SOUTH CAROLINA ADOPT-A-STREAM VOLUNTEER TIDAL SALTWATER MONITORING HANDBOOK

ADOPT a STREAM

CENTER for WATERSHED EXCELLENCE
Clemson Public Service and Agriculture

dhec
Healthy People. Healthy Communities.

MAY 2021

SOUTH CAROLINA ADOPT-A-STREAM "WHO TO CALL LIST"

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If there is evidence of criminal activity, leave the area immediately and call local law enforcement.

If there is evidence of dangerous pollution discharges, fish kills, or public health hazards, call the DHEC Hotline at 1-888-481-0125.

For questions about monitoring techniques, contact your SC AAS Trainer ________________________

Please remember to take detailed notes on the following:

- Exact location: address or GPS coordinates,
- The nature of the issue,
- Date and time the issue occurred (or started),
- Pictures of the site.

Water quality parameters are sensitive to weather conditions, temperature, and rainfall. SC Adopt-a-Stream data are collected by trained citizen water quality monitoring volunteers. It is baseline, screening data for educational purposes, and is not used in any regulatory procedures.

ACKNOWLEDGEMENTS

The development of the SC Adopt-a-Stream program has been inspired by those who care enough about waterways and their future to take action. This program is for those volunteers and community leaders who are taking the time to teach others about ecosystem functions, values, and complexities of the marine ecosystem.

The SC Adopt-a-Stream State Team would also like to acknowledge and thank the many great programs that helped shape this SC Adopt-a-Stream Volunteer Tidal Saltwater Monitoring Handbook.

Charleston Waterkeeper,
NOAA Phytoplankton Monitoring Network,
Georgia Adopt-A-Stream led by Georgia Environmental Protection Division,
SC Department of Natural Resources,
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Virginia Citizen Water Quality Monitoring Program.

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South Carolina Department of Health and Environmental Control and Clemson University Center for Watershed Excellence recognize the integral role that citizen scientists play in collecting and sharing data towards the improved management of natural resources and are proud to offer you this program. This program is created for the volunteers; therefore, we thank these dedicated individuals and the Trainers that volunteer their time and expertise.

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TO PROMOTE AND PROTECT SOUTH CAROLINA'S WATERWAYS THROUGH CERTIFIED VOLUNTEER WATER QUALITY AND ECOSYSTEM MONITORING. -SC ADOPT-A-STREAM MISSION STATEMENT

1.1 INTRODUCTION

Welcome to the South Carolina Adopt-a-Stream (SC AAS) family. You are joining a team of like-minded individuals working to build awareness of watershed health and devoted to the improved management and protection of South Carolina's waterways and ecosystems.

South Carolina is blessed with fast-moving mountain and piedmont mountain streams, low country black waters and slow-moving streams, wetlands, estuaries and beaches, and the largest intact expanse of old growth bottomland hardwood forest remaining in the southeastern United States at Congaree National Park.

SC AAS provides the opportunity for those interested in the protection and improved management of South Carolina waterways to be directly involved in their monitoring and reporting. Volunteer monitors provide vital baseline data that complements local and state data used to determine the health of our waterways. In sharing this information about waterway conditions, volunteers, local communities, educators, and local government agencies can partner to protect and restore our waters. SC AAS trained volunteers have the potential to increase awareness within their own community of the relationship between pollution, watershed management, land use changes, and the personal responsibility of each individual within the watershed to be a better steward.

SC AAS operates in freshwater and saltwater systems. As a SC AAS Volunteer Monitor of tidal saltwater systems, you will be trained in Habitat Assessment and certified in Physical and Chemical Monitoring. There is also the option to become a part of NOAA's Phytoplankton Monitoring Network (see Chapter 5). In addition, SC AAS seeks to create a network of information and resource sharing, helping connect volunteers with equipment and information, as well as a mobile-friendly, secure database to share their water quality monitoring data. This handbook will serve as your reference for monitoring, as well as a resource for more information on why these monitoring data are meaningful to water resource management. Words in italics are found in Appendix 2, the Glossary.

