# CHAPTER 2

# BIOLOGICAL MONITORING REQUIREMENTS

Biological organisms are collected and identified in a manner that, in most cases, permits an assessment of community composition and integrity. Most of this manual focuses on the collection and assessment methods for habitat (Chapter 9), freshwater benthic macroinvertebrates (Chapter 3) and freshwater fish (Chapter 5). It also addresses collection and assessment methods for saltwater nekton (Chapter 4), saltwater benthic macroinvertebrates (Chapter 6), benthic algae and aquatic macrophytes (Chapter 7), and plankton (Chapter 8); however, assessment methods for saltwater, lakes, and reservoirs are not as developed as those for freshwater streams. As estuarine, lake, and reservoir methods are developed or expanded to include assessment tools, they will appear in later revisions of this manual.

## Index Period

In order to determine ALUs or to evaluate support of existing ALUs, the TCEQ has established an *index period* during which most bioassessments of aquatic assemblages in freshwater river and stream (lotic) systems should be conducted.

The index period was established to:

- Minimize year-to-year variability resulting from natural events.
- Maximize gear efficiency.
- Maximize accessibility of targeted assemblages.
- Allow adequate time for completion, considering sampling requirements and potential environmental and logistical constraints.
- Make the most efficient use of available resources.
- Ensure that a portion of the samples is collected during critical low-flow and temperature conditions.

The index period represents the warmer seasons of the year from March 15−October 15 (see Figure 2.1). The index period is further broken down into the *critical period*, July 1−September 30. The critical period is the time of year when minimum streamflows, maximum temperatures, and minimum dissolved oxygen concentrations typically occur in Texas.

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| | | | ***Index Period*** | | | | | | | | | | |
| ***Jan*** | ***Feb*** | | ***Mar 15*** | ***Apr*** | ***May*** | ***Jun*** | ***Jul 1*** | ***Aug*** | ***Sep 30*** | ***Oct 15*** | | ***Nov*** | ***Dec*** |
| | | | ***Non-Critical Period*** | | | | ***Critical Period*** | | | ***Non-Critical Period*** | | | |

**Figure 2.1.** The index period.

## *Scheduling Biological Monitor Events*

The TSWQS establishes the criteria for water quality conditions that need to be met in order to support and protect designated uses (30 TAC, Chapter 307).

All bioassessment sampling for freshwater streams must be conducted during the index period of March 15 to October 15. **Note:** Two exceptions are RWAs, which are carried out as needed, and special studies, which are completed with specific seasonal objectives.

Collecting a portion of the samples during critical conditions (when water temperature approximates critical summer values) helps determine if the criteria set for the designated uses are being met and maintained when streamflow is at or above critical low flow.

**Note:** The assumption is that criteria met under these conditions would be met during other seasons when expected streamflow is greater and water temperatures are lower.

## General Sampling Guidelines

Before planning any specific biological monitoring event such as an RWA or UAA, refer to Appendix D, "Biological Fact Sheets," for detailed information on the required number of samples for that type of study.

When collecting only one sample, schedule the event during the critical period. If that is not possible, submit a written justification of why that objective was not met.

When collecting two samples at the same site during the same year, both samples must be collected during the index period—one in the noncritical period, and one in the critical period.

When collecting more than two samples at the same site, the study must be at least two years long with at least two samples collected per year—one event in the noncritical period and one in the critical period. At least half but not more than two-thirds of the events must occur during the critical period. No more than two-thirds of the total number of samples in the data set may be from any one year. Sampling events must be separated by at least one month.

### *Exceptions*

When the intent is to use sample results to assess use support (ALM, ALA) or to establish the appropriate use (UAA, RWA), bioassessment events should fall within the critical and noncritical portions of the index period.

