.).

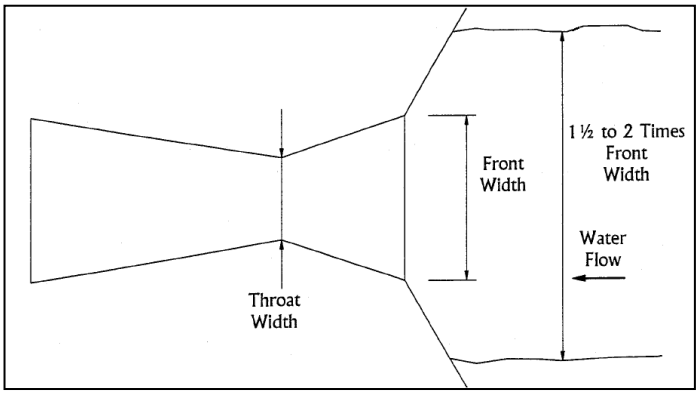


Figure 3.36. Top view of the cutthroat flume (Baski, Inc.).

Cutthroat-Flume Method

- Find an area where all of the streamflow can be diverted through the flume neck.
- Set the flume firmly on the stream bottom. Make sure the flume is level from side to side and front to back.
- Use a bubble level to determine if the instrument is level on the stream bottom.
- Extend the 19-inch wing walls out as far as possible blocking any flow (see Figure 3.36).

- Create a dam behind the wing walls with substrate material, preferably clay. This helps to keep all of the flow diverted through the flume, increasing the accuracy of the measurement.
- Read the measurement off the staff gauge—mounted on the inside of the flume wall, marked in hundredths of a foot, it measures the amount of water passing through the flume.
- Record the measurement off the staff gauge and convert it to cfs using Table 3.7.

Table 3.7. Cutthroat-flume flow conversion.

Gauge Height (ft)	2 in	4 in	Gauge Height (ft)	2 in	4 in
0.01	0.000102	0.000208	0.38	0.147	0.300
0.02	0.000408	0.000832	0.39	0.155	0.316
0.03	0.000918	0.00187	0.40	0.163	0.333
0.04	0.00163	0.00333	0.41	0.171	0.350
0.05	0.00250	0.0052	0.42	0.180	0.367
0.06	0.00367	0.00749	0.43	0.189	0.385
0.07	0.005	0.0102	0.44	0.197	0.403
0.08	0.00653	0.0133	0.45	0.207	0.421
0.09	0.00826	0.0168	0.46	0.216	0.440
0.10	0.0102	0.0208	0.47	0.225	0.459
0.11	0.0123	0.0252	0.48	0.235	0.479
0.12	0.0147	0.030	0.49	0.245	0.499
0.13	0.0172	0.0352	0.50	0.255	0.520
0.14	0.0200	0.0408	0.51	0.265	0.541
0.15	0.0229	0.0468	0.52	0.276	0.562
0.16	0.0261	0.0532	0.53	0.287	0.584
0.17	0.0295	0.0601	0.54	0.297	0.607
0.18	0.033	0.0674	0.55	0.309	0.629
0.19	0.0368	0.0751	0.56	0.320	0.652
0.20	0.0408	0.0832	0.57	0.331	0.676
0.21	0.045	0.0917	0.58	0.343	0.700
0.22	0.0494	0.101	0.59	0.355	0.724
0.23	0.054	0.110	0.60	0.367	0.749
0.24	0.0588	0.120	0.61	0.380	0.774
0.25	0.0638	0.130	0.62	0.392	0.800
0.26	0.069	0.141	0.63	0.405	0.826
0.27	0.0744	0.152	0.64	0.418	0.852
0.28	0.080	0.163	0.65	0.431	0.879
0.29	0.0858	0.175	0.66	0.444	0.906
0.30	0.0918	0.187	0.67	0.458	0.934
0.31	0.098	0.200	0.68	0.472	0.962
0.32	0.104	0.213	0.69	0.486	0.990
0.33	0.111	0.227	0.70	0.500	1.02
0.34	0.118	0.240	0.71	0.514	1.05
0.35	0.125	0.255	0.72	0.529	1.08
0.36	0.132	0.270	0.73	0.544	1.11
0.37	0.140	0.285	0.74	0.559	1.14

Flow Estimate (ft^3/s)

Parameter Code 74069

Flow-estimate data may be used for a non–tidally influenced stream. Flow estimates are generally subjective measurements based on the ability of experienced field staffers to estimate distances, depths, and velocities. Never use estimated flow in place of measured flow for baseline SWQM stations, in biological assessments, or for other regulatory sampling. The TCEQ evaluates alternative methods for estimating flow case by case.

How to Estimate Flow

- Choose a reach of the stream where it is possible to estimate its cross-section and velocity.
- Estimate the stream width (ft) at that reach and record the estimate.
- Estimate the average stream depth (ft) at that reach and record the estimate.
- Estimate stream velocity (ft/s) at that reach and record. A good method is to time the travel of a piece of floating debris. To use this method from a bridge, measure its width. Have one person drop a floating object (that can be distinguished from other floating material) at the upstream side of the bridge and say, "Start." The person on the downstream side of the bridge stops the clock when the floating object reaches the downstream side. Divide the bridge width by the number of seconds to calculate the velocity. The velocity can be measured at multiple locations along the bridge, and those velocities averaged. If you are doing this alone, watch out for road traffic.
- Multiply stream width (ft) by average stream depth (ft) to determine the cross-sectional area (ft^2), which, when multiplied by the stream velocity (ft/s) and a correction constant, gives an estimated flow (ft^3/s).

  ***Example**:* The stream width was around 15 ft. It appeared the average depth on this reach was about 0.75 ft. The sampler timed a piece of floating debris as it moved a distance of 10 ft in 25 seconds (= 2.5 ft/sec) downstream over the reach. An estimated flow with a smooth bottom was calculated, using the following formula:

  width × depth × velocity × A (correction factor) = estimated flow

  15 ft (width) × 0.75 ft (depth) × 2.5 ft/s (velocity) × 0.9 =25 ft^3/s (cfs)

  A is a correction constant: 0.8 for rough bottom and 0.9 for smooth bottom

Experienced field personnel are able to estimate flow to within 20 percent of actual flow values less than 50 ft^3/s. The best way to develop this skill is to practice estimating flow before making measurements at all monitoring visits to nontidally influenced flowing streams. Then compare estimated flows with those obtained from USGS gauges or from instantaneous flow measurements.

Estimating Flow from a Staff Gauge

At routine sampling sites on wadeable streams, it is often useful to establish a staff gauge. This will enable the creation of a flowchart (rating curve) after a number of visits. Flow charts are useful because they can display a lot of information in a concise format. They are inexpensive to establish and only require four or five visits at different flow severities in order to establish a representative graph.

Purchase a standard staff gauge from a vendor (for example, Ben Meadows or Forestry

Supply) or a more inexpensive T-post from any hardware or farm supply store. Place the gauge on a permanent structure, such as a tree or piling in the water or on the bank (see Figure 3.37). The staff gauge must be placed in an area with laminar flow. Avoid backwater areas, eddy pools, and areas with uneven flow (riffles).

It is best to establish the gauge during low-water conditions so the zero point can be located on the bottom of the streambed, or at the lowest expected flow. If flow falls below the zero point, it is possible to estimate the distance to the water surface below the zero point with a ruler, and graph negative numbers. Once the staff gauge is installed, take a minimum of four instantaneous flow measurements according to SWQM procedures. The water depth on the established staff gauge (gauge height) must be recorded each time an instantaneous flow measurement is made. By plotting four to 10 instantaneous flow values (along the *y*-axis) versus gauge height (*x*-axis), a flow chart or *rating curve* can be developed. The rating curve allows instantaneous flow to be determined by simply reading the gauge height and identifying the associated instantaneous-flow value from the curve (Figures 3.38, 3.39).

Figure 3.37. Staff gauge.

Enter data into Excel where it can be graphed after several different flow measurements have been taken. Figure 3.38 is an example of a site where the gauge was established during low flow and then a subsequent measurement was made when the stream became intermittent with perennial pool-flow severity.

The two graphs in Figures 3.38 and 3.39 were created in Excel using the "scatter plot with smoothed line" option. In order to have the line drawn between the individual points, it is necessary to hide all the staff-gauge readings (for example, in Figure 3.38, *0.3* to *0.8*) that do not have instantaneous flow values associated with them. These values can be reinserted by clicking on the *x*-axis, then right-clicking the mouse and choosing "format axis," then "scale."

Once a flow graph has become established at a site, it is possible to get an accurate flow estimate on a given day without actually measuring flow. The estimate is made by getting a staff gauge reading and interpolating flow from the graph. The most accurate flow estimates are those that fall between the lowest and highest measured flow values. It is possible to extrapolate the graph beyond the last measurement, but note that, once flow goes beyond bank-full stage, the graph changes character and the estimates are less

accurate. Flow graphs work best at sites with similar left and right bank angles. They do not work well at locations with low bank angles (for example, less than 20°).

Note: Every rating curve is unique. Some remain very stable over time while others change. For example, high flow events may alter upstream channel characteristics. After several readings fail to fall on the curve, it may be time to revise the rating curve by dropping some older readings.

Flow values determined based on rating curves derived from four to 10 instantaneous flow measurements are reported as flow estimates (parameter code 74069). By establishing a staff-gauge using a larger number of instantaneous flow measurements (for example, 10 to 20) and calculating a statistically significant regression, it is possible to report a flow value based on gauge height as a measured value (parameter code 00061).

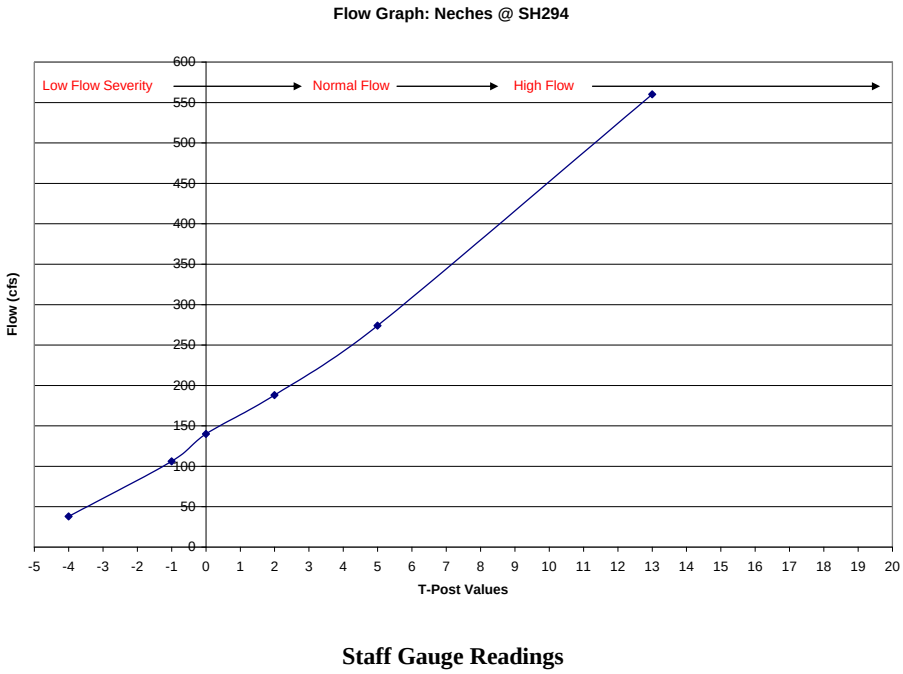


Figure 3.38. Staff gauge established at low flow.

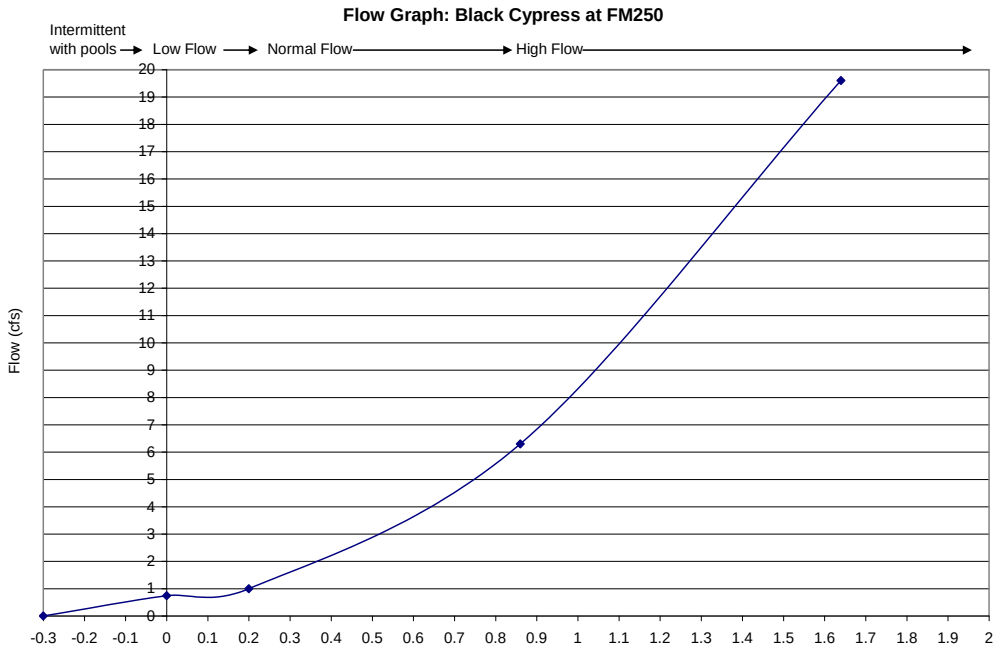


Figure 3.39. Flow graph.

CHAPTER 4
COLLECTING AND ANALYZING BACTERIOLOGICAL SAMPLES

National Environmental Laboratory Accreditation Program (NELAP)

All bacteriological data submitted to the TCEQ for decision making must come from a lab accredited by the National Environmental Laboratory Accreditation Program (NELAP). As a result of these accreditation requirements (established in 2008), some analytical elements formerly included in this chapter were removed to avoid redundancy or confusion with the NELAP Standard, test methods, laboratory SOPs, etc. However, program-specific requirements and some guidance pertaining to laboratory analysis are still included. These should be incorporated into laboratory protocols when running bacteria samples for the TCEQ surface water quality monitoring programs.

Bacteriological-Sample Collection

Sample-Collection Bottles

IDEXX Containers

The preferred bacteriological sample containers are the 120 and 290 mL bottles from IDEXX. Containers purchased from IDEXX have quality-assurance documentation associated with each lot received, allowing for a controlled source of bacteriological sample bottles and ensuring that QC checks have been performed. The IDEXX containers have lot numbers etched on the bottom that are documented throughout collection and analysis. Record the lot number on the RFA or COC form. The lot number is a 5-digit number such as *KF007*.

IDEXX maintains "Certificates of Quality" for each lot of bacteriological sample bottles. To download IDEXX bottle-quality-control certificates go to the IDEXX "Water Microbiology" webpage (see Appendix A). Under "Quick Links", select "Quality Certificates" which opens the "Certificates of Quality Request Form" (see Figure 4.1). To download a certificate of quality for IDEXX sample bottles, select the product from the list provided, enter the lot number and click the "Request Certificate" button. The certificate can be saved electronically. The following product numbers are those most commonly used for SWQM purposes.

IDEXX Bottle	Product Number
120 mL	WV120ST-200, 120 mL Vessel
290 mL	WV290SBST-100, 290 mL Vessel

Other Containers

Others using this SOP must ensure that the source of bacteriological sample containers is controlled and their quality is confirmed and documented. If laboratories supply the sample containers, then the NELAC requirements related to Chapter 5, Appendix D.3.1.a must be followed.

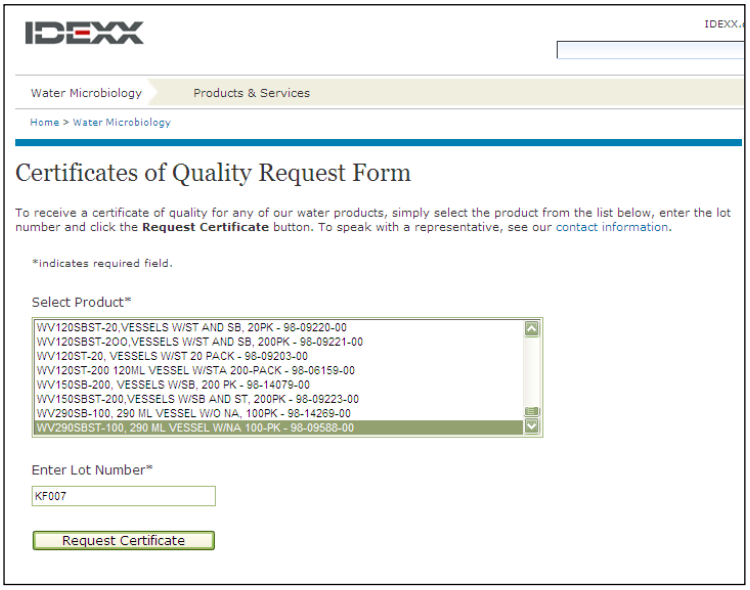
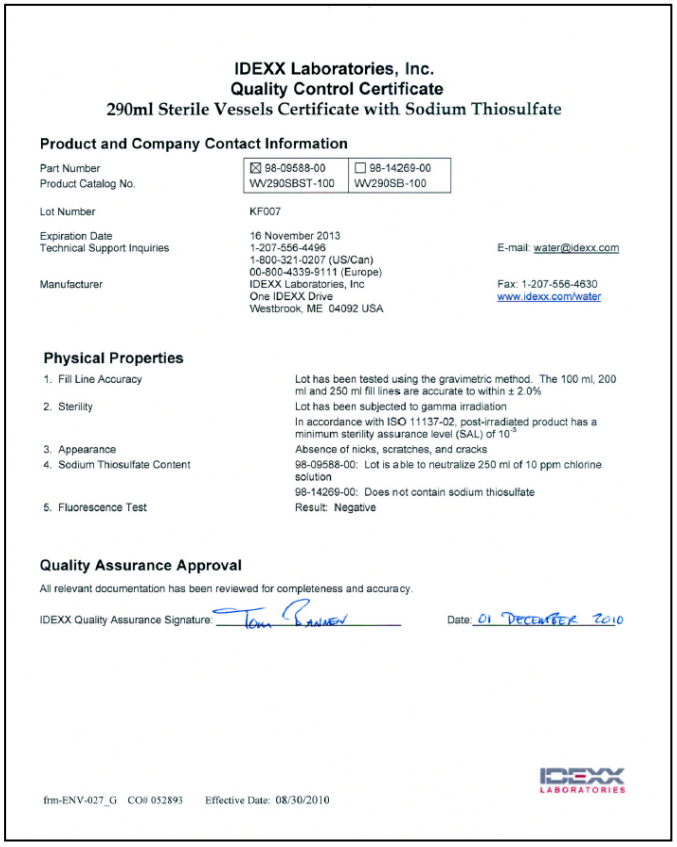


Figure 4.1. IDEXX Certificates of Quality Request Form.



IDEXX Laboratories, Inc.
Quality Control Certificate
290ml Sterile Vessels Certificate with Sodium Thiosulfate

Product and Company Contact Information

Part Number Product Catalog No.	☒ 98-09588-00 WV290SBST-100	☐ 98-14269-00 WV290SB-100
Lot Number	KF007	
Expiration Date	16 November 2013	
Technical Support Inquiries	1-207-556-4496 1-800-321-0207 (US/Can) 00-800-4339-9111 (Europe)	E-mail: water@idexx.com
Manufacturer	IDEXX Laboratories, Inc One IDEXX Drive Westbrook, ME 04092 USA	Fax: 1-207-556-4630 www.idexx.com/water

Physical Properties

1. Fill Line Accuracy	Lot has been tested using the gravimetric method. The 100 ml, 200 ml and 250 ml fill lines are accurate to within ± 2.0%
2. Sterility	Lot has been subjected to gamma irradiation In accordance with ISO 11137-02, post-irradiated product has a minimum sterility assurance level (SAL) of 10^{-3}
3. Appearance	Absence of nicks, scratches, and cracks
4. Sodium Thiosulfate Content	98-09588-00: Lot is able to neutralize 250 ml of 10 ppm chlorine solution 98-14269-00: Does not contain sodium thiosulfate
5. Fluorescence Test	Result: Negative

Quality Assurance Approval

All relevant documentation has been reviewed for completeness and accuracy.

IDEXX Quality Assurance Signature: Tom Danner Date: 01 DECEMBER 2010

frm-ENV-027_G CO# 052893 Effective Date: 08/30/2010

IDEXX LABORATORIES

Figure 4.2. IDEXX Quality-Control Certificate.

Sampling Considerations

The indicator organisms used for determining support of the recreation use are *Escherichia coli* in freshwater and *Enterococcus* in marine waters and some saline inland waters.

Baseline bacteriological samples **should be collected at all routine monitoring sites under all flow conditions.** To maximize the processing time for the laboratory collect bacteriological samples last at a site. In streams and rivers, take care to find an undisturbed location if other work, like flow or sediment collection, is being done at the site.

When collecting samples from a bucket of water (bridge site), collect the bacteriological sample before other samples. Pour water into the bacteriological-sample container. Never immerse water-sample containers in the bucket; doing so could introduce contamination.

Sample Collection

Clean hands. Bacteria samples are the easiest to contaminate. Take steps to help eliminate possible contamination by using either an alcohol-based hand sanitizer that contains at least 60 percent alcohol prior to sample collection or wearing disposable latex gloves when collecting a sample.

Never prerinse the sample container. When submerging the sample container, take care to avoid contamination by surface scum. The surface film is enriched with particles and bacteria not representative of the water mass.

Leave sufficient headspace. The lab needs to mix the sample prior to processing to redistribute bacteria in the sample. Fill the sample container to the top (not the 100 mL or 250mL line.) This allows the lab to process the sample according to their procedures.

Flowing streams. Dip the open sample container to a depth of 0.3 m, or roughly half the depth in very shallow streams. Avoid contact with the sediment. With the open end facing upstream, push the mouth of the bag upstream at this depth until full. Always hold the mouth of the sample container upstream of the sampler, the sampling apparatus, and any disturbed sediments.

Reservoirs and coastal waters. Dip the sample container to a depth of 0.3 m. At that depth, push the mouth of the sample container away from the boat, the sampler, sampling apparatus, and any disturbed sediment.

Sample Labeling

Label each sample with the station number, date, and time collected.

Documenting Sample Collection

Complete either a Request for Analysis (RFA) or Chain of Custody (COC) form. Indicate the type of bacteriological analysis that needs to be run. Record the lot number of the sample bottle on the RFA Tag or the COC. Provide specific field notes on the RFA Tag or COC to aid the laboratory staff in determining what or if sample dilutions should be prepared. Always include the results of field conductivity measurements.

Sample Treatment in the Presence of Chlorine

Chlorine residual should be analyzed from samples collected downstream of chlorinated effluent discharges or in areas where the presence of chlorine is suspected. Test strips or a standard chlorine residual test may be used as a way to determine the presence of chlorine.

- If the sample bottle contains sodium thiosulfate, field testing for chlorine is not necessary—unless a high level of chlorine is suspected or requested by the lab analyzing your samples.
- If the sample bottle does not contain sodium thiosulfate, field testing for chlorine is necessary. If residual chlorine is present, add 0.1 mL of 10 percent sodium thiosulfate to the sample.

Safety note: Although sodium thiosulfate has a low toxicity, it can cause eye irritation. Wear safety glasses when preparing sodium thiosulfate solution and when adding it to a sample.

Sample Preservation

Place samples on ice immediately after collection. No more than one bacteria sample per gallon of cooler capacity may be placed inside the cooler; these should be evenly spaced inside the cooler and completely covered with wet ice. Cool the samples as quickly as possible to < 6.0ºC but do not allow the samples to freeze.

Sample Shipping

Sample shipping should be coordinated between sample collectors and laboratories. TCEQ staff—ship samples to the TCEQ Houston Laboratory between Monday and Wednesday, arriving no later than Thursday. Samples may be shipped to the LCRA on Thursday or Friday, but only by prearrangement.

Quality-Control Samples

Collect one large sample (> 200 mL) at the same time you collect field splits for other parameters. This sample provides enough volume for the lab to analyze the ambient sample and a bacteriological laboratory duplicate. It is preferable to collect bacteriological laboratory duplicate samples where elevated bacteria concentrations have occurred in the past. Further, it is preferable to vary the location where duplicate samples are collected over time. Field splits and field blanks are not required for bacteriological analysis.

Sample Holding Time

Holding time is defined as the amount of time between collection and the initiation of analysis. Plan sample collection so that samples are set up within the required holding time. Do not report samples that are not prepared within the time limit or are reported from the laboratory as exceeding the holding time.

Laboratories are required to process bacteriological samples within **eight hours** of sample collection whenever possible. The 8-hour holding time includes 6 for transporting and 2 for processing. Field personnel should submit samples to the lab within 6 hours when possible. When transport conditions cause delays in sample preparation longer than 8 hours, the holding time may be extended up to 48 hours for *E. coli*. However,

any extension should be minimized. This extended holding time applies **only** to *E. coli* analysis using the IDEXX Colilert Quanti-Tray/2000.

Bacteria Sample	Holding Time
E. coli	up to 48 hours
Enterococci	up to 8 hours
Fecal coliform	up to 8 hours

Note: There is no extension of holding times for *Enterococcus*. Regions needing this analysis must contact the SWQM quality assurance office to arrange for the use of a local NELAP-accredited laboratory.

Selecting an Indicator for Classified Water Bodies

In monitoring for attainment of the recreational use the appropriate indicator must be determined before sample collection. The indicators for classified water bodies, which appear in Appendix A of the TSWQS, must be used at all times regardless of the specific conductance at the time of sampling.

Selecting an Indicator for Unclassified Water Bodies

- Unclassified water bodies within the watershed of a classified segment designated as **freshwater** should be sampled for *E. coli*.
- Unclassified water bodies within the watershed of a classified segment designated **high saline** should be sampled for enterococci.
    - However, if it can be demonstrated that the unclassified water body is not high saline through a historical review of the specific conductance data—the maximum of all measurements must be less than 10,000 µS/cm—then *E. coli* may be chosen as the indicator. See the following information on selecting the appropriate method for *E. coli*.
- Unclassified water bodies within the watershed of a classified segment designated **tidal** should be sampled for enterococci.
    - However, if it can be demonstrated that the unclassified water body is not tidal through a historical review of the specific conductance data, then *E. coli* may be chosen as the indicator. Due to variable conditions along the Texas coast these are addressed case by case.

Note: The chosen indicator must be used during all sampling events. Use that indicator regardless of the specific conductance value measured during sampling. This ensures that all data collected can be reasonably compared to the single most appropriate criterion.

Program-Specific Requirements and Guidance

This section discusses program-specific requirements and other program-specific guidance pertaining to IDEXX Colilert and Enterolert methods for detecting *E. coli* in freshwater and enterococci in marine waters or high saline inland waters (APHA, et al. 2005; ASTM 2004).

Note: Information specific to IDEXX methods are discussed in this chapter. While the IDEXX methods are encouraged for laboratories supporting the state's surface water

quality monitoring programs, other appropriate methods (for example, membrane filtration) may also be used. In such cases, information specifically related to IDEXX methods may be disregarded. However, program-specific quality-control requirements and some program-specific reporting rules are applicable no matter what method is chosen.

Selecting a Method

E. coli

In monitoring for attainment of the recreational use, *E. coli* is the indicator for all non-tidal water bodies classified as freshwater in the TSWQS.

However, many inland water bodies with high specific conductance remain classified as freshwater in the TSWQS. There have been false positive results for *E. coli* when using the Colilert methods in these water bodies. Because of this issue, the TCEQ has revised the guidelines regarding the use of Colilert media and sample dilutions.

The following guidelines apply to freshwater bodies with *E. coli* as the designated indicator:

- Choose an *E. coli* analysis procedure after evaluating long-term specific-conductance results.
- Use Colilert-18 or Colilert-24 for freshwater samples with specific-conductance values less than 3,000 µS/cm.
- Use Colilert-18 for freshwater samples with specific conductance values greater than 3,000 µS/cm.

Enterococci

Enterococci are the indicator for water bodies classified as tidal, marine, or high saline inland listed in Appendix A of the 2010 TSWQS.

Fecal Coliform

Fecal coliform is used only in monitoring for attainment of the oyster-water use and not for the recreational use. Oyster waters are monitored by the Texas Department of State Health Services Seafood and Aquatic Life Group. The DSHS Seafood Safety Program is governed by the guidelines of the U.S. Food and Drug Administration's National Shellfish Sanitation Program. Information about the Seafood Safety Program is available at the DSHS website (see Appendix A).

Selecting Sample Dilutions

Dilutions, if necessary, should be determined based on the historical concentrations at the sampling site, field notes, and/or the examination of samples themselves. The goal of sample dilutions is to achieve quantifiable results and remove interferences.

For the detection of *E. coli* in freshwater and enterococci in marine and inland saline waters, the following dilutions are recommended as starting points for most common situations.

***E. coli*, standard test volume.** Use a single standard test volume of 100 mL for water that is determined through experience to be relatively free of bacterial contamination (< 2400 MPN/100 mL), as well as turbidity, color, and suspended solids. If the bacterial level is unknown, other dilutions should be performed in addition to using the standard test volume. This applies to Colilert-18 or Colilert-24.

E. coli*, interference and/or high (> 2400 MPN/100 mL) bacteria count.** Run multiple dilutions to achieve quantifiable results and remove interfering factors (suspended solids, color, or turbidity) that might mask fluorescence. ***Note: When using Colilert-18 on samples with specific conductance values greater than 3,000 µS/cm the minimum dilution should be 1 to 10.

Enterococci, standard test volume, all waters. Use the standard test volume of 10 mL on all waters.

Reporting Rules

IDEXX Methods

- Report the result from the tray with the smallest dilution (largest sample volume) which does not have all positive wells.
- If all trays have all positive wells, report the largest dilution (smallest sample volume).
- If all trays have no positive wells, report the smallest dilution (largest sample volume).

All Bacteriological Methods

- Report final results as two significant figures.
- Report results as *E. coli* MPN/100 mL or CFU/100 mL, as appropriate.

Quality-Control Requirements

Laboratories should refer to the NELAP standard and test methods for a full listing of quality control requirements related to bacterial analysis. The requirements discussed below are program-specific requirements which are not found in the NELAP standard.

Bacteriological Laboratory Duplicate

Analyze a laboratory duplicate with every tenth sample. If fewer than 10 samples are collected in a month, analyze one duplicate per month.

When analyzing a laboratory duplicate for a microbiology sample, use another aliquot from the parent sample. To ensure that enough sample volume is available, collect > 200 mL of sample at stations for which samples are analyzed at full strength (100 mL). Remember to mix the sample well before dividing. For other samples that normally require dilution, take the appropriate dilution from the 100 mL sample. Add the reagent to each dilution and mix until the reagent is completely dissolved. Pour each dilution into a separate tray, seal it, and incubate it with the other samples.

Comparison Counting

For routine evaluation, repeat counts on one or more positive samples at least monthly. If possible, compare counts with an analyst who also performs the analysis. Replicate counts by the same analyst should agree within 5 percent, and those between analysts should agree within 10 percent. Record the results of comparison counts in an appropriate location.

CHAPTER 5

COLLECTING WATER SAMPLES

General Principles

Collect water samples at the same location for both bacteriological and chemical analysis. If meeting holding times for water and bacteriological samples is an issue, field measurements (including flow) may be taken first. See Chapter 3 for details.

If other work is being done at the site—for example, measuring flow, collecting sediment samples, collecting biological samples, or habitat assessment activities—make sure to collect representative samples from an undisturbed area of the stream.

If in doubt about containers, holding times, or preservation measures, call the laboratory receiving the samples.

Required Equipment

See Chapter 9 for the list of basic SWQM equipment.