PROGRAM LEADERSHIP AND FUNDING

SC AAS is co-lead by the SC Department of Health and Environmental Control (SC DHEC) and the Clemson University Center for Watershed Excellence (CU CWE). Initial funding was provided by SC DHEC, Clemson University Public Service & Agriculture, and US Environmental Protection Agency (EPA) Region 4.

There are many opportunities for organizations and communities to offer local support by providing sampling equipment, supplies, and program trainers, thereby helping to develop a program built for the volunteers.

What does it mean to ADOPT?

There are several goals of the SC Adopt-a-Stream program:

1. Increase citizen knowledge on water issues within their watershed.
2. Provide more information about waterways and potential sources of pollution.
3. Lead to a change in knowledge and behavior that begins with the responsibility to monitor a waterway and the health of its ecosystem.
4. Provide opportunities for watershed stewardship in action.

QUICK FACT

The concept of ADOPT comes from the following operations of SC AAS:

A for ACTIVE – SC AAS Volunteers are actively documenting waterway conditions and ecological health.

D for DATA –Through this SC AAS volunteer network, we are working in a consistent way to quantitatively describe river or estuarine health.

O for OUTDOORS – Understanding waterway health and human-nature interactions means getting outside!

P for PRESERVATION – Waterways are shared natural resources, and not just by humans! Quality data on less frequently monitored waterways can advise leaders on where to divert resources for improved management or preservation.

T for TOGETHER – Through this network and program resources, you as an individual volunteer are not working alone. You are working alongside members of your neighborhood, community, and watershed, and share useful data regarding our waterways.

1.2 LEVELS OF INVOLVEMENT

Levels of involvement have been developed for several purposes and meeting different training requirements.

1. Certified Volunteer – trained stewards that are certified to collect data according to the procedures outlined by the SC AAS program.
2. Certified Trainer – a network of mentoring and peer training, which increases partnerships with agencies, conservation organizations, and communities across the state.
3. SC AAS "Hub" – a coordinating entity that utilizes SC AAS in their programming and provides additional resources and mentoring to local volunteer monitoring groups. This may include the lending of kits, assisting with data interpretation, regularly hosting workshops, and more.

1.3 QUALITY OF PROGRAM AND DATA INTEGRITY

SC AAS is developed for educational purposes, first and foremost, and to provide additional watershed insights to resource managers at the local and state level. The consistency of trainings and resources, sampling protocols, duplicate samples, and calibration requirements ensure consistency and integrity of the data collected. In tidal saltwater systems, SC AAS trains and collects data under the following protocols and assessment, all contained within this tidal saltwater handbook.

PROTOCOL TYPE	PARAMETERS	MINIMUM FRQUENCY PER ACTIVE SITE
HABITAT ASSESSMENT	• Saltwater creeks, marsh, and estuary conditions • Presence or absence of estuarine animals and plants	Monthly
PHYSICAL/CHEMICAL	• Dissolved oxygen (DO) • Air and water temperature • pH • Salinity • Clarity	Monthly

SC AAS also partners with the National Oceanic and Atmospheric Administration (NOAA) and their Phytoplankton Monitoring Network (PMN) to assess the phytoplankton community, which records the presence of marine phytoplankton, as well as harmful algal blooms (HABs).

Each of these protocols include the recording of basic observations, including current and recent weather and precipitation, tide stage, water clarity, color and odor, presence of trash, conditions in and around the estuary, and photos. These observations, while they may appear minor, are critical to connecting conditions to monitoring results, and trends in data and stream management. In this way, citizen scientists are the eyes and ears of the estuary, documenting baseline conditions where no entity may be monitoring otherwise.