However, strict adherence to these temporal guidelines may not always be feasible as a result of either normal or unusual variability of local flow and temperature. For example, during a year with abnormally high flows, critical low-flow and temperature conditions may not begin exactly on July 1, so the noncritical period might extend into early July. In situations such as these, when conditions preclude meeting exact calendar guidelines, consult the TCEQ SWQM Team or WQSG before adjusting sample regimes and explain any deviation from temporal guidelines in writing when submitting results.

## *Representativeness of Sites*

Select monitoring sites that best represent conditions of an entire water body for both biological and water quality. The reach must have a good variety of microhabitats to sample, such as a mixture of riffles, runs, and pools. Avoid selecting a reach where water quality and hydrology change dramatically over the reach, such as areas with a major tributary or contaminant source. RWAs are the only category of biological sampling that requires the reach to be located specifically in relation to the existing outfall or proposed outfall of a permitted discharge. Refer to the RWA section in this chapter for details on locating RWA reaches.

## *Site Reconnaissance*

Perform a reconnaissance of the water body and surrounding watershed before biological sampling begins at a site. Include an assessment of stream access, appropriate reaches for biological sampling, and site stability. Mark potential sites on a topographic map (7.5-minute series) before a reconnaissance trip. Determine stream reaches based on biological collection sites and habitat-assessment requirements. Adequate representation of the ecological community requires that a large enough distance of a stream site be evaluated. See Chapter 9, “Physical Habitat of Aquatic Systems,” for details on selecting a stream reach.

Make an effort to collect the sample at least 30 to 100 m upstream from any road or bridge crossing (depending on the size of the bridge and crossing) to minimize its effect on stream velocity, depth, and overall habitat quality.

There are situations in which the best sampling reach can only be accessed through private property. Obtain landowner permission before accessing any private property.

## *Sampling Conditions*

Collect all biological samples during stable, unscoured flow conditions, ideally when flow is at, or just above, the 7Q2 of a stream—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. If sampling a stream that is intermittent with perennial pools, the 7Q2 rules do not apply and sampling should proceed in the pools.

If stream conditions are not stable and do not reflect baseline conditions, reschedule the sampling event. Allow a minimum of two weeks of normal flow after a significant scouring event before collecting biological samples. If extreme weather conditions occur, such as significant drought or heavy rains, or if the stream has been dry, allow at least one month of normal flow before collecting biological samples. Use your best professional judgment to determine the appropriate sampling condition, since the return of the stream to normal conditions may depend on recruitment sources.

## *Low-Flow Monitoring*

In order to maintain continuity for TCEQ SWQM activities during periods of drought, guidance is available online to facilitate meeting monitoring commitments specified in the coordinated monitoring schedule (CMS):

<www.tceq.texas.gov/goto/swqm-procedures>

# *Other Monitoring Requirements*

## Documentation and Field Notes

Use a bound field-data logbook to record biological information in the field. Record general information, field measurements, and other field observations. General information includes:

- station ID
- location
- sampling date, time, and depth
- collector's initials and employer

Field measurements include physicochemical parameters and other measurements, such as flow. Field observations include:

**Water appearance.** Note color; unusual amounts of suspended matter, debris, or foam; and other similar observations.

**Water odors.** Note unusual odors, such as hydrogen sulfide, musty odor, sewage odor, and others.

**Weather.** Document meteorological events that may have affected water quality, such as heavy rains or cold fronts. Record the number of days since the last precipitation that was significant enough to influence water quality.

**Biological activity.** Excessive macrophyte, phytoplankton, or periphyton growth may be present. The observation of water color and excessive algal growth is very important in explaining high chlorophyll *a* values. Note other observations, such as the presence of fish, birds, amphibians, reptiles, and mammals.

**Stream uses.** Note stream uses such as swimming, wading, boating, fishing, irrigation pumps, navigation, and others.

**Watershed activities.** Note activities or events in the watershed that have the potential to affect water quality. These may include bridge construction, shoreline mowing, and livestock watering upstream.

