Site Selection

The main factors to consider in selecting a water-quality monitoring site are the purpose of monitoring and the data-quality objectives. All other factors used in the site-selection process must be balanced against these two key factors. Defining the purpose of monitoring includes making decisions about the field parameters to be measured, the period and duration of monitoring, and the frequency of data collection. Stream characteristics, site characteristics, and data-quality objectives determine whether a data sonde will be placed in situ (fig. 1) or whether a flow-through receptacle with a pump- ing sampler (fig. 2) will be a better choice. More site-specific considerations in monitor placement include site-design requirements, monitor-installation type, physical constraints of the site, and servicing requirements (table 1).

Table 1. Factors for consideration in the placement and installation of continuous water-quality monitoring systems.

Site characteristics
Potential for water-quality measurements at the site to be representative of the location being monitored.
Degree of cross-section variation and vertical stratification.
A channel configuration that may pose unique constraints.
Range of stream stage (from low flow to flood) that can be expected.
Water velocity.
Presence of turbulence that will affect water-quality measurements.
Conditions that may enhance the rate of fouling, such as excessive fine sediments, algae, or invertebrates.
Range of values for water-quality field parameters.
Need for protection from high-water debris damage.
Need for protection from vandalism.
Monitor installation
Type of state or local permits required before installation can begin.
Safety hazards relevant to monitor construction and installation.
Optimal type and design of installation.
Consideration of unique difficulties or costs of installation.
Logistics (maintenance requirements)
Accessibility of site, including parking or boat access.
Safe and adequate space in which to perform maintenance.
Presence of conditions that increase the frequency of servicing intervals needed to meet data-quality objectives.
For stream sites, proximity to an adequate location for making cross-section measurements.
Accessibility and safety of the site during extreme events (for example, floods or high winds).
Availability of electrical power or telephone service.
Need for real-time reporting.

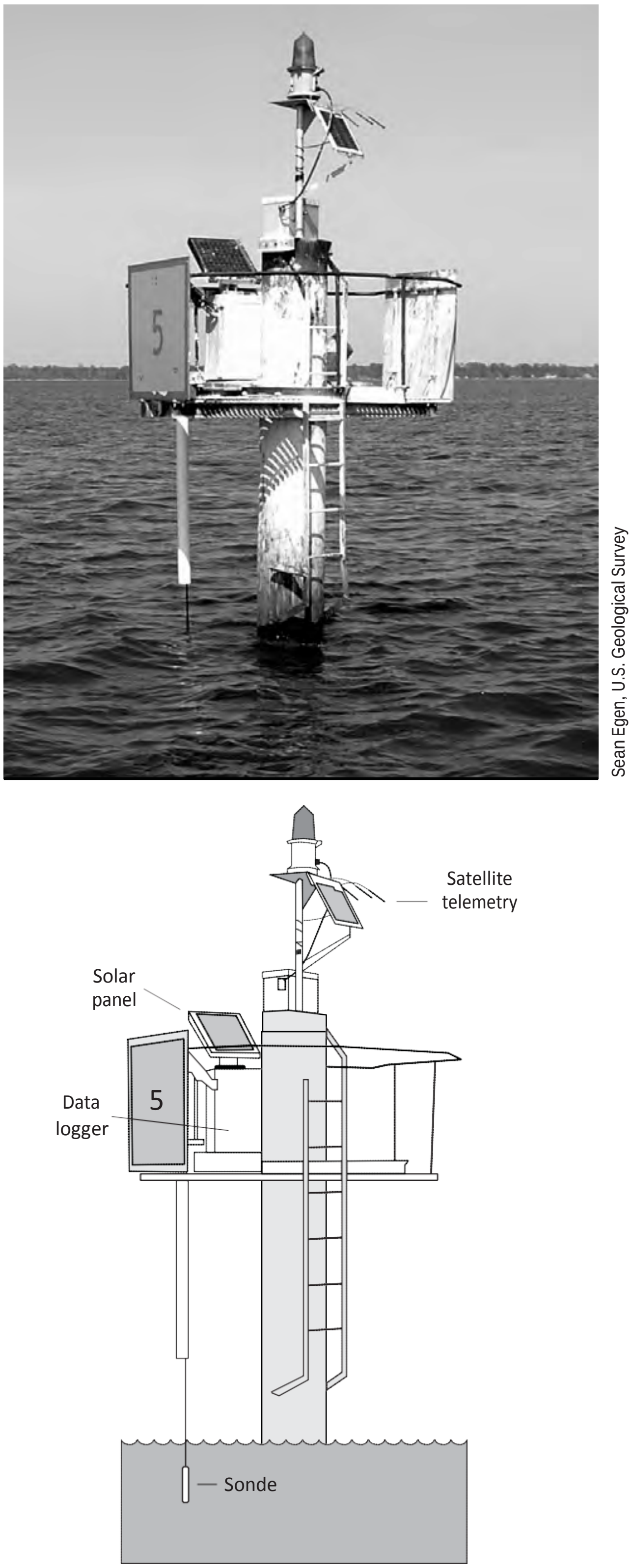

Figure 1. Light 5 on the Pamlico River near Bath, North Carolina, and schematic of in-situ water-quality monitoring station.