A Quality Assurance Project Plan (QAPP) ensures consistency of data collection, trainings, handbook, and program policies and procedures. The SC AAS Freshwater Monitoring Program QAPP was approved by US Environmental Protection Agency (EPA) Region 4 and SC DHEC in April 2018 and was amended to include the saltwater protocols. It will be regularly reviewed by collaborators and can be modified and resubmitted as this SC AAS program evolves and grows and is available at the SC AAS website, www.scadoptastream.org. The QAPP is an important reference document for the volunteer and trainer and guides SC AAS policies and operations.

USE OF DATA

While the screening level data generated by the program method does not meet the rigorous data quality requirements for SC DHEC regulatory decisions, it provides many benefits. Data collected by SC AAS Volunteer Monitors is used to establish baseline conditions for determining stream health based on chemical, physical, biological, and habitat parameters. Volunteer monitor's data will be useful in screening waterbodies for water quality problems, and in assessing the overall health of a watershed. This data may also be used to:

- Identify waterbodies in need of more detailed monitoring,
- Identify specific areas within a watershed in need of water quality improvement,
- Assist local watershed councils and partners in making environmental management decisions in their local and regional watersheds,
- Enlist community involvement in their local watershed,
- Prioritize areas in a watershed for Best Management Practices (BMPs),
- Assess BMP/remediation project performance,
- Identify potential pollution sources, and
- Provide educational and involvement opportunities for all interested in learning more about the health of their local waterways.

Identifying Your Monitoring Objectives

Volunteer monitors come to the program with different goals, and these goals may direct the protocol you select to seek training in and use. Or, you may want to seek training in all protocols, leaving no stone unturned! Keep in mind that monitoring a waterway is a long-term commitment. In very few and fortunate cases is a water quality concern solved with just a few data points. Therefore, let's consider why you want to become a SC AAS Volunteer Monitor to help determine what protocols may be the most suitable for your objectives.

SC AAS protocols are not intended for use monitoring stormwater ponds. Stormwater ponds are engineered systems, designed to retain and treat stormwater runoff, and not for recreation. They must be maintained by the owner, typically, the neighborhood or community association. Their ability to treat stormwater over time is highly dependent on regular maintenance. For more information, see Clemson Extension's stormwater pond website, https://www.clemson.edu/extension/water/stormwater-ponds/index.html.

WHY ARE YOU A MEMBER?

You are concerned that growth and development may be impacting this marine ecosystem.

The saltwater environment is changed more frequently by tides, storms, and anthropogenic changes in the landscape. Documenting conditions in the habitat assessment provides important clues as to stressors on marine life and in this sensitive ecosystem. Since the saltwater system is dynamic, the frequency of conducting this sampling event is monthly.

Further, high temperature discharges can be a pollutant when this results in warmer water conditions and impacts to organisms; these can be monitored using the Physical/Chemical Protocol. In addition, increased land being converted from farm and forest to impervious surfaces means more freshwater is being added to the estuary from rain events. This load of freshwater can lower *salinity* in receiving waters, affecting habitat conditions for animals living in tidal saltwaters.
The role of the citizen scientist is integral in maintaining healthy, viable ecosystems and waterways. The questions answered by citizen scientists working through this problem include:

- Is there a concern?
- Is the concern seasonal or year-round?
- How does this data compare with other nearby collected data?

You are concerned about the health of your watershed and want to see where smaller creeks may be impacting the larger watershed collection point.
This type of inquiry may require you to monitor more than one site, such as all feeder tributaries, but not necessarily require many protocols at first. The Habitat Assessment, which takes less than 30 minutes to perform, can be used to quickly record changing conditions. From this broader data gathering perspective, the volunteer can view trends in waterway corridor health, identify potential problematic inputs, then further narrow down a more specific protocol for those waterways to document physical, chemical, and other conditions.

This amount of more widespread data collection can inform neighborhoods and lead to the development of watershed organizations, building towards more collective resources, talents, and a motivated public watching and monitoring their local waterways.