Depth of Sample Collection

If the water depth at the sampling point is **less than 0.5 m**, collect samples at a depth equal to one-third of the water depth measured from the water surface.

If the water depth is **greater than 0.5 m**, collect samples at a depth of 0.3 m below the surface.

Where to Collect Samples

Collect water samples at the centroid of flow, if the stream appears to be completely mixed from shore to shore. The *centroid* is defined as the midpoint of that portion of the stream width which contains 50 percent of the total flow. For stream samples, the centroid of flow must be accessible for sampling physicochemical parameters, either by wading, from a bridge, or from a boat.

Stream samples are generally collected upstream of a bridge to avoid any influence bridge runoff might have on whether the sample is representative. Sampling from the shoreline of any water body is the least acceptable method unless containers can be filled away from the bank. If shoreline sampling is necessary, avoid backwater areas and stagnant pooled areas in flowing streams. Take care to avoid contaminating the sample with debris from the bank. Collect reservoir and bay samples from boats.

Collecting Water Samples from a Bridge

When it is **not** possible to collect samples directly from a water body, use a discrete sampling device (bailer, Van Dorn bottle). In general, discrete sampling devices are safer and easier to use than a bucket and are the preferred method. However, if a discrete sampler is not available, a plastic bucket may be used. This technique generally applies to sample stations located at bridge crossings where access is an issue.

Rinse the sampling device at least three times with ambient water before collecting the final sample. Pour slowly to avoid creating bubbles. When filling sample containers, pour the water into them; dipping sample containers into the bucket could introduce contamination. Always collect bacteriological samples first.

Collecting Water Samples and Field Measurements from the Same Container

In certain rare circumstances, where personal safety is an issue and the goal is to reduce the time on a bridge, the collector may use a single container for both water samples and field measurements. In that case, rinse the plastic bucket or other appropriate container and the multiprobe instrument at least three times with water from the site. For more information, see Chapter 3, "Field Measurements from a Bucket."

When collecting samples and field measurements from a single container of sample water, always collect the bacteria sample before the multiprobe instrument is placed in the container—carefully, so that the sample water is not agitated. Gently pour water into the bacteria-sample container. After field measurements have been recorded, pour sample water into containers. To avoid contamination, do not immerse water-sample containers in the bucket.

Collecting water samples under this scenario is only appropriate for conventional water chemistry sampling. It is **not** appropriate for collecting metals or organic samples.

Collecting Water-Chemistry Samples

In most water bodies, near-surface water is considered representative of the water mass. Collect a water sample by directly immersing the container beneath the water surface to a depth of 0.3 m. Sites accessed by bridge can be sampled with a plastic bucket, disposable bailer, or Van Dorn bottle. If using a bucket or bailer, take extreme care to avoid contaminating the sample with debris from the rope and bridge. Be sure to rinse the sample-collection device between stations. Rinse at least three times with ambient water from the next station.

See Table 5.2 for sample volumes, containers, preservatives, and holding times. Also refer to Table A7.3 of the *SWQM QAPP* for a list of methods used to analyze water samples (see Appendix A).

Conventional Parameters

Examples of routine (baseline) conventional parameters include alkalinity, total suspended solids (TSS), chloride, sulfate, nitrite + nitrate, total Kjeldahl nitrogen (TKN), ammonia, total phosphorus (TP), total organic carbon (TOC), and chlorophyll *a*. Laboratory measured total dissolved solids (TDS) and orthophosphate (OP) are not routine parameters. Both laboratory analyzed TDS and field-filtered OP may be sampled and analyzed as needed for specific purposes. Since TSWQS criteria for TDS were developed using specific conductance data and, to be consistent, TDS is calculated using specific conductance.

Nutrient Sample Collection

Due to an increased focus on nutrient impacts in Texas and the U.S., states are facing an increasing need to collect additional data on parameters to help assess and control eutrophication. Most researchers working with nutrient impacts argue for the use of TP rather than OP for defining trophic status, conducting TMDLs, looking for trends in eutrophication, and setting water quality criteria (the EPA's national guidance criteria are expressed as TN and TP). When evaluating and controlling nutrient loadings, loads can only be effectively expressed as TP.

Recent efforts by the TCEQ include: (1) developing methods to estimate percent aquatic vegetation coverage in streams, (2) improving quantification levels for total phosphorus (TP) and potentially total nitrogen (TN), and (3) acquiring additional routine data on TN (TKN and nitrate/nitrite).

Collecting data to determine total nutrients is important to fully characterize the trophic condition of water bodies and to directly relate the effect of nutrient loadings to instream conditions. Core parameters should include paired nitrogen parameters nitrate, nitrite (or nitrate + nitrite), ammonia, and TKN as well as TP and Secchi-disk transparency.

Orthophosphate (optional)

A separate sample for orthophosphate (OP) must be filtered in the field within 15 minutes of collection. The sample must be filtered using a 0.45 µ filter. This is needed to separate dissolved and suspended forms of orthophosphate. The parameter code for field-filtered OP is 00671.

OP Sampling Supplies

The most cost-effective and least time-consuming method uses a 60 mL Luer Lock syringe, a 25 mm 0.45 µ syringe filter, and a 60 mL Nalgene bottle. The equipment does not have to be sterile but must be clean and protected from potential contaminants. Keep unused supplies in plastic bags or another container.

The Whatman GD/X syringe filter is designed for highly turbid samples. A single filter contains a prefiltration stack with layers starting at 10 µ to the final 0.45 µ filter (see Figure 5.1). This filter processes 3 to 7 times more sample volume, which decreases hand pressure and increases efficiency for hard-to-filter samples. However, as with any method, there can be limitations and it may not be as effective in all areas of the state. Sample collection may require multiple filters. Alternative filtration methods may be substituted, as long as filtration is performed within 15 minutes of collection using a 0.45 µ filter.

OP Sample Collection Method

Draw the ambient water into a clean 60 mL Luer Lock syringe by pulling back on the plunger. Fill the syringe to the 60 mL mark. Attach a new GD/X syringe filter to the syringe by screwing it onto the tip (see Figure 5.1). Push in on the syringe plunger to start filtering the sample until it starts to come out of the filter. Place the end of the filter over the sample container and filter the sample directly into its container. If flow through the filter slows and increased pressure is required, replace the filter and continue until the required volume is collected. The volume may vary depending on the lab performing the

analysis but in general a minimum of 50 mL is required. Discard any used filters. The syringes may be reused if cleaned following appropriate protocols.

Sample Containers and Volumes

Sample containers should be new, unused, clean polyethylene containers or glass jars or used laboratory cleaned containers. Prior to sample collection, collectors should rinse containers three times with ambient water and discard water away from the sample location. However, new, unused containers or those cleaned in a laboratory may be used without rinsing. You must remain consistent with whichever method is chosen. See Table 5.2 for suggested sample containers and volumes.

Note: If using cubitainers, do not inflate them by blowing into them.

Routine conventional parameters require at least three containers. Routine parameters require one unpreserved sample (alkalinity, chloride, sulfate, fluoride, nitrate + nitrite, TSS, and VSS), one preserved sample (ammonia, TKN, TOC, TP), and one unpreserved for chlorophyll *a*. Collect the chlorophyll *a* sample in a wide-mouth amber container or place the container in an amber-colored plastic bag.

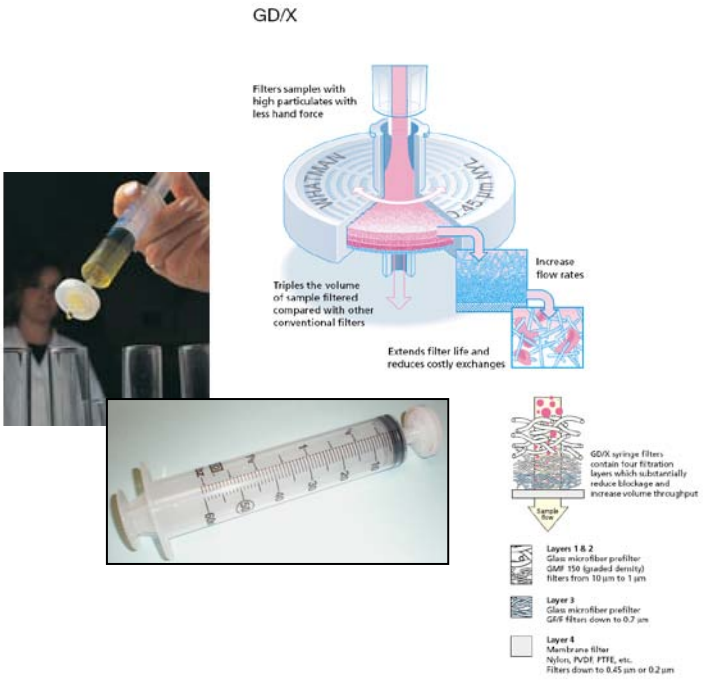


Figure 5.1. Whatman GD/X syringe filter and filtration apparatus.

Container Label

Label each container with enough information to allow the lab to associate the sample with the request for analysis tag or chain of custody; key sample information includes identifiers such as *Station ID#*, *Sample Tag ID#*, *preservative, sample date,* and *station description*.

Sample Preservation

Ice. Samples must be placed on ice immediately after collection. Place all samples that require cooling only on ice before preserving other samples with acid. Sufficient ice will be needed to lower sample temperature to < 6ºC but not to the freezing point. Sample temperature must be maintained at < 6ºC until delivery to the laboratory. This may mean repacking samples prior to shipment.

Samples that are hand delivered to the laboratory the same day of collection may not meet the < 6ºC requirement. In this case, the samples are considered acceptable if there is evidence that chilling has begun, such as arrival on ice.

Take care at all times during collection, handling, and transport to prevent exposure of the sample to direct sunlight. For cubitainers, try to remove excess head space.

Acid. Label samples requiring preservation with sulfuric acid (H_2SO_4) in a way that lets the laboratory know that acid has been added. For example, put an **X** on the container cap to signify that acid was used for preservation, or label container "2 mL H_2SO_4 added." Add approximately 2 mL of 1:1, analytical reagent grade H_2SO_4 to each liter of sample to be analyzed for ammonia, total Kjeldahl nitrogen, total phosphorus, and total organic carbon. This amount is adequate to reduce the pH to less than 2. Invert about several times before placing the sample on ice, in the dark. Maintain the temperature at < 6°C until arrival at the laboratory.

Preservation with acid must occur in the field within 15 minutes of collection. Samples must be cooled to < 6°C but should never be frozen. See Table 5.2.

Safety note: Wear safety glasses when working with acids. Transport acids in a secure container that will prevent spills. Always carry sodium bicarbonate (baking soda) with acids to use in case of spills. Clean up all spills and splashes. Have a supply of freshwater nearby: it comes in handy if acid is spilled on the skin.

Field QC Samples

Field splits (FS) are collected with every 10th conventional water sample. If fewer than 10 samples are collected in a month, submit one set of field splits for that month. Field blanks are not routinely required but may be inserted into the sample regime if needed for a specific reason. Submit QC sample results for field splits are submitted to the TCEQ for storage in SWQMIS using the *monitoring type code* "FS." See Chapter 10 for detailed information on field QC samples.

Metals-in-Water Samples

Basic metals-in-water monitoring focuses on the TSWQS for the protection of aquatic life.

Routine Status Monitoring for Metals

For routine status monitoring (sometimes called "TSWQS metals"), collect samples for *dissolved* and *total metals*. Routine dissolved metals include arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, nickel, silver, and zinc. Routine total metals include only selenium and mercury.

Routine metals-in-water samples are not collected during periods of abnormally high turbidity associated with high or flood flows. Samples with high turbidity are unstable, making it difficult to collect a representative grab sample of soluble metals. High suspended solids can also interfere with the sample analysis. However, metals should be collected at sites that are normally turbid, but special-study sampling may be an exception. For example, wet-weather sampling is likely to include some samples with high turbidity.

Delay sampling for metals for at least 48 hours following a heavy rainfall.

Sample-Collection Depth

Collect metals-in-water samples from a depth of 0.3 m, using a peristaltic pump or other pumping system. Near-surface water is considered representative of the water mass in all water-body types. For determining compliance with numerical toxic-substance standards, a sample taken at the surface (as previously defined) is adequate.

Sampling Equipment and Preparation

Total- and dissolved-metals equipment preparation and cleaning procedures are based on EPA Method 1669 (EPA 1996). Metals-in-water sampling materials must be cleaned and prepared by a laboratory that can perform adequate quality-control checks (for example, equipment and bottle blanks). See Table 5.1 for components of a standard metals-in-water sample-collection kit.

The following applies to the information in Table 5.1:

- Disposable supplies must not be reused. This includes filters, gloves, storage bags, and ground cloths.
- Resuable supplies must be properly cleaned before reuse.
- Bottles may be used new without additional cleaning if they are certified pre-clean and metals free, and a blank is run from each lot.
- Materials should be stored and transported in dust-free containers, such as plastic bags, included in laboratory-prepared sampling kits.
- Materials such as gloves, storage bags, and plastic wrap, may be used new without additional cleaning unless the results of the equipment blank pinpoint any of these materials as a source of contamination. In that case, either a different supplier must be obtained or the materials must be cleaned.

Field Filtration

Sample filtration for dissolved metals *must be performed in the field within 15 minutes of collection* and with extreme care to avoid contamination. If samples are allowed to sit for an extended period of time, metals will settle out or adhere to the sides of the plastic container. Pump and filter samples directly into their container.

Table 5.1. Components of a standard metals-in-water sample-collection kit.

Item	Use	Cleaning	Storage	QC Check
Reusable Supplies				
250 mL plastic bottles	dissolved-metals blank, dissolved-metals sample, total-metals sample, total metals blank)	HNO_3	dust-free containers	Upon opening a new box of bottles, one in every 100 bottles are checked for contamination by filling with purified reagent water and submitting for analysis by ICP, ICP-MS, or CVAFS. The water must not show metals concentrations above the reporting limits.
250 mL glass or Teflon bottles	mercury blank and sample	HNO_3	dust-free containers	
Peristaltic pump	dissolved-metals sample	Pump modules do not require cleaning. However, nearly all peristaltic pumps contain a metal head and metal controls. Touching the head or controls necessitates changing of gloves before touching the tubing and/or cartridge filter.		equipment blank
1 L bottle of blank water	field blank	Metals-free deionized water	dust-free containers	Used for field and equipment blanks.
Disposable Supplies				
0.45 µ metals-free cartridge filter	dissolved-metals samples	Not required. Purchase certified pre-cleaned and bagged samples	dust-free containers	Record lot number. Upon opening a new lot of filters, one in every 100 filters are checked for contamination by filling with purified reagent water and submitting for analysis by ICP, ICP-MS, or CVAFS. The water must not show metals concentrations above the reporting limits.
plastic (3' × 3')	ground cloth	Not required		equipment blank
60 mL plastic syringe	dissolved-metals sample	Not required. Purchase certified pre-cleaned	dust-free containers	equipment blank
Teflon tubing (for use with peristaltic pump)	dissolved-metals sample	Soaking in 5–10% HCl solution for 8–24 hours, rinsing with reagent water in a clean bench in a clean room, and drying in the clean bench by purging with mercury-free air or nitrogen	double-bagged in clear polyethylene bags, serialized with a unique number, and stored until use.	equipment blank
powder-free gloves	sample collection	Not required	dust-free containers	equipment blank

Labeling the Sample Container

Do not write directly on the sample container. Use a labeling material that will not contaminate the sample. Write the sample information on the plastic bag holding the sample container. Provide enough information for the laboratory receiving the sample to easily match it to the analysis request or chain of custody (for example, date, location, type of sample). For the dissolved metals-in-water sample indicate that the sample has been field filtered.

Sample Preservation

Metals-in-water samples are preserved with a 1:1 HNO_3/H_2O solution made from metals-grade HNO_3 and metals-free deionized water. To eliminate potential contamination in the field, metals-in-water samples are shipped to the lab unpreserved. Samples are preserved upon arrival at the laboratory. The lab will add acid to bring the pH down to < 2. The holding time for acid-preserved samples is six months, except for mercury—28 days.

Companion Samples for Metals in Water

Request total-hardness analysis whenever metals in water are to be analyzed from an inland site (estuarine sites do not require hardness analysis). Typically, hardness can be calculated from the analysis of calcium and magnesium. The same sample used for total metals may also be used for hardness.

If a *total-metals sample* is collected, submit a sample for total suspended solids (TSS) if not already requested in a companion sample for routine water chemistry.

See Table 5.2 for sample volumes, containers, preservatives, and holding times for hardness and TSS samples.

Clean Hands / Dirty Hands Sampling

Total- and dissolved-metals sampling procedures are based on EPA Method 1669 (EPA 1996).

Clean sampling procedures, including *Clean Hands* (CH) / *Dirty Hands* (DH) techniques, are required when collecting samples for metals and other trace elements. *CH/DH* techniques require two people working together. At the field site, one person is designated as *CH* and the second as *DH.* Although specific tasks are assigned at the start, some tasks overlap and can be handled by either *CH* or *DH* as long as no contamination is introduced into samples. Both *CH* and *DH* wear non-contaminating, disposable, powder-free gloves during the entire sampling process and may change gloves frequently as the tasks change. Specifically, *CH* changes gloves between samples and whenever anything not trace-metals clean has been touched.

CH takes care of all tasks involving direct contact with the sample bottle and transfer of sample from the collection device to the bottle. *CH* generally works inside a clean area, usually inside a large plastic bag near the water body (see Figure 5.2) or inside a vehicle. *DH* works outside of the clean area on tasks such as preparing the sampler, operating sampling equipment, and all other activities that do not involve direct contact with the sample.

If two people are not available, metals-in-water samples may be collected by an individual who changes gloves when switching between CH and DH tasks.

Avoiding Contamination

The key to collecting a good metals-in-water sample is to avoid potential sources of contamination. Collect samples upstream from bridge crossings. Whenever possible, collect samples facing upstream and upwind to minimize contamination. Other sources of contamination to avoid include airborne dust, automobile exhaust, cigarette smoke, and nearby corroded and rusty bridges, pipes, poles, or wires. Mark sample information on the plastic bag and not on the bottle.

Figure 5.2. Collecting a dissolved-metals sample with a TCEQ Clean Metals Kit.

Look for ways to reduce the number of sample handling steps. This is not generally an issue when collecting a sample with a peristaltic pump, tubing, and a 0.45 µ cartridge filter. A large volume of water can be processed quickly filling sample containers directly from the water body.

However, using a 60 mL syringe requires multiple steps to fill the syringe and filter sample to obtain the appropriate volume. The potential for introducing unwanted contaminants is high. An efficient way to reduce the number of sample handling steps is to use a larger laboratory-prepared container to collect the sample. An empty blank water container can be used to collect the ambient water sample. This supplies a large volume of sample allowing the entire filtering process to be done inside the clean area. Refer to "TCEQ Houston Laboratory Clean Metals Kit—Sampling Procedure," below, for additional information on this collection method.

Metals-in-Water Collection Procedures

Metals sampling procedures are based on EPA Method 1669 (EPA 1996). The following section outlines sample collection using the traditional EPA Method 1669—peristaltic pump, tubing, and cartridge filter.

Total-Metals Sample

At the site *DH* opens the outer, dirty bag holding the total-metals sample bottle while avoiding contact with the clean inner bag (if present). *CH* opens the inner bag (if present) and pulls out the sample bottle. *CH* does not touch anything but the sample bottle, the cap, and the water being sampled. *CH* opens the bottle, making sure not to lay the cap on any surface while off the bottle.

For a total-metals sample, fill the container directly from a water body or from a precleaned sample collection device. To reduce contamination, containers can be filled and capped under the surface of the water. Allow enough space for the addition of acid. Samples are preserved by the laboratory performing the analysis. *CH* places the container

back in the plastic bag and sealed by *DH*. The holding time for preserved metals samples is six months.

Follow the same process for a total-mercury sample. Allow enough space for the addition of acid. Mercury samples are preserved by the laboratory doing the analysis. The holding time for a preserved mercury sample is 28 days.

Dissolved-Metals Sample

At the site, *DH* sets up the pump, while *CH* places the bottle in a *container holder*—anything nonmetal that supports the bottle, freeing up the collector's hands. *DH* opens the bag containing the filter. *CH* takes an end of the tubing and attaches the 0.45 µ cartridge filter making sure the flow arrow points in the correct direction. The filter end is approximately 18 inches from the pump, and the other end is long enough to easily reach beneath the water surface. *DH* closes the pump head, locking the tubing in place.

DH pulls the dissolved-sample container from the cooler and opens the outer, dirty bag while avoiding contact with the clean inner bag (if present). *CH* opens the inner bag (if present) and pulls out the sample bottle. *CH* does not touch anything but the sample bottle, the cap, and the water being sampled.

DH immerses the intake tube directly into the water and operates the pump. *CH* allows the ambient water to flush the tube and filter with the filter held upright. This allows water to run over the filter and remove any dirt or dust particles that might be on the filter. *CH* removes the cap from the sample bottle, holds the filter over the container opening, and allows the container to fill, leaving some head space. *CH* puts the cap back on the bottle and places the bottle back inside the plastic bag. *DH* seals the bag and places it in the ice chest.

Whenever *CH* touches the boat or equipment, which may be contaminated, *CH* should change gloves immediately.

As an alternative method, use a 0.45 µ cartridge filter and a 60 mL syringe to collect a dissolved-metals sample. For details on using this method, refer to "TCEQ Houston Laboratory Clean Metals Kit—Sampling Procedure," below.

TCEQ Houston Laboratory Clean Metals Kit—Sampling Procedure

The TCEQ Houston Laboratory currently supplies *Clean Metals Kits* to TCEQ personnel and some CRP partners. The following are procedures, based on EPA Method 1669 (EPA 1996), for collecting samples using the TCEQ Houston Lab Clean Metals Kit. Each kit comes with supplies to collect dissolved metals, total metals, total mercury, and the associated blanks. The Clean Metals Kits are prepared according to the Houston Lab standard operating procedure no. 7, "Preparation of Clean Kits for Collection of Trace Metals Samples."

Note: Not all of the supplies in the kit may be required for all sampling events. Return unused supplies to the lab as described in "Sample Handling and Shipping," below.

Sampling Kits

Ideally, metals sampling will be pre-planned and appear on the CMS. TCEQ personnel and other monitors using the Clean Metals Kits should notify the TCEQ lab of the number of kits and the delivery schedule that will be required for the coming fiscal year. Then, the kits must be ordered from the TCEQ lab prior to samplings, allowing at least two weeks for kit preparation and delivery. A limited number of kits are often available for instantaneous orders. The TCEQ lab supplies an order form for kits. The shelf life of a kit is approximately one year, provided the kit has remained sealed and there is no visible deterioration of components. Individual kits are enclosed in two plastic bags and shipped in a clean plastic ice chest. A kit contains all equipment and bottles for proper collection of samples from one site for the analyses of dissolved metals, total metals, and mercury. The kit also contains the metals-free water and bottles for the collection of required QC blanks.

A standard Clean Metals Kit contains the following supplies in a black sample kit box enclosed in 2 (3' × 3') plastic bags with a cable tie:

4 250 mL plastic bottles labeled with the sample type (BDM—*blank dissolved metals*, BTM—*blank total metals*, SDM—*sample dissolved metals*, STM—*sample total metals*) and a unique identification number

1 125 mL glass bottle (BHG—*blank mercury*)

1 250 mL glass bottle (SHG—*sample mercury*)

1 packet of supplies (two 5" × 8" bags, two 6" × 4" sheets of Parafilm, cork, one AquaPrep 600 filter, and one 60 mL plastic syringe)

1 1 L bottle (BH20—*blank water*)

All Clean Metals Kit supplies are shipped in an ice chest marked for metals samples only. In addition to the black sample kit box the ice chest contains the following supplies:

1 plastic bag (3' × 3') to be used as a ground cloth

2 plastic containers for shipping glass bottles

1 plastic container with Velcro on the bottom to hold the sample bottles while filtering—referred to below as the "Velcro container"

1 packet of bubble bags (2)

1 sheet of bubble wrap to line the cooler for shipping

1 manila envelope to hold the original request form, kit instructions, and two packets of gloves (medium—3 pairs and large—4 pairs)

2 binder clips to attach "clean enclosure" plastic bags to black box

1 black box (Sampling Kit)

1 set of sampling instructions

Using the Sampling Kit

Collect samples upstream from bridge crossings. Whenever possible, sample facing upstream and upwind to minimize contamination. Other sources of contamination to avoid include airborne dust, automobile exhaust, cigarette smoke, and nearby corroded or rusty bridges, pipes, poles, or wires. Mark sample information on the plastic bag, not on the bottle.

Kit Preparation

1. Put on gloves.
2. Lay the ground cloth down.
3. Remove the black box from the cooler and carefully cut the cable ties from both bags.
4. Open the black box and use the binder clips to attach "clean enclosure" plastic bags to the box.
5. Place the cork in the hinge of the black box.
6. Remove the contents from the black box and set them aside.
7. Attach Velcro container to the bottom of the black box.

Collecting Blank Samples

Total Mercury (Hg) Blank

1. Using the *blank mercury bottle* (BHG-), slide the double plastic bags partially down, and place them inside the Velcro container in the black box.
2. Open the *blank water* (BH2O-) labeled for mercury use.
3. Fill the BHG bottle up to its neck with blank water; recap the bottle, reseal the plastic bags and set them aside.

Total Metals Blank

4. Using the *blank total metals bottle* (BTM-), slide the double plastic bags partially down and place the bottle (still inside the plastic bags) inside the Velcro container in the black box.
5. Open the *blank water* (BH2O-) designated for metals use.
6. Fill the BTM- bottle up to its neck with blank water; recap the bottle, reseal the plastic bags, and set them aside.

Dissolved-Metals Blank

7. Using the *blank dissolved metals* bottle (BDM-), slide the double plastic bags partially down and place the bottle (still inside the plastic bags) inside the Velcro container in the black box.
8. Open the blank water (BH2O-) labeled for *Trace Metals* use.
9. Remove the plunger from syringe and insert the syringe tip into the filter. Note the flow direction on the filter.
10. Fill the syringe with blank water and use the plunger to flush the filter with 120 mL of blank water
11. Attach the filter to the top of the BDM- bottle and wrap its neck securely with one piece of Parafilm.
12. Fill the syringe with blank water. Repeat until the bottle is filled to its neck.
13. Remove the filter and Parafilm from bottle. Recap the bottle, reseal the plastic bags, and set them aside.

Collecting Metals Samples

Dissolved Metals

1. Remove the *total metals bottle* (STM-) from its double bags and collect a sample from the water body. An alternative is to empty the one-liter blank-water container

and use the bottle to collect sample for filtering under the protection of the plastic enclosure.

2. Before filtering a dissolved-metals sample, fill the syringe with sample water and use the plunger to displace any blank water remaining in the filter.
3. Using the *sample dissolved-metals* bottle (SDM-); attach the filtering apparatus as in step 8 (above) using a new piece of Parafilm.
4. Fill the syringe with the sample from the STM- bottle and use plunger as needed. Repeat until the bottle is filled to its neck.
5. Disassemble the filtering apparatus. Recap the bottle, reseal the plastic bags, and set them aside.

Total Metals

6. Refill the *sample total bottle* (STM-) from the water body.
7. Recap the bottle and put it in its original double bags, reseal them, and set aside.

Total Mercury

8. Remove the *sample mercury bottle* (SHG-) from its double bags and collect a sample from the water body.
9. Recap the bottle and put it in its original double bags. Reseal the bags and set them aside.

Shipping

1. Put double-bagged glass bottles into bubble sleeves, then into plastic shipping containers.
2. Put the shipping containers into bubble bags and seal them.
3. Put all other sample bottles into the black box, including those in shipping containers.
4. **Do not** preserve samples in the field. Samples will be preserved by laboratory staff in a controlled environment to reduce contamination.
5. Put the black box and all unused and reusable equipment into the cooler (**do not** use ice).
6. Place all refuse (used filters, wrappings, gloves, plastic bags) in the plastic bag that was used for the ground cloth and dispose of it properly. **Do not** ship trash back to the laboratory.
7. Ship samples and all unused and reusable equipment to the TCEQ Houston Laboratory using next-day delivery to ensure timely preservation.

Each sample bottle has a unique number assigned by the laboratory. Record these numbers with other field information. Also, record these numbers on the TCEQ *Request for Analysis* sheets. Do not write on the bottles. If additional labeling of a sample is required, write on the plastic bag containing the bottle.

Requirements for Collecting QC Samples for Metals in Water

To detect contamination during sampling, blanks are submitted for analysis. Run a blank for each type of metal sample collected. Field blanks (FB) are required for total-metals

samples; equipment blanks (EB) for dissolved-metals samples. See Table 5.2 and Chapter 10 for detailed information on field QC samples.

Collecting Field Equipment Blanks

Before using any metals sampling equipment the laboratory or equipment cleaning contractor is required to generate equipment blanks to demonstrate that the equipment is free from contamination.

Equipment blanks must be run on all equipment being used in the field. Equipment blanks are run by the sampler at a frequency defined in Chapter 10, which has detailed information on field QC samples.

Note: For those using the TCEQ metals-in-water kits, the standard frequency for equipment blanks does not apply. Equipment blanks are collected and submitted with each sample. See Table 10.1.

Blank Water

Take an adequate supply of metals-free deionized water into the field for each field blank collected. Metals-free deionized water is supplied by the laboratory performing metals analysis. Keep the deionized-water containers clean and dust-free on the outside by wrapping them in plastic bags.

Organics-in-Water Samples

Collect organic samples at a depth of 0.3 m by submerging the sample container by hand. A discrete sampler (Van Dorn) may be used, if necessary. Since organic compounds tend to concentrate on the surface of the sampling device or container, do not rinse the sampling device and sample container with native water before filling it.

Sample Containers and Collection

Volatile Organics

Fill three 40 mL volatile-organics analysis (VOA) vials with no headspace or air bubbles. Slowly fill each container to prevent tiny air bubbles from purging the sample during collection. Avoid trapping air bubbles in the sample. Fill one vial at a time, allowing enough room to add 2-4 drops HCl to pH < 2. The meniscus formed by the sample will help prevent bubbles when capping the vial. After capping the vial, invert the sample to check for large bubbles. If bubbles are present uncap the vial and add more sample. Tape the three vials together, label them "VOA," and submit them as a set. Cool them to < 6ºC but do not freeze them.

Note: Submit a trip blank for VOA samples (three 40 mL VOA vials) with each ice chest full of such samples shipped to the lab. Prepare trip blanks in advance, just before the sampling trip, and transport them to the field. Ask the laboratory for DI water and specify that it is for a VOA trip blank. Trip blanks demonstrate that the containers and sample handling did not introduce contamination. Submit sample results for trip blanks to the TCEQ for storage in SWQMIS using the monitoring-type code "TB." See Table 5.2 and Chapter 10 for detailed information on field QC samples.

Pesticides and Herbicides

The sample container for pesticides and herbicides is a new, clean, unused glass jar with a Teflon liner inside the cap, prerinsed with pesticide-grade hexane, acetone, or methylene chloride. Collect one liter of water for each of the three sample types (organophosphorus pesticides, organochlorine pesticides and chlorinated herbicides). **Each parameter group requires three separate 1 L jars.** If all three parameter groups are collected, nine 1 L jars must be submitted to the laboratory. Minimize the air space in the top of the jar. Preserve the sample immediately after collection by placing it on ice in the dark. In addition to other sample information, label the jar "ORGANICS—chlorinated herbicides," "—organophosphorus pesticides," or "—organochlorine pesticides," depending on the sample type.

Semivolatile Organics

Sample containers for semivolatile organics must be new, clean, unused glass bottles with a Teflon liner inside the cap, and prerinsed with pesticide-grade hexane, acetone, or methylene chloride. Fill two 1-quart jars to the top and place them on ice in the dark. In addition to other sample information, label the jar "Semivolatiles."