**Sample information.** Make specific comments about the sample itself, such as number of sediment grabs or type and number of fish in a tissue sample—these comments may be useful in interpreting the results of the analysis. If the sample was collected for a complaint or fish kill, make a note of this in the observation section.

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

A field-data logbook must indicate whether data recorded in the logbook have been transcribed onto data forms.

## Creating New Monitoring Stations

Sites where biological data are collected should have a station number associated with the data. The TCEQ prefers that the station location be set at the point in the reach where the multiprobe for 24-hour data collection is deployed.

Procedures for generating a new monitoring station are found in Chapter 3 of the *SWQM Data Management Reference Guide* (*SWQM DMRG*), available online. 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). Check the list of existing stations before submitting a station location (SLOC) form for a new Station ID. A list of existing stations, arranged by basin, can be found online:

<www.tceq.texas.gov/goto/dmrg>

**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.

## Additional Latitude and Longitude Coordinates

In addition to the station coordinates, collecting the coordinates of the ends of the reach is strongly encouraged as well. Collect latitude and longitude coordinates using a global positioning system or geographic information system (GIS). For RWAs, collect the GPS coordinates at the existing or proposed wastewater discharge point as well. Specific GPS requirements for geolocational data appear in Chapter 3 of the *SWQM DMRG.*

## Non-Biological Parameters

Non-biological parameters such as flow, 24-hour DO, and water chemistry are integral parts of any biological assessment. Flow is always required with a biological assessment, whereas water chemistry samples and 24-hour DO measurements are required in some assessments and are strongly encouraged in others. Methods for these parameters may be found in *Surface Water Quality Monitoring Procedures, Volume 1: Physical and Chemical Monitoring Methods,* RG-415 (TCEQ 2012).

# *Monitoring Categories for Wadable Freshwater Streams*

Data collection requirements for ALM, ALA, RWA, and UAA categories are similar. The main differences are the frequency and duration of sample collection. Detailed requirements regarding sampling effort and required parameters for these four categories are found in Appendix D.

## ALM

ALM, a SWQM Program and CRP activity, is for selected routine monitoring sites. It is conducted to provide baseline data on environmental conditions or to determine if an ALU is being attained. Sites selected for ALM must be appropriate for biological monitoring as described in the “Site Representativeness” section of this chapter. Therefore, if a site historically monitored for routine water chemistry is chosen for ALM, every effort must be made to locate the best possible reach around that station for biological and habitat data collection. Data collected as part of an ALM are used for the State of Texas IR. Detailed ALM sampling requirements outlined in Appendix D.

### *Ecoregion ALM*

In the early to mid-1980s, the TCEQ and TPWD undertook to develop a more effective approach to establishing attainable conditions for aquatic life in Texas streams. Studies, such as *An Assessment of Six Least Disturbed Unclassified Texas Streams* (Twidwell and Davis 1989) and the *Texas Aquatic Ecoregion Project* (Bayer et al. 1992), established the utility of the ecoregion approach, which uses carefully selected, least-disturbed streams within the same ecoregion as water quality reference sites to estimate attainable conditions. Ecoregions are geographic regions of relative ecological uniformity and may be delineated at varying levels (Omernik, 1985). These studies identified minimally impacted reference streams in 11 of the ecoregions found in Texas.

#### Identifying Minimally Impacted Ecoregion Reference Streams

The process used to identify minimally impacted reference streams begins with the professional knowledge of TCEQ central-office and regional biologists, as well as information from other sources, such as river authorities, TPWD, and academia, to identify candidate reference streams in each ecoregion whose watersheds meet the following criteria:

- No, or very little, urban development.
- No significant or atypical point sources of pollution.
- No channelization.
- Characterized by perennial flow or perennial pools.

Mapping the watershed also allows determination of areal coverage and provides the information necessary to ensure that selected streams represent a range of potential watershed sizes. To this end, the TCEQ has identified three relatively broad drainage-basin-size categories, small (< 100 sq mi), medium (100–200 sq mi), and large (> 200 sq mi). Biological characteristics, such as species richness and trophic organization, vary according to watershed size, especially in the fish community (Karr et al. 1986; Vannote et al. 1980).