You are concerned about flooding and impacts of a changing climate affecting storm patterns.
The Physical/Chemical protocol in SC AAS asks volunteers to photograph water height each time. Taking this photo at the same angle, from the same location each time can be useful in model calibration for flood risk modeling. You may also wish to install a staff gauge and record those quantitative observations. Further, the Phytoplankton Monitoring Protocol will also gauge changes in *plankton* community species and frequency and abundance of *harmful algal blooms* (HABs).

You often smell or observe irregularities in water conditions and feel that these instances are difficult to record, leaving you unsure of what to report and when to report these concerns.
There is no reason not to report suspicions or observations when it comes to illegal *discharges*, spills, and wastewater overflows. Your call can expedite response and action to protect the waterway and its creatures. Data and photos can provide further information for the responding resource managers.

The Physical/Chemical Protocol includes water temperature, DO, pH, *clarity*, and salinity. Establishing a baseline for these parameters across seasons will aid local resource managers with their assessment of potential problems.

If observations include the smell of sewer waste, or you have observed black water or staining coming from pipes discharging to the waterway, your entry of these oberservatons in the SC AAS Database will trigger an alert to local authorities, where they have signed up to receive such an alert, as well as SC DHEC.

All of us have surely smelled rotten eggs when exploring marshes and wetlands. This is evidence of sulfuric gas, which is natural in areas where vegetation is slowly decomposing amid changing water levels. This should be considered a natural odor in these marsh and wetland settings.

1.4 SC AAS VOLUNTEER CODE OF ETHICS

SC AAS Volunteer Monitors and Trainers represent this program with integrity, by doing the following:

- Following the SC AAS monitoring methods.
- Fully and accurately documenting observations.
- Reporting data directly to the SC AAS database.
- Representing SC AAS with integrity when performing monitoring and discussing the program with others.

It is also expected that certified volunteer monitors foster positive relationships with landowners, inviting all audiences to be stewards of our shared water resources, by:

- Seeking written permission to access private property, if necessary, to monitor a stretch of waterway.
- Always being clear and truthful in identifying themselves as a certified volunteer monitor of SC AAS, as well as the intended use of monitoring results.
- Making every effort to contact the landowner in advance with exact date(s) of sampling or an agreed upon monitoring schedule.
- Never misusing or harming private property.
- Taking extra precautions for everyone's personal safety when on private property.
- Making good faith efforts to regularly share results of monitoring with landowners.

Selecting Your Monitoring Site

SC AAS encourages you to identify the site, or sites, that best meet your objectives previously described, after first considering safety and access.

- Identify a site with easy access for you to carry equipment, and with a stable, clear location for you to set things down such as bottles, supplies, and more.
- Select a station where others have left off and not continued monitoring. You might be able to adopt that site and all of its historical data!
- Docks most often provide easy access to the estuary, though their presence modifies the natural stream setting.

1.5 SAFETY IS OUR FIRST PRIORITY

Practicing safe sampling begins during your monitoring site selection and underscores all field activities.

- Site selection includes the consideration of many factors – distance from vehicle, access, steepness of slope, history of flash flooding, year round flow, and more.
- Always use the "buddy system" and sample with your group or another volunteer monitor.
- Always alert someone else that you are going out into the field and approximately how long sampling should take.
- Use caution when approaching a waterway. **In the saltwater environment, no monitoring protocol requires walking into the waterway.** All procedures can be followed safely from the top of the bank along a creek or performed on a dock. This precaution is built into the protocols to avoid any harming of the marsh ecosystem and protection of the volunteer from oyster beds (cuts and scrapes) and pluff mud (getting stuck).
- Do not access water that is above your knees, as a general rule of thumb.
- Monitor during the day.
- Wear proper attire – closed toed shoes and enough clothing to protect your body from brush, insects, and UV rays.
- Be cognizant of signs of heat stroke and hypothermia and how to treat these conditions. Stay hydrated.