Note: Collect one sample, in a set of 10 or fewer (not blanks), in triplicate. This gives the laboratory enough sample volume for laboratory QC.

Sample Treatment in the Presence of Chlorine

Chlorine has an effect on pesticides, herbicides, and semivolatile organics. If instream chlorine residual is suspected, measure the chlorine residual using a separate subsample. Test strips or a standard chlorine residual test may be used as a way to determine the presence of chlorine and the need to treat water samples with sodium thiosulfate. Free chlorine will oxidize organic compounds in the water sample, even after it is collected.

If chlorine residual is above a detectable level (the pink color is observed upon adding the reagents or presence indicated by test strips), immediately add 100 mg of sodium thiosulfate to pesticide, herbicide, semivolatile, and VOA samples. Invert the sample until the sodium thiosulfate is dissolved. Record the chlorine residual concentration, or presence or absence, in the field logbook and on the request for analysis tag or chain of custody. If the chlorine residual is below detectable levels, no additional sample treatment is necessary.

Safety note: Although sodium thiosulfate has a low toxicity, it can cause eye irritation. Wear safety glasses during preparation of the sodium thiosulfate solution and when adding solution to the sample.

Methyl-Tert-Butyl Ether (MTBE)

Collect three VOA vials at each site. The three vials equal one sample; they may be taped together as one sample.

Preserve all vials with hydrochloric acid (HCl). Fill the vial by slowly submerging and cap it underwater. Later, remove the cap and add two drops of 1:1 HCl. Carefully recap the vial, avoiding the introduction of bubbles larger than a pea.

An alternative method is to acidify the vial prior to sampling. Ensure that the pH is less than 2. If the water may be alkaline or have a significant buffering capacity, or if there is

concern that pre-acidified samples may have the acid wash out, take a few practice vials to test with litmus paper. It may take more than two drops, and it will then be clear how to preserve the other samples that are being submitted to the lab. If an alternative method has proven successful, continue with that method.

Note: If vigorous foaming is observed following acidification, discard that sample and collect another set. Do not acidify the second set. Clearly mark the sample "not acidified" and the lab will run the analysis immediately. The holding time is 14 days with acid, 24 hours without acid.

Perchlorate

Surface water samples for perchlorate should be collected in a new unused 1 L polyethylene or glass container. Perchlorate samples do not require cooling, but can be put on ice with other samples. The sample holding time is 28 days.

Propellants, Explosives, and Pyrotechnics (PEPs)

Surface water samples for PEPs should be collected in triplicate at each site in1 L brown glass containers that have been prerinsed with methylene chloride. Keep the samples out of direct sunlight and put them immediately on ice to maintain the temperature at < 6ºC. The sample holding time is seven days under refrigeration.

Miscellaneous Parameters

Hexavalent Chromium

Acidification alters the hexavalent form of chromium. A separate, unacidified sample must be submitted if hexavalent chromium is to be analyzed. Filter, using the same procedure described for dissolved metals, and submit at least 500 mL of water. Collect the sample in a DI water-rinsed plastic or glass container, place it on ice, and ship it to the lab in time for analysis to begin within 24 hours of collection, preferably with at least 24 hours' notice. The lab must be notified when a hexavalent chromium sample will arrive. Hexavalent chromium is not usually analyzed on unfiltered samples and is not a routine parameter. However, criteria for this specific parameter are included in Table 1 of the TSWQS.

Cyanide

If a sample for cyanide is requested, a separate 1 L sample must be submitted in a separate plastic or glass container (a cubitainer, rinsed with deionized water, will work). Cyanide samples must be preserved immediately by the addition of ascorbic acid and sodium hydroxide, and then put on ice.

Chlorine Removal

Ascorbic acid is added first to remove chlorine when present. Unless it is known that chlorine or other oxidizers are **not** present, a test for chlorine residual should be made. Obviously, collection points from open waters in streams which are **not** immediately downstream from outfalls present little chance of chlorine being present. The decision to test for chlorine and to omit ascorbic acid is based on the circumstances at the time of collection. ***Note:*** Excess ascorbic acid interferes with the analysis.

Sample Preparation

Oxidizing agents such as chlorine decompose most cyanides. To dechlorinate a sample, add 0.2 g of ascorbic acid before adding sodium hydroxide (NaOH). Excess ascorbic acid can interfere with sample analysis at the lab. Ascorbic acid crystals are nontoxic and can be carried to the collection site.

Sample Preservation

After the ascorbic acid is added (or not, due to a negative chlorine residual test), add the 2 mL of 10 N NaOH (about six pellets or 2 mL of solution). The final pH must be greater than 12. To confirm this, a sampler who has not yet gained experience in determining the necessary amount may use pH test paper. The sample must be preserved with NaOH. Label the container "Preserved with NaOH" or "Preserved with ascorbic acid and NaOH."

Samples must be analyzed as rapidly as possible after collection. If storage is required, store the samples in a refrigerator or in an ice chest filled with ice to maintain the temperature at < 6ºC. The sample holding time under refrigeration is 14 days. Tests for cyanide are not usually conducted on filtered samples.

Handling and Shipping Samples

Ideally, samples are shipped on the same day they are collected. Due to increased shipping restrictions, samples being sent via a freight carrier may require additional packing. Even if care is taken to seal the ice chest, leaks can and do occur. To avoid leaks, place samples and ice in a large plastic bag inside the ice chest for shipping. The bag can be sealed by simply twisting it closed while removing excess air and taping the tail down. Leaking ice chests can cause samples to be returned or to arrive at the lab beyond the holding time. Some shipping companies, depending on the location, may require this extra step before shipping ice chests.

Place laboratory analytical request forms corresponding to samples in the ice chest in a Ziploc bag and tape the bag to the inside of the lid. Secure the lid with tape. This is essential if samples and ice are not in a large plastic bag. This method of handling chain-of-custody forms should not override existing protocols of the TCEQ region or sampling organization.

Take special care when shipping glass. When shipping a combination of plastic and glass, plastic containers can be used to cushion glass containers. If the majority of containers are glass, take extra care to prevent breakage during shipping by using suitable shipping materials (bubble wrap or plastic netting made for slipping over jars).

Data Reporting

Appropriate procedures and parameter codes necessary for submitting data are discussed in the *SWQM DMRG* (see Appendix A).

Table 5.2. Quick reference guide—water-sample collection methods, preservation, storage, and handling.

Note: If in doubt about containers, holding times, or preservation measures, call the laboratory receiving the sample(s).				
Parameters	**Recommended Containers**	**Sample Volume (mL)**	**Preservation**	**General Holding Times**
Routine Water-Chemistry Samples (3 containers: 2 unpreserved, 1 preserved with H_2SO_4)				
Container 1				
Alkalinity, Chloride, Fluoride, Sulfate, TDS, TSS, VSS See individual volumes and holding times for parameters taken from Container 1 listed below	Plastic or glass	1000	Cool to < 6°C but not frozen	see below
Alkalinity		100		14 days
Chloride (Cl)		100		28 days
Fluoride (F)		100		28 days
Sulfate (SO_4)		100		28 days
Total Dissolved Solids (TDS)—laboratory analysis of TDS is optional		200		7 days
Total Suspended Solids (TSS)		400		7 days
Volatile Suspended Solids (VSS)				7 days
Container 2				
NH_3, NO_3 + NO_2, TKN, TOC, TPO_4 See individual volumes and holding times required for parameters taken from Container 2 listed below	Plastic or glass	1000	2 mL 1:1 H_2SO_4 to pH < 2 and cool to < 6°C but not frozen	see below
Ammonia (NH_3)		150		28 days
Nitrate + Nitrite (NO_3 + NO_2)		150		28 days
Total Kjeldahl Nitrogen (TKN)		100		28 days
Total Organic Carbon (TOC)		100		28 days
Total Phosphorus (TPO_4)		150		28 days
Container 3				
Chlorophyll Chlorophyll *a*	Amber glass or plastic	1000	Cool to < 6°C but not frozen, dark	• Filter ≤ 48 hours • Samples must be filtered as soon as possible and filters stored frozen up to 24 days
Container 4 (Optional)				
Orthophosphate (OP) field filter within 15 minutes of collection with a 0.45 µ filter; volume varies based on lab	Plastic	25–50 mL	Field filter; cool to < 6°C but not frozen	48 hours

Notes appear at the end of metals in water. *(continued)*

Table 5.2. Quick reference guide—water sample collection methods, preservation, storage, and handling (continued).

Procedures for Collecting Routine Water-Chemistry Samples

- Label containers before collection with tag number, station location, date, and sample type.
- Write an *X* on the container lid to identify the acidified sample.
- If containers are new and unused or cleaned in a laboratory rinsing with ambient water is not required. However, containers may be rinsed with ambient water. Rinse three times and discard water away for sample location. Choose and method and be consistent.
- Fill each container with ambient water by submerging container approximately 0.3 m below the surface. Collect stream samples in the centroid of flow.
- Acidify the **X** container immediately after collection; place all containers on ice immediately. "Immediately" is defined as within 15 minutes of collection.

Shipping Procedures

- Due to increased shipping restrictions, samples being sent via a freight carrier may require additional packing. This varies by location.
- If required, place samples and ice in a large plastic bag inside the ice chest for shipping. Seal the bag by simply twisting it closed while removing excess air and taping the tail down. **Leaking ice chests will cause samples to be returned or to arrive at the lab beyond the holding time.**
- Place laboratory analytical request forms corresponding to samples in the ice chest in a Ziploc bag and taped to the inside of the lid. Secure the ice-chest lid with tape.
- Ship samples on ice and cooled to < 6°C. Samples arriving past the holding time will not be analyzed for certain parameters. Samples are ideally shipped within 24 hours, and never later than 48 hours.
- Take care when shipping glass. When shipping a combination of plastic and glass, plastic containers can be used to cushion glass containers. If the majority of containers are glass, extra care must be taken to prevent breakage during shipping. Suitable shipping materials include bubble wrap or plastic netting made for slipping over jars.

Optional Water Quality Parameters

Parameters	Recommended Containers	Sample Volume (mL)	Preservation	General Holding Times
Oil and Grease (hexane extraction method)	Glass jar with Teflon-lined lid, rinsed with hexane or methylene chloride	1,000	2.5 mL 1:1 HCl to pH between 1.5 to 2.5; cool to < 6°C but not frozen, dark; do not use H_2SO_4.	28 days
Phenols	Glass jar with Teflon-lined lid	1,000	2 mL 1:1 H_2SO_4 to pH < 2; cool to < 6°C but not frozen, dark	28 days
Cyanide	Plastic	1,000	Add 0.2 g ascorbic acid to dechlorinate sample, if necessary; add about 2 mL 1:1 NaOH to pH > 12; cool to < 6°C but not frozen, dark	14 days
Biochemical Oxygen Demand	Plastic	1,000	Cool to < 6°C but not frozen, dark	48 hours
Chemical Oxygen Demand	Plastic	110	2 mL 1:1 H_2SO_4 to pH < 2; cool to < 6°C but not frozen, dark	28 days

(continued)

Table 5.2. Quick reference guide—water sample collection methods, preservation, storage, and handling (continued).

METALS IN WATER				
Parameters	**Recommended Containers**	**Sample Volume (mL)**	**Preservation**	**General Holding Times**
Routine Dissolved Metals arsenic cadmium calcium chromium copper iron lead magnesium manganese nickel silver zinc	HNO_3-cleaned plastic bottle	250	Filter at sample site; preserved by lab with ultra-pure HNO_3 to pH < 2	6 months
Routine Total Metals Selenium	HNO_3-cleaned plastic bottle	250	Preserved by lab with ultra-pure HNO_3 to pH < 2	6 months
Routine Total Mercury Mercury	HNO_3-cleaned glass or Teflon bottle	250	Preserved by lab with ultra-pure HNO_3 to pH < 2	28 days
Total Hardness Laboratory analysis can be run on sample from the total-metals container; a separate sample is not required if submitting a total metals sample	Plastic	250	Cool to < 6°C but not frozen Add 1–2 mL of HNO_3 to pH < 2; preserve in the field	6 months
Hexavalent Chromium (Not routine)	Plastic or glass	600	Cool to < 6°C but not frozen, dark, no acid; filter	24 hours; must notify lab in advance

(continued)

Table 5.2. Quick reference guide—water sample collection methods, preservation, storage, and handling (continued).

ORGANICS and PESTICIDES IN WATER				
Parameters	**Recommended Containers**	**Sample Volume (mL)**	**Preservation**	**General Holding Times**
Volatile Organics (VOA)	Three 40 mL VOA Vials	120	Add 2–4 drops HCL to pH < 2; cool to < 6°C, dark but do not freeze	14 days
MTBE (methyl-tert-butyl ether)	Three 40 mL VOA vials	120	Cool to < 6°C but not frozen, dark; or add 2–4 drops HCl to pH < 2 and cool to < 6°C, dark	14 days preserved, 24 hours unpreserved
ORGANICS **Pesticides** • Organophosphorus pesticides • Organochlorine pesticides **Herbicides** • Chlorinated herbicides **Semivolatile Organics**	Three1 liter amber glass jars with Teflon-lined lid per parameter group; **must be prerinsed with hexane, acetone, or methylene chloride** ***Note:*** Each parameter group requires 3 L of sample; if all three parameter groups are requested submit nine 1 L jars	3,000 (3 L) for each parameter group	Cool to < 6°C but not frozen, dark If chlorine is present, add 0.1 g sodium thiosulfate to dechlorinate	7 days until extraction
Propellants, Explosives, and Pyrotechnics (PEPs)	Three 1 liter amber glass jars with Teflon-lined lid per sample type; **must be prerinsed with methylene chloride**	3,000	Cool to < 6°C but not frozen, dark	7 days
Perchlorate	1 qt glass or plastic container	1,000	None	28 days

Procedure for Collecting Organics in Water

- Label each container with tag number, station location, date, and *ORGANICS—organophosphorus pesticides, —organochlorine pesticides, —chlorinated herbicides,* or *SEMIVOLATILES* (depending on sample type).
- Fill quart jar(s) to the top. Collect from a depth of 0.3 m. To avoid atmospheric contamination, sample jars may be filled and capped under water. Put in the dark and on ice.
- For a sample set of 10 or fewer, submit samples in triplicate (send in three jars instead of one per sample type) for laboratory QC.

Table 5.3. Summary of quality-control samples for water.

***Field Split (FS)*—Conventionals in Water**
• Field splits represent variability introduced during preservation and handling and at the lab. Submit field splits with every 10th sample. If fewer than 10 samples are collected in a month, submit one set of splits for that month. This requirement applies to conventional water samples only. • Collect two sets of conventional water samples from the same ambient water sample, using the same method. Use identical procedures in handling, storing, shipping, and analyzing samples. This applies to all cases of routine surface water collection procedures, including instream grab samples, bucket grab samples from bridges, pumps, and other water-sampling devices. • Each set of samples is to have a separate tag number. Submit both sets of water samples to the same lab for analysis.
***VOA Trip Blank (TB)*—Volatile Organics**
• Run trip blanks for volatile organic samples **only**. • Submit one set of DI water samples for each ice chest containing volatile organic samples. • VOA trip blanks are samples prepared in the laboratory with pure laboratory water, preserved as required. Transport to the sample site, handle like other VOA samples, and ship to the laboratory for analysis. Do not open trip blanks in the field. • VOA trip blanks are used to check contamination of the sample through leaching of the septum. • Submit trip blanks to the same lab for analysis.
***Field Blank (FB)*—Total Metals Collected without Equipment**
• Field blanks are required for total metals collected directly from a water body. This QC sample must be collected in the field. • Collect blanks at the last station of a sampling trip or sampling day. • Obtain reagent-grade water from a laboratory. • In the field, fill sample containers with reagent-grade water. Field blanks are handled, stored, shipped, and analyzed the same as ambient water samples. • A field equipment blank is submitted with every 10th sample, per day or per sample run. If fewer than 10 samples are collected in a day, submit blank per day or per sample run. • ***Note***: For those using the TCEQ metals-in-water kits, the standard frequency for equipment blanks does not apply. Equipment blanks are collected and submitted with each sample. • Field blanks are not routinely required for routine chemistry, pesticides, or semivolatile organics, but may be inserted into the sample regime, if needed for a specific reason.
***Equipment Blank (EB)*—Dissolved Metals and Total Metals Collected with Equipment**
• Collect field equipment blanks at the last station of a sampling trip or sampling day. • Submit a field equipment blank with every 10th sample, per day or per sample run. If fewer than 10 samples are collected in a day, submit one blank per day or per sample run. • ***Note***: For those using the TCEQ metals-in-water kits, the standard frequency for equipment blanks does not apply. Equipment blanks are collected and submitted with each sample. • Obtain reagent-grade water from the lab.
Note: This summary table includes only basic QC sample requirements for routine sample collection. See Chapter 10 for details on optional QC samples.

CHAPTER 6

COLLECTING SEDIMENT SAMPLES

Sediment Samples

Sediment chemistry samples can give information both on trends in contaminant loading and on the potential for adverse effects on sediment and aquatic biota. The evaluation of sediment concerns depends on the site and the way in which the sediment is collected. In order to compare samples over time and from site to site, samples must be collected consistently and from representative sites.

Characteristics of Sediment

Many of the chemical constituents of concern are adsorbed onto fine particles. An objective in collecting a sediment sample is to obtain recently deposited fine sediment (see Figure 6.1A). Fine sediment generally consists of a mixture of silt, clay, and some sand. Avoid hard clay, bank deposits, gravel, sand, and disturbed or filled areas (see Figure 6.1B). Any sediment that resists being scooped with a dredge is probably not fine, recently deposited material.

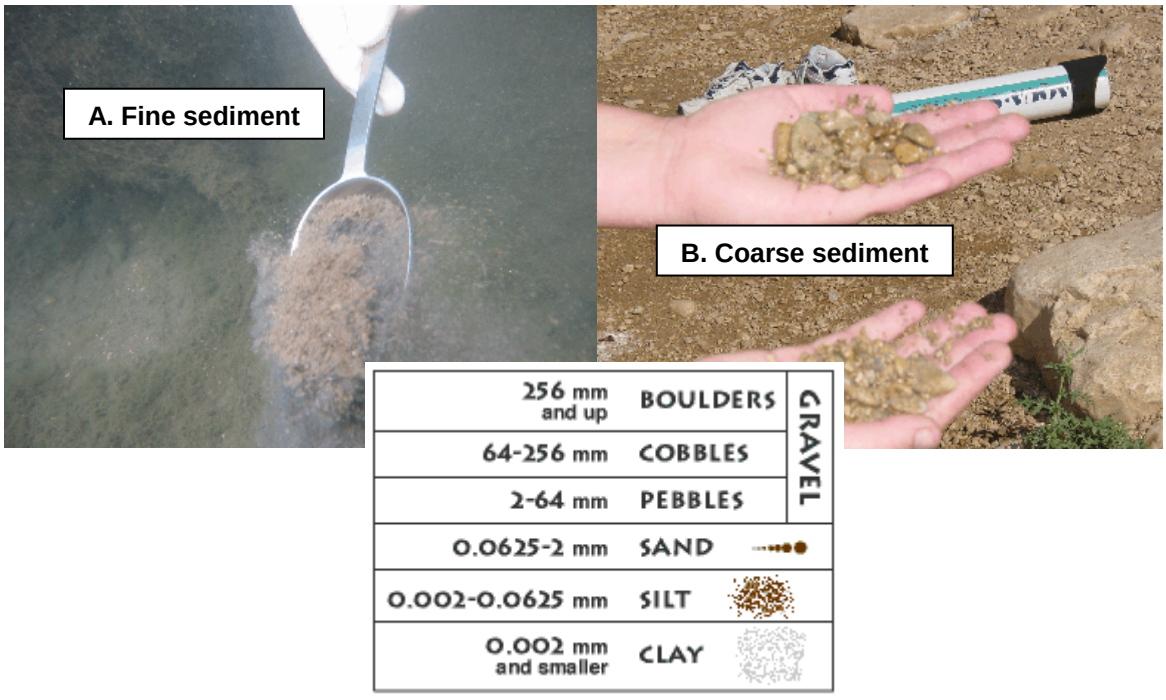


Figure 6.1. Sediment characteristics.

Characteristics of an Ideal Site

In streams and rivers, choose a sampling site with lower hydrologic energy, such as the inner (*depositional*) side of a bend or eddy where the water movement may be slower. Quiescent areas are conducive to the settling of finer materials. Reservoirs and estuaries are depositional environments where finding a suitable site is generally not a problem.

Sediment is often difficult to collect in streams with sandy, hard clay, and bedrock bottoms.

If a suitable site for collecting sediments cannot be found at a station, sampling personnel should consider collecting at a more representative location, or attempt to reschedule the sample collection. It is recommended that sites where samples are difficult to collect be eliminated from the routine sample schedule.

Selecting the Appropriate Sediment Type for Analysis

Sediment will vary from site to site and can vary between samplings at a particular site.

Streams and rivers. Sediment collection in flowing streams is often a challenge. In areas of frequent scouring, there may not be sufficient sediment for collection during or after periods of high flow. Sediment collection during these times may prove unsuccessful and may have to be rescheduled. **It is important to collect sediment from depositional areas.**

When the suspended load in rivers and streams precipitates due to reduction of velocity, most of the resulting sediment will be **fresh**. In such instances, the entire bite from the dredge subsample may be used. More often than not a dredge does not function very well in smaller streams. In these cases, sediment may have to be collected into a pan (or a jar for volatile organics) using a Teflon scoop or other suitable collection device, such as a Ponar dredge.

Reservoirs and estuaries. In areas where very little scouring normally occurs, such as in estuaries and reservoirs, the sediment will be vertically stratified. In reservoirs and estuaries, sediment is generally consolidated enough to be emptied into a flat, prerinsed plastic or Teflon pan as a cubical block of mud. Vertical stratification can then be observed. Typically, there may be light brown silt on top, followed by a gray aerobic zone overlying a typically black anaerobic layer. Because the thickness of these layers is variable, it is difficult to prescribe a certain thickness representing "recent deposits" to be sampled. Only the aerobic layer is sampled, because this zone represents more recent deposits and is where most of the benthic infauna live. If the sediment does not have an aerobic zone, collect the top 2 cm for analysis. If the aerobic zone is deeper than 5 cm, collect the sample for analysis from the top 5 cm to obtain the most recently deposited sediments (see Figure 6.2). Three or more grabs are composited for the sediment sample.

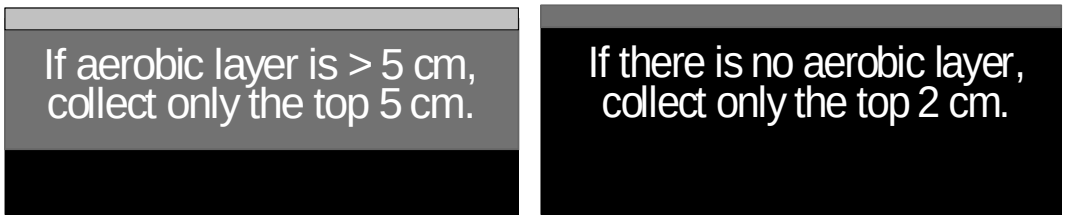


Figure 6.2. Typical sediment stratification.

Required Equipment

Basic sediment sampling equipment consists of either an Ekman or a Ponar dredge (see Figure 6.3), a plastic or Teflon pan or bucket, Teflon or stainless steel scoops, and 500 mL glass jars with Teflon lids for metals, organics, and conventionals (detergent washed and DI rinsed). See Chapter 9 for the list of basic SWQM equipment.

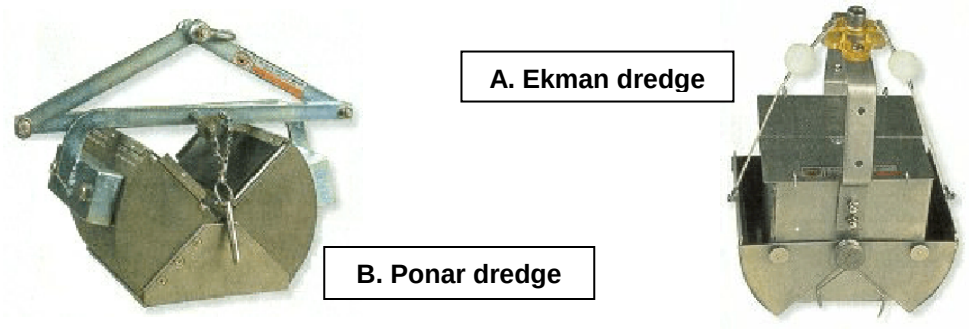


Figure 6.3. Sediment dredges.

General Collection Procedure

Collect sediment samples after the water samples. Submit sediment samples for metals and organics in separate pre-cleaned glass jars. Acid-rinsed jars (for metals) and solvent-rinsed jars (for organics) are not required.

After choosing an appropriate site, collect the sample using the following procedure: After setting the dredge in the open position, slowly lower it to the bottom, disturbing the substrate as little as possible. The idea is to lower the dredge at a rate that allows for an even grab of sediment without it coming out of the dredge. Adjust this method as necessary to accommodate the type of sediment at a site. Retrieve the closed dredge at a moderate speed (less than 2 ft/s). Upon retrieval, examine the grab to ensure that the sediment surface is undisturbed.

Things to consider when collecting sediment samples with a dredge:

- The mud surface must not be pressing out of the top of the sampler. If it is, lower the dredge more slowly.
- Overlying water must not be leaking out along the sides of the sediment in the dredge. This ensures that the surface sediment is not washed out.
- Sediment surface must be flat and level in the sampler. If it is not level, the dredge has tilted over before closing.
- The water overlying the sediment in the dredge must be very gently decanted by slightly tipping the dredge with the lid closed until the water runs out the top. Decanting should remove all of the overlying water but not the surface sediments. The laboratory reports the percentage of water for the sample. Overlying water is not included in the sample container. The sample should contain as little water as possible and must not have more water than sediment.
- Empty the sample into a pan (see Figure 6.4A). Examine the sediment for depth of penetration, color, thickness of top aerobic zone, and texture (see Figure 6.4B). Record these observations in the logbook.
- ***For estuarine and reservoir samples***—collect the top aerobic zone (up to 5 cm) from at least three subsamples and composite in a pan (see Figure 6.5).

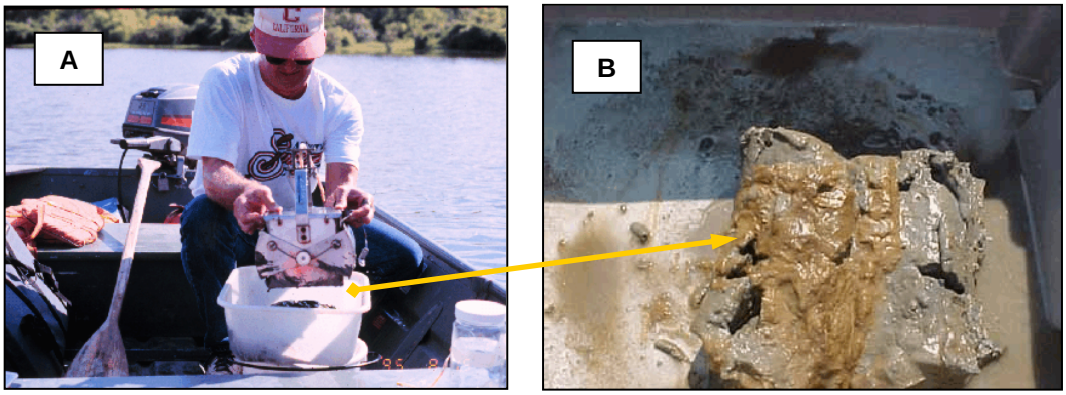


Figure 6.4. (A) Emptying the sample into a pan. (B) Sediment sample.

- ***For stream samples***—the entire grab may be composited. In streams with excessive bottom debris (rocks, sticks, leaves) where the use of an Ekman or a Ponar dredge is ineffective (the dredge does not close, causing loss of sediment), samples may be collected by hand, using a clean Teflon scoop or stainless steel spoon. Otherwise, exclude the bottom most layer and composite. Handle sediment as described in the following sections on metals and organics.

Figure 6.5. Compositing a sediment sample in a bucket or pan.

Note: Even if the volume of one dredge grab is sufficient to fill the required number of containers, a minimum of three separate dredge grabs are required for all sediment samples. This is required to get a representative sample for an area, rather than a single location.

Metals, Pesticides, and Semivolatile Organics in Sediment

For metals and semivolatile organics, a minimum of three grabs may be mixed in a clean pan or bucket, and distributed to the sample containers. Mixing is generally done with a Teflon or stainless steel scoop or spoon. Remember, the pan and dredge must be cleaned with native water between sites. Try not to transfer rocks, large leaves, or sticks into the container.

Collecting Metal, Semivolatile, or Pesticide Samples

Make sure the sample volume is adequate, but the containers do not need to be filled to the top. Seal the jars with the Teflon liner in the lid. There is no need to eliminate head space in the jar, as "no head space" applies only to volatile organics. If semivolatiles are requested, use only glass, Teflon, or metal items to collect samples; plastic equipment can contaminate a sample. See Table A7.3 of the SWQM Program QAPP for a list of methods used to analyze sediment (see Appendix A).

Sediment Conventionals

Sediment conventionals—including grain-size analysis, total organic carbon, and percent solids (moisture content)—are always requested with samples for both organics and metals samples. They are extremely important in determining the availability of metals and organics in sediment. The collection method is the same as for metals, semivolatile organics, and pesticides.

Volatile Organics in Sediment

For volatile organics, sediment collection slightly differs in order to reduce the release of volatiles. Composite the grabs by transferring an equal portion of successive grabs (at least three) to the sample containers with a clean Teflon or stainless steel scoop. Distribute each grab to the sample containers in a different sequence—rotating the order in which sediment is added to the jars.

First add to Jar 1, 2, then 3. Next start with Jar 2, 3, and 1, and so on until the jars are filled. This method is used when volatile organics are to be run on a sample. **Fill each container to the top, leaving no head space,** and seal the jars with the Teflon liner in the lid. "No head space" means that sediment must be to the lip of the jar. Compositing a sample in a pan or bucket may release volatiles from the sediment. Try not to transfer rocks, large leaves, or sticks into the container. To reduce handling of a volatile organic sample, sediment can be taken directly from the dredge (see Figure 6.6).

Figure 6.6. Collecting a sample directly from the dredge.

Sediment samples with high water content will settle leaving a layer of water on top. A sample with no head space in the field may arrive with a half inch or more of water on

top. This is not a problem for metals and conventional parameters but will cause headspace in a volatile organic sample.

Volatile organics are no longer collected routinely. If they are collected, it is generally for a special project.

Sample Containers

Place sediment samples in glass jars with Teflon liners. Jars for sediment samples require no special treatment. Acid and solvent rinses are no longer required for metals or organics in sediment.

Sample Size

Metals, organics (volatile, semivolatile, and pesticides), and conventionals in sediment each require 500 grams of sample. If you are collecting both organics and metals at the same station, fill three glass jars—one for metals, one for organics, and one for conventionals. When collecting only metals or organics at a station, fill two glass jars—one for metals (or organics), and the second for conventionals. Please note that the number of jars and sample size is a suggestion based on TCEQ laboratory protocols. The number, type of container, and sample size can be determined by the laboratory doing the analysis.

***Note*:** Even if you can get the entire sample volume in one grab, at least three grabs are required to get a more representative sample.

Labeling

Label the jars with the station ID and date of collection, as well as the type of analysis requested (metals, conventionals, organics, pesticides).

Preservation

Immediately place the labeled jar on ice, cool it to < 6°C (do not freeze it), and keep it in the dark until delivery to the laboratory. See Table 6.1.

Handling and Shipping Samples

Due to increased shipping restrictions, samples being sent via a freight carrier require additional packing. Even if care is taken to seal an ice chest, leaks do occur. To avoid leaks, place samples and ice in a large plastic bag inside the chest for shipping. The bag can be sealed by simply twisting it closed while removing excess air and taping the tail down. Leaking ice chests can cause samples to be returned or to arrive at the lab beyond the holding time. Some shipping companies, depending on the location, may require this extra step before shipping ice chests.