Conduct ground-truthing for candidate sites, where possible, across several access points within each watershed to verify conformity with the criteria described above, to confirm GIS land-use data, to identify local and unmapped disturbances within the watershed, and to ensure the availability of appropriate habitat for sampling the target group (for example, benthic macroinvertebrates and fish). The goal of the SWQM Program is to continue to revisit a subset of the population of minimally impacted ecoregion reference streams to refine biological and water-chemistry criteria and to document variability in biological and physicochemical characteristics over time.

## Aquatic-Life Assessments

ALAs are conducted on unclassified water bodies, not included in Appendix D of the TSWQS, that have previously been assessed and found not to support the presumed ALU. Unclassified waters are those smaller water bodies—such as small rivers, streams, and ditches—that are not designated in the TSWQS as segments with specific uses and criteria.

The presumed ALU for unclassified streams, not in Appendix D of the TSWQS, with the following flow types are:

- Perennial—High
- Intermittent with perennial pools—Limited
- Intermitent—Minimal

Classified water bodies refer to water bodies that are protected by site-specific criteria. The classified segments are listed and described in Appendix A and C of Chapter 307.10 in the TSWQS. The site-specific uses and criteria are described in Appendix A. Classified waters include most rivers and their major tributaries, major reservoirs, and estuaries. The purpose of an ALA is to confirm if indications of nonsupport are appropriate, and if necessary to identify more appropriate ALU and DO criteria. Appendix D details ALA sampling requirements.

Site and reach selection must ensure that adequate data are generated to accurately characterize biotic integrity through the entire study area. This will require at least one site, depending on the size of the water body. The number of sites needed to adequately characterize the water body must be negotiated with the WQSG. Sampling of multiple sites and reaches may be necessary for most water bodies.

Data collected as part of an ALA are used by the WQSG to determine if the water body is meeting its presumed high ALU designation. The result of this type of monitoring may lead to the development of a UAA to propose the appropriate site-specific ALU designation and DO criterion in the next revision of the TSWQS.

## Receiving-Water Assessments

RWAs are conducted on unclassified water bodies with existing or proposed wastewater discharges during a single study, on a specific reach of a stream, to assess their physical, chemical, and biological characteristics. Unclassified waters are those smaller bodies—such as small rivers, streams, and ditches—that are not designated in the TSWQS as segments with specific uses and criteria. RWAs are requested by the Water Quality Standards Implementation Team when the applicable ALU category for an unclassified stream has not been determined and cannot be adequately established from existing information. Generally, RWAs are conducted in response to a proposed amendment to an existing wastewater permit or before a new permit is issued. Data collected during an RWA are used to determine the appropriate ALU and DO criterion. RWAs are conducted on freshwater streams only.

RWA data are used primarily by the WQSIT for two TCEQ objectives—reviewing wastewater-permit applications and establishing site-specific standards. Within the Texas Pollutant Discharge Elimination System (TPDES), wastewater-permit applications are reviewed for potential water quality impacts on surface waters of the state. RWA data help the WQSIT assign appropriate ALUs and standards to water bodies potentially affected by proposed or existing wastewater discharges. By studying the area upstream of an existing discharge or downstream of a proposed discharge, it is possible to determine the appropriate ALU for a stream receiving wastewater effluent.

For discharges from existing wastewater treatment plants (WWTPs), the RWA must be conducted upstream from the discharge. A reach beginning approximately 30 m upstream of the discharge point is mandatory. If this area is not accessible, or is not representative of conditions downstream of the discharge, the reach may be further upstream where access is possible or conditions are more representative of the stream downstream of the wastewater discharge. For new wastewater permits for treatment plants that have not yet discharged, the RWA must be conducted on a reach immediately downstream of the proposed discharge point.