- Always be aware of your surroundings, including traffic, poisonous plants, stinging insects, slippery surfaces, loose rock (such as riprap), and other people.
- Use soap and water or hand sanitizer at the completion of monitoring and consider showering when you get back home or to the office.
- If you believe that your monitoring location has experienced significant or harmful contamination, do not sample. Please discuss these concerns with SC AAS State Team members. STOP monitoring if you witness any illegal or suspicious discharge entering the waterway.

Working as a Team

Whether you join SC AAS as an individual, a family, a church, or group of neighbors, for safety's sake, monitoring should always be completed by more than one person. Therefore, Groups can be named, registered, joined, and identified in the SC AAS Database. After registering in the database, joining or registering a Group is the absolute next step before registering a Site. While others may accompany you, only Certified Volunteers and Trainers are recorded in the database as present during monitoring and in the Group profile.

While the safety of volunteers is of the highest priority in SC AAS, working amongst a Group comes with many other benefits. These include discussing observations and ratings, drawing conclusions together about what is happening at your monitoring site, inviting more people to the SC AAS program and to become stewards of our watersheds, and adds credibility to the data being recorded. During or following the monitoring event, only one member of the onsite Group enters the Site's event data and results; however, all present members of the Group have the ability to edit that Site's results.

CONDITION	DEHYDRATION	HEAT STROKE	HYPOTHERMIA
SIGNS AND SYMPTOMS	• Increased thirst • Dry mouth • Overly tired • Headache • Decreased urine output • Dizziness	• High body temperature • Flushed skin • Rapid breathing • Headache • Alteration in sweating	• Shivering • Slurred speech • Weak pulse • Clumsiness • Slow, shallow breathing • Confusion
WHAT TO DO	• Replace fluids with water, juice, or sports drink. • Drink extra (2 quarts) of cool liquids in the next 2 to 4 hours.	• Call 911 • Apply ice packs to the person's armpits, groin, neck, and back. • Immerse the person in shower, tub, or pool of cold water.	• Restore warmth slowly. • Bring person indoors. • Give warm fluids. • Keep body temperature up.

CHAPTER END

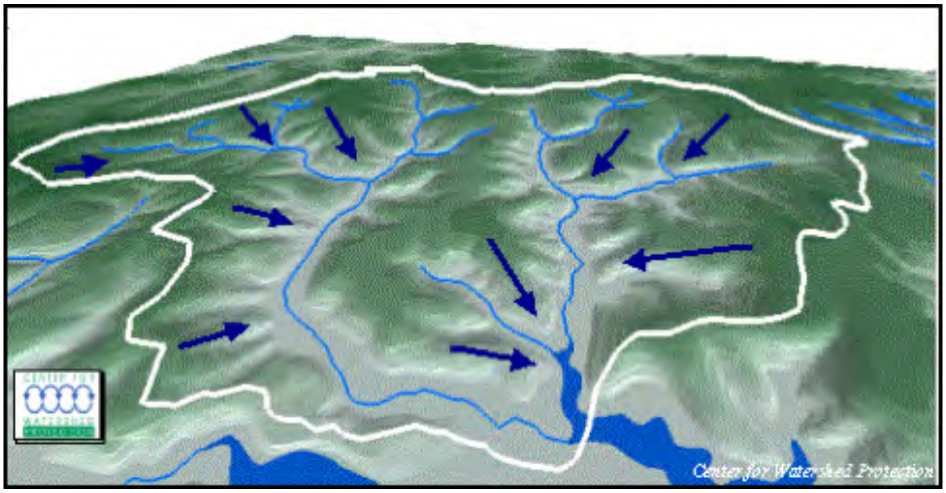
CH.2: WATERSHEDS AND WATER MONITORING

2.1 INTRODUCTION

A watershed is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a river's channel. The word watershed is sometimes used interchangeably with drainage basin or catchment. Ridges and hills that separate two watersheds are called the drainage divide. Rain and runoff from these divides drains to the streams in the watershed, as shown in the following figure. Larger watersheds contain many smaller watersheds, leading to an outflow point. All of the land that drains water to the outflow point is the watershed for that outflow location. Understanding the boundaries of your watershed and how it is affected by the larger watershed provides you insights on how land use, permitting, and other occurrences in the watershed may result in changes in your data and observations at your site(s). Watersheds rarely align with city or county boundaries.