Place laboratory analytical request forms corresponding to samples in the ice chest in a Ziploc bag, taped to the inside of the lid. Secure the lid with tape. This is essential if samples and ice are not in a large plastic bag. This method of handling chain-of-custody forms should not override existing protocols of the TCEQ region or sampling organization.

Take special care when shipping glass. When shipping a combination of plastic and glass, plastic containers can be used to cushion glass containers. If most of the containers are

glass, extra care must be taken to prevent breakage during shipping. Suitable shipping materials include bubble wrap or plastic netting made for slipping over jars.

Field Notes

In the field logbook, record the depth at the location where the sample was taken. Record a gross description of the sample, including its color and texture, the number of grabs, the thickness of the grab sample, and the depth of the aerobic zone included in the composite sample. This information can be reported as comments with the sediment analytical results.

Field notes for each sample should include the following information:

Type of composite. Sediment composites are considered both time and space composites.

Number of grabs. Report the number of grab samples used in the composite. The minimum is three.

Start and end time and date. These are required fields for reporting composite-sample data.

Start and end depth. These are required fields for reporting composite-sample data. This number should reflect the depth of the water over the sediment. The depth is never reported as zero, since sediment must be covered by water at the time of collection. The start and end depth may be the same.

Data Reporting

Appropriate procedures and parameter codes necessary for submitting data are discussed in the *SWQM DMRG*.

Table 6.1. Quick reference guide—sediment-sample collection methods, preservation, storage, and handling**.**

Parameter	Recommended Containers	Sample Volume (grams)	Preservation	Hold Time
SEDIMENT				
Metals-All but mercury	1-pint glass jar with Teflon-lined lid; special treatment not required	500	Cool to < 6°C, dark; do not freeze	180 days
Metals-mercury				28 days
Organics (pesticides, semivolatiles, volatiles)	1-pint glass with Teflon-lined lid; special treatment not required	500	Cool to < 6°C, dark; do not freeze	14 days
Conventionals TOC, grain size, percent solids (moisture content)	1-pint glass jar with Teflon-lined lid	500	Cool to < 6°C, dark; do not freeze	28 days

Procedure for Collecting Sediment Samples

- Label containers with tag number, station location, date, and sample type.
- Wash dredge pan and bucket with ambient water before and after sample collection.
- Slowly lower the dredge into the sediment. Raise closed dredge at a rate of about 2 ft/s.
- Slowly decant overlying water. Empty sediment grab into a pan.
- **Composite a minimum of three grab samples.**

For **metals, semivolatile organics, and pesticides:**

- Composite sample may be collected in a pan or bucket. Put a minimum of three grab samples in a bucket, stir with Teflon scoop or spoon, and transfer to the container(s).
- Place samples into clean glass jars with Teflon lids. Put samples in dark and on ice. Containers do not have to be filled to the top.
- Record in field notebook the location and sediment description (color, texture, odor, and number of grabs).
- Put on ice and ship to lab.

For **volatile organics** (typically collected as part of a special project):

- Since compositing in a pan or bucket can release volatile compounds, care must be taken to limit disturbance of the sediment during collection and compositing.
- For first grab—put first scoop off top into Container 1; second scoop into Container 2; and third scoop into Container 3.
- Second grab—put first scoop in Container 3; second scoop in Container 2; and third in Container 1.
- Keep rotating until the jars are full.
- Place samples into clean glass jars with Teflon lids. Put samples in dark and on ice. **Fill containers to top with no head space.** No head space = sediment to the top of the jar.
- Record in field notebook the location, sediment description (color, texture, odor, and number of grabs).
- Put on ice, cool to < 6°C, and ship to lab.

Reject grab if: mud is coming out of top of dredge, overlying water is leaking out of dredge (removes surface sediment), or sediment is sloping in the dredge (surface of sediment bite in dredge should be relatively flat). This may be difficult for flowing-water samples. Entire bites from a flowing water site may be used.

For ***estuarine and reservoir samples***, collect the top aerobic zone (up to 5 cm) from at least three subsamples and composite a minimum of three grabs.

For ***stream samples***, the entire grab may be composited. Otherwise, exclude the bottommost layer and composite a minimum of three grabs.

CHAPTER 7

COLLECTING TISSUE SAMPLES

This chapter describes guidelines for collecting biological tissue samples (fish, crabs, crayfish, oysters, mussels). The tissue sampling guidelines have been standardized among the resource agencies in Texas.

Guidelines for Tissue Sampling in Texas

Various federal, state, and local agencies collect and prepare tissue samples from surface waters in Texas. The purpose of these guidelines is to ensure that tissue data collected by the different agencies are comparable. Tissues are sampled for a variety of reasons, including the assessment of both ecological and human-health risks, background conditions, the impacts of pollution, and long-term status monitoring.

However, tissue sampling and analysis are costly and time consuming, and decisions based on these data can have various effects on the public. For these reasons, it is important to maximize the comparability of data from tissue analysis by following a set of sampling guidelines used by all authorities that conduct tissue sampling in Texas.

These tissue-monitoring guidelines are intended to be general and may not apply to all special-purpose studies. Variations from these guidelines must be detailed in quality-assurance-project plans.

Selecting a Sample Type

Before collecting tissue samples the sample type needs to be determined.

- Determine in advance what is being looking for, what is the concern—human health or ecosystem health?
- Select species and type of sample (edible tissue or whole fish) that best fits the concern.
- Determine what parameters need to be analyzed.
- Consider limiting the parameters requested, if the contaminants are known.
- Try to select species that are common to the area of concern.

Different sampling strategies are required, depending on the objectives. The four main objectives for collecting tissue data are assessing:

- background conditions
- long-term trends
- ecosystem health
- human-health risk

Background Conditions

The objective in sampling background conditions is to determine the level of contaminants in fish from areas least affected by pollution or pollutants. Sampling sites should be limited to freshwater or tidal streams. The Texas Parks and Wildlife Department (TPWD) already maintains fish-tissue data from least affected bays and

many reservoirs (for example, Christmas Bay, Espiritu Santo Bay, and South Bay). Contrary to a common assumption, many ecoregion sites are not suitable for tissue sampling. Sampling for background conditions is typically done by the TPWD.

Where to sample—Areas of minimal or no impact (ecoregion sites).

Type of sample—Whole-body composites of mature fish.

Number of species—Two to three, including both predators and bottom-feeders.

Number of individuals—Three to five, preferred, of the same species composited.

Size of individuals—Larger fish are preferred, due to bioaccumulation, with individuals varying in total length by no more than 25 percent within the sample.

Sampling frequency—All specimens may be collected in a single event, if possible.

Example species—*Freshwater:* bass, sunfish, buffalo, crappie, catfish, carp. *Estuarine:* catfish, seatrout, sheepshead, oysters.

Long-Term Trends

The objective of long-term-trend sampling is to monitor accumulation of contaminants in fish from sites where a major cleanup has occurred or where future impacts are likely. The sampling would be conducted once a year for an indefinite period. Therefore, it is imperative that the target species be common and easily collected year after year to facilitate data analysis. Long-term trends for ecological health are assessed by taking samples from whole, mature fish. A long-term-trend study can include fillets if there is a need to assess the status of a human-health issue.

Where to sample—Sites with historical data, sites where a major cleanup has occurred, or where expected future impacts are likely to occur.

Type of sample—Whole body composites of mature fish for ecosystem health; fillets for health issues (for example, assessing the status of a consumption advisory).

Number of species—Two to three species.

Number of individuals—Three to five of the same species composited.

Size of individuals—By no more than 25 percent variance in total length.

Sample frequency—Once a year indefinitely.

Example species—*Freshwater:* bass, buffalo, sunfish, catfish, carp. *Estuarine:* oysters, catfish, seatrout, sheepshead.

Ecosystem Health

The objective of ecosystem health sampling is to monitor bioaccumulation of contaminants in fish from sites affected by point or nonpoint sources. This type of sampling may be combined with sampling for human-health risk. Whole-fish samples are analyzed.

Where to sample—Areas affected by point or nonpoint sources.

Type of sample—Whole-body composites.

Number of species—Two to three for each sampling event.

Number of individuals—Three to five of the same species composited.

Size of individuals—Larger fish are preferred, due to bioaccumulation, with individuals varying in total length by no more than 25 percent within the sample.

Sampling frequency—All specimens may be collected in a single event, if possible.

Example species—*Freshwater:* bass, freshwater drum, sunfish, catfish, carp, forage fish. *Estuarine:* catfish, flounder, drum, seatrout, sheepshead.

Human-Health Risk

The objective of this sampling strategy is to monitor the bioaccumulation of contaminants in fish at sites affected by point or nonpoint sources that are the target of recreational fishing. This type of sampling may be combined with sampling for ecosystem-health risk. Target species may differ based on regional preferences. If a problem is detected, the information will be referred to the DSHS for further studies or consumption advisories.

Where to sample—Areas affected by point or nonpoint sources that are commonly used for recreational fishing.

Type of sample—Individual fillets of muscle tissue.

Number of species—Two to four.

Number of individuals—Three to five of the same species (individual analysis).

Size of individuals—At least the legal limit; however, larger individuals are preferred. Individual fish should vary in length by no more than 25 percent.

Sampling frequency—All specimens may be collected in a single event, if possible.

Example species—*Freshwater:* bass, crappie, catfish, freshwater drum. *Estuarine:* oysters, Atlantic croaker, sand trout, speckled trout, red drum, black drum.

Site Description

Site descriptions include the latitude and longitude (measured to the nearest second), the county, and a detailed description of the site so it can be located on a county road map. The sites are described as primarily used for sport fishing, commercial fishing, or a combination of both, or not used for fishing. Permanently maintained field notes describe the specific sampling location, the date, and if appropriate, the chain-of-custody tag numbers. Field notes also describe the method of collection, including electrofisher setting and number of seine hauls, time of collection, hydrologic conditions (for example, high or low flow, incoming or outgoing tide), water temperature, days since the last significant rainfall, and if collected, other physicochemical field measurements.

Notifying the TPWD in Advance of Collecting

A TPWD Scientific Collection Permit requires **notification before sampling.** A confirmed response from the local game warden is required prior to collection if sampling activities involve methods of capture ordinarily classified as illegal. Be prepared to give information on when, where, and why fish will be collected. This is required. Obtain phone numbers for regional offices from the TPWD Communications Center: Austin, 512-389-4848, or Houston, 281-842-8100. Always carry a copy of the permit when collecting biological samples.

Safety

See Chapter 11 for safety considerations.

Sampling Techniques for Fish

Collect samples using active procedures such as electrofishing, trawling, or seining. Passive capture techniques (gill nets and trammel nets) for fish can be used, as long as gear is clearly marked with the permittee's name and permit number, and frequently checked. Samples can begin to deteriorate in as little as 2 hours in warm water and 6 hours in cold water.

Collection Methods

The method by which tissue samples are collected will depend on several factors, including characteristics of the water body, the number of sampling personnel, and the availability of sampling equipment. For example, electrofishing does not work in estuarine waters, so a trawl or gill net might be used. In places where access is limited, hook and line may be the best approach. Chemicals, such as rotenone, should not be used to collect tissue samples. The following are methods generally used in tissue collection:

- trawl
- boat-mounted electrofisher
- hook and line
- bag seine
- gill net

Continue collection until the appropriate species and number of individuals are caught.

Reference for collection methods. Murphy and Willis (1996).

Required Equipment

See Chapter 9 for the list of basic SWQM equipment.

Handling Fish Specimens

Scrub the coolers with detergent and rinse them with tap water, distilled water, or ambient water before use. Hold live fish in clean live wells or in an ice chest until specimens are chosen for analysis. If necessary, rinse debris from the fish with ambient or clean water and immediately ice them in clean coolers.

Selecting Specimens

Time of Collection

For many objectives it is preferable to collect specimens outside of the active spawning season. Concentrations of some pollutants are not as stable during spawning season. Specimens should be sexually mature, if possible and if compatible with study objectives.

Sample Size

The total sample weight needs to be greater than 300 grams. Sometimes that may not be possible; in such a case, alert the laboratory to the less-than-optimal sample size. Using present analytical methods, 200 grams is the minimum. Large fish are preferable—a consideration when choosing fish for a composite sample.

Species Selection

Select species suitable to the sampling objective. When possible, try to sample fish that are permanent residents of the area. This might not be practical if a particular species is being evaluated for human-health risk.

Composite Samples

In composite samples, the smallest fish in the composite should be no more than 25 percent smaller than the largest. It is best to select specimens in the same size range, even if the total number of individuals in the sample will be fewer.

Composite samples should consist of the largest fish possible.

Composite samples should consist of specimens from the same species and, if possible, the same sex.

Other Tissue Types

Special studies concerning possible pollution sources may require the collection of other tissues (for example, from the liver, kidney, or gills) for specific contaminants of concern. The same procedures described for edible tissue can generally be followed for these other tissue types.

Selecting Species Specific to a Study or Investigation

Different species have varying food habits, and rates of bioaccumulation differ among organic compounds, fish age, and life-cycle stage. The focus of a project (for example, human health, pollution uptake, environmental impacts) will determine which species are best for sampling. The value of a fish species for sport and human consumption differs in various regions of the state.

Several species (and suggested minimum size for each) are recommended because of their abundance, sport or commercial importance, position in the food chain, and potential for bioaccumulation. Table 7.1 lists target species and suggested minimum sizes.

Collecting Information in the Field

While in the field, or as soon as possible after collecting specimens, record the following information.

Length and weight of fish. Measure and record the total length of each fish to the nearest millimeter and the weight to the nearest gram.

Sex. If a visual determination can be made, record the sex of the specimen if an individual whole fish is submitted for analysis. This is optional if composite samples are submitted, or if edible tissues are to be analyzed.

Anomalies. Record any unusual deformities, wounds, or infections (for example, fin erosion, tumors, scoliosis, or parasites).

Sample Preparation for Edible Portions

Preparing Fish Samples in the Laboratory

Ship whole fish specimens to the laboratory and request that fillets be prepared by laboratory personnel. Keep in mind that this adds to the cost of analyzing samples.

Follow the procedures for packaging and shipping whole fish samples. **Field personnel with appropriate facilities and experience are encouraged to prepare fillets in the field or office laboratory.**

Preparing Fish Samples in the Field

Equipment

When processing samples in the field, a clean working area is required when filleting fish, removing internal organs, or preparing shellfish samples. Fillet samples on a polypropylene cutting board that has been covered in aluminum foil with the dull side of the foil toward the fish.

- Thoroughly clean the plastic cutting board, glass jars, and stainless steel knives with plastic handles and scales (for weighing) with distilled water and allow them to air dry.
- Use electric knives only when necessary (typically with hard-scaled fishes) because they are difficult to keep clean.
- Replace the aluminum foil covering the cutting board between each sample.
- Rinse the knife and cutting board with distilled water between samples.

Preparation

- Fillet the fish and remove the skin, unless a special study requires that the skin be left on.
- Scale the fish if the skin is left on.
- Fleecing (slicing off some of the underlying skin with a knife) may be substituted for scaling carp and buffalo, rather than the more typical method of knocking off scales. Use of this alternative method should be recorded in the field notes.
- Use the fillet from the left side of the fish. The fillet includes the muscle tissue beginning at the mid-dorsal line (all large bones removed except for intramuscular bones).
- If there is a sufficient sample from the left side, the fillet from the right side of the fish may be kept separate as a duplicate or backup sample.
- For very large specimens, collect only a posterior and anterior portion of the left fillet. **Do not puncture any of the internal organs**. Do not rinse the fillet with water—this may contaminate the sample or wash away pollutants of concern.

Observations

Note unusual conditions of the internal organs and record any in the field notes.

Packaging

- Wrap the fillet in aluminum foil with the dull side toward the fillet, twice. At a minimum, 200 grams of tissue is needed for analysis.
- Avoid using tape, since the sample may be contaminated if the foil tears. Tape may be used to secure the outer plastic bag.
- Place the foil-wrapped fillets to be composited together in the same plastic bag and label the bag with pencil or waterproof marker with the sample type, tag or sample number, date, and analyses requested. A glass jar can be used for small specimens. A plastic bag or glass jar affords the best protection from melting ice.

- Use fish and fillets or portions of fillets with similar weights (within ± 10 percent). The fillets can then be composited in a jar or wrapped in the same piece of aluminum foil.
- When fillets of unequal sizes are composited, they are homogenized in the laboratory. Equal aliquots of homogenate from each fillet are used for the composite to minimize the potential influence of unequal sizes.

Special Samples

Special studies may, on rare occasions, require internal organs—such as the liver, kidneys, or gills—or eggs. Remove internal organs or eggs and prepare them in a manner similar to that for fillets. The laboratory may request a different sample weight for these kinds of sample.

Preparing Crab Samples

Characterizing Specimens

Measure the total width of the carapace from the tip of one lateral spine to the tip of the opposite lateral spine, and record to the nearest millimeter. Weigh crabs individually. Record species collected.

Laboratory Preparation

For edible portions, ship specimens to the laboratory whole and request that samples be prepared by laboratory personnel. This reduces sample contamination.

Field Preparation

If samples must be prepared in the field, a clean working area is required. For edible portions, pull away the top of the carapace of the crab (called "backing"), and remove the internal organs by shaking. The remaining crab can be folded and put in a jar.

Preparing Whole-Organism Samples

Fish

Packaging

- Rinse fish, if necessary, with ambient, tap, or distilled water.
- Use excess aluminum foil to carefully wrap and rewrap the fish with the dull side of the foil toward the fish. Avoid using tape, since the sample may be contaminated if the foil tears. For spiny-rayed specimens, clip the dorsal and pectoral spines before wrapping to avoid puncturing the aluminum foil.
- Place the foil-wrapped sample in a plastic bag. For large specimens, a plastic tie may be used to secure the plastic bag.
- Whole-fish samples consisting of numerous small fish may be placed in glass jars that have been rinsed with distilled water and allowed to air dry.

Crabs

Field Observations

Measure the total width of the carapace from the tip of one lateral spine to the tip of the opposite lateral spine, and record it to the nearest millimeter. Weigh crabs individually. Record species collected.

Packaging

Place samples in glass jars. Lids must have Teflon liners or be lined with aluminum foil, with the dull side toward the sample. If the specimens are too large for jars, they can be wrapped in foil.

Crayfish and Prawns

Field Observations

- Weigh crayfish or prawns individually. If the specimens are small, an average weight can be calculated. Record species collected.
- Record the total length from the tip of the rostrum to the tip of the telson, to the nearest millimeter.
- Use whole crayfish or prawns for the sample, unless the study requires tails only.

Packaging

Place samples in pre-cleaned glass jars. Lids must have Teflon liners, or be lined with aluminum foil, with the dull side toward the sample.

Oysters, Clams, Rangia, and Mussels

Laboratory Preparation

Ship specimens to the laboratory intact and request that samples be prepared by laboratory personnel. This reduces sample contamination. Record species collected.

Preparing Samples in the Field

If samples must be prepared in the field, a clean working area is required.

- Scrub unopened specimens with ambient, distilled, or tap water, and shake them to remove excess water. In order to facilitate opening clamshells, it may be useful to wrap the scrubbed specimens in pre-cleaned aluminum foil, or to place them in jars and cool or freeze them until they open slightly.
- With clean hands, insert the point of a pre-cleaned knife between the shells on the ventral side of the specimen.
- Cut the adductor muscle from the upper shell half (the flat shell half for oysters) and pry the shell open enough to drain the liquor into the sample container.
- Discard the upper shell half, cut away the meat, and drop it into the sample container.
- Avoid cutting into the soft-tissued organism and spilling the internal contents in or on the shell.

Handling and Shipping Samples

Labeling

Label the container with pencil or waterproof marker with the sample type, tag or sample number, date, and analyses requested.

Preservation

Whenever possible, analyze tissue samples that have not been frozen. The samples should not be kept on wet ice for more than 24 hours. Keep samples frozen until chemical analyses are performed.

Shipping Samples

Pack fish in ice and ship them to the lab as soon as possible. Samples may be kept on ice overnight and shipped the next day, if necessary. If possible, effort should be made to immediately ship tissue samples. If there is to be a delay in shipping, tissue samples may be frozen. Check with the laboratory conducting the tissue analysis for its preference; some labs may prefer receiving frozen samples.

Due to increased shipping restrictions, samples being sent by a freight carrier may require additional packing. No matter how much care is taken in sealing the ice chest, leaks can and do occur. For shipping, place samples and ice in a large plastic bag inside the ice chest. The bag can be sealed by simply twisting the bag closed (while removing excess air) and taping the tail down. Leaking ice chests can cause samples to be returned or to arrive at the lab beyond the holding time. Some shipping companies, depending on the location, may require this extra step before shipping ice chests.

Place laboratory analytical request forms corresponding to samples in the ice chest in a Ziploc bag and tape the bag to the inside of the lid. Secure the lid with tape. This is essential if samples and ice are not in a large plastic bag. This method of handling chain-of-custody forms should not override existing protocols of the TCEQ region or sampling organization.

If shipping samples containing dry ice by public carrier, be sure to label them properly and notify the carrier that dry ice is being shipped.

Submitting Tissue Data

Information on submitting tissue data and details on necessary parameter, anatomical, and EPA species codes are located in the *SWQM DMRG*. Submit field data, and if scheduled, chemical data associated with the sampling events, as described in the *SWQM DMRG*.

Use the Fish-Collection Reporting Form (Figure 7.1) and the Species-Collection Report (Figure 7.2) to record data from each collection event. These data must be included in an annual report to the TPWD. For additional information on scientific collection permit reporting requirements, see Appendix A.

Table 7.1. Target species and suggested minimum sizes.

Freshwater Species		
Common Name	**Scientific Name**	**Minimum Length or Size Range (mm)**
Bass, hybrid striped	*Morone saxatilis* × *M. chrysops*	457
Bass, largemouth	*Micropterus salmoides*	356
Bass, striped	*Morone saxatilis*	457
Bass, white	*Morone chrysops*	254
Catfish, blue	*Ictalurus furcatus*	305
Catfish, channel	*Ictalurus punctatus*	305
Catfish, flathead	*Pylodictus olivaris*	457
Common carp	*Cyprinus carpio*	No minimum
Crappie, white	*Pomoxis annularis*	254
Crappie, black	*Pomoxis nigromaculatus*	254
Freshwater drum	*Aplodinotus grunniens*	No minimum
Gar, longnose	*Lepisosteus osseus*	No minimum
Gar, spotted	*Lepisosteus oculatus*	No minimum
Gray redhorse	*Moxostoma congestum*	No minimum
River carpsucker	*Carpiodes carpio*	No minimum
Shad, gizzard	*Dorosoma cepedianum*	No minimum
Shad, threadfin	*Dorosoma pentenense*	No minimum
Smallmouth buffalo	*Ictiobus bubalus*	No minimum
Sunfish	*Lepomis* spp. (do not mix sunfish species)	No minimum
Walleye	*Sander vitreum*	No minimum
Crayfish	*Procambarus* spp.	No minimum

(continued)

Table 7.1. Target species and suggested minimum sizes (continued).

Estuarine Species		
Common Name	**Scientific Name**	**Minimum Length or Size Range (mm)**
Catfish, hardhead	*Arius felis*	No minimum
Atlantic croaker	*Micropogonias undulatus*	No minimum
Drum, black	*Pogonias cromis*	356–762
Drum, red	*Sciaenops ocellatus*	508–711
Sheepshead	*Archosargus probatocephalus*	No minimum
Spot	*Leiostomus xanthurus*	No minimum
Southern flounder	*Paralichthys lethostigma*	356
Spotted gar	*Lepisosteus oculatus*	No minimum
Trout, spotted sea	*Cynoscion nebulosus*	381–635
Trout, sand	*Cynoscion arenarius*	No minimum
Trout, gulf	*Cynoscion nothus*	No minimum
Blue crab	*Callinectes sapidus*	No minimum
Oyster	*Crassostrea virginica*	No minimum
Shrimp, brown	*Penaeus aztecus*	No minimum
Shrimp, white	*Penaeus setiferus*	No minimum
Shrimp, pink	*Penaeus duorarum*	No minimum

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Fish-Collection Data

Scientific-Collection Permit No. _____

Water body:*		**Date:***	**Time:***
Location:*			
Station no.:		**County:***	
Weather:		Lat/Long:	
Secchi depth (m):	Flow (cfs):	Avg depth:	Max depth:
Water temp (1'):	DO (1'):	Spec cond (1'):	pH (1'):
Collectors:**			
Gear Used			
Boat-Mounted Electrofisher	Low range:	High range:	AC or DC?
	Pulses/sec:	% on:	
	Amps:____A	Duration: _____sec	
Backpack Electrofisher	Voltage_____V	Frequency ____pps	
	Pulse width ____msec		Duration_____sec
Gill net	Mesh size:	Length:	Duration of set:
Trawl	Width:	No. hauls _____	Duration of haul:
Seine	Length:	No. hauls _____	Duration of haul:
Cast net	Diameter:	No. casts _____ or Duration of casting:	
Other (specify)			
Habitat(s) sampled:			
Observations/comments:			

* **Required information** when reporting fish-collection data to the Texas Parks and Wildlife Department. Holders of scientific-collection permits are required to submit an annual collection summary to the TPWD.

**Collectors must be listed in Appendix I of the scientific-collection permit. Each permit contains detailed requirements.

TCEQ-20233 (rev. August 2008)

Figure 7.1. Fish-collection reporting form.

TCEQ SPECIES-COLLECTION REPORT

Permittee Name(s):			**Scientific Collection Permit Number:**				
Common Name *or* Scientific Name	**Date of Collection**	**County *or* Location Where Collected**	**No. Caught and Released**	**No. Collected (live take)**	**No. Salvaged**	**No. Incidental Mortalities**	**Disposition of Specimens**

If specimens were donated, please attach list of recipients of all donated specimens.

Definitions:
No. Caught and Released—self-explanatory; **No. Collected (live take)**—number kept to ID in lab or as voucher specimens; **No. Salvaged**—number counted as a result of a fish kill, by-catch, etc.; **No. Incidental Mortalities**—number killed during collection activities; **Disposition of Specimens**—self-explanatory

TCEQ-20234 (rev. August 2008)

Figure 7.2. Species-collection report.

(continued)

TCEQ SPECIES-COLLECTION REPORT

Permittee Name(s):			**Scientific-Collection Permit Number:**				
Common Name *or* Scientific Name	**Date of Collection**	**County *or* Location Where Collected**	**No. Caught and Released**	**No. Collected (live take)**	**No. Salvaged**	**No. Incidental Mortalities**	**Disposition of Specimens**
Signature of Permittee:			**Date:**				

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Figure 7.2. Species-collection report (continued).

Table 7.2. Quick reference guide—procedures for collecting fish tissue.

Routine Fish Tissue							
Objectives	**Where to Sample**	**Type of Sample** **How Much?**	**Number of Species**	**Number of Individuals**	**Size of Individuals**	**Sampling Frequency**	**Example Species**
Background conditions	Areas of minimal or no impact (ecoregion sites)	Whole-body composites, mature fish > 300 grams	2 to 3 Both predators and bottom-feeders	3 to 5, same species, composited	Individual fish may vary in length by no more than 25%	All specimens collected in a single event	***Freshwater:*** bass, catfish, sunfish, buffalo, crappie, catfish, carp ***Estuary:*** catfish, seatrout, sheepshead, oysters
Long-term trends	Sites with historical data, where a major cleanup has occurred or future impacts are expected	Whole-body composites of mature fish-ecosystem health; fillets for human health issues > 300 grams	2 to 3	3 to 5, same species, composited	Individual fish may vary in length by no more than 25%	Once a year indefinitely	***Freshwater:*** bass, buffalo, catfish, carp ***Estuary:*** catfish, seatrout, sheepshead, oysters
Ecosystem health	Areas affected by point or nonpoint sources	Whole-body composites > 300 grams	2 to 3	3 to 5 per species composited	Larger fish preferred, with Individual fish varying in length by no more than 25%	All specimens collected in a single event	***Freshwater:*** bass, freshwater drum, catfish, carp ***Estuary:*** catfish, flounder, drum, seatrout, sheepshead
Human health	Areas affected by point or nonpoint sources commonly used for recreational fishing	Muscle-tissue fillets > 300 grams	2 to 4	3 to 5 per species	Large; > legal and larger; individual fish may vary in length by no more than 25%	All specimens collected in a single event	***Freshwater:*** bass, catfish, crappie, freshwater drum ***Estuary:*** oysters, Atlantic croaker, sand trout, speckled trout, red drum, black drum
Sampling techniques	**Active:** Electrofishing, trawling, seining (preferred). **Passive:** Gill nets and trammel nets. This gear must be checked frequently. Sample deterioration can occur in as little as two hours in warm water, and 6 hours in cold.						
Sample information	Record total length; weight in grams, sex of fish; and note any deformities, wounds, tumors, or infections for each fish.						
Equipment	Aluminum foil, scale, measuring board, plastic bags, tape, marking pen.						
Sample preparation	Edible tissue samples are prepared in the field or by the lab performing the analysis. If samples are prepared by the lab, specify that the lab is to fillet the sample, and the fillet is to be analyzed. It is best to contact the lab prior to shipping.						
Sample handling	**1.** Fish may be held in live well (or ice chest) in native water until specimens are chosen. **2.** Rinse fish, if necessary, with ambient water. **3.** Double-wrap fish in aluminum foil with dull side toward fish. **4.** Before wrapping, clip dorsal and pectoral spines, if necessary. **5.** Put fish wrapped in aluminum foil into plastic bag and tape shut. **6.** Label with tag number, station location, type of sample (muscle or whole), species, number of fish in composite. **7.** Pack fish in ice and ship to lab ASAP. Samples may be kept on ice overnight and shipped the next day, if necessary. If possible, ship tissue samples immediately. If there is to be a delay in shipping, tissue samples may be frozen. Check with the laboratory conducting the tissue analysis for its preference.						
See Table A7.3 of the SWQM Program QAPP for a list of methods used to analyze fish tissue.							

CHAPTER 8

CALIBRATING AND MAINTAINING MULTIPROBE INSTRUMENTS

This chapter describes the calibration procedures for the most commonly used multiprobe instruments. Since the TCEQ and the CRP planning agencies use Hydrolab and YSI products, this section addresses their calibration and maintenance. If another multiprobe instrument (for example, Greenspan, In-Situ) is being used, refer to the manufacturer's instruction manual. Such other instruments must meet the post-calibration error limits discussed in this chapter. The manufacturers' manuals also detail other instrument functions not described in this chapter, such as downloading data. For all instruments used, manufacturers' maintenance and calibration manuals must be kept for reference. All calibration and maintenance activities must be recorded in an *SWQM Multiprobe Calibration Log* or something similar (see Figures 8.4 and 8.5 for examples). Calibration records may also be stored in electronic format.

Calibrate parameters in the order given in this chapter and on the calibration log sheets—specific conductance, pH, and DO.

Calibration Logs for SWQM

Each instrument must have its own log to facilitate efficient review of calibration and post-calibration results and maintenance procedures. The SWQM Program has developed a standardized log format for use with Hydrolab and YSI instruments. See Figures 8.4 and 8.5 for YSI and Hydrolab calibration log sheets. The electronic versions (in PDF format) of the calibration logs are available on the Web (see Appendix A).

Keep full calibration logs on file for at least five years or as defined in a program or project QAPP.

The following is basic information to be recorded in a log for each calibration.

- The date, time, and the initials of the person performing the calibration.
- The name and model number of the instrument being calibrated.
- The battery voltage.
- Initial instrument readings during immersion in the calibration standard before calibration (temperature, value of standard, and initial reading).
- The *calibrated to* value obtained after adjusting the instrument to the calibration standard value.

As needed, the following information is recorded for each instrument.