In addition, for WWTP dischargers that could potentially affect DO on other larger tributaries downstream of the discharge, RWA data must be collected on selected reaches downstream of those tributary confluences. Use Table B.1 in Appendix B to determine if other downstream tributaries need to be assessed. Typically, with larger wastewater plants, downstream tributaries will require assessment. In some cases, the receiving stream may be dry or have limited uses upstream of the outfall, but the impact zone may extend to the next Strahler stream order unclassified stream. In those cases, for an existing wastewater discharge, an additional RWA reach must be assessed upstream of the confluence of the secondary receiving stream. For new wastewater permits for treatment plants that have not yet discharged, an additional RWA reach must be assessed downstream of the confluence of the secondary receiving stream. Additional RWA reaches must be assessed if the impact zone extends into even larger unclassified streams. Figure B.8 (Appendix B) illustrates the RWA reach for an existing discharge of 3.6 million gallons per day into an intermittent and perennial stream. Figure B.9 illustrates the RWA reach for a proposed discharge of 3.6 MGD discharge into an intermittent and perennial stream. RWAs should be planned in consultation with the TCEQ's WQSIT to ensure that all necessary data are collected.

Ideally, RWAs should be conducted during summer low-flow conditions or the critical period (July 1 through September 30), but may be performed anytime during the index period. Occasionally, RWAs may have to be performed outside the index period because action on a permit is necessary. Whenever possible, RWAs must be completed six months before the wastewater-permit renewal or amendment. RWAs must be coordinated with representatives from other interested parties, such as wastewater permittees, TCEQ central and regional offices, the TPWD, and any other entities associated with the permit action. RWAs may serve as the basis for the development of a UAA on the unclassified water body at a future time. Detailed RWA sampling requirements are outlined in Appendix D.

## Use-Attainability Analyses

As part of the triennial revision of the TSWQS, UAAs are primarily used by the WQSG to review and set site-specific standards for water bodies. The purpose is to determine if the existing designated or presumed ALU and associated DO criterion are appropriate and, if not, to develop information for adjusting designated uses or criteria. UAAs require coordination with the WQSG. A UAA considers the physical, chemical, and biological characteristics of a water body, as well as economic factors to determine the existing and attainable uses. Completed UAAs are submitted to the EPA for technical approval. If approved, the changes are incorporated into the next triennial review of the TSWQS after public notice and full public participation.

Site and reach selection must ensure that sufficient sites and reaches are monitored to derive adequate data to accurately characterize the ALU for the entire study area. Sampling of multiple sites or reaches will be required for most water bodies. Land use–land cover analysis of the proposed sites is strongly recommended before selection of the sites. As each water body differs in the number of sites necessary to adequately characterize it, coordinate with the WQST to determine the appropriate number. Detailed requirements for UAA sampling appear in Appendix D.

## *Monitoring and Assessment of Large Rivers*

Collecting and assessing fish assemblages in predominantly large, runoff-dominated streams and rivers present substantially greater complexity and potential for problems than work in wadable streams. The scale of the systems and corresponding fauna and habitats can be quite different. Most major drainages in Texas begin within the state or just outside its borders, and drain into the Gulf of Mexico. Depending on the reach surveyed, large rivers and streams in Texas may be similar to wadable streams in terms of discharge and scale. However, most have significant reaches that are not primarily wadable, have substantial flow, and may pass through multiple ecoregions. Unlike smaller water bodies, which are normally replicated across a given region or basin, large rivers are typically unique (Emery et al. 2003).

The summer index period may not be appropriate in large rivers, depending on issues such as system hydrology including seasonal releases from reservoirs and irrigation withdrawals. Instead, sampling periods should be specific to the sites and collection methods and meet the objectives of the study. Before adjusting the index-period sampling strategy to better fit the system where work is being conducted, consult with TCEQ central-office SWQM personnel or the WQSG (or both). Reference streams may not be available, given human-induced modifications to larger waterways and the lack of streams of similar size and faunal composition. Aside from issues associated with establishing a comparative baseline, large streams and rivers require different equipment or application of equipment than wadable streams to adequately assess assemblages, and may require different assessment tools. Obtaining a representative sample can be difficult given the scale and distribution of habitat patches within large rivers, making reach selection extremely important.