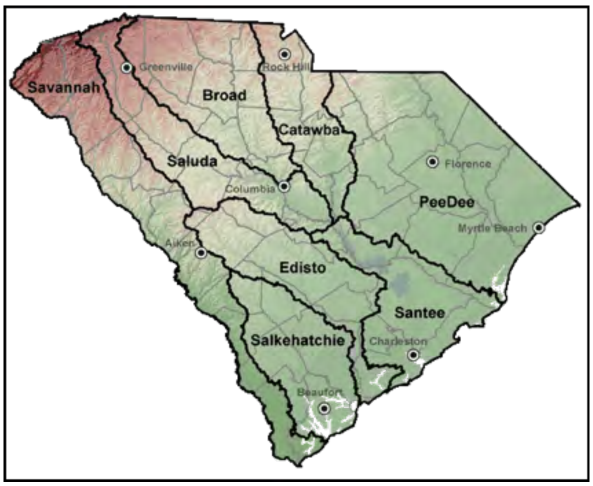
There are eight major river basins in South Carolina: the Savannah, Saluda, Broad, Catawba, Pee Dee, Edisto, Santee, and Salkehatchie. Of these, the Savannah, Pee Dee, Edisto, Santee, and Salkehatchie include coastal waterways.

Basins are subdivided into smaller basins. Each watershed is identified by a unique Hydrologic Unit Code, or "HUC." HUCs are useful in identifying which watershed you want to consider as you plan to monitor. Within the HUC system, the United States is divided and subdivided into successively smaller watersheds or basins. As the watershed area gets smaller, the unique HUC numbers get longer.



Direction of Water Flow in a Watershed (Center for Watershed Protection)

Let's look at this example from the Salkehatchie River Basin:



Major River Basins of South Carolina

Salkahatchie River Basin, at greater than 1.8 million acres in size, is identified as 030502, a 6-digit HUC.

It is further subdivided as the Combahee River Basin, 03050207, identified by its 8-digit HUC.

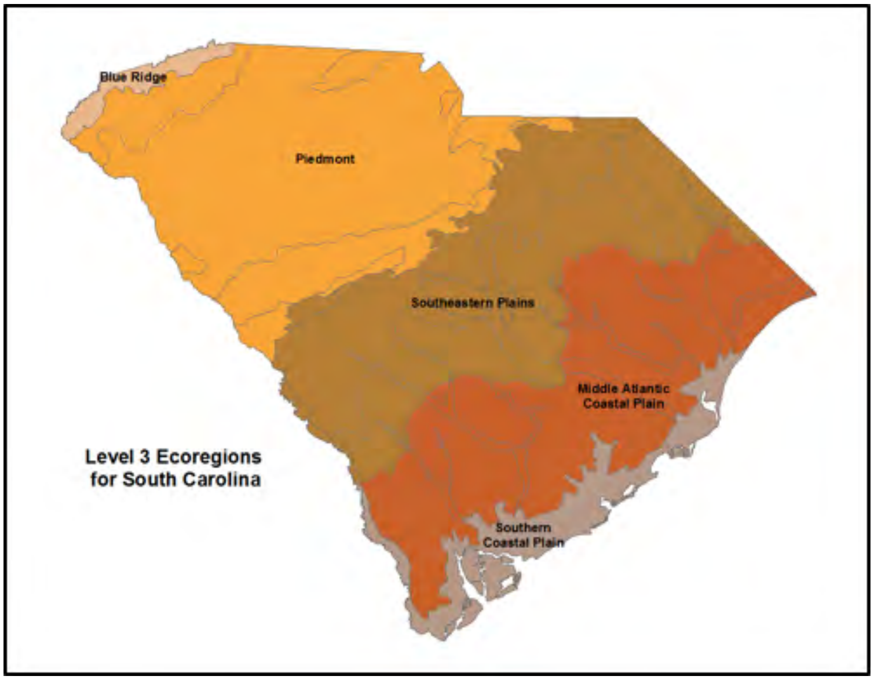
Within the Combahee River Basin, a smaller watershed is the Coosaw River-Port Royal Sound, HUC 0305020711, a ten-digit HUC.