Once the purposes of monitoring and data-quality objectives are defined, balancing the numerous considerations for placement of a continuous water-quality monitoring system still can be difficult. Obtaining measurements representative of the water body usually is an important data-quality objective. The optimum site consideration for achieving this objective is placing the pump intake, sensor package, or sonde in a location that best represents the water body being measured. Thus, an optimal site is one that permits sensors to be located at a point that best represents the section of interest for the aquatic environment being monitored.

For streams, cross-section surveys of field parameters must be made to determine the most representative location for monitor placement. A site must not be selected without first determining that the data-quality objective for cross-section variability will be met. Sufficient measurements must be made at the cross section to determine the degree of mixing at the prospective site under different flow conditions and to verify that cross-section variability at the site does not exceed that needed to meet data-quality objectives. Additional cross-section measurements must be made after equipment installation to ensure that the monitor installation is representative of the stream during all seasons and hydrographic flow conditions.

Water-quality characteristics in lakes, bays, estuaries, or coastal waters also may be variable, making it difficult to find a single location that is representative of the entire water body. Sufficient measurement surveys of field parameters must be made to provide adequate confidence that the magnitude and spatial distribution of variability are understood. Vertical-profile surveys should be made in lakes, deep rivers, or estuaries. If substantial horizontal or vertical variability is determined, consideration should be given to choosing another site with less vertical or horizontal variability, or using a different approach to meet the data-quality objectives (see *Placement of Sensors in the Aquatic Environment*). For example, estuaries, lakes, or large rivers may be chemically or thermally stratified. Sensors or pump intakes at multiple depths may be a solution for providing adequate data in stratified bodies of water. Multiple sensors or multiple pump intakes for a flow-through monitoring system may be needed to meet the monitoring and data-quality objectives for measuring field parameters in deep lakes, estuarine sites, or other vertically stratified sites.

The best location for a monitoring site is often one that is best for measuring surface-water discharge. Although hydraulic factors in site location must be considered, it is more important to consider factors that affect water-quality conditions. The same hydraulic factors that must be considered when selecting a specific site for measuring discharge in a channel also should be considered in selecting a water-quality monitoring location. Both purposes require a representative site that approaches uniform conditions across the entire width of the stream. Rantz and others (1982) identified nine