Collection technologies appropriate for large rivers have varying limitations with regard to how each type of gear can thoroughly sample a single habitat or be uniformly applied to multiple habitats (Emery et al. 2003). In general, multiple types of collection gear must be employed to obtain a representative sample.

When analyzing biological data collected in large stream and rivers, consider that the assessment tools and regionalized indices of biotic integrity described by Linam et al. (2002) for nekton assemblages, and Harrison (1996) for benthic macroinvertebrate assemblages, are a starting point, but were designed for wadable streams (≤ 4th order). Thus, they may not apply directly in all situations and depend on the system being sampled. One potential test of the adequacy of wadable-stream sampling methods is whether at least 50 percent of the reach can be sampled by wading methods. Example methods include backpack electrofishing, seines, benthic kicknet, and Surber samplers.

Many reaches may be marginally wadable, whereas others are predominantly deep except for the stream margins. The former might be adequately sampled using a combination of a backpack electrofisher and seines for fish, and a kicknet for benthic macroinvertebrates as in the wadable-stream protocols, whereas boat electrofishing equipment for fish and snag sampling and near-bank sweep-net samples for benthic macroinvertebrates would be more appropriate in non-wadable sites. In the latter case, seines must still be used as a complementary tool for sampling.

Other kinds of gear may be required, depending on the objectives of the study and stream conditions. Example gear includes gill nets, hoop nets for fish, and artificial substrates, dredges, or snag samplers. Sampling duration may vary depending upon the system scale. The EPA has proposed 40 to 100 times the wetted stream width as a reach length for sampling in large streams and rivers. Simon and Sanders (1999) observed that 500 m was long enough to capture sufficient numbers of species to characterize biological integrity but not biological diversity in great rivers. The study objectives will influence the number of reaches sampled and sampling duration. Given the aforementioned complexity in sampling and assessment, personnel from the TCEQ must be consulted to determine the proper sampling regime and method for evaluating the samples if a study is anticipated on large, nonwadable streams and rivers.

## *Monitoring and Assessment of Lakes and Reservoirs*

The index period for sampling freshwater streams, as described above, may not be appropriate for lakes and reservoirs. In these types of habitat, the appropriate sampling period should be specific to the study and collection method. In general, the period of summer stratification—when water temperature is highest, the volume of suitable, well-oxygenated habitat is reduced, and inflows are usually lowest—will be considered the critical period. In these situations, a written explanation of how appropriate sample windows were established must be included with the results. For example, the TPWD procedures for assessment of inland fisheries allow for collection methods (boat-mounted elecrofishing, gill netting, and trap netting) during optimum conditions based on surface water temperature, fish ecology, and assessment needs. Electrofishing has a preferred surface water temperature range of 15.5°–23° C. This occurs in the fall (September through December) and in the spring (March through May). Gill netting is conducted from January through June. The gill-netting sampling period is based on fish ecology and assessment needs more than water temperature. Trap netting has a preferred surface water temperature range of 10°–18° C.

To date, there is limited guidance on assessing the biological and habitat integrity of lakes and reservoirs. The artificial nature of reservoirs complicates regulatory processes, as it may be difficult to determine the specific biological communities that correspond with designated ALUs. The TCEQ has well-developed guidance for assessing the biology and habitat in freshwater streams. There is a growing need for the same guidance in lakes and reservoirs. TPWD (2002) began preliminary work on developing procedures for assessing biological and habitat integrity of lakes and reservoirs. This work was prompted by concerns that some reservoirs or portions of reservoirs were not meeting designated ALUs based on DO concentrations. Reservoirs will continue to be a growing concern and a uniform approach to assessment of these water bodies will be an important regulatory tool.