The Major Basin of the Salkahatchie River is subdivided into 8-digit HUCs in the image below left.

The SC AAS Database organizes sites by 8-digit HUC.

The Ecoregions of South Carolina

An Ecoregion is a large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions. This includes geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology. South Carolina is divided into five (Level 3) Ecoregions, which will affect the stream habitats and parameters you are monitoring. For example, it is in the Blue Ridge and Piedmont Ecoregions that you will encounter natural rocky bottom streams. In the Southeastern and Middle Atlantic Coastal Plains, you will encounter black water streams with naturally lower pH and DO levels.



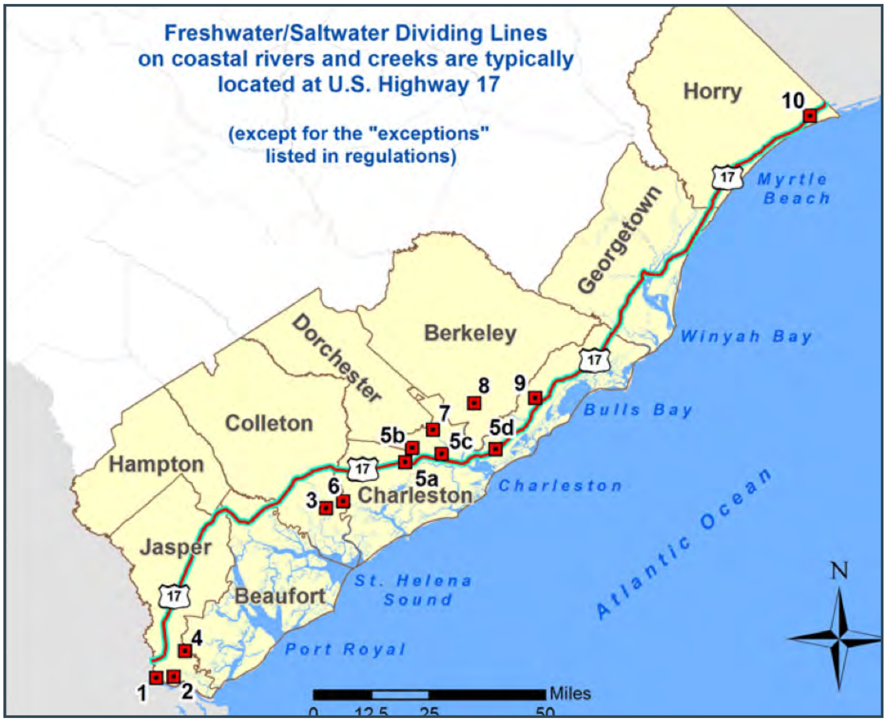
Level 3 Ecoregions of South Carolina

Establishing Tidal Saltwaters

A freshwater/saltwater dividing line is really not definable, as there is a transition zone between the two waters. This zone will shift inland with rising tides and moon phase, and oceanward with heavy rain events. The definitive factor of whether or not you are in a tidal saltwater or freshwater waterbody is the salinity reading.

- **If your refractometer reads 0.5 ppt or greater, it is a saltwater habitat.**
- **If your refractometer reads under 0.5 ppt, you are in freshwater.**

A very rough estimate of the freshwater/saltwater boundary is Highway 17 in South Carolina's coastal counties.