- Factory maintenance, including the date shipped for any repairs, the date returned from repair, and a description of the repair work.
- In-house instrument maintenance, including the date and a description of any maintenance activity (for example, battery replacement, probe cleaning, membrane replacement, stirrer cleaning, reference-solution replacement).

Temperature-Controlled Environment

Take into consideration the environment in which the multiprobe instrument will be calibrated. It is very important that the standards, buffers, rinse waters, and the instrument itself be acclimated in an environment with stable temperature. Deionized (DI) water used for rinsing sensors should be stored in a large container in the room normally used for calibration. The temperature of tap water or DI water from a column used for rinsing is often very different from room temperature.

If the instrument, standards, buffers, and rinse water are transported to the field, and calibration or a post-calibration check away from the laboratory becomes necessary, make sure the instruments have acclimated to the same temperature. For example, keep the solutions and instruments in a motel room in the evening and calibrate them in the morning.

Rinsing the Sensors

It is very important to rinse with DI water between the calibration of specific conductance and pH.

- Unscrew the cap and remove it from the calibration cup.
- Fill the calibration cup about halfway with DI water.
- Place the cap on the calibration cup.
- Shake the sonde to rinse any contaminants that might interfere with calibration. Rinse with DI water at least twice.
- Repeat this procedure with the appropriate calibration standard. Rinse at least twice, discarding the rinse each time. Fill the calibration cup with the standard and proceed with calibration.
- ***Warning:*** Do not allow the calibration cup to touch any of the sensors during this procedure. Damage can occur if the cup makes hard contact with a sensor face.
- During specific conductance and pH calibration the sonde may be oriented with the sensors facing up (see Figure 8.1) or down. Make sure that the calibration standard covers the sensors. However, while calibrating DO (Clark cell type) the sensors are typically facing up.

Temperature-Sensor Check

Temperature is essential to the successful calibration of the other instrument parameters (DO, pH, and specific conductance) so it is important to determine the continued accuracy of the temperature probe. Multiprobe temperature sensors are typically very stable and accurate over a long period of time. Temperature sensors are factory calibrated and cannot be adjusted by the user. Calibration and maintenance (other than general cleaning) of the sensor are not required. However, for other multiprobe water quality sensors, a check must be performed to ensure their proper calibration. Temperature data are used by **every** sensor in the sonde. A malfunctioning temperature probe will cause calibration errors.

Check the temperature-sensor accuracy during routine instrument maintenance at least once a month.

- Using water acclimated to room temperature, put a laboratory thermistor or thermometer with an accuracy of ± 0.2 °C and the instrument into the same water bath. This can be an ice chest or a large bucket.
- Allow the temperature to stabilize and record the reading from the multiprobe instrument and the laboratory thermistor or thermometer in the calibration log. The difference between the two temperatures must be within ± 0.2°C.
- If the temperature of the multiprobe is off by more than ± 0.2°C, perform instrument maintenance. If this does not correct the problem, schedule the instrument for maintenance by the manufacturer or an authorized service vendor. If the temperature is off by ± 0.5°C or more, data collected between the accuracy checks may need to be flagged.

The laboratory thermistor or thermometer must be calibrated annually against a traceable thermometer that meets the standard set by the National Institute of Standards and Technology. Some electronic thermistors can be calibrated and are to be adjusted to the NIST value. Traditional thermometers cannot be changed; check the NIST thermometer against the lab thermometer and determine a correction value. For example, if the lab thermometer reads *23.1°C* and the NIST thermometer reads *23.3°C,* a correction factor must be applied to the laboratory thermometer. Each time you take a reading, add 0.2°C. Attach a correction-factor label to the thermometer. The calibration can be performed for TCEQ personnel either during the annual audit or at the annual SWQM meeting. Other monitoring organizations may choose an appropriate time for their annual calibration.

Calibration Standards and Multiprobe-Sensor Solutions

Store calibration standards and electrolyte solutions in a temperature-controlled environment. Date containers upon receipt and again after opening them. Label any secondary containers with their contents and expiration date. Commercially purchased calibration standards, which must be NIST traceable, come with an expiration date. Do not use calibration standards for specific conductance and pH beyond their expiration dates. However, expired calibration standards can be used for rinsing probes during and after calibration. DO-electrolyte and pH reference solutions have an indefinite shelf life but should be discarded when the solutions become crystalline.

Specific-Conductance Calibration Standards

Calibrate the conductivity system with a potassium chloride (KCl) solution of known specific conductance. Choose a standard solution with a specific conductance similar to, but higher than, that of the water being sampled. ***Note:*** The lowest KCl standard value must be at least 1000 µS/cm or greater.

Calibrating Hydrolab Instruments

Specific Conductance

Series 3 (DataSonde 3, H20, Recorder, Reporter) and Quanta Sondes

Series 3 and Quanta sondes require a one-point conductivity calibration (no zero needed).

- Before calibration, rinse the sensors twice with DI water.
- Use the rubber cap to cover the calibration cup and shake vigorously.
- Rinse at least twice with the chosen standard solution and dispose of the solution.
- Fill the calibration cup, covering the DO sensor, with the calibration standard and allow the sensor to stabilize (see Figure 8.1).
- In Series 3 sondes, check for air bubbles that may have become trapped in the conductivity cell block. Remove bubbles if present.
- Record the initial specific conductance value, value of standard, and temperature of the calibration standard in the calibration log.
- Using the four Function Keys under the LCD Screen, select *Setup/Cal*, *Calibrate*, and then *Sonde*.
- Use the arrow keys to scroll through the MiniSonde menu options.
- Scroll to *SpCond:µS/cm* (or *SpCond:mS/cm*); Press *Select*.
- Use the arrow keys to move the cursor left or right to enter the conductivity standard concentration. Press *Select* to select the appropriate number. Enter the appropriate concentration, and press *Done*.

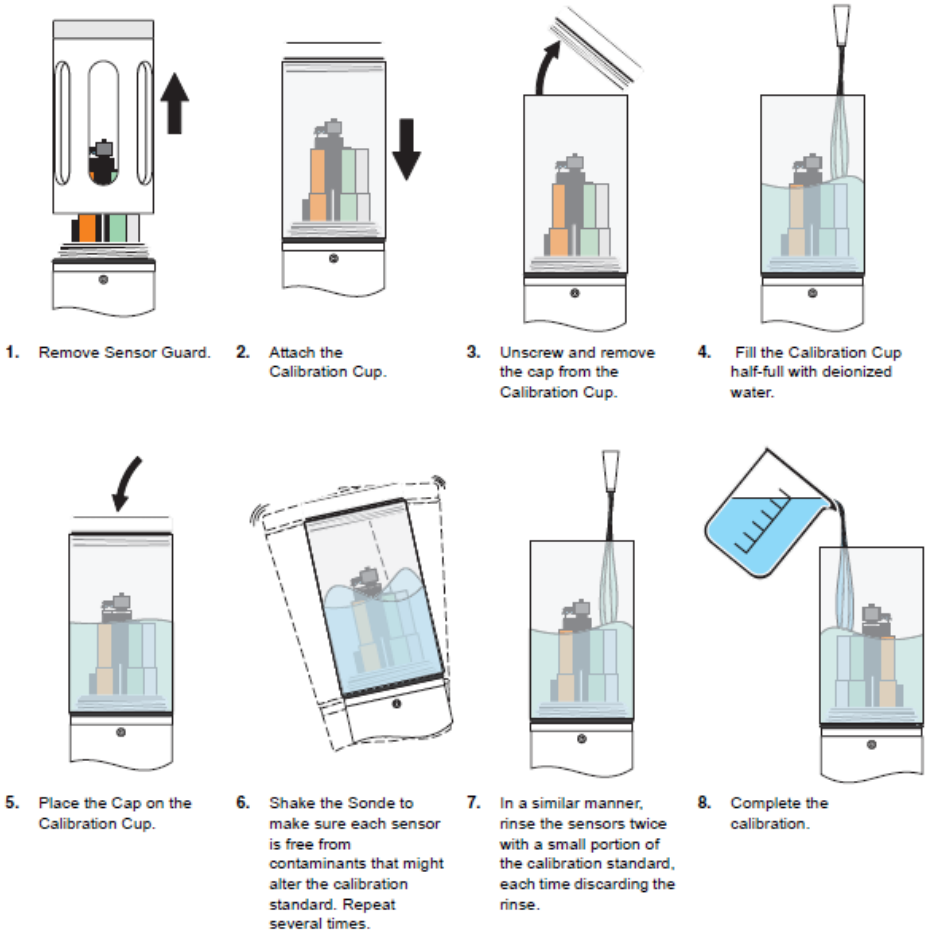

Figure 8.1. Standard setup for calibrating Hydrolab sondes.

- The messages *Calibration Successful, Press any key* should appear. Select any function key to remove the message.
- Select *Go Back* and confirm the specific conductance reading from the display screen.
- Record the value *calibrated to* in the calibration log.

Series 4, Series 4a, and Series 5 Sondes (DataSonde and MiniSonde)

Series 4, 4a, and 5 sondes require a two-point conductivity calibration.

- Before calibration, rinse the sensors twice with DI water.
- Replace the storage cup cap to cover the storage cup and shake vigorously.
- Calibrate the zero point first by leaving the conductivity sensor in air.
- Record the initial value, the value calibrated to, and the temperature in the calibration log.
- Correct the initial specific-conductance value to zero and save the calibration.
- Record the initial value and the value *calibrated to* (zero) in the calibration log, and the temperature in the calibration log.
- Calibrate the second point ("slope") by first rinsing at least twice with the chosen standard solution.
- Fill the storage cup with calibration standard, covering the DO sensor, and allow the sensor to stabilize.
- Record the initial specific-conductance value, the value of the standard, and the temperature of the standard in the calibration log.
- Correct the initial specific conductance value to match the standard value and save the calibration.
- Record the initial value, the value of the standard, the value calibrated to, and the temperature in the calibration log.

Reporting Salinity

To report salinity values at ≥ 2 ppth select the specific conductance function *StdMth* (Standard Method) prior to calibration. The StdMth function calculates salinity using the Practical Salinity Scale—1978 (PSS-1978). This algorithm, defined for salinities ranging from 2 to 42 ppth and uses conductivity values corrected to 15°C, is described in section 2520B of Standard Methods, 18th Edition.

pH Sensor

Calibrate the pH system with a buffer of pH 7.0, and either pH 4.0 for naturally acidic waters or pH 10.0 for alkaline waters. The pH buffers contain high concentrations of phosphate. During calibration, avoid leaving traces of buffer on equipment or at the workplace that could contaminate water samples.

- Before calibration, check the condition of the probes—ensure that they are intact and free of surface films. If probes appear questionable, perform sensor maintenance according to accepted procedures.
- For Series 3 and Quanta sondes, remove the storage cup from the sonde and replace with the calibration cup. For Series 4, 4a, and 5 sondes, remove the cap from the storage cup. Rinse the sensors twice with DI water. Cover the cup and shake it.

- Rinse at least twice with the pH 7 buffer solution.
- Fill the cup, covering the DO sensor, with the pH 7 buffer solution and allow the sensor to stabilize for two minutes.
- Record the initial pH value and the temperature of the calibration standard in the calibration log.
- Using the temperature of the pH 7 buffer solution, determine the pH 7 calibration value. See Table 8.1 for pH-calibration values corrected for temperature.
- Record the calibration standard value in the calibration log.
- Using the four function keys under the LCD Screen, select *Setup/Cal*, *Calibrate*, and then *Sonde*.
- Use the arrow keys to scroll through the MiniSonde menu options.
- Scroll to *pH.* Press *Select*.
- Use the arrow keys to move the cursor left or right to enter the pH standard concentration. Press *Select* to choose the appropriate number, then press *Done*.
- The messages *Calibration Successful, Press any key* should appear. Press any function key to remove the message.
- Record the value *calibrated to* in the calibration log.
- Select *Go Back* and confirm the pH reading from the display screen.
- Repeat this procedure with either pH 4 or pH 10 buffer solution. Choose a pH buffer that best represents the pH of the environment to be monitored.

Dissolved-Oxygen Sensor

DO concentrations in water are measured using either a polarographic electrode or optical sensors. The preferred calibration method is percent saturation.

DO-sensor calibration requires a current uncorrected reading for barometric pressure (BP). See below, "Barometric Pressure."

Clark Polarographic DO Cell

Before Calibration

Clean the sonde and the stirrer using running water to remove debris. Check the condition of the DO membrane—ensure it is intact and free of wrinkles, bubbles, and surface films. Inspect the appearance of the DO sensor and the electrolyte. Note any discoloration. If probes appear questionable, perform sensor maintenance according to accepted procedures. Confirm that the circulator or stirrer is operational.

Calibration

- Invert the sonde (point its sensors upward) with the calibration cup in place.
- Carefully blot the DO membrane dry using a Kimwipe or a soft towel. Be careful not to apply pressure to the membrane, which can change its tension.
- Fill the calibration cup with water to a level just below the trimmed edge of the DO membrane and O-ring.
- Cover the calibration cup loosely with the cap to prevent air exchange and allow the sensor to stabilize for about five minutes.
- Record the *initial DO% saturation value, temperature, and calibration standard* (100%) in the calibration log.

- Calibrate the DO sensor using *DO% Saturation*. Enter the uncorrected BP stated in mm Hg. See below, "Barometric Pressure." Using the four function keys under the LCD Screen, select *Setup/Cal*, *Calibrate*, and then *Sonde*.
- Use the arrow keys to scroll through the Minisonde menu options.
- Scroll to *DO%: Sat.* Press *Select*.
- Use the arrow keys to move the cursor left or right to enter the absolute BP. Select the appropriate number, then press *Done*.
- The messages *Calibration Successful*, *Press any key* should appear. Select any function key to remove the second message.
- Select *Go Back* and confirm the DO percent saturation reading from the display screen. The value should be at or near 100 percent.
- Record the value *calibrated to* in the calibration log. For Hydrolab instruments the value is 100 percent, indicating oxygen saturation referenced to the uncorrected BP input by the user.

Luminescent DO Cell—Series 5 Sondes Only

Before Calibration

Clean the sonde using running water to remove debris. Inspect the cap of the luminescent dissolved-oxygen (LDO) sensor. If the cap or the sensor appears questionable, perform sensor maintenance according to accepted procedures.

Water-Saturated-Air Calibration

Note: It is important to maintain temperature stability during calibration. Keep the sonde out of direct sunlight and away from any other source of heat or other energy that may change the temperature in the cup during calibration. If the temperature in the cup changes more than 0.5°C during calibration, recalibration is recommended.

To calibrate the sensor using water-saturated air:

- Remove the calibration cup from the sonde. Fill the calibration cup with approximately ½ inch of DI water or tap water (specific conductance < 0.5 mS/cm).
- Before attaching the calibration cup to the sonde, carefully remove any water droplets from the sensor cap.
- Gently set the sonde with the sensors down into the calibration cup. Do not fully attach the calibration cup. The goal is to block air exchange with the outside environment. Fully attaching the cup increases the inside pressure and will give a false reading. The water should not touch the sensor cap (see Figure 8.2).
- Allow the DO and temperature readings to stabilize for approximately 5–10 minutes. At this point the air inside the calibration cup should be fully saturated with water.
- Record the initial DO% saturation value, temperature, and calibration standard (100%) in the calibration log.
- Calibrate the DO sensor using *LDO% Saturation*. Enter the uncorrected BP stated in mm Hg. See below, "Barometric Pressure." Using the four function keys under the LCD Screen, select *Setup/Cal*, *Calibrate*, and then *Sonde*.
- Use the arrow keys to scroll through the Minisonde menu options.
- Scroll to *LDO%: Sat.* Press *Select*.

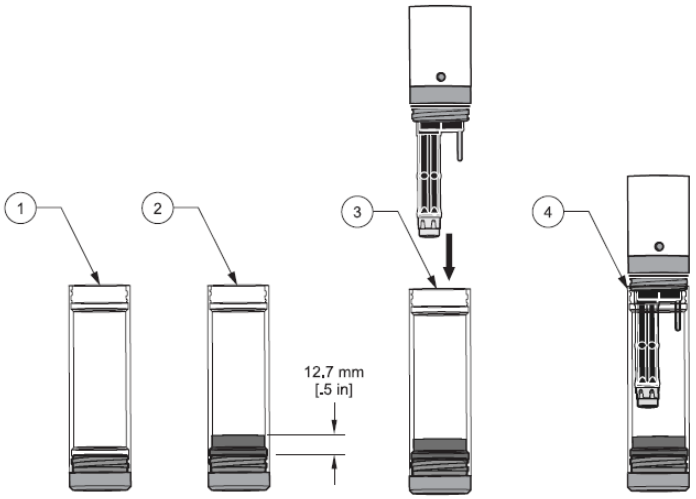

Figure 8.2. Water-saturated-air calibration of the LDO sensor: (1) calibration cup, (2) filling calibration cup, (3) putting sonde in cup, (4) screwing calibration cup to sonde.

- Use the arrow keys to move the cursor left or right to enter the absolute BP. *Select* the appropriate number, then press *Done*.
- The messages *Calibration Successful, Press any key* should appear. Select any function key to remove the message.
- Select *Go Back* and confirm the reading for DO percent saturation from the display screen. The value should be at or near 100 percent.
- Record the value *calibrated to* in the calibration log. For Hydrolab instruments the value is 100 percent, indicating oxygen saturation referenced to the uncorrected BP input by the user.

Air-Saturated-Water Calibration

Note: It is important to maintain temperature stability during calibration. Keep the sonde out of direct sunlight and away from any other source of heat that may influence the temperature in the cup during calibration. It is also important that the end of the LDO sensor cap and the temperature sensor are at the same temperature during calibration. If the temperature in the cup changes more than 0.5°C during calibration, recalibration is recommended.

In order to retain calibration accuracy between multiple uses, it is best to store the sensor fully immersed in water at all times. At minimum, make sure the storage cap has at least 10 mL of water and is sealed to prevent evaporation.

To calibrate the sensor using air-saturated water:

- When calibrating in air-saturated-water, immerse the temperature sensor in water.
- Calibrate the sensor using temperature-stabilized, air-saturated water. In a laboratory environment, fill a container with water from a faucet or decanted from an opened water bottle and allow it to equilibrate for at least 12 hours. Air-saturate the water in a temperature-stabilized container, using an air stone that injects air into the well-mixed water bath. Continuous use of compressed air can lead to super-saturation of oxygen in the water bath. To minimize this effect, turn off the air purge prior to final calibration.

To produce air-saturated water in the field:

- Take a 1 L bottle and fill 50% with water. Or, use a 4 L bottle with 500mL of water. Use water that has been at equilibrium with atmospheric pressure and the calibration environment for at least 12 hours.
- Seal the bottle and shake it very vigorously for 40 seconds.
- With the sonde positioned with sensors facing upright, pour the water into the calibration cup, fully submersing the Hach LDO sensor cap and the temperature sensor (Figure 1). Make sure the water comes close to the top of the calibration cup. Place the calibration-cup cap upside down on top of the cup to cover the cup. This stops the exchange of air and allows the local environment to equilibrate. Do not tightly seal or otherwise raise the barometric pressure in the cup. Make sure that the cup is not in direct sunlight, or in the presence of a heat or light source that could change the temperature inside it.
- Allow the DO and temperature readings to stabilize for 3–5 minutes. Record the initial DO% saturation value, temperature, and calibration standard (100%) in the calibration log.
- Calibrate the DO sensor using *LDO% Saturation*. Enter the uncorrected barometric pressure (BP) stated in mm Hg. Using the four function keys under the LCD Screen, select *Setup/Cal*, *Calibrate*, and then *Sonde*.

Use air-saturated water to calibrate the sensor:

- Use the arrow keys to scroll through the Minisonde menu options. Scroll to *LDO%: Sat*. Press *Select*.
- Use the arrow keys to move the cursor left or right to enter the absolute *BP*. Select the appropriate number, then press *Done*.
- The messages *Calibration Successful, Press any key* should appear. Select any function key to remove the message.
- Select *Go Back* and confirm the reading for DO% saturation from the display screen. The value should be at or near 100 percent.
- Record the value *calibrated to* in the calibration log. For Hydrolab instruments the value is 100 percent, indicating oxygen saturation referenced to the uncorrected BP input by the user.

Calibrating YSI Instruments

Specific Conductance

This procedure calibrates conductivity, specific conductance (SC), and salinity. Calibration of the conductivity sensor is a single-point calibration with a KCl solution. The KCl solution value must be 1,000 µS/cm or greater, depending on the water body.

Before Calibration

Before calibration, the sensor's zero response must be checked in ambient air. Make sure the sensor body and sensor interface are clean and dry. In ambient air, SC measurements must be ≤ 3 µS/cm, or else the sensor must be replaced before calibration. ***Note:*** If the sensor fails this check, take the multiprobe away from all potential electrical interferences and redo the check. If the sensor still fails, replace it.

Calibration

After the zero-response check, calibrate the conductivity sensor.

- Pour enough standard into the calibration cup to fully immerse the cell and temperature sensor. Choose a standard within the same conductivity range as the ambient water to be measured.
- Rinse the sensor twice with the conductivity standard. Fill the calibration cup with the standard. Make sure that the probe is completely immersed past the vent hole. Gently tap the side of the calibration cup to dislodge any air bubbles from the cell.
- Allow at least 1 minute for temperature equilibration before processing.
- From the Calibrate Menu, select *1—Conductivity* to access the calibration procedure or
  1—SpCond to initiate the procedure for calibrating specific conductance. Enter the calibration value of the standard ms/cm at 25°C and press *Enter*. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- Record the initial specific conductance value, value of standard, and temperature of the standard in the calibration log.
- Observe readings under *Specific Conductance*; when no significant change is observed for approximately 30 seconds, press *Enter*. The screen will indicate that the calibration has been accepted; press *Enter* again and return to the *Calibrate* menu.
- Record calibration information in the calibration log. Rinse the sonde with DI water.

Conductivity Cell Constant

The conductivity cell constant is a maintenance tool, not a QA or QC measurement. Record the conductivity probe *cell constant* after calibration.

Access the cell constant from the sonde's *Advanced* menu, select *Calibration Constants*. The acceptable range is between 4.5 to 5.5. The probe cell constant is similar in principle to an instrument offset, and is an indication of how well an instrument has been calibrated. Accepting a bad calibration will cause the cell constant to fall outside the acceptable range. If the sonde reports *Out of Range* after calibration, investigate the cause. Never override a calibration error message without knowing the reason. Typical causes for this error message are incorrect entries (entering "1.0 ms/cm" instead of "1,000 µS/cm"), not enough calibration standard, air bubbles in the probe cell, calibrating in conductivity instead of specific conductance, or bad calibration standard.

An out-of-range cell constant does not signify an inaccurate measurement and does not mean that data need to be flagged as suspect. Maintenance and recalibration of the sensor are recommended if the cell constant is out of range. Replacement of the sensor is necessary if the cell constant remains out of range and the sensor fails to calibrate properly.

pH Two-Point Calibration

pH 7

- Rinse the sensors at least twice with pH 7 buffer.

- Place enough pH 7 buffer into the prerinsed calibration cup to immerse the pH probe, reference junction, and thermistor. Allow at least one minute for the temperature to equilibrate before reading.
- Using the temperature of the buffer solution, determine the pH 7 calibration value. See Table 8.1 for pH-calibration values corrected for temperature.
- From the *Calibrate Menu*, select *4-ISE 1 pH* to access the pH calibration choices, then press *2-2 Point* (or *3-3 Point*). Press *Enter* and input the value of the buffer at the prompt. Press *Enter*, and the current values of all enabled sensors will appear on the screen. Observe the pH mV reading. This value should be 0.0 mV ± 50 mV. Record this value in the calibration log. See "pH Millivolt Response" for additional information.
- Record the initial pH value and temperature of the calibration standard in the calibration log.
- Observe the pH reading and, when it shows no significant change for approximately 30 seconds, press *Enter*. The display will indicate that the calibration is accepted.
- Record the value *calibrated to* in the calibration log.
- After the pH 7 calibration is complete, press *Enter* again to continue. Rinse the sonde with DI water.

pH 4 or 10

- Rinse the sensors at least twice with pH buffer.
- Place enough pH 4 (or 10) buffer into a prerinsed calibration cup to immerse the pH probe, reference junction, and thermistor. Allow at least one minute for the temperature to equilibrate before reading.
- Using the temperature of the pH 4 or 10 buffer solution, determine the pH calibration value. See Table 8.1 for pH-calibration values corrected for temperature.
- Press *Enter* and input the value of the second buffer at the prompt. Press *Enter* and the current values of all enabled sensors will appear on the screen.
- Observe the pH mV reading. This value should range from 130 to 230 in pH 4 buffer, and from –130 to –230 mV in pH 10 buffer. Record this value in the calibration log. See "pH Millivolt Response," below, for additional information on this response indicator.
- Record the initial pH value and the temperature of the calibration standard in the calibration log.
- Observe the pH reading. When it shows no significant change for approximately 30 seconds, press *Enter*. After the second calibration is completed, press *Enter* again. If you are performing a two-point calibration, the screen will return to the *Calibrate Menu*.
- Record the calibration information in the calibration log. Rinse the sonde with DI water.
- Discard the pH buffer and rinse with DI water (to remove any residual buffer) before calibrating the DO sensor.

pH Millivolt Response

YSI multiprobe instruments report millivolts (mV) as an indicator of pH sensor response. *Millivolt response* should be recorded in the logbook to assist the user with

in troubleshooting activities, and to track sensor performance over time. An out-of-range response alerts the user that a probe may soon require reconditioning or replacement. There are expected *mV response* ranges for the various pH buffers:

Buffer	Response
4	130 to 230
7	–50 to +50
10	–130 to –230
Slope	165 to 180

The *mV response* is a maintenance tool, not a QA or QC measurement. An out-of-range mV response does not signify an inaccurate measurement and does not mean that data need to be flagged as suspect. However, a sensor slope (mV difference between pH 7 and 10 or pH 4 and 7) less than 160 mV is an indication that the sensor is malfunctioning and pH data are suspect. Once the slope drops below 160, the sensor should be replaced.

Note: Do not use a probe that has given any "Calibration Error" or "Out of Range" warnings.

Dissolved-Oxygen Sensor

DO concentrations in water are measured using either a rapid pulse or optical sensors. The preferred calibration method is percent saturation.

DO-sensor calibration requires a current uncorrected reading for barometric pressure (BP). See below, "Barometric Pressure."

DO (Rapid Pulse Sensor) Calibration for Instantaneous Sampling

- When using the YSI Model 600XLM or Model 6920 for instantaneous (discrete) sampling, disable the auto-sleep function. From the *Main Menu*, select *8—Advanced* and then *2—Setup*. If the auto-sleep functions are enabled, select *5—Auto Sleep RS232* and *6—Auto Sleep SDI12* and press *Enter* to disable them.
- Pour about ⅛ inch of water in the bottom of the calibration cup. Place the probe in the cup. Make certain that the DO and temperature probes are not immersed in the water. Engage only one thread of the calibration cup to ensure that the DO probe is vented to the atmosphere. Wait at least 10 to 15 minutes for the air in the calibration cup to become saturated with water and for the temperature to equilibrate. ***Note:*** Run the sonde in *Discrete Mode* while waiting to help burn in the sensor and improve stability.
- Record the initial DO% saturation value and temperature in the calibration log.
- From the *Calibrate Menu*, select *2—Dissolved Oxygen*, then *1—DO%* to access the calibration procedure for DO percent saturation.
- Enter the current BP in mmHg. See below, "Barometric Pressure."
- Observe the temperature and DO readings; when there is no significant change for approximately 30 seconds, press *Enter*. The screen will indicate that the calibration has been accepted. Press *Enter* again to return to the *Calibrate Menu*.

- Record calibration information in the calibration log. For YSI instruments the value *calibrated to* is determined for each calibration site and oxygen saturation referenced to 760 mmHg. To determine the calibration standard for DO percent saturation, use the following equation:

Current barometric pressure in mmHg / 7.6 = DO% saturation calibration standard

Example: 752 mmHg / 7.6 = 98.94%

DO (Rapid Pulse Sensor) Indicators

There are two indicators of DO sensor response, *DO gain* and *DO charge*. These indicators are recorded in the calibration log. DO gain and DO charge ranges should not be considered QC criteria, but rather guidelines to assist in maintenance and calibration.

- Record the DO gain, located in the *Advanced Menu* > *Cal Constants*. Acceptable DO gain values should fall between –0.7 to 1.4. DO gain is an indication of how well an instrument has been calibrated. If you accept a bad calibration, the gain will fall outside of range. If DO gain remains out of range, and the sensor ceases to calibrate properly, it may need replacement.
- Record the DO charge, which can be set to appear on the display screen from the *Report Menu*. Acceptable DO charge values should fall between 25 to 75. The DO charge is an indicator of membrane, electrolyte, and sensor-electrode condition. When the DO charge falls outside of the acceptable range, perform maintenance procedures—including polishing the electrode and replacing the KCl solution and the Teflon membrane.

DO (Rapid Pulse Sensor) Calibration for Unattended Sampling

When using the Model 600XLM or Model 6920 in unattended mode, make sure the auto-sleep functions are enabled. From the *Main Menu*, select *8—Advanced* and then *2—Setup*. Ensure that *5—Auto Sleep RS232* and *6—Auto Sleep SDI12* are enabled. If not, select *5—Auto Sleep RS232* and *6—Auto Sleep SDI12* and press *Enter* to enable each functions.

Verify that the sonde DO warm-up time—located in the *Advanced Menu* > *Sensor*—is set correctly. The 600XLM factory default is 40 seconds; for all other instruments, 60 seconds is recommended. When setting up any YSI instrument, ensure that the warm-up time is set at **90 seconds,** rather than the default.

Calibrate as described in the previous section, "YSI Instruments DO (Rapid Pulse Sensor) Calibration Procedure for Instantaneous Sampling."

Place the sonde in the calibration cup (vented) with water and allow 15 minutes for the water to saturate. Select *DO%* and activate the countdown timer for the DO warm-up time. After DO warm-up is complete, the readings just before and after calibration are displayed. Press *Enter* when prompted and the screen will return to the *DO Calibration Menu*.

Record the DO gain found at the *Advanced Menu* > *Cal Constants*. The range should fall between –0.7 and 1.4.

Record the DO charge, enabled from the *Report Menu*. The range should be 25 to 75.

DO ROX Optical-Sensor Calibration

Calibration Using Percent Air Saturation—One Point

The calibration procedure for the DO ROX optical sensor is the same for both discrete and unattended sampling. There are several methods for calibrating this sensor. YSI recommends one-point calibration using water-saturated air to obtain sufficient accuracy under normal operating conditions.

Water-Saturated-Air Calibration

- Place the YSI optical DO sensor (6150) into a calibration cup—vented (by loosening the threads)—containing about ⅛ inch of water. Wait approximately 15 minutes before proceeding to allow the temperature and oxygen sensors to equilibrate.
- Select *ODO sat%* and then *1-Point* to access the DO-calibration procedure. Calibration of the optical DO sensor in the *DO%* mode results in the calibration of the *DO mg/L* mode.
- Enter the current uncorrected BP reading in mmHg (mm = in × 25.4). See below, "Barometric Pressure."
- Press *Enter* and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under *ODO sat%*. When there is no change for approximately 30 seconds, press *Enter*. The screen will indicate that the calibration has been accepted. Press *Enter* again to return to the *Calibrate* menu.
- Record the initial value, the value calibrated to, and the temperature in the calibration log. Record the ODO Gain also found at the sonde's *Advanced Menu* > *Calibration Constants*. The value should fall between 0.85 and 1.15.

Note: Air-saturated-water calibration of the optical DO sensor will provide the maximum accuracy, since it reduces variability associated with changing air temperature. This method uses a saturated water bath which can simply be a 5-gallon pail that has been sparged with room-temperature air (using an aquarium air pump) for at least 1 hour. Since the air-saturated water method is time-consuming, the water-saturated air method is accepted for routine water quality monitoring in the SWQM program.