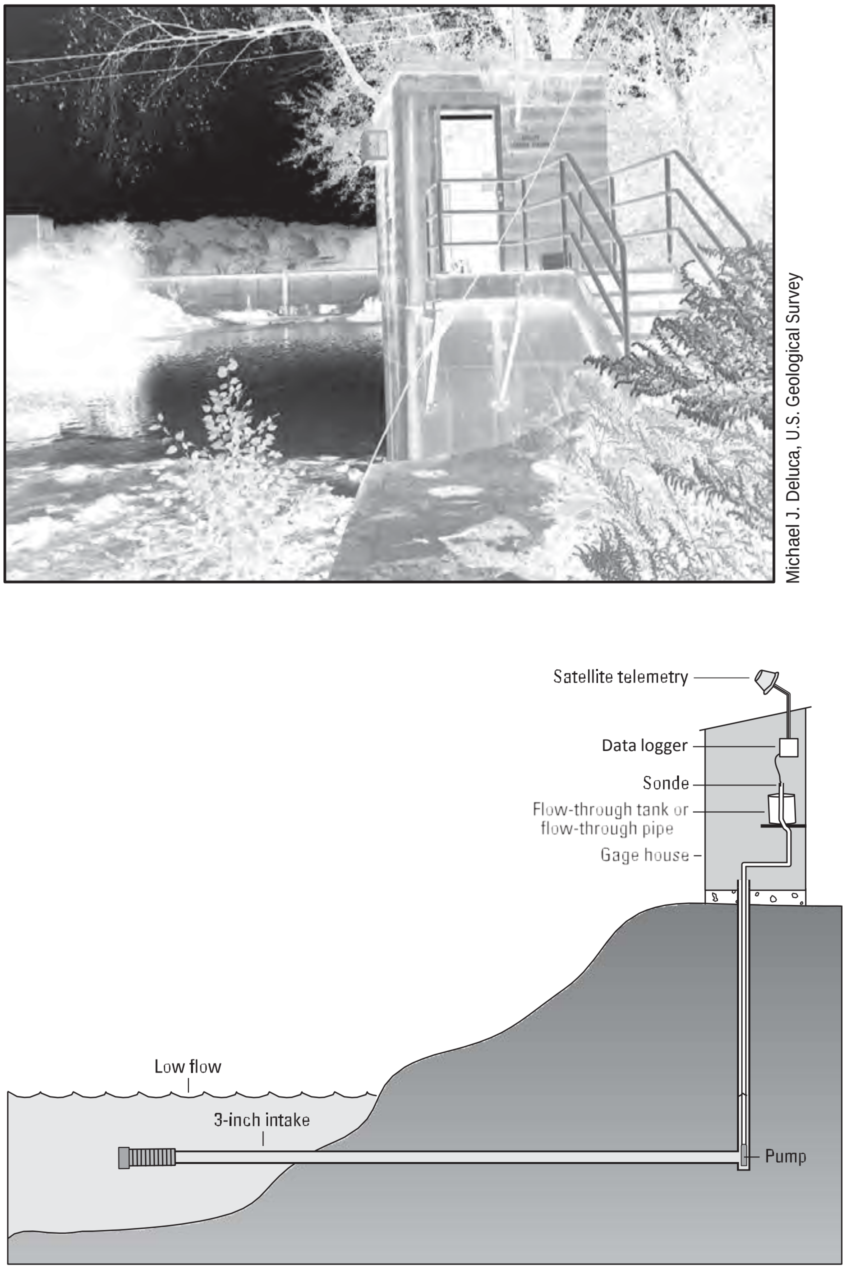

Figure 2. Ramapo River at Pompton Lakes, New Jersey, and schematic of flow-through water-quality monitoring station.

hydraulic conditions for an ideal gage site, and these also must be considered in site selection for water-quality sites (table 2).

Some aquatic environments may present unique challenges for optimal site location. Lateral mixing in large rivers often is not complete for tens of miles downstream from a tributary or outfall. Turbulent streamflow may aid in mixing, but turbulence can create problems in monitoring field parameters, such as DO or turbidity. A location near the streambank may be more representative of local runoff or affected by point-source discharges upstream, whereas a location in the channel center may be more representative of areas farther upstream in the drainage basin. Large streams and rivers usually are monitored from the downstream side of bridge abutments, assuming that safety hazards and other difficulties can be reduced or overcome.

The measurement point in the vertical dimension of larger flow systems also needs to be appropriate for the primary purpose of the monitoring installation. The vertical measurement point can be chosen for low-, medium-, or high-flow conditions; if bed movement or sensor location during low flow is a problem, consideration should be given to moving the sensors along the bridge to the optimal location. For a medium to small stream with alternating pools and riffles, the best flow and mixing occurs in the riffle portion of the stream; however, if flooding changes the locations of shoals upstream from the monitoring site, the measurement point may no longer represent the overall water-quality characteristics of the water body. Streams subject to substantial bed movement can result in the sensors being located out of water following a major streamflow event, or at a point no longer representative of the flow. A site may be ideal for monitoring high flow but not satisfactory during low flows. Site selection often is a choice of meeting as many of the applicable criteria as possible.

Assessment of a site also is dependent on fouling potential, ease of access, susceptibility to vandalism, and susceptibility of instruments or telemetry to interference from high-tension power lines or radio towers. The configuration and placement of water-quality monitoring sensors in cold regions require additional considerations in order to obtain data during periods of ice formation. White (1999) discusses environmental factors in the site selection of an automated water-quality station in British Columbia, Canada, but also generalizes morphological stream factors and the importance of selecting a site that has minimal chance of damage or destruction from natural forces and vandalism. White (1999) emphasizes that a site should (1) meet minimum stream-depth requirements for instruments, (2) be safe and accessible under all conditions, and (3) be located to avoid the danger of vandalism. Also emphasized is exposure to direct sunlight if optical sensors are deployed. White (1999) adds that sites should be selected based on program objectives and field reconnaissance under several flow conditions.

Table 2. Hydraulic conditions of the ideal gage site (modified from Rantz and others, 1982).

1.	The general course of the stream is straight for about 300 feet upstream and downstream from the gage site.
2.	The total flow is confined to one channel at all stages, and no flow bypasses the site as subsurface flow.
3.	The streambed is not subject to scour and fill, and is free of aquatic growth.
4.	Banks are permanent, high enough to contain flood waters, and free of brush.
5.	Unchanging natural controls are present in the form of a bedrock outcrop or other stable riffle for low flow and a channel constriction for high flow, or a falls or cascade that is not submerged at all stages.
6.	A pool is present upstream from the control at extremely low stages to ensure a recording stage at extremely low flow, and to avoid high velocities at the streamward end of gaging-site intakes during periods of high flow.
7.	The gaging site is far enough upstream from a confluence with another stream or from tidal effect to avoid any variable influence on stage at the gage site from the other stream or tide.
8.	A satisfactory reach for measuring discharge at all stages is available within reasonable proximity of the gage site. (It is not necessary that low and high flows be measured at the same stream cross section.)
9.	The site is readily accessible for ease of installation and operation of the gaging station.
10.	The site is not susceptible to manmade disturbances, nearby tributaries, or point-source discharges.