In addition to the preliminary work in Texas, a few other states and the EPA have developed methodologies for assessing the biological integrity of lakes or reservoirs. The Ohio EPA developed a multimetric assessment for inland lakes or reservoirs—the Ohio Lake Condition Index (Davic and DeShon 1989). The Tennessee Valley Authority developed biological assessment methods for its reservoirs that use a similar approach to what has been developed for stream assessment (Dycus and Baker 2001). The EPA (1998) has also published a technical guide for the development of lake and reservoir bioassessment and biocriteria programs.

Before conducting any biological monitoring at a lake or reservoir, it is imperative to coordinate this work with the TCEQ and the TPWD. As methodologies and metrics are established, this manual will be updated to reflect those changes.

## *Categories of Saltwater Biological Monitoring*

The three categories of saltwater biological monitoring are ALM, ALA, and UAA. Each is designed to serve the same regulatory purpose as those for freshwater.

While the purposes for conducting these assessments in saltwater are the same as for freshwater, the protocols used to collect the data are quite different and, in many cases, are still under development. Additionally, standardized metrics for evaluating aquatic-life uses for saltwater bodies do not exist at this time. Before conducting any biological monitoring activities on a saltwater or tidally influenced water body, it is imperative to coordinate this work with the TCEQ WQST. As methodologies and metrics are established, this manual will be updated to reflect those changes.

## Tidal Streams and Estuaries

The biological monitoring process of tidal streams and estuaries for regulatory purposes is not clearly defined in Texas. When the water quality standards were originally formulated and codified, state environmental professionals ranked aquatic-life uses of tidal streams as “high” or “exceptional,” based on their best professional judgment. As development occurs along the coast, UAAs have begun for tidal streams. Additionally, a number of tidal streams being assessed are not meeting DO criteria. Important considerations for UAAs on tidal streams and estuaries include:

**Water quality sampling.** Instantaneous field measurements must be collected, including profiles, since the water column is often stratified due to temperature and salinity. Samples can be collected for analysis of routine water chemistry and carbonaceous biochemical oxygen demand, five-day ($CBOD_5$). Profiles and grab samples should be collected at depths specified in Volume 1 (RG-415).

**Flow.** Tidal-stream hydrology is very different from freshwater-stream hydrology. The multi-directional nature of these flows is critical to tidal stream and estuary communities. Technologies to measure multidirectional streamflows may be considered in order to derive information about the hydrology in these systems.

**Biological.** Important biological components of tidal streams and estuaries include nekton, benthic macroinvertebrates, zooplankton, phytoplankton, and macrophytes.

**Habitat.** Both instream habitat and riparian habitat must be considered for tidal streams. In estuaries, bottom structure and sediment must be sampled.

**Dissolved oxygen.** DO measurements, collected over a minimum of 24 hours, are important in tidal streams. The nature of the hydrology in these streams makes low DO concentrations more likely. Refer to Volume 1 (RG-415) for details on collecting 24-hour DO.

**Land-use and land-cover analysis.** This type of analysis derives valuable information about potential sources of pollution in a watershed and must be considered when doing biological assessments.

## Sampling Index Period

Marine and tidal systems may require adjustment of the temporal guidelines mentioned above to ensure that bioassessment events are conducted during an index period that meets the objectives of the study.

In general, the critical period for most tidal and marine systems is similar to that set out for freshwater streams—in late summer, when water temperatures are highest, inflows are lowest, and many tidal systems tend to stratify at times of greatest stress for estuarine biotic assemblages.

The noncritical portion of the index period may not be so easily defined and may be related to fish migration patterns, and periods of high runoff and inflow, as well as tidal patterns and temperature. Consult the TCEQ SWQM Program or WQSG before establishing the sample regime in these systems. Include a written explanation of how appropriate sample windows were established with results.