Barometric Pressure

Obtaining the correct BP is essential in calibrating the DO sensor. BP affects the partial pressure of oxygen in saturated water. The higher the BP, the more oxygen can be dissolved in water—thus, the percent-saturation calibration value will also be higher.

Internal Barometer Check

If the instrument display unit has an internal BP function installed, take the reading directly from the unit. However, the internal BP function should be checked against a known BP at least once a month. The internal BP function should be within ± 10mm Hg of the known BP. Barometric pressure for both YSI and Hydrolab handheld display units can be calibrated. The calibration of BP follows the general calibration procedure used for other parameters.

Details on calibrating the BP are outlined in the operating manuals for the display units (Appendix 3 for Hydrolab and Section 9.2 for YSI).

For display units without a BP function, a detailed discussion on obtaining the uncorrected absolute BP follows.

Absolute Barometric Pressure

Barometer. Absolute BP is defined as what a mercury barometer would read in the room where the calibration is taking place. There are several options for absolute determining BP. The most direct method is to read a handheld or fixed (mounted) barometer. No corrections are required.

Weather reports. The second option is to obtain a BP reading from a local weather office, radio or television station, weather radio, or similar source. Many local television stations have Web sites or links to sites where local weather information, including BP, is continuously updated.
The National Weather Service also offers easy-to-access weather information online. See Appendix A.

Uncorrecting barometric readings corrected to sea level. Most barometric readings obtained from local and Internet sources are corrected to sea level to remove the effect of altitude and are reported in inches of mercury. Sometimes corrections are reported as altimeter readings in inches of mercury.

Convert the barometric reading reported in inches Hg to millimeters (mm) Hg by multiplying inches by 25.4. The **corrected** BP value will always be available; however, you may ask for the **uncorrected** BP. Many stations can provide this absolute reading. The *uncorrected* BP reading (after conversion to mm) can be directly entered, provided the weather station is located nearby and at the same general elevation.

If the BP reading supplied is corrected to sea level, obtain the local altitude where the instrument is being calibrated in feet above sea level from a USGS topographic map or other source and use the following equation (which is also located on each calibration log sheet), to account for altitude.

Barometric Pressure (BP) = Corrected Barometric Pressure (CBP) – 2.5(A/100)

where BP = estimated absolute barometric pressure

CBP = local BP corrected to sea level (from a weather bureau or other source); convert reading supplied in inches to mm: inches × 25.4 = mm

2.5 = decrease in constant atmospheric pressure decreases (in mm Hg) for each increase in altitude of 30.5 meters (100 feet)

A = local altitude in feet above mean sea level

Example: A BP reading of 29.50 inches, corrected to sea level, at an altitude of 650 feet above sea level is uncorrected by:

29.5 inches × 25.4 = 749 mm Hg
BP = 749 mm – 2.5(650/100)
BP = 732.8 mm Hg

The above equation should be posted in the laboratory or at the site where the instruments are routinely calibrated. Once an initial calculation is made, the last term of the equation, *2.5(A/100),* will then be constant and can be subtracted from the corrected BP.

If an instrument needs to be calibrated at a remote location where the BP is not available from the usual sources, the BP can be estimated from the following equation:

Barometric Pressure (BP) = 760 – 2.5 (A/100)
Example: If the altitude at the site of calibration is 1,200 feet above sea level, the estimated BP is: BP = 760 – 2.5 (1200/100) BP = 730 mmHg

Calculating a DO Calibration Value (mg/L)

Hydrolab and YSI multiprobe instruments use DO% saturation to calibrate the DO sensor. This is the preferred DO calibration method. Other instruments may be calibrated using a calculated DO-calibration value in mg/L. Use the following procedure to calculate a DO calibration value in mg/L.

- Using the temperature recorded at the start of calibration, go to the DO saturation table (Table 8.1) to obtain the *DO saturation value*. For example, the temperature is 22.2°C. The DO saturation value for this temperature is 8.68 mg/L.
- Get the local BP value as described in the previous section. Uncorrect the BP if necessary. For this example, the uncorrected BP is 756.8 mm.
- Next, calculate the *correction factor (CF)* for the DO saturation value. This adjusts the table DO saturation value to the local BP. The correction factor is determined using the following calculation:

  uncorrected BP mmHg / 760 mmHg = CF
  (for example, 756.8 mmHg / 760 mmHg = 0.996)

- After determining the correction factor, calculate the *calibration value* using the following equation:

  table saturation value × CF = calibration value
  (for example, 8.68 × 0.996 = 8.82 mg/L)

Calibrating the Depth Sensor

- Zero the depth sensor immediately before making the initial measurement with the instrument at the first station of the day.
- For Hydrolab instruments, calibrate by entering zero for the standard at the monitoring site or laboratory (if the BP at the lab is the same as that of the sample site) to cancel the effect of changes in BP.
- For YSI instruments, from the *Calibration* menu, select *Pressure-Abs* to begin depth calibration. Input *0.00*, press *Enter*, and wait for the reading to stabilize. If no significant change occurs after 30 seconds, press *Enter* to confirm the calibration. This zeroes the sensor with regard to the current BP. Press *Enter* again to return to the *Calibration* menu.

Note: All new multiprobe instruments should be ordered with an internal depth sensor. Older instruments may not have a depth sensor. If not, the instrument cable should be marked in increments (meters) that allow depth measurements to be made with each set of profile readings.

Calibration Summary

Multiprobe calibration is summarized in Table 8.2.

Post-Calibration Check

The post-calibration check is a QC measure to verify the measurement accuracy of the instrument. A post-calibration check must be performed after each use of the instrument and before any instrument maintenance. The sooner this procedure is performed, the more representative the results will be for assessing performance during the preceding field measurements. Calibration and post-calibration should be no more than 24 hours apart when used for routine monitoring.

After making measurements at the last station, fill the sampling cup with ambient water (not deionized or tap water) and return to the lab. In the lab, take the same care used in performing the initial calibration and—

- Rinse with DI water and the appropriate calibration standard.
- Fill the calibration cup with the standard and allow the instrument to stabilize.
- Read the value directly off the instrument display unit.
- Record the value in the same log used for the calibration.

Do not use the calibration menu during the post-calibration check. No adjustments are made during this process.

The purpose of post-calibration is to determine if the instrument has held calibration during the day of sampling. Compare the post-calibration values to the expected values for the standards, so the field measurements for the day can be reported with confidence. The difference between the post-calibration value and expected standard value can be used to indicate both calibration precision and instrument performance.

24-Hour DO Monitoring

Post-calibration-check requirements for other monitoring activities such as 24-hour DO and continuous monitoring vary depending on the deployment time and location of the site. For 24-hour DO monitoring, the post-calibration check should be done as soon as possible when returning from the field. How long an instrument is left at a site when collecting 24-hour DO data is generally based on the instrument being used, the conditions at the site, and the operator's experience with the instrument. The risk of expanding the time between calibration and the post-calibration check is the loss of data if the instrument fails the QC checks. See Chapter 3, "24-Hour DO Monitoring" for more information.

Table 8.1. DO saturation values in mg/L (oxygen content of air-saturated freshwater at 760 mm Hg).

	Oxygen Solubility at 760 mmHg									
Temp (°C)	**0.0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
1	14.17	14.13	14.09	14.06	14.02	13.98	13.94	13.90	13.87	13.83
2	13.79	13.75	13.72	13.68	13.65	13.61	13.57	13.54	13.50	13.47
3	13.43	13.40	13.36	13.33	13.29	13.26	13.22	13.19	13.15	13.12
4	13.08	13.05	13.01	12.98	12.94	12.91	12.88	12.84	12.81	12.77
5	12.74	12.71	12.68	12.64	12.61	12.58	12.55	12.52	12.48	12.45
6	12.42	12.39	12.36	12.33	12.30	12.27	12.23	12.20	12.17	12.14
7	12.11	12.08	12.05	12.02	11.99	11.96	11.93	11.90	11.87	11.84
8	11.81	11.78	11.75	11.73	11.70	11.67	11.64	11.61	11.59	11.56
9	11.53	11.50	11.48	11.45	11.42	11.40	11.37	11.34	11.31	11.29
10	11.26	11.23	11.21	11.18	11.15	11.13	11.10	11.07	11.04	11.02
11	10.99	10.97	10.94	10.92	10.89	10.87	10.84	10.82	10.79	10.77
12	10.74	10.72	10.69	10.67	10.64	10.62	10.60	10.57	10.55	10.52
13	10.50	10.48	10.45	10.43	10.41	10.39	10.36	10.34	10.32	10.29
14	10.27	10.25	10.23	10.20	10.18	10.16	10.14	10.12	10.09	10.07
15	10.05	10.03	10.01	9.98	9.96	9.94	9.92	9.90	9.87	9.85
16	9.83	9.81	9.79	9.77	9.75	9.73	9.71	9.69	9.67	9.65
17	9.63	9.61	9.59	9.57	9.55	9.53	9.51	9.49	9.47	9.45
18	9.43	9.41	9.39	9.37	9.35	9.34	9.32	9.30	9.28	9.26
19	9.24	9.22	9.20	9.19	9.17	9.15	9.13	9.11	9.10	9.08
20	9.06	9.04	9.02	9.01	8.99	8.97	8.95	8.93	8.92	8.90
21	8.88	8.86	8.85	8.83	8.81	8.80	8.78	8.76	8.74	8.73
22	8.71	8.69	8.68	8.66	8.65	8.63	8.61	8.60	8.58	8.57
23	8.55	8.53	8.52	8.50	8.49	8.47	8.45	8.44	8.42	8.41
24	8.39	8.38	8.36	8.35	8.33	8.32	8.30	8.29	8.27	8.26
25	8.24	8.23	8.21	8.20	8.18	8.17	8.15	8.14	8.12	8.11
26	8.09	8.08	8.06	8.05	8.03	8.02	8.01	7.99	7.98	7.96
27	7.95	7.94	7.92	7.91	7.89	7.88	7.87	7.85	7.84	7.82
28	7.81	7.80	7.78	7.77	7.76	7.75	7.73	7.72	7.71	7.69
29	7.68	7.67	7.65	7.64	7.63	7.62	7.60	7.59	7.58	7.56
30	7.55	7.54	7.52	7.51	7.50	7.49	7.47	7.46	7.45	7.43
31	7.42	7.41	7.40	7.38	7.37	7.36	7.35	7.34	7.32	7.31
32	7.30	7.29	7.28	7.26	7.25	7.24	7.23	7.22	7.20	7.19
33	7.18	7.17	7.16	7.15	7.14	7.13	7.11	7.10	7.09	7.08
34	7.07	7.06	7.05	7.03	7.02	7.01	7.00	6.99	6.97	6.96
35	6.95	6.94	6.93	6.92	6.91	6.90	6.88	6.87	6.86	6.85

Table 8.2. Multiprobe calibration: summary.

Sensor	Purpose	Calibration/Check Frequency	Calibration/Check Standard	Acceptable Error Limits	YSI Sensor Response Indicators
Temperature	To assess thermistor accuracy	Check during routine maintenance	NIST traceable thermometer	± 0.20 °C (schedule factory maintenance) ± 0.50 °C (flag data)	
Barometer	To assess internal BP function	Monthly	Against a known BP	± 10 mm Hg	
SC zero check in ambient air	To assess sensor zero response	Before each SC-sensor calibration		0.0 ±3 µS/cm	
Single-Point SC Calibration	To establish the slope	Before each sampling event	KCl solutions tracebale to NIST standards; minimum value 1,000 µS/cm	± 5.0% see Table 8.3	Cell constant; 4.5 to 5.5
Two-Point pH Calibration	To establish the slope	Before each sampling event	NIST traceable pH 7.00, 4.00 or 10.00 buffer	± 0.50 standard units see Table 8.3	pH 7.0; −50 to + 50 mV pH 4.0; +130 to + 230mV pH 10; −130 to −230 mV Slope; 165 to 180
Single-Point DO Calibration	To establish the slope	Before each sampling event	DO% saturation standard for*:* YSI = current BP/7.6 Hydrolab = 100%	±6% saturation (preferred method) ± 0.5 mg/L see Table 8.3	***Membrane Electrode*** DO Charge; 25 to 75 DO Gain; −0.7 to 1.4 ***Optical Sensor*** ODO Gain; 0.85 to 1.15
Depth	To assess depth sensor accuracy	Zero the depth sensor before the initial measurement			

Post-Calibration Check—Error Limits

If post-calibration values fall outside the error limits for DO, pH, and specific conductance, then the data collected do not pass QA and should not be reported (Table 8.3). If post-calibration measurements do not consistently fall within the error limits after in-house troubleshooting, return the instrument to the manufacturer for maintenance. For depth and temperature, errors found during the routine checks need to be corrected by the manufacturer.

Table 8.3. Error limits for the post-calibration check.

Parameter	Value
Dissolved oxygen	± 6% saturation, ± 0.5 mg/L
pH	± 0.5 standard units
Specific conductance	± 5%
Temperature	± 0.2°C (schedule maintenance); ± 0.5°C (flag data)

General Maintenance

Document maintenance in the calibration and maintenance log.

Short-Term Instrument Storage

- Keep the sensors moist.
- Thoroughly rinse the sensors with tap water upon returning from the field.
- Pour a small amount of tap water into the storage cup. It is not required that the sensors be immersed in water. It is recommended that the sensors be stored with at least 10 mL (approximately 2 teaspoons) of water in the sealed storage cup.
- Avoid storing the sondes where they would be subjected to extreme high and low temperatures. Do not allow water to freeze in the storage cup.

Note: Never use alcohol to prevent freezing—it may damage sensors.

Scheduled Maintenance

The following schedule is the minimum maintenance required for frequently used instruments. To keep instruments in good working order this schedule should be followed for all instruments regardless of how much use an instruments gets. However, for less frequently used instruments (used for special studies or 24-hour monitoring) maintenance may be performed before use.

Hydrolab Multiprobes

Routine Maintenance

Carry out these important steps in preventive maintenance.

- Post-calibrate the instrument before general cleaning and maintenance.
- Following post-calibration, rinse off the sensors and store them in tap water. Do not use distilled or deionized water for storage.
- Keep the watertight rubber cable connectors well-lubricated and dry on the inside. The best procedure is to store the instrument with all connectors separated and open to the air until dry.
- Check rubber cable connectors regularly to ensure that the mated surfaces are covered with a **thin** film of white silicone.
- As necessary, use tissue paper to remove old traces of silicone and dirt and then reapply the silicone.
- Before calibrating, flush the entire instrument with clean, fresh water. Use soapy water and a soft brush to clean the outside surfaces of the instrument. A mild dishwashing detergent will work very well. Soak the entire instrument in fresh water for at least 30 minutes.

Note (DO membrane): Exercise particular caution when cleaning the polarographic dissolved-oxygen membrane as its tension may be affected.

Note (pH electrode): Use a cotton swab or a soft brush to clean the glass bulb of the pH electrode.

Conductivity

Every two months or once every 15 field trips

- For instruments with cell blocks, polish the conductivity electrode shafts and tips with emery paper.
- Remove the O-rings on the electrodes before polishing the shafts. Take care not to scratch the glass pH probe.
- Swab the conductivity cell block with a cotton swab soaked in methanol to remove dirt, grease, and other substances. Rinse twice with deionized water.
- Inspect the small O-rings and replace them if stiff, cut, or flattened.
- Reassemble the components, ensuring that the O-rings are wet to create a proper seal.
- Rinse well with deionized water.
- If possible, let the conductivity electrodes stand in tap water overnight before calibrating again.
- For newer-generation products without cell blocks, clean the conductivity sensor with a cotton swab soaked with methanol or detergent.

pH

Every two months or once every 15 field trips

- Wipe the pH probe with a cotton swab soaked in warm, soapy water.

Note: Alcohol is **not** recommended for cleaning the pH probe as it may damage some of the sensors by drying the glass electrode.

4000 series, Surveyor 2, and DataSonde 1 Instruments

- Replace the pH electrolyte solution in the pH reference probe sleeve with 3M KCl solution in pH 7 buffer (225g KCl in 1L of pH 7 buffer).

Series 3, 4, 4a, and 5 Sondes and Quanta Transmitters

- Replace the pH electrolyte solution with pH reference electrolyte (Hydrolab part number 005308HY), 4M KCl saturated with silver chloride. Additionally, potassium chloride pellets (Hydrolab part number 005376HY) may be added. The KCl pellets serve to maintain the pH reference electrolyte at saturation—useful if working long term in waters of very low conductivity.
- Clean the plastic reference probe sleeve and Teflon junction inside and out with a cotton swab soaked in warm, soapy water.

For 4000 Series, Surveyor 2, and DataSonde 1 Instruments

- Wipe the reference pH electrode (glass bulb) with a cotton swab soaked in warm, soapy water.
- Series 3, Series 4, Series 4a, and Series 5 sondes and Quanta transmitters use a silver anode in the pH reference probe. This anode should not require cleaning or general maintenance.
- Rinse everything with deionized water before refilling and reassembling.
- When replacing the pH reference sleeve, fill the sleeve completely with pH reference electrolyte. Point the sonde downward and push the sleeve up until it contacts and just covers the O-ring. Then point the sonde upward and continue to push the sleeve all the way to the base of the probe. This allows any trapped air to rise to the top, where

it is forced out through the porous Teflon junction with excess electrolyte. As a side benefit, it also serves to clean the Teflon junction.

- Inspect the pH reference sleeve for air bubbles by observing the pH reference probe while inverting the sonde. If a large bubble is found, repeat the filling procedure.
- Some Series 4, 4a, and 5 sondes may be configured with an integrated pH-reference probe. In those cases, the Teflon junction is noticeably smaller and installed using a screwdriver.
- To refill an integrated pH-reference probe with pH-reference electrolyte, point the sonde upward and fill the reference reservoir using a plastic syringe. This ensures that the reservoir is completely filled and no large air bubbles are left. When it is full, install the Teflon junction with a screwdriver, using care to not over tighten the junction. Observe excess electrolyte being forced out through the porous Teflon junction.

Every 12 months

- Replace the Teflon junction and O-ring.
- Store spare junctions in a 2–5 molar (> 50,000 µS/cm) KCl solution.

pH Troubleshooting

If pH still doesn't calibrate correctly, do the following:

- Evaluate the condition of the Teflon junction on the terminal end of the pH reference sleeve. The sleeve should slide on easily with some force applied. If the sleeve is difficult to apply, then the junction may have become clogged. In contrast, if the sleeve slides on too easily with little resistance, the junction is too porous. In both instances the junction must be replaced.
- If replacing the junction does not solve pH problems, then clean the probe by alternately soaking it in 0.1 N HCl and then in 0.1 N NaOH for five minutes in each solution. Use the small black caps that protect display unit terminals to isolate the probes for soaking with these solutions.
- ***Safety Note:*** Wear safety glasses and gloves when working with these corrosive chemicals.
- For 4000 series, Surveyor 2, and DataSonde 1 instruments, clean the glass pH and reference probes at the same time. **Do not** use these solutions on the metallic posts of newer-generation products (H20, Reporters, Recorders, DataSondes 3 or 4, and MiniSondes).
- Reattach the calibration cup, fill it with pH 4.0 buffer, and allow all probes to soak an additional 10 minutes.
- Thoroughly rinse with deionized water and refill the pH reference sleeve.
- If those two procedures do not correct pH problems, check with the manufacturer. A new probe may be required.

Batteries

Every two months or once every 15 field trips

- Review the calibration and replacement schedule for batteries.
- Recharge the 6-volt NiCad Gel cell batteries (nickel-cadmium) for 12 to 24 hours, regardless of the voltage displayed by the instrument. Ensure that NiCad batteries are recycled or disposed of properly—never put in the regular trash.

Stirrer

Every two months or once every 15 field trips

For 4000 Series, Surveyor 2, and Series 3 Stirrers

Lift the impeller off its post. Thoroughly clean all lubricant, dirt, and debris from the impeller and the post. Reapply a very small amount of silicon grease to the tip and replace the impeller on its post. Test the stirrer's performance; if sluggish, wipe away excess silicon grease from the impeller post and retest.

For Series 4, 4a, and 5 Sondes and Quanta Transmitters

Remove the screw that holds the impeller in place. Inspect the impeller—it should move very freely on the screw. If there is any resistance, clean the bore in the impeller using the screw. Replace the impeller if it should show extreme wear.

Test the screw for straightness by laying it on a desktop and gently pushing it. A straight screw should roll in a circle without any noticeable wobble. Replace it if it is crooked.

Visually inspect the impeller bearing for extreme wear. Replace it if it is worn out.

Reinstall the impeller bushing, the impeller, and the impeller screw. Make certain that the impeller is oriented with the dimples upward. Test the stirrer performance.

Dissolved Oxygen

Every 30 days or once every 15 field trips

Clark Polarographic DO Cell

- Change the DO membrane and add fresh DO electrolyte (Hydrolab part number 000537HY).
- Invert the sonde on a ring stand.
- Remove the DO guard, the O-ring, and the old membrane.
- Shake out the old DO electrolyte.
- Rinse the DO cell twice with fresh DO electrolyte.
- Fill the DO cell with fresh DO electrolyte until a large meniscus covers the gold-colored cathode. Gently tap the side of the DO cell to release any bubbles trapped in the DO cell.
- Replace the DO membrane (Hydrolab part number 002589HY) and secure with the O-ring (Hydrolab part number 000498HY) using the following steps. See Figure 8.3.

  A. Secure a membrane between your thumb and the probe body. ***Note:*** Handle membrane material with care, touching only the edges.

  B. With the thumb and forefinger of your other hand, grasp the free end of the membrane.

  C. With a continuous motion, stretch the membrane up, over, and down the other side of the sensor. Stretching forms the membrane to the contour of the sensor tip.

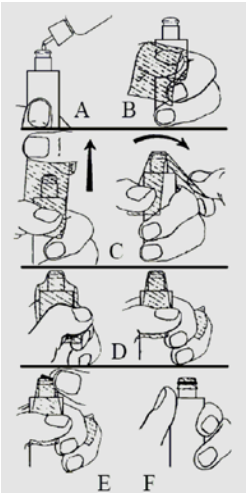

Figure 8.3. Replacing the DO membrane.

D. Secure the end of the membrane under your forefinger while still holding the probe.

E. Roll the O-ring over the end of the probe, being careful not to touch the membrane surface. Visually inspect the membrane for wrinkles, tears, or trapped air bubbles. Small wrinkles may be removed by lightly tugging on the edges of the membrane beyond the O-ring.

F. Trim off excess membrane with scissors or a knife.

Troubleshooting Notes

1. If anything other than a rapid and stable oxygen calibration occurs, replace the membrane as a first step in troubleshooting. Please note that the new DO membrane is stretched during installation (see Figure 8.3). This stretching affects the rate of diffusion for oxygen molecules passing through the membrane to the DO cell. As the membrane relaxes, the rate of diffusion will change unpredictably. For that reason it is recommended that the newly installed DO membrane be allowed up to eight hours to ensure total relaxation. If the sonde must be pressed into service, 2 to 3 hours is recommended to allow the membrane to achieve at least approximately 80 percent relaxation.
2. If it is necessary to use the DO probe before the new membrane has eight hours to relax, carefully recalibrate the probe immediately before taking each set of measurements.
3. If the gold cathode ring is discolored or appears tarnished, polish it lightly with a lint-free cloth or a pencil eraser. Point the sonde downward to prevent any debris from falling into the DO cell. Flush the cell twice with DO electrolyte to remove any debris.
4. The white triangular anode in the center of the DO cell may discolor with use, darkening from white to gray to black. The darkening is generally caused by a buildup of silver oxide. Darkening of the anode indicates wear, but does not automatically indicate a problem. The anode may be cleaned using a 1:1 solution of household ammonia and deionized water.

Luminescent DO Cell—Series 5 Sondes Only

The Hach LDO sensor is not affected by fouling or other debris, unless the growth is an organism that locally consumes or produces oxygen, such as barnacles, or algae growing on the sensor cap. Nevertheless, the manufacturer recommends periodic maintenance to remove contaminants such as oil, biological growth, and dirt. Sensor maintenance should be conducted after every deployment cycle.

Visually inspect the LDO sensor cap. Use optical tissue or a cotton swab with soapy water to clean the sensor cap. Rinse with fresh water.

Note: Do not use organic solvent solutions such as acetone or methanol with the Hach LDO sensor. Those solvents will damage the plastic sensor cap.

Avoid removing the LDO sensor cap unless the cap is being replaced. If the cap is sealed properly using the top O-ring seal, no water should be present between the cap and the clear plastic window and the top of the probe. If water is present, remove the cap and thoroughly dry the inside of the cap and the clear plastic window. The cap may require replacement.

For detailed instructions on replacing the LDO sensor cap, refer to the *Hach LDO Sensor Instruction Sheet* (see Appendix A).

Sonde

Every 12 months

Replace the desiccant inside the display and sonde units.

YSI Multiprobes

DO Probe (Clark Cell)

Every 30 days or once every 15 field trips

- Change the KCl solution and membrane before each long-term deployment and at least once every 30 days.
- Replace the KCl and membrane if (a) air bubbles are visible under the membrane, (b) deposits of dried KCl appear on the membrane or O-ring, (c) the readings are unstable, or (d) the DO charge reading is less than 25 or greater than 75.
- If the DO charge is higher than 75, perform maintenance on the DO probe.
- Remove the membrane and dry the probe completely with lens-cleaning tissue.
- Next, hold the probe in a vertical position, place one of the fine sanding disks (in the 6035 DO Probe Reconditioning Kit) under your thumb, and stroke the probe face in a direction parallel to the gold electrode. The motion should be similar to that used in striking a match. Stroke the electrodes 10 times in each direction.
- After sanding, rinse the probe face with water and wipe it with lens-cleaning tissue to remove any grit left by the sanding disk.
- After cleaning, thoroughly rinse the entire tip of the probe with water.
- Replace the KCl solution, install a new membrane, and change the O-ring that retains the membrane. A loose fitting O-ring can allow the electrolyte to leak out and cause noisy data.

Notes: (1) Use **only** the fine sanding disks from the 6035 maintenance kits and (2) sand parallel to the gold electrode.

DO Probe (Optical)

Inspect every six months or once every 15 field trips

There are two issues related to the performance of an ODO sensor; (1) the dye starts to break down and the black protective coating gets worn away with heavy use. Visually check the protective coating. If greater than 25 percent of the black coating is missing and/or there is light shining through greater than 25 percent of the disc, replace the membrane. The optical DO gain is an indicator of a bad membrane. Check the ODO gain in the Advanced Menu. An acceptable range is 0.85 to 1.15.

Conductivity and Temperature Probe

Every two months or once every 15 field trips

- The conductivity cell must be cleaned regularly to remove deposits formed on the electrode. The conductivity-cell constant should be in the range between 4.5 to 5.5.
- Dip the cleaning brush into water and insert it into each hole 15 to 20 times. You may also use a mild detergent to remove deposits from the electrodes.
- First rinse the cell with tap water and then several times with deionized water.

- After cleaning, check the response and accuracy of the conductivity cell with fresh standard.
- Check the cell constant to ensure that it is within the specified range.
- Dry the sonde port and probe connector.
- Clean probe O-rings and apply a very thin coat of lubricant before installation.
- Keep the thermistor clean and free of debris, using water and a cotton swab. Use mild detergent and a cloth, as necessary.

Notes:

- To access the conductivity cell constant using the 610-D display: from the main menu, select *Smart Terminal*, then choose *Advanced*, and choose *Cal constants*.
- To access the cell constant using the 610-DM display-logger: From the *Main Menu*, select *Communications* and then *Smart Terminal*. Select *Advanced* and then choose *Cal constants*.
- To access the conductivity cell constant using PC 6000 or Ecowatch software, select *8—Advanced*, press *Enter*, and then choose *1—Cal constants*.

pH Probe

Every two months or once every 15 field trips

Cleaning is required whenever deposits or contaminants appear on the glass surface of the probe. Use clean water and a cotton swab to remove all foreign material from the glass bulb. Use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

If pH is not restored, perform the following procedure:

1. Soak the probe for 10 to 15 minutes in clean water containing a few drops of dishwashing liquid.
2. **Gently** clean the glass bulb with a cotton swab.
3. Rinse the probe with clean water, wipe it with a cotton swab saturated with clean water, and then rinse it with clean water again.

If you suspect biological contamination of the reference junction, or if good response is not restored by the above procedures, perform the following cleaning steps:

1. Soak the probe for approximately one hour in a 1:1 dilution of commercially available chlorine bleach and water.
2. Rinse the probe with clean water and then soak it for at least one hour in clean water with occasional stirring to remove residual bleach from the junction. If possible, soak the probe for longer than 1 hour in order to remove all traces of chlorine bleach. Then rinse the probe again with clean water and retest.

Caution: Dry the probe port and probe connector and apply a very thin coat of lubricant to all O-rings before reinstallation.

Depth Sensor

Clean the depth sensor after each deployment or when readings become unstable. At the side of the instrument there is a circular cap with two or four small holes that protect the depth sensor. The cap cannot be removed, but a syringe is supplied in the maintenance kit for cleaning the pressure port. Fill the syringe with clean water, place the tip of the

syringe into one of the holes, and gently force water through the pressure port. Ensure that water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

Note: Never try to remove the circular pressure-port cap.

Long-Term Storage of Hydrolab Instruments

Field instruments are often stored for indefinite periods of time. For example, backup instruments are used during repair of the primary instrument. The instrument cannot be kept in a perpetual state of readiness without regular maintenance.

Whenever multiprobe instruments are to be stored for extended periods of time, take the following basic steps:

- Thoroughly clean the probes.
- Remove installed batteries such as AA or C cells. If a lithium battery powers the multiprobe internal clock, **do not** remove it.
- Fill the storage cup with 1 inch of clean tap water and screw the cap onto the instrument. DO and pH sensors must be stored in a moist environment.
- Store the instrument in a location where freezing temperatures will not occur, away from direct sunlight.

Refer to the operations manual for additional steps to prepare an instrument for long-term storage. Following the recommended steps will prepare the instrument for reactivation with minimal effort.

Downloading Data

HyperTerminal is readily available software that can be used to download data from both YSI and Hydrolab instruments. YSI also uses EcoWatch for Windows to download data—its use is detailed in the *YSI 6-Series User's Manual*. See Appendix A; also refer to the manufacturer's instruction manual for specific details on programming instruments and downloading data from long-term deployments.

Date:	Time:	Employee name:
Battery Voltage:		Sonde Type and Serial No.

Calibration

Function	Temp. of Standard	Value of Standard	Initial Reading	Calibrated to	Comments
Specific conductance ≥1,000 µS/cm					Zero Check ☐Pass ☐Fail; Value =
Conductivity cell constant					Range 5.0 ± 0.5
pH calibrated (~7)					
pH mv for pH 7 solution					Range 0 ± 50 mv
pH slope (~ 4/10)					
pH mv for pH 10 pH mv for pH 4					Range: -130 to -230 mv Range: 130 to 230 mv
Dissolved oxygen (%sat) *					
Dissolved oxygen charge					Range 25 to 75
Dissolved oxygen gain					Range 0.7 to 1.4
Optional Sensors (include parameter: turbidity, etc.)					

DATA NEEDED FOR DISSOLVED OXYGEN CALIBRATION

Altitude (A) =_____feet above msl Barometric pressure _____ inches _____ mm

Barometric Pressure (BP) Options	Barometric Pressure Formulas
Barometer	Barometric pressure (inches) _____ × 25.4 = BP _____mm
From local source after correction (CBP)	BP _____ mm = CBP _____mm – 2.5 (altitude ____/100)
Estimated from altitude only	BP _____ mm= 760 mm - 2.5 (altitude _____/100)
DO % saturation standard calculation *	**DO% sat Standard = Absolute BP mm Hg/760 × 100**

Deployment Checklist (required for data logging only)

Logging interval: Yes No	SDI-12 Autosleep enabled: Yes No	RS 232 autosleep enabled: Yes No	DO warm-up time:	Battery volts in Sonde (days):	Available memory in Sonde (days):

Post-Calibration Check

Date:	Time:	Employee Name:
Battery Voltage:		Sonde Type and Serial No.

Function	Temp. of Standard	Value of Standard	Initial Reading	Pass Post-Cal?	Comments
Specific conductance				☐Yes ☐No	
pH calibrated (~7)				☐Yes ☐No	
pH slope (~ 4/10)				☐Yes ☐No	
Dissolved oxygen (%sat) *				☐Yes ☐No	
Optional Sensors (include parameter: turbidity, etc.)				☐Yes ☐No	
				☐Yes ☐No	

Location of Deployment, Routine Run, or Special Study:	Date/Time Deployed:	Date/Time Retrieved:
Use(circle one): 24-hour	Continuous	Grab

MAINTENANCE—Refer to Chapter 8 for maintenance requirements—Perform temperature check along with regular maintenance. The laboratory thermometer must be checked against NIST traceable thermometer annually.

Sensor	**Date**	**Initials**	**Maintenance Completed**
pH			
DO			
Specific Conductance			

Annual NIST traceable check	Date:	NIST Temp:	Lab Thermometer Temp:	Correction Factor:
Maintenance temperature check	Date:	Sonde Temp:	Lab Thermometer Temp:	

Factory maintenance/repair notes:

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Figure 8.4. YSI Multiprobe calibration and maintenance log.

depth sensor. The cap cannot be removed, but a syringe is supplied in the maintenance kit for cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes, and gently force water through the pressure port. Ensure that water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

Note: Never try to remove the circular pressure-port cap.

Long-Term Storage of Hydrolab Instruments

Field instruments are often stored for indefinite periods of time. For example, backup instruments are used during repair of the primary instrument. The instrument cannot be kept in a perpetual state of readiness without regular maintenance.

Whenever multiprobe instruments are to be stored for extended periods of time, take the following basic steps:

- Thoroughly clean the probes.
- Remove installed batteries such as AA or C cells. If a lithium battery powers the multiprobe internal clock, **do not** remove it.
- Fill the storage cup with 1 inch of clean tap water and screw the cap onto the instrument. DO and pH sensors must be stored in a moist environment.
- Store the instrument in a location where freezing temperatures will not occur, away from direct sunlight.

Refer to the operations manual for additional steps to prepare an instrument for long-term storage. Following the recommended steps will prepare the instrument for reactivation with minimal effort.

Downloading Data

HyperTerminal is readily available software that can be used to download data from both YSI and Hydrolab instruments. YSI also uses EcoWatch for Windows to download data—its use is detailed in the *YSI 6-Series User's Manual*. See Appendix A; also refer to the manufacturer's instruction manual for specific details on programming instruments and downloading data from long-term deployments.

Date:	Time:	Employee name:
Battery Voltage:		Sonde Type and Serial No.

Calibration

Function	Temp. of Standard	Value of Standard	Initial Reading	Calibrated to	Comments
Specific conductance ≥1,000 µS/cm					Zero Check ☐Pass ☐Fail; Value =
Conductivity cell constant					Range 5.0 ± 0.5
pH calibrated (~7)					
pH mv for pH 7 solution					Range 0 ± 50 mv
pH slope (~ 4/10)					
pH mv for pH 10 pH mv for pH 4					Range: -130 to -230 mv Range: 130 to 230 mv
Dissolved oxygen (%sat) *					
Dissolved oxygen charge					Range 25 to 75
Dissolved oxygen gain					Range 0.7 to 1.4
Optional Sensors (include parameter: turbidity, etc.)					

DATA NEEDED FOR DISSOLVED OXYGEN CALIBRATION

Altitude (A) =_____feet above msl Barometric pressure _____ inches _____ mm

Barometric Pressure (BP) Options	Barometric Pressure Formulas
Barometer	Barometric pressure (inches) _____ × 25.4 = BP _____mm
From local source after correction (CBP)	BP _____ mm = CBP _____mm – 2.5 (altitude ____/100)
Estimated from altitude only	BP _____ mm= 760 mm - 2.5 (altitude _____/100)
DO % saturation standard calculation *	**DO% sat Standard = Absolute BP mm Hg/760 × 100**

Deployment Checklist (required for data logging only)

Logging interval: Yes No	SDI-12 Autosleep enabled: Yes No	RS 232 autosleep enabled: Yes No	DO warm-up time:	Battery volts in Sonde (days):	Available memory in Sonde (days):

Post-Calibration Check

Date:	Time:	Employee Name:
Battery Voltage:		Sonde Type and Serial No.

Function	Temp. of Standard	Value of Standard	Initial Reading	Pass Post-Cal?	Comments
Specific conductance				☐Yes ☐No	
pH calibrated (~7)				☐Yes ☐No	
pH slope (~ 4/10)				☐Yes ☐No	
Dissolved oxygen (%sat) *				☐Yes ☐No	
Optional Sensors (include parameter: turbidity, etc.)				☐Yes ☐No	
				☐Yes ☐No	

Location of Deployment, Routine Run, or Special Study:	Date/Time Deployed:	Date/Time Retrieved:
Use(circle one): 24-hour	Continuous	Grab

MAINTENANCE—Refer to Chapter 8 for maintenance requirements**—**Perform temperature check along with regular maintenance. The laboratory thermometer must be checked against NIST traceable thermometer annually.

Sensor	**Date**	**Initials**	**Maintenance Completed**
pH			
DO			
Specific Conductance			

Annual NIST traceable check	Date:	NIST Temp:	Lab Thermometer Temp:	Correction Factor:
Maintenance temperature check	Date:	Sonde Temp:	Lab Thermometer Temp:	

Factory maintenance/repair notes:

CHAPTER 9

REQUIRED EQUIPMENT AND SPARE PARTS

Routine Field Measurements

- multiprobe instrument(s)—capable of unattended, automated monitoring hourly over a minimum of 24 hours
- long and short cables for multiprobe instrument(s)
- maintenance kits and electrolyte solutions for DO and pH sensors (varies by manufacturer)
- calibration standards for pH and specific conductance
- instrument-specific software for downloading multiprobe data
- weather radio or barometer
- pocket calculator
- flow meter, top-setting wading rod, 100 ft measuring tape
- Secchi disk with long cord made of wire, chain or Dacron, marked in metric units
- backup multiprobe instrument in working condition
- NIST traceable thermometer

Water Sampling

- clean plastic bucket with rope (bridge sampling)
- sample containers appropriate for type of sampling being conducted (see Table 5.2 for details)
- discrete water-sampling device (e.g., alpha sampler,Van Dorn, Kemmerer, bailer)
- sulfuric acid (H_2SO_4) for preserving routine water samples
- hydrochloric acid (HCl) for preserving VOAs
- **Metals in water:** see Chapter 5, Table 5.1 for required components of a metals sampling kit

Bacteriological Sampling

E. coli *and Enterococci*

- 120 mL sterile IDEXX bacteriological bottles or equivalent containers (for sample collection)
- > 250mL sterile IDEXX bacteriological bottles or equivalent containers (for sample collection)

Sediment Sampling

- Ekman or Ponar dredge
- plastic or Teflon pans for sediment sampling
- Teflon or stainless steel scoops

- clear 500 mL glass jars with Teflon lids for metals, organics, and conventionals (detergent-washed and DI-rinsed)

Fish-Tissue Sampling

- seines: short (6–10'), $^{3}/_{16}$-inch mesh; long (20–25'), ¼-inch mesh
- boat-mounted electrofishing unit—Smith Root Type VII or equivalent
- backpack shocker—Smith Root Type VII or equivalent and extra battery
- 5-gallon plastic buckets
- neoprene chest waders(backpack/barge electrofishing), hip or knee boots (boat electrofishing)
- heavy rubber gloves for electrofishing; rated for a minimum of 1,000 volts
- nonconductive dip nets for fish (both medium and small mesh)
- fish-measuring board
- heavy aluminum foil (for shipping tissue samples)
- plastic bags (for shipping tissue samples)
- trawl (for coastal regions)
- gill net

Other Office and Field Equipment

- boat, motor, trailer
- global positioning system
- refrigerator and freezer
- ice machine (unless an ice-delivery contract is in place)
- insulated coolers (for shipping samples)
- large plastic bags for lining ice chests (for shipping)
- battery charger
- rubber knee boots
- first-aid kit
- heavy-duty flashlight
- personal flotation devices
- rain gear
- cell phone

Optional Equipment

- tube floater (for non-wadable streams where a boat is not practical)
- telescoping survey rod (for depth measurements)
- scale for weighing fish
- deionizing water column in the office
- oyster dredge (for coastal regions)

- Peterson dredge (for coastal regions)
- peristaltic pump

Additionally, all SWQM personnel should keep on hand all necessary forms, calibration logbooks, procedures manuals, equipment instructional manuals, and identification manuals for biological specimens. All essential SWQM guidance, manuals, and forms are available online (see Appendix A). The multiprobe calibration logbook is available at the TCEQ website as a PDF (see Appendix A). Monitoring personnel are responsible for creating their own calibration logbooks.

CHAPTER 10

QUALITY ASSURANCE AND QUALITY CONTROL

This chapter outlines basic QA requirements. It is not meant to be a single source for all QA information related to the SWQM programs. Detailed QA requirements are outlined in project QAPPs.

Quality Assurance

Quality assurance (QA) is an integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure a process is of the type and quality needed and expected by the customer. Systematic project planning is central to an integrated QA approach and is fundamental to the success of water quality monitoring projects. Quality-assurance documents are required by TCEQ to plan, organize, and define the QA process in order for data to be collected with the level of reliability needed for decision-making. The QA process considers:

- project objectives
- measurement performance specifications
- appropriate methods
- field and laboratory quality control
- data management
- verification and validation of data
- project oversight
- corrective action

Quality-Assurance Documents

The generation, acquisition, and use of environmental data are planned through the development of quality-assurance-project plans (QAPPs), project plans, quality-assurance plans (QAPs) or other planning documents. These documents are developed by project managers, quality assurance staff, technical staff, management, and contractors using a systematic planning process, such as developing data-quality objectives as defined in the *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4. Program specific guidance for the development of QA documents can be found on the Web (see Appendix A).

Technical and Monitoring Systems Audits

Technical systems audits are conducted on monitoring staff to detect deviations from QAPP and procedural requirements, so that corrective action can be taken. For TCEQ Regional programs, TSAs are conducted every other year unless there was a deficiency the previous year or there are new personnel in the program. A TSA involves an on-site qualitative audit of activities related to monitoring and data management, during which facilities, equipment, and records are reviewed for conformance to program QAPPs. The TSA visit is conducted by personnel from the TCEQ central office.

Note: The TSA process is outlined in the SWQM QAPP, Section C1 (see Appendix A). The CRP refers to TSAs as *monitoring systems audits* (MSAs). The requirements of a TSA are similar to those for a CRP MSA. Detailed MSA requirements can be found in Task 2 of the CRP guidance (see Appendix A).

The following is a general summary of the TSA process. Please refer to the SWQM QAPP for details on audit requirements.

Records Review

A TSA visit includes a review of the following records:

- ***Field data.*** Keep SWQM field data on file as a permanent record for all monitoring trips. These records serve as a permanent file of observations and field measurements made during every sampling event.
- ***Calibration records.*** Keep copies of the *SWQM Multiprobe Calibration Logbook* on file at each office. Keep a separate logbook for each multiprobe instrument. The logbook contains calibration and post-calibration-check data, as well as maintenance and troubleshooting notes.
- ***Flow data.*** Keep flow data, including raw velocity data and calculated flow (discharge), from each field measurement on file at each office.

  Since only final values, expressed in standard units of measurement, are reported to the TCEQ central office, the raw data used to produce these values serve as evidence of the collection method and calculation of reported values. This information must be recorded and maintained with other field data.
- ***Data management portion of TSA.*** Prior to each audit visit TCEQ Data Management staff complete a portion of the audit checklist related to data management activities. This portion of the audit serves to ensure timely and accurate data reporting as well as to identify any areas where data management training may be needed by field staff. The assigned auditor will review this information with the regional programs during the audit visit.

Procedures for Instrument Calibration

SWQM personnel must be prepared to demonstrate the proper calibration procedure for the primary instruments used for measuring dissolved oxygen, pH, temperature, and specific conductance. Where two or more personnel share SWQM responsibilities, they may each be required to demonstrate proper calibration procedures that are outlined in Chapter 8.

Instrument calibration, maintenance, and repairs performed by monitoring personnel must be recorded in an *SWQM Multiprobe Calibration Logbook*. If calibration checks or maintenance is carried out in the field, this information may be included in the field data record, in addition to the instrument-calibration logbook. Serious malfunctions must be noted in the logbook on return from the field.

Data and Sample Collection Procedures

At least one person from each region must demonstrate the proper procedures for data and sample collection at one or more SWQM stations. Collection procedures evaluated may include, but are not limited to, the following:

- field measurement protocols (dissolved oxygen [including 24-hour deployment], pH, specific conductance, temperature, Secchi-disk transparency, total depth, and flow)
- collection, preservation, and shipping of water quality samples (including samples of routine water chemistry, metals in water, and organics in water) and bacteriological samples
- collection of sediment samples
- calculation of flow from raw data
- biological-sample collection, sample analysis, and data management
- protocols for sample handling and analysis

TSA Review Follow-Up

Each TSA review is followed by a verbal and written review of its findings. Central-office personnel conduct the verbal review at the conclusion of the TSA, before leaving the office at which the review was conducted. If possible, the review will be conducted in the presence of the person's immediate supervisor.

The following topics are discussed during the verbal review:

- materials and procedures checked during the TSA
- a summary of any deficiencies
- necessary or suggested changes in sampling procedures, and necessary action to correct any deficiencies

Corrective actions will be laid out in a subsequent memorandum, but they are effective immediately.

The memorandum is directed from the auditor to the appropriate TCEQ regional-office director or CRP planning agency. Copies are also sent to the TCEQ Water Section manager, to all the regional SWQM staff members evaluated, and to the participating data manager.

According to the TCEQ Quality Management Plan, the Water Section manager is required to respond to all deficiencies in writing within 30 days from the date of the follow-up memo. In the response, the manager should describe any corrective actions that will mitigate the deficiency in the future.

The next scheduled TSA includes a review to ensure that required corrective actions were initiated and continued. Until corrective actions are completed, the TCEQ may stop accepting SWQM data, effective from the date of the TSA. If the TCEQ staff determines that data quality has been compromised, central-office data-management personnel will conduct a thorough review and will flag any questionable data in the database as not having passed QC requirements.

Annual Workshop on Surface Water Quality Monitoring

Each year, water quality monitoring personnel from around the state who contribute data to the SWQM Program participate in a three-day workshop to review existing policies and to learn new procedures relevant to the monitoring program.

Additional training workshops may be conducted several times a year to enable professionals in water quality monitoring who contribute data to the TCEQ to improve

their skills in monitoring, hydraulic measurements and biological assessment, data reporting, and analysis.

Quality-Control Samples

Periodic testing of field-sample collection and handling skills is included in a field QC program through the use of QC samples including field splits, field blanks, and equipment blanks. For more information on samples of metals and volatile organics in water—which require the collection of laboratory-equipment blanks and trip blanks, respectively—refer to Chapter 5. See Table 10.1 for a summary of QC sampling. Submit QC-sample results to the TCEQ for storage in SWQMIS using the appropriate *monitoring type code* (FS, FB, TB, EB)—for details, see Chapter 4 of the *DMRG*.

QC Sample Results

Submit QC sample results to the TCEQ for storage in SWQMIS.

Field Split (Required)

A field split is a single sample subdivided by field staff immediately following collection and submitted to the laboratory as two separate, identified samples. Split samples are preserved, handled, shipped, and analyzed identically and are used to assess variability in all of these processes. Field splits are required for **all routine conventional water quality parameters.** Split samples are sealed, handled, stored, shipped, and analyzed in the same manner. **Field splits do not apply to any other parameters** (unless needed for a special project).

A field split is collected by dividing an ambient water sample from a single container (for example, a 5-gallon bucket or 2.5-gallon cubitainer) between two sets of containers. A field split mimics preservation, handling, and shipping.

Submit field splits with every 10th sample. If fewer than 10 samples are collected in a month, submit one set of splits for that month.

Equipment Blank (Required for Metals in Water)

Equipment blanks are samples of reagent water poured into or over a sampling device or pumped through a sampling device. Blanks are collected in the same type of container as the environmental sample, preserved in the same manner, and analyzed for the same parameter. This procedure always applies to dissolved-metals-in-water samples and occasionally to total-metals-in-water samples (when a sampling device is needed).

Submit an equipment blank for metals in water with each batch of samples. If fewer than 10 samples are collected during a sample run, submit one blank. If more than 10 samples are collected during a sample run, submit one blank for each 10 samples. See Table 10.1.

Note: For those using the TCEQ metals-in-water kits, the standard frequency noted above does not apply. Collect and submit an equipment blank with each sample.

Table 10.1. Summary of quality-control sampling.

QA Sample Type	Parameter (Group)	Minimum Frequency	Purpose	Required	Submit to SWQMIS
Field splits (FS)	Routine water chemistry	1 per 10 samples or 1 per month (< 10 samples)	Check for consistency of preservation, handling, shipping	Yes	Yes
Equipment blank (EB)	Metals in water (dissolved)	1 per sample run or 1 per 10 samples if > 10 samples collected in one run; **Houston metals kits—collect 1 per sample**	Check for contamination from sampling equipment, supplies	Yes	Yes
Field blank (FB)	Total metals in water (collected directly from a water body)	1 per sample run or 1 per 10 samples if > 10 samples collected in one run**; Houston metals kits—collect 1 per sample**	Check for contamination from sample collection, preservation, handling, shipping	Yes	Yes
Trip blank (TB)	Volatile organics in water	One per ice chest containing VOA samples	Check for sample contamination	Yes	Yes
Field (environmental) duplicate	Water (organics, routine chemistry)	1 per 10 samples or 1 per month (< 10 samples)	Environmental variability	Optional	Optional
Field splits (FS)	Organics, metals	1 per 10 samples or 1 per month (< 10 samples)	Check for consistency of preservation, handling, shipping	Optional	Optional
Equipment blank (EB)	Water (organics, routine water chemistry)	1 per sample run or 1 per 10 (> 10 samples collected in one run)	Check for contamination from sampling equipment, supplies	Optional	Optional
Field blank (FB)	Water (organics, metals, routine chemistry)	1 per 10 samples or 1 per month (< 10 samples)	Check for contamination from sample collection, preservation, handling, shipping	Optional	Optional
Replicate	Sediment	Determined by project needs	Environmental variability	Project specific	Optional

If collecting both dissolved and total metals, using tubing, an in-line filter, and a peristaltic pump, the same tubing and filter may be used for collecting equipment blanks and ambient water samples. Collect in the following sequence:

1. Collect the total-metals blank.
2. Add the filter; collect the dissolved-metal blank.

3. Flush tubing with ambient water and collect the dissolved-metals sample.
4. Remove the filter and collect the total-metals sample.

If there is a delay between collecting the blanks and the ambient samples, place a bag over the filter, without removing it from the tubing, to avoid contamination.

Note: If contamination is detected in equipment blanks, blanks are required for **every** metals-in-water sample until the problem is resolved.

Field Blank (Required for Total Metals in Water)

Field blanks are required for total metals-in-water samples when collected without sample equipment (for example, as grab samples). A field blank consists of deionized water that is taken to the field and poured into the sample container. Field blanks are used to assess the contamination from field sources, such as airborne materials, containers, and preservatives. The frequency for total-metals field blanks is one per day or per sample run. If more than 10 samples are collected, submit one blank for every 10 samples.

Note: For those using the TCEQ metals-in-water kits, the standard frequency noted above does not apply. Collect and submit a field blank with each sample.

VOA Trip Blank (Required)

Trip blanks are required for volatile-organics analysis only. VOA trip blanks are samples prepared in the laboratory with purged laboratory water and preserved, as required. They are transported to the sampling site, handled in the same way as an environmental sample, and returned to the laboratory for analysis. Trip blanks are not opened in the field. They are used to check contamination of the sample through leaching of the septum. Submit a trip blank for VOA samples with each ice chest full of VOA samples shipped to the lab.

Laboratory Equipment Blank for Metals-in-Water Supplies

Laboratory-equipment blanks are run by the laboratory where collection materials are cleaned and distributed. An equipment blank documents that materials supplied by the laboratory are free of contamination. When each batch of tubes, filters, bottles, acid, and deionized water is prepared, about 10 percent of the materials are chosen for QC checks—analyses of metals-free water that has been pumped through the filter and tube, collected in a sample container, and preserved.

Optional QC Samples

Equipment Blank—Other than Metals

All other types of equipment blanks are not required as part of the routine SWQM Program, but may be inserted into the sample regime, if needed for a specific reason.

For samples, other than metals in water, the recommended minimum frequency is one with every 10th sample. If fewer than 10 samples are collected in a month, submit one set of field blanks for that month.

Field Blanks—Other than Total Metals

Field blanks are optional for all sample types, with the exception of total metals in water. Field blanks, not required as part of the routine SWQM Program, may be inserted into the

sample regime, if needed for a specific reason. The frequency is determined by the needs of the project or special study.

If the needs of a sampling project are met with field blanks, the recommended minimum frequency is one in 10. If fewer than 10 samples are collected in a month, submit one field blank for that month.

Field (Environmental) Duplicates

A field or environmental duplicate a second sample from the same location, collected in immediate succession, using identical techniques. Duplicate samples are sealed, handled, stored, shipped, and analyzed in the same manner as the primary sample.

Field duplicates are not required as part of the routine SWQM Program, but may be inserted into the sample regime, if needed for a specific reason.

If the needs of a sampling project are met with field blanks, the recommended minimum frequency is one with every 10th sample. If fewer than 10 samples are collected in a month, submit one set of field blanks for that month.

Sediment and Tissue Samples

QC samples are not required for sediment or tissue. Replicate sediment samples are not required as part of the routine SWQM Program, but may be inserted into the sample regime, if needed for a specific reason. The frequency is determined by the needs of the project or special study.

Tracking QC Data

Submit blank, field split, and duplicate results to the SWQMIS. Specific uses of QC data are defined by the TCEQ SWQM Program, the CRP, and other water program QAPPs. QC data are used in the review of ambient data as specified by each program area.

CHAPTER 11

FIELD SAFETY

This chapter is intended to assist field personnel in the safe performance and collection of water quality data. Fieldwork requires an awareness of potential hazards and knowledge of basic safety procedures. Field personnel routinely come in direct and indirect contact with waterborne pathogens, chemicals, and potentially hazardous plants and animals. Safety depends on using common sense and being aware of your surroundings. Advanced planning can eliminate many safety hazards, or at least reduce them.

Basic Safety Preparation

Basic preparations should become routine before every sampling. At a minimum, complete a plan for each field trip, and leave it at a designated location in the office. The trip plan should include the following information:

- the names of participants, including guests and observers, with emergency contact information
- a basic itinerary, including where and when sampling will occur, along with departure and return times and dates
- hotel information and contact phone numbers (for overnight trips)
- cell-phone numbers or radio frequencies

Remember:

- Fieldwork should be carried out in pairs. Always carry a cell phone or other communication device.
- Carry basic safety equipment: a first-aid kit, a flashlight, boots, rain gear, and antibacterial soap or hand cleaner.
- Be aware of changing weather conditions and the potential for flash floods, storms, or tornadoes.
- Be aware of potential hazards at a monitoring site.
- Make a habit of carrying a packet of general safety information in each vehicle or boat—
  - material-safety data sheets (MSDSs) for preservatives
  - basic first-aid protocols
  - emergency phone numbers
  - locations of emergency facilities (hospitals, police and fire departments, U.S. Coast Guard)

Use the checklist in Table 11.1 to ensure that all appropriate safety equipment is available during a sampling trip.

Table 11.1. Basic safety-equipment checklist.

Yes	No	Safety Items
		Waders, hip boots, rubber knee boots
		Personal flotation device
		First-aid kit
		Fire extinguisher
		Flashlight and spare batteries
		Cell phone and marine radio
		Rain gear
		Hat, sun screen, and sunglasses
		Drinking water or sports drinks
		Safety cones, orange safety vest (for working on bridges)
		Toolbox with basic tools
		Antibacterial soap or hand cleaner
		Spill kits (for preservatives)
		MSDSs for preservatives
		Hand-held eyewash unit
		Protective goggles
		Container to carry preservatives
		List of emergency phone numbers and office contacts

Transporting Chemicals

Ensure that MSDSs are available for all chemicals used on a trip. These reports describe signs and symptoms of exposure, list first-aid procedures, and give details on cleaning up spills. Here are tips to remember:

- Protect field personnel by securing all chemicals, using containers that will control the material in the event of an accident.
- Dilute concentrated acid to 1:1 before traveling to the field.
- Use a secondary container (for example, an ice chest) to protect against breakage and spills.
- Carry a spill kit containing neutralizing agents. (The most common and dangerous chemicals carried during sampling trips are sulfuric and nitric acids).

- Use safety glasses and gloves when handling acid preservatives.
- Label all chemical containers clearly.
- Never carry large quantities of acid in the field. Always transfer the acid to smaller containers or, for sulfuric and nitric acids, use premeasured vials. Although there is always a chance of a spill, the risk is significantly reduced by transporting small quantities.
- Do not pipette by mouth. Always use mechanical pipettes or pipette bulbs.

Consider these safety tips for transporting gasoline:

- If extra gasoline is carried, ensure that it is transported and stored in approved containers.
- Remove portable tanks from vehicles or boats before filling them with fuel. Touch fuel pipes or tanks with the spout to prevent buildup of static electricity.
- Do not fill tanks completely full; leave room for the gasoline to expand.
- Cap tanks tightly to prevent vapors from escaping.
- Clean up spills immediately and air used rags before storing them. Store containers in a well-ventilated area away from the engine.

Wading

Follow these guidelines on wading:

- Stream flow can be deceiving. If there is any question about safety, do not get in the water.
- Do not attempt wading in a stream where the depth multiplied by the velocity is 10 ft^2/s or more. For example, a stream only 2 ft deep with velocities of 5 ft^2/s or more can be dangerous (Lane and Fay 1997).
- Always wear a Coast Guard–approved personal flotation device (PFD) while wading. Although the stream may not appear deep, depressions, holes, or loose footing may cause a fall.
- Wear hip boots or chest waders. Boots and waders protect against cold, contaminants, and underwater objects. Be aware of the possibility of slipping and going under water while wearing them.
- For waders with loose-fitting tops, consider wearing a belt to prevent them from filling with water.
- Be aware of surrounding conditions. Watch for floating debris, areas of quicksand, underwater hazards, and deep pools. Watch the stream stage, especially if there is a chance it could rise rapidly.

Working from Bridges

Samples are often collected from bridges. Such work is very dangerous, so take steps to minimize the risks. Use basic safety equipment for bridge sampling, including reflective vests, orange safety cones, and a revolving amber light.

According to Texas Department of Transportation requirements:

- Use an activated flashing or revolving light on vehicles involved in short-term, short-duration work (60 minutes or less) on the road shoulder.
- Use orange safety cones, in addition to the flashing amber light, for vehicles parked on the shoulder for longer than 60 minutes. The cones should begin at 40 ft ahead of the vehicle where the posted speed limit is 30 miles per hour or less, up to 250 ft ahead of the vehicle where the speed limit is 70 mph.

If a field vehicle is parked on the bridge:

- Never stand in front of it while sampling. Field personnel cannot see traffic, and drivers cannot see field personnel.
- Sample away from the vehicle at a location where you can observe traffic from both directions.
- Be aware of any boat traffic.
- Wear a Coast Guard–approved PFD when working on bridges over large rivers.

Working from Boats

Use a boating-safety checklist when planning a trip (Table 11.2). Leave an itinerary for each boat trip at a designated location in the office. The plan should include:

- the date and purpose of the trip
- the names of all operators and any guests or observers, along with emergency contact information
- the destination and route
- the time of departure and estimated time of return
- a cell-phone number or radio frequency
- the type of boat, including its color, length, and identification number and any other unique features

Follow these precautions when using a boat:

- Know its capacity. Look for a capacity plate near the operator's position or on the transom indicating the maximum capacity (weight or persons). The maximum weight includes the combined weight of passengers and gear.
- On outboard powerboats, check the capacity plate for the maximum horsepower rating; do not exceed the rating.
- Use caution when refueling a boat. Check the entire fuel system for leaks, and tighten connections frequently. Turn off the engine and all electrical equipment before adding fuel to the tanks. Never smoke or strike a match while fueling or near a fueling dock.
- Make sure the boat is in good operating condition and full of gas before taking it out on the water. Use the checklist in Table 11.2 to ensure that the boat is ready for use.

Table 11.2. Boating-safety checklist.

TRAILER	YES	NO	COMMENTS:
Sizes of coupler and ball hitch match			
Tire pressures are at the maximum noted on the rim			
Tire treads are at least $^{3}/_{32}$"			
Tires are in good condition			
Brake lights and turn signals function			
Safety chains are attached in an *X* under the coupling			
All boat straps are tight			
License plate is present and firmly attached			
Trailer stand is secure			
BOAT	**YES**	**NO**	**COMMENTS:**
Boat plugs are present			
Battery is charged			
Gas tank is full			
Anchor and rope are aboard			
Navigation lights are operational			
Emergency paddles are aboard			
First-aid kit is available			
First extinguisher is charged and accessible			
Flashlight with working batteries is available			
An air horn or whistle is aboard			
Rain gear is aboard			
Personal flotation devices are available for every person on board			
The emergency kill switch for the boat motor is functioning			
Radio or cell phone is available and functioning			

- Check weather conditions before departure. If a storm comes up while on the water, head for shore. Always carry a marine radio or cell phone. Never go boating alone.
- Do not wear waders and hip boots in a boat because they could be a safety hazard if the boat should tip or a person is thrown out. When wearing waders or hip boots is necessary, a life jacket must be worn.
- Always wear a Coast Guard–approved life jacket.

- Remember that Texas law requires operators of vessels involved in any collision, accident, or other casualty that results in death or injury to any person or property damage exceeding $500 to file a complete report of the accident within 30 days. Obtain report forms from the TPWD. Keep in mind that vessel operators involved in a boating accident must stop and render whatever assistance is necessary unless such actions would endanger their own vessel, crew, or passengers. Operators must give their name, address, and vessel identification number in writing to any injured person and to the owner of any damaged property.

Personal Flotation Devices

Approximately 90 percent of all boating fatalities are from drowning. Virtually all drowning victims are not wearing personal flotation devices, or are wearing inadequate ones. All boats must be equipped with life jackets or PFDs approved by the U.S. Coast Guard (Table 11.3). The quantity and type depend on the length of the boat and the number of persons aboard. Additional information is available at the U.S. Coast Guard Web site (see Appendix A).

Follow these guidelines:

- PFDs must be in good condition. Regularly test the buoyancy in shallow water or a swimming pool.
- Inspect the PFDs for weakened material or insecure snaps or zippers.
- Inflatable PFDs require maintenance. Replace spent cartridges in inflatable PFDs or tag used cartridges as out of service, so they are not used accidentally.

Table 11.3. Types of personal flotation devices.

Type	Conditions of Use	Positives	Negatives
I	Offshore work or remote areas where rescue may take a while	Excellent for flotation and will turn most unconscious persons face up in the water.	None.
II	Near-shore vests	Good for calm waters and fast rescues.	Lacks the capacity to turn wearers face up.
III	Vests or flotation aids	Good for calm waters and fast rescues.	Will not turn an unconscious person face up and should not be used in rough waters.
IV	Throwable devices—cushions or buoy rings	Designed to be thrown to someone in trouble.	Not good for long hours in the water, rough water, nonswimmers, or the unconscious.
V	Type V, (special-use) devices are designed for specific activities. They are only appropriate for use in accordance with the specific instructions on the label of the device.		

- Inflatable PFDs are not recommended for nonswimmers.
- Ensure that all PFDs are the proper size for the intended wearer. Read the label to ensure that it is the right size for a person's weight and chest size.
- Keep all PFDs readily accessible.
- Make sure all sampling personnel wear PFDs when in boats and when wading. TCEQ SWQM personnel are required to wear PFDs when under way.
- For boats 16 feet long or longer, keep an extra Type IV PFD immediately available, besides those required for passengers.
- Select PFDs that are appropriate for the area being sampled.

Collecting Fish

Electrofishing

Electrofishing is hazardous work. The batteries and generators used provide more than enough current to electrocute a person. **Use extreme caution. Never electrofish alone.** Ensure that everyone associated with electrofishing is aware of the hazards and safety requirements before beginning the project.

General Electrofishing Safety

- Use only commercially produced electrofishing equipment.
- Be familiar with the equipment and inspect it before each use. Correct any equipment problems immediately. If equipment must wait to be repaired, tag it "out of service" so it won't be used accidentally.
- Evaluate the equipment annually during a preventive-maintenance inspection.
- Do not allow wiring splices. If connections are necessary, ensure that the rating of the connector is at least as high as that of the wire.
- Ensure that at least one member of the crew is trained in CPR. Consider carrying a portable automated external defribrillator.
- Inspect all dip nets to ensure they are made of nonconductive material and that they are long enough to keep the user's hands out of the water.

Backpack Electrofishing

- When backpack electrofishing, wear neoprene waders and rubber lineman gloves. The rubber lineman gloves must be rated for at least 1,000 volts. Never wear breathable waders, as electric current can pass through them.
- At least two people are required when backpack electrofishing (one to carry the backpack and the other to net fishes), though three make the optimal crew.
- Ensure that batteries used on backpack electrofishing units are of a gel type that will not leak when tipped or overturned.
- Check hip and shoulder straps to make sure they are of the quick-release type, are not damaged, and are long enough for the person who will use them.
- Ensure that the backpack unit is equipped with a trip switch that breaks the circuit if the user falls. This switch must be the type that is manually reset before reestablishing the circuit.

Boat Electrofishing

- A minimum of three people are required when electrofishing from a boat.
- All personnel must wear a Coast Guard–approved PFD, rubber gloves rated for a voltage above that used by the electrofishing unit, and rubber boots when electrofishing from a boat—with no exceptions.
- Hearing protection is highly recommended.
- Members of an electrofishing team must be aware of each other. The boat driver should watch those on the front netting fish, while the netters need to take care of those around them while maneuvering the nets.
- Ensure that all junction boxes are weatherproof or rain tight, depending on their use. Junction boxes with switching equipment must be weatherproof.

Working with Nets

Remove all jewelry from hands and wrists and from around the neck when using gill nets or other nets with large mesh. Nets can get caught on watchbands, bracelets, necklaces, or rings. Since gill nets are deployed from boats, it can become a serious safety issue if someone gets tangled or a piece of jewelry gets hooked to the net. The driver of the boat must be very conscious of those deploying the nets. All personnel must wear a Coast Guard–approved PFD.

Working with Fish

Take care when working with catfish or other fish with barbs. When handling catfish it is easy to receive a puncture wound from barbs on the pectoral or dorsal fins. These can be very painful and are a risk for infection. Infections that occur after contact with coastal waters should be checked by a doctor.

Contaminated Water

Always consider the possibility that the water being sampled may be contaminated with pathogens or hazardous chemicals. Use caution and extra protection when working in or around water with known or suspected contamination. Use sample tags to indicate the level of contamination so the laboratory can handle the sample appropriately. Communicate known or suspected contamination to all personnel who could come in contact with a contaminated sample.

Waterborne, disease-causing organisms (pathogens) are found in nearly all surface water systems. Pathogens enter surface water through untreated sewage discharges and bypasses, storm and agricultural runoff, and direct contact. Bacteria, viruses, and other pathogens can occur in the most pristine environments. Never drink sample water, no matter how pristine the environment appears. Consider making antibacterial soap or hand cleaner a routine item to carry while in the field.

When working in water bodies with questionable water quality, consider wearing gloves and waders when in contact with the water. Equipment used in contaminated water bodies should be washed after use.

Weather

Weather can change rapidly and create unexpected situations for sampling personnel, whether they are in a boat or in isolated sampling areas. Check local weather forecasts frequently. Be alert to visual weather cues, such as developing clouds, wind shifts, and graying skies.

If you see these signs and you are in a boat head for shore immediately. Head the bow into the waves at a 45° angle. Reduce speed, but keep enough power to maintain headway. Make sure all passengers and equipment are secured in case of rough water.

Leave small creeks and rivers to avoid flash floods. Don't cross low-water crossings, as the integrity of the underlying roadway is uncertain. Floating debris may damage the vehicle, or even push it from the roadway.

Lightning Safety

When you first see lightning or hear thunder, seek shelter either in a vehicle with the windows closed, or in a substantial building. Avoid high ground, water, and open spaces. Unsafe shelter includes canopies, small picnic or rain shelters, or the vicinity of trees. Activities should be suspended until 30 minutes after the last observed lightning or thunder.

Temperature Exposure

The two most common health risks faced by field staff are the result of temperature extremes. Extremes of air temperature occur in all parts of the country. The ideal comfort range for humans is 10–32°C (60–90°F). Hypothermia (cold) and hyperthermia (heat) normally occur outside this range.

Cold Emergencies

Hypothermia is a condition of reduced body temperature caused by exposure to cold, and aggravated by wet clothes, wind, hunger, and exhaustion. Hypothermia can occur with air temperatures above 16°C (60°F) under wet or windy conditions.

Warning Signs

Symptoms of hypothermia include uncontrollable fits of shivering, incoherence, listlessness, fumbling hands, frequent stumbling, drowsiness, and the inability to get up after resting.

Treatment

Remove the victim from the cold and into a dry, warm place. Take the following temporary measures until medical help is available: Replace wet clothes with dry ones. Warm the body slowly. Give warm, nonalcoholic drinks.

Prevention

The best way to prevent hypothermia is to stay warm and dry. Put on rain gear before it rains. Dress in layers and add more before getting cold. Find shelter before conditions become severe. During colder weather, carry a complete change of dry clothes.

Heat Emergencies

Hyperthermia is caused by increasing body temperature due to exposure to extreme heat. The two forms of hyperthermia are heatstroke and heat exhaustion. Heat emergencies can be brought about by a combination of factors: physical exertion, heavy clothing (e.g., waders), humidity, no breeze, air temperature, and the rate of fluid intake. Working in the extreme summer heat creates a very real threat of heat-related stress.

Warning Signs

Symptoms of hyperthermia include chilling, headache, unsteadiness, dizziness, nausea, dry skin (hot and red—heatstroke; cool and pale—heat exhaustion), rapid pulse, and muscle pain and spasms.

Treatment

General treatment for heat emergencies involves cooling down and giving plenty of fluids. **Do not give salt tablets**. A common symptom of dehydration is a headache. Heatstroke requires immediate medical attention and can cause death. Cool down victims of heatstroke quickly and watch for signs of shock. Call 911 or, if in an isolated area, transport the victim to a medical facility immediately.

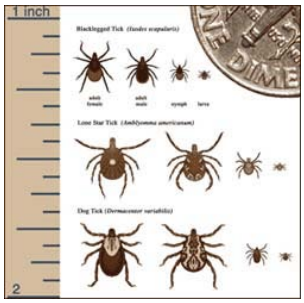
Prevention

- Hydrate well before working outdoors. Drink water in moderate amounts every 15 minutes. Do not rely on thirst to indicate dehydration.
- Avoid alcohol, caffeinated drinks, and sodas. These liquids are not water substitutes and can increase the rate of dehydration.
- Wear lightweight, light-colored clothing and a wide-brimmed hat.
- Start work early and finish before the hottest part of the day. Find some shade and take breaks during the day.

Plants and Animals

Certain insects, reptiles, and plants are always potential hazards for field personnel. Tables 11.4 and 11.5 sum up the most common plant and animal hazards encountered by field personnel. Carrying a first-aid reference is recommended for all field activities.

Table 11.4. Common wildlife hazards.

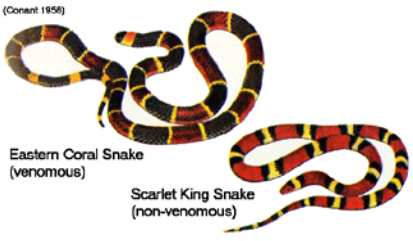
Animal	Characteristics and Habitat	
SPIDERS, SCORPIONS, TICKS, BEES and WASPS		
Black widow spider	Inhabits fallen branches and lives under objects. Red and brown widow spiders are less common, but do inhabit the Gulf Coast region. Take care when reaching into small, dark spaces. If bitten by a black widow, seek medical attention as soon as possible.	
Brown recluse spider	Frequents areas of human habitation and prefer dark spaces. Found outdoors in sheltered corners, among loose debris; indoors on the floor and behind furniture. Take care when reaching into small, dark spaces. If bitten by a brown recluse, seek medical attention as soon as possible.	
Scorpions	Nocturnal, sensitive to vibrations. Not easily seen in the wild. Field boots are a favorite hiding place. Most scorpions are not dangerous and do not attack. The poison of most North American species is not lethal to humans, but scorpions do inflict a painful sting. Scorpion stings may not require medical attention.	
Ticks	Small, less than 3 mm (< ⅛ in) long. Clamp to hosts using a dart-like anchor located just below the mouth. Wear long pants and tuck pants legs into socks. Use a repellent containing DEET. Check for ticks during and after field work.	

(continued)

Table 11.4. Common wildlife hazards (continued).

Animal	Characteristics and Habitat	
SPIDERS, SCORPIONS, TICKS, BEES and WASPS (continued)		
Bees	Vary in size from 2 mm (0.08 in) to 4 cm (1.6 in) long. Locations vary from ground nests to trees and human-built structures. • Avoid beehives and wasp nests. • Scrape off the stinger with a knife or other flat object (e.g., a credit card). • Wash well with soap and water. • Use a cold pack to reduce swelling. • Apply an over-the-counter sting ointment or a solution of water and baking soda.	
Wasps	Vary in size from minute to 5 cm (2 in) long. Adults have a narrow waist between the first and second abdominal segments. **Habitat:** Locations vary from ground nests to trees and human-built structures. Members of a field team who are allergic to insect bites or stings should notify the rest of the team and should carry a sting kit for use in emergencies. Symptoms of an allergic reaction include pain, swelling of the throat, redness or discoloration in the area of the sting, itching, hives, decreased consciousness, and difficult or noisy breathing.	
ALLIGATORS and SNAKES		
Alligator	Found in swamps, rivers, and lakes, mainly in eastern and southeastern Texas. Treat alligators with extreme caution. Never approach an alligator on land or in water. During breeding and nesting season (April–May) alligators can be very aggressive. They can outrun humans for short distances. If sampling involves fish collection, get the specimens out and away from the water as soon as possible.	

Table 11.4. Common wildlife hazards (continued).

Animal	Characteristics and Habitat	
ALLIGATORS and SNAKES (continued)		
Cottonmouth (water moccasin)	Unlike other water snakes, swims with head well out of water. Never far from water. Most active at night, although may be seen sunning during the day. Found in lowland swamps, lakes, rivers, irrigation ditches, canals, and rice fields. Take care when electrofishing and seining near logjams, fallen trees, and undercut banks.	
Copperhead	Found in wooded hillsides with rock outcrops above streams or ponds, edges of swamps, and periodically flooded coastal plains; near canyon springs and dense river-cane stands along the Rio Grande. Favorite warm-weather habitats include stone walls, piles of debris, rotting logs, and large, flat stones near streams. Best defense is avoidance. Most snakes will go the other way unless unusually agitated or disturbed.	
Rattlesnakes	Found in arid and semiarid areas from plains to mountains; brushy desert, rocky canyons, bluffs along rivers, sparsely vegetated rocky foothills. When disturbed they normally stand their ground, lifting their heads well above the coils. The warning is a buzzing sound.	
Coral snake	Distinctly colored with wide red and black bands separated by a narrow, bright yellow band. Red and black bands never touch. At least two harmless snakes (the scarlet king snake and scarlet snake) have similar color patterns. Found in densely vegetated upland areas near ponds or streams in hardwood forests, and in rocky hillsides and canyons. Usually seen under rotting logs or leaves. Coral snakes must chew prey. The venom is a strong neurotoxin and bites can be fatal.	

(continued)

Table 11.5. Common plant hazards.

Plant	Characteristics and Habitat	
Poison ivy (poison oak)	Climbing poison ivy has alternate, trifoliate leaves with aerial roots that grow straight and are fuzzy. Found in most environments. Non-climbing poison ivy lacks aerial roots. The leaves are the same shape as those of climbing poison ivy, but are larger and broader. Vines without leaves can still cause a rash. If a piece of vine is used as firewood, the oily resins can be released into the air. People who breathe in the smoke and soot may develop serious inflammation of respiratory mucous membranes. The resin can also remain on unwashed clothing and equipment. Poison ivy and poison oak are two species in the same genus.	  

APPENDIX A

MONITORING RESOURCES ONLINE

Resource	Web Link
Ambient-water reporting limits	www.tceq.texas.gov/goto/crp/qa
Atlas of Texas Surface Waters	www.tceq.texas.gov/goto/gi-316
Boater safety	www.uscgboating.org/
Boater safety courses	www.tpwd.state.tx.us/learning/boater_education/
CRP guidance	www.tceq.texas.gov/goto/crp/guidance
CRP program resources	www.tceq.texas.gov/goto/crp/resources
CRP QAPP shell	www.tceq.texas.gov/goto/crp/qa
Continuous water quality monitoring information	www.texaswaterdata.org
Coordinated monitoring resources	www.tceq.texas.gov/goto/swqm/coord
Coordinated monitoring schedule	cms.lcra.org/
Conversion, online	www.onlineconversion.com/
Data Management Reference Guide (*DMRG*)	www.tceq.texas.gov/goto/swqm/dmr
Drought-monitoring guidance	www.tceq.texas.gov/goto/swqm/procedures
First aid online	www.mayoclinic.com/health/FirstAidIndex/FirstAidIndex
Fish-consumption advisories—Texas Department of State Health Services	www.dshs.state.tx.us/seafood/survey.shtm#info
Flow data online	USGS—statewide: waterdata.usgs.gov/tx/nwis/rt IBWC—Rio Grande Basin: www.ibwc.state.gov/Water_Data/Reports/RG_Flow_data.html
FlowTracker Handheld ADV® Operation Manual	www.tceq.texas.gov/goto/swqm/guides
Golden-alga information	www.tpwd.state.tx.us/landwater/water/environconcerns/hab/ga/
Guidance for Assessing and Reporting Surface Water Quality in Texas	www.tceq.texas.gov/goto/305_303
Hydrolab instrument and sensor manuals	www.hydrolab.com//web/ott_hach.nsf/id/pa_users_manuals_e.html
IDEXX water microbiology and quality certificates	www.idexx.ca/view/xhtml/en_ca/water/water-microbiology.jsf www.idexx.ca/view/xhtml/en_ca/water/certificates.jsf
Multiprobe instrument calibration logbooks—YSI and Hydrolab	www.tceq.texas.gov/waterquality/monitoring/swqm_forms-n-quality.html

Resource	Web Link
NELAC Accreditation	www.tceq.texas.gov/goto/labcred www.nelac-institute.org/
National Weather Service	www.nws.noaa.gov
Red-tide information	www.tpwd.state.tx.us/landwater/water/environconcerns/hab/redtide/
Seafood Safety Program—Texas Department of State Health Services	www.dshs.state.tx.us/seafood/
SWQM guidance, manuals, and procedures and interim changes	www.tceq.texas.gov/goto/swqm/guides www.tceq.texas.gov/goto/swqm/updates
SWQM forms for collecting and managing data	www.tceq.texas.gov/waterquality/monitoring/swqm_forms-n-quality.html
SWQMIS (water quality database—public access)	www.tceq.texas.gov/goto/swqm/reporting
SWQMIS forms	www.tceq.texas.gov/goto/wdmaforms
SWQM QAPP and QAP shell	www.tceq.texas.gov/goto/swqm/dataforms
SWQM monitoring station inventory	www.tceq.texas.gov/goto/crp/station
SWQM parameter descriptions	www.tceq.texas.gov/goto/swqm/parameters
TCEQ *Quality Management Plan*	www.tceq.texas.gov/goto/qa
Texas Parks and Wildlife—Scientific Collection Permit	www.tpwd.state.tx.us/business/permits/land/wildlife/
Texas Surface Water Quality Standards	www.tceq.texas.gov/goto/tswqs
Texas Surface Water Quality Standards—implementation	www.tceq.texas.gov/goto/swqm/implementing
Texas water data	www.tceq.texas.gov/goto/waterdata
U.S. Coast Guard, Lifesaving and Fire Safety Division	www.uscg.mil/hq/cg5/cg5214/
U.S. EPA Quality Assurance Guidance—EPA QA/G-4	www.epa.gov/quality/qs-docs/g4-final.pdf
U.S. EPA, *Method 1669: Sampling Ambient Water for Trace Metals*	www.epa.gov/waterscience/methods/method/inorganics/1669.pdf
USGS, *Measurement and Computation of Stream Flow*	pubs.usgs.gov/wsp/wsp2175/
Weather calculator	maps.redcross.org/website/weather/ARC_Calculators.html
YSI Instrument Manuals/Software (Ecowatch)	www.ysi.com/ysi/Support

APPENDIX B

GLOSSARY

acute toxicity	An indicator of the adverse effects on living organisms that result from single or multiple exposures to a toxic substance in a short space of time (usually less than 24 hours). See also **chronic toxicity**.
alkalinity	A measure of the acid-neutralizing capacity of water. Bicarbonate, carbonate, and hydroxide are the primary causes of alkalinity in natural waters. Concentrations are expressed as mg/L of $CaCO_3$.
ammonia-nitrogen (NH_3-N)	Ammonia, naturally occurring in surface water and wastewater, is produced by the breakdown of compounds containing organic nitrogen. It is commonly referred to as ammonia-nitrogen which indicates the relationship to total nitrogen.
biochemical oxygen demand (BOD)	A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.
BOD_5	The amount of dissolved oxygen consumed in 5 days by biological processes breaking down organic matter.
centroid	The midpoint of that portion of the stream width which contains 50 percent of the total flow.
channel	That portion of the landscape that contains the bank and the stream bottom. It is distinct from the surrounding area due to breaks in the general slope of the land, lack of terrestrial vegetation, and changes in the composition of substrate materials.
chemical oxygen demand (COD)	A measure of the oxygen required to oxidize all compounds in the water, both organic and inorganic.
chloride (Cl^{-1})	One of the major inorganic ions in water, especially wastewater. Concentrations can be increased by industrial processes. High chloride concentrations can affect metal objects and growing plants.
chlorophyll *a*	A photosynthetic pigment that is found in all green plants. Its concentration is used to estimate phytoplankton biomass (all of the phytoplankton in a given area) in surface water.

chronic toxicity	An indicator of the adverse effects on living organisms as a result of long-term exposure to a toxic substance (months or years). See also **acute toxicity**.
contact recreation	Recreational activities involving a significant risk of ingestion of water, such as wading, swimming, waterskiing, diving and surfing. A use protected by the TSWQS. *E. coli* (freshwater) and enterococci (saline waters) are used as indicators of potential waterborne pathogens. See also **indicator organisms**.
contaminant	Any physical, chemical, or biological substance or matter that has an adverse effect on water, air, or soil.
criteria	Water quality conditions that are to be met in order to support and protect desired uses.
cubic feet per second (ft^3/s)	A commonly used measure of the rate of flow.
decibel (dB)	A logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power) relative to a specified or implied reference level. Its logarithmic nature allows very large or very small ratios to be represented by a convenient number, in a similar manner to scientific notation. It is a dimensionless unit. Decibels are useful for a wide variety of measurements in acoustics, physics, electronics and other disciplines.
detritus	Decaying organic material.
dissolved oxygen (DO)	The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life.
ecoregion	A relatively homogeneous ecological area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.
eddy current	A circular water movement formed at the side of a main current. Eddies may be formed where the main stream passes obstructions (logs, rocks).
effluent	Wastewater (treated or untreated) that flows out of a treatment plant or industrial outfall (point source), before entering a water body.

epilimnion	The warmer oxygen-rich region of a lake or reservoir that extends from the surface to the thermocline.
estuary	A region of interaction between rivers and ocean waters near the shore, where tidal action and river flow create a mixing of fresh and salt water.
indicator organisms	*Escherichia coli* (*E. coli*) and enterococci are used as indicators of possible contamination by the fecal material of warm-blooded animals. Although generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Their presence in water suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might pose a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is tested for *E. coli* or enterococci instead. See also **contact recreation**.
inorganic	Lacking carbon.
nitrate-nitrogen (NO_3-N)	A compound containing nitrogen that can exist as a dissolved solid in water. Excessive amounts (>10 mg/L) can have harmful effects on humans and animals.
nitrite-nitrogen (NO_2-N)	An intermediate oxidation state in the nitrification process (ammonia, nitrite, nitrate).
nonpoint source	Any pollution source that is diffuse and does not have a single point of origin, or is not introduced into a receiving stream from a specific outfall. The pollutants are generally carried off the land by stormwater runoff. The commonly used categories of nonpoint sources are agriculture, forestry, urban, mining, construction, disposal, and saltwater intrusion.
nutrient	Any substance used by living things to promote growth. The term is generally applied to nitrogen and phosphorus in water and wastewater, but is also applied to other essential and trace elements.
oligotrophic	A water body characterized by few nutrients entering it, few shoreline aquatic plants (or none), and rare plankton blooms.
organophosphate pesticides	Pesticides that contain phosphorus; short-lived, but some can be toxic when first applied.

orthophosphate (O-P)	The most important form of inorganic phosphorus, making up 90 percent of the total. The only form of soluble inorganic phosphorus that can be directly used by plants, it is the least abundant of any nutrient and is commonly the limiting factor.
outfall	A designated point of effluent discharge.
pH	A measurement of hydrogen ion concentration used to describe the acidity or alkalinity of a solution. A pH value less than 7 is acidic, while a pH value greater than 7 is basic (alkaline). A pH value of 7 is neutral.
phosphorus	Essential nutrient to the growth of organisms and can be the nutrient that limits the primary productivity of water. In excessive amounts—from wastewater, agricultural drainage, and certain industrial wastes—it also contributes to the eutrophication of lakes and other water bodies.
point source	A specific location from which pollutants are discharged. It can also be defined as a single identifiable source of pollution (for example, a pipe or a ship).
salinity	The amount of dissolved salts in water, generally expressed in parts per thousand (ppt).
sediment	Particles or clumps of particles of sand, clay, silt, and plant or animal matter carried in water, which are deposited in reservoirs and slow-moving areas of streams and rivers.
segment	Waters designated by the TCEQ in the Texas Surface Water Quality Standards (TSWQS) that include most rivers and their major tributaries, major reservoirs, and lakes and marine waters. Segmented waters have designated physical boundaries, specific uses, and numerical physicochemical criteria (for example, DO, temperature, *E. coli*, chloride, sulfate) in the state's water quality standards.
specific conductance	A measure of the electrical current-carrying capacity, in microsiemens/cm (µS/cm), of 1 cm^3 of water at 25°C. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. Specific conductance is a measure of salinity in water. Salty water has high specific conductance. Also used to estimate total dissolved solids.
7Q2 (seven-day, two-year low flow)	The lowest average stream flow for seven consecutive days with a recurrence interval of two years, as statistically determined from historical data.

sulfate (SO_4^{-2})	An ion derived from rocks and soils containing gypsum, iron sulfide, and other sulfur compounds. Widely distributed in nature.
surface water quality standards	Established limits of certain chemical, physical, and biological parameters in a water body; established for the different designated uses of a water body (for example, aquatic life, contact recreation, public water supply).
total dissolved solids (TDS)	The amount of material (inorganic salts and small amounts of organic material) dissolved in water. Measured by laboratory analysis or estimated using specific conductance times a conversion factor, typically 0.65.
total hardness	The sum of the calcium and magnesium concentrations, expressed as calcium carbonate in mg/L.
total suspended solids (TSS)	A measure of the total suspended solids in water, both organic and inorganic. In laboratory terms it is defined as the portion of total solids retained by a filter.
volatile organic compound (VOC)	A substance containing carbon, hydrogen, and oxygen that easily becomes a vapor or gas.
volatile suspended solids (VSS)	The portion of the TSS that is lost after ignition. This represents the organic part of the TSS.

APPENDIX C

CONVERSION TABLE

ENGLISH TO METRIC				
Symbol	From ***English***	Multiply by	To ***Metric***	Symbol
LENGTH				
in	inches	2.54	centimeters	cm
in	inches	25.4	millimeters	mm
ft	feet	30	centimeters	cm
ft	feet	0.3048	meter	m
yd	yard	0.9	meter	m
mi	mile	1.609	kilometer	km
AREA				
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.0929	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.59	square kilometers	km^2
ac	acres	4047	square meters	m^2
ac	acres	0.4	hectares	ha
VOLUME				
fl oz	fluid ounces	30	milliliters	mL
pt	pint	0.47	liter	L
qt	quart	0.95	liter	L
gal	gallon	3.8	liter	L
ft^3	cubic feet	0.0283	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
cfs or ft^3/s	cubic feet per second	0.0283	cubic meters per second	m^3/s
cfs or ft^3/s	cubic feet per second	0.646	million gallons per day	mgd
mgd	million gallons per day	0.0438	cubic meters per second	m^3/s
mgd	million gallons per day	1.547	cubic feet per second	cfs or ft^3/s

TEMPERATURE				
°F	degrees Fahrenheit	5/9 (°F – 32)	degrees Celsius	°C
METRIC TO ENGLISH				
Symbol	From ***Metric***	Multiply by	To ***English***	Symbol
LENGTH				
cm	centimeters	0.4	inches	in
m	meters	3.281	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6214	miles	mi
AREA				
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	10.76	square feet	ft^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.3861	square miles	mi^2
m^2	square meters	0.0002471	acres	ac
ha	hectares (10,000 m^2)	2.5	acres	ac
VOLUME				
mL	milliliters	0.03	fluid ounces	fl oz
L	liters	2.1	pint	pt
L	liters	1.06	quart	qt
L	liters	0.26	gallon	gal
m^3	cubic meters	35.31	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
m^3/s	cubic meters per second	35.31	cubic feet per second	ft^3/s or cfs
m^3/s	cubic meters per second	22.821	million gallons per day	mgd
TEMPERATURE				
°C	degrees Celsius	9/5 (°C + 32)	degrees Fahrenheit	°F

APPENDIX D

ABBREVIATIONS

7Q2	seven-day, two-year low-flow
ALA	aquatic-life assessment
APHA	American Public Health Association
AWRL	ambient water reporting limit
BDM	blank dissolved metals
BH20	blank water
BHG	blank mercury
BMPs	best management practices
BOD	biochemical oxygen demand
BP	barometric pressure
BTM	blank total metals
°C	degrees Celsius
CFR	Code of Federal Regulations
cfs or ft^3/s	cubic feet per second
CH	clean hands
Cl	chloride
COD	chemical oxygen demand
CMS	coordinated monitoring schedule
CRP	Clean Rivers Program
CWA	Clean Water Act
dB	decibel(s)
DH	dirty hands
DI	deionized
DMRG	*Data Management Reference Guide*
DO	dissolved oxygen
DSHS	Texas Department of State Health Services
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
ft	feet
ft^2/s	square feet per second
HCl	hydrochloric acid
Hg	mercury
HNO_3	nitric acid
H_2SO_4	sulfuric acid
IBWC	International Boundary and Water Commission
IR	Integrated Report
IS	intensive survey
KCl	potassium chloride
LDO	luminescent dissolved oxygen
m	meter
µg/L	micrograms per liter
mg/L	milligrams per liter
mm	millimeters

mL	milliliter
mgd	million gallons per day
MPN	most probable number
MSA	monitoring systems audit
MSL	mean sea level
MSDS	material safety data sheet
NaOH	sodium hydroxide
NELAC	National Environmental Laboratory Accreditation Conference
NH_3	ammonia-nitrogen
NPS	nonpoint source
NWS	National Weather Service
$NO_3 + NO_2$	nitrate-nitrogen + nitrite-nitrogen
NOAA	National Oceanic and Atmospheric Administration
OP	orthophosphate
PELs	probable effects levels
PEPs	propellants, explosives, and pyrotechnics
PFD	personal flotation device
ppth	part(s) per thousand (salinity)
QA	quality assurance
QAP	quality assurance plan
QAPP	quality assurance project plan
QC	quality control
RWA	receiving-water assessment
SDM	sample dissolved metals
SHG	sample mercury
SLOC	station location
SNR	signal-to-noise ratio
SO_4	sulfate
STM	sample total metals
SWQM	surface water quality monitoring
SWQMIS	surface water quality monitoring information system
TAC	Texas Administrative Code
30 TAC …	Title 30, Texas Administrative Code, Chapter *or* Section…
TDS	total dissolved solids
TCEQ	Texas Commission on Environmental Quality
TKN	total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TP	total phosphorus
TPWD	Texas Parks and Wildlife Department
TSA	technical systems audit
TSI	trophic-state index
TSS	total suspended solids
TSWQS	Texas Surface Water Quality Standards
UAA	use-attainability analysis
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOA	volatile-organics analysis

VOC	volatile organic compounds
VSS	volatile suspended solids
WQS	water quality standards
σV	standard error of velocity

REFERENCES

American Public Health Association, et al. 1992. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association, American Water Works Association, and Water Environment Federation. 18th edition, Washington.

———. 2005. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association, American Water Works Association, and Water Environment Federation. 21st edition, Washington.

American Society for Testing and Materials. 2004. *Annual Book of Standards*, Vol 11.02. West Conshohocken, PA. [Standard Test Method for Enterococci in Water, D6503–99].

Carlson, R. E. 1977. "A Trophic State Index for Lakes." *Limnology and Oceanography* 22: 361–69.

Lane, S. L., and R. G. Fay. 1997. *National Field Manual for the Collection of Water-Quality Data.* TWRI Book 9. Chapter A9: "Safety in Field Activities." 5-60. Reston, VA: USGS.

Murphy, B. R., and D. W. E. Willis. 1996. *Fisheries Techniques.* Bethesda, MD: American Fisheries Society.

[a] Rantz, S.E., et al. 1982. *Meaurement and Computation of Streamflow.* Vol. 1. *Measurement of Stage and Discharge.* USGS Water Supply Paper 2175. Chapter 5: "Measurement of Discharge by Conventional Current-Meter Method." 79–183. Washington: USGS.

Stewart, R.H. 2008. *Introduction to Physical Oceanography*. Chapter 6: *Temperature, Salinity, and Density*. Department of Oceanography, Texas A&M University. Online textbook, available at <oceanworld.tamu.edu/home/course_book.htm>. Accessed February 28, 2012.

[a] Texas Commission on Environmental Quality. 2007. *Surface Water Quality Monitoring Procedures.* Vol. 2. *Methods for Collecting and Analyzing Biological Community and Habitat Data.* Austin: TCEQ publication RG-416.

[a] ———. 2010a. *Procedures to Implement the Texas Surface Water Quality Standards*. Austin: TCEQ publication RG-194.

[a] ———2010b. *Surface Water Quality Monitoring Program and Water Quality Assessment Program Quality Assurance Project Plan*. Rev. 13. Unpublished. Austin.

[a] ———. 2010c. *Texas Surface Water Quality Standards*. Title 30, Texas Administrative Code, Chapter 307.

[a] ———. 2011. *Surface Water Quality Monitoring Data Management Reference Guide* (*SWQM DMRG*). Unpublished. Austin.

[a] U.S. Environmental Protection Agency. 1996. *Method 1669 Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*. Washington. EPA publication no. 821R96011.

[a] ———. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process.* Washington. EPA publication no. 240/B-06/001.

[a] See Appendix A for URLs of publications available online.