Highway 17 stretches through all coastal counties of South Carolina and is a rough estimate of freshwater and saltwater divide.
Credit: SC DNR

2.2 ASSESSING THE HEALTH OF TIDAL SALTWATER SYSTEMS

Nationwide, half of our US population lives in coastal areas (US EPA, 2006). SC now has a population greater than 5 million persons and a steady growth rate over 1% statewide each year since 2012. The coastal counties have experienced a much greater rate of growth, with Horry County growing over 14% from 2010 to 2015, followed by Berkeley (13%), Jasper (12%), and Charleston (10%) counties (US Census Bureau, 2019). This growth is also closely tied to new industries relocating and growing in coastal SC.

In the past two centuries, human activities have had a significant affect on water quantity and quality. Point and nonpoint source pollution contribute to water quality problems. Point sources (regulated discharges) have been the focus of regulatory oversight for decades, which has resulted in significant improvements in water quality. Nonpoint sources are now a substantial detriment to achieving designated uses for our state's streams and rivers. SC AAS volunteers can play an important role in tracking and monitoring water quality and sharing information about local water resources with their communities. SC AAS Protocols provide important information and observations related to tidal saltwater conditions that can be assessed further by resource managers.

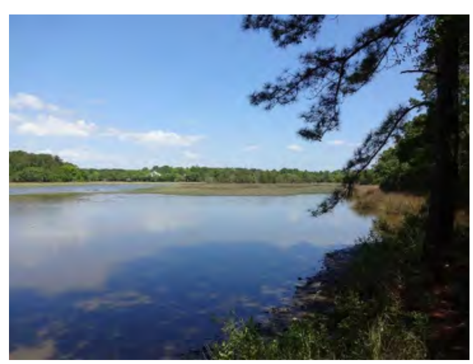
The salt marsh-tidal creek ecosystem is a highly productive coastal wetland that occurs between upland areas, such as forests and urban environments, and estuaries, where fresh and salt water mix. The surface of the salt marsh is under water at high tide and dry at low tide. A finger-like network of tidal creeks winds through the marsh allowing for the movement of tidal water onto the marsh surface and back into the estuary. South Carolina, North Carolina, and Georgia together have approximately 575,000 acres of salt marshes and tidal creeks, supporting nearly two-thirds of salt marsh habitat found along the east coast.

Salinity, DO, and Tides

The plants and animals of this ecosystem are adapted to changes in conditions that occur hourly, daily, seasonally, and annually. The major physical variables influencing the salt marsh-tidal creek ecosystem includes tides, salinity, sediments, air and water temperature, precipitation, and sunlight. *Salinity* is the measure of dissolved salts in water, typically reported in parts per thousand (ppt), and is the major determining factor in plant and animal distribution and changes from a freshwater environment to saltwater. Freshwater has a salinity of 0 parts per thousand (ppt), and the Atlantic Ocean is 36 ppt. As you travel up-river, salt marshes and tidal creeks have a lower salinity of around 5-10 ppt. Closer to the ocean, salinities range from 20-35 ppt.

Low Tide

Salinity also influcences the saturation level of DO. As salinity increases (for example, as a river moves towards the ocean), the amount of DO that the river can hold decreases. Tidal creeks naturally have low and fluctuating oxygen levels. The low oxygen is thought to keep out the larger predators, making creeks and marshes good nursery habitat for smaller organisms that can withstand lower oxygen levels. Salinity and its dissolved salts also affect turbidity, thus affecting temperature. Cold, saltwater is denser than warm freshwater and will sink below the freshwater. This stratification is critical to habitat and species diversity in the estuarine environment.



High Tide

The Southeastern salt marsh-tidal creek ecosystem has *semi-diurnal tides*, meaning they experience two high tides and two low tides each day, each lasting about six hours. Tides result from the gravitational pull of the moon and the sun on the earth's oceans. Approximately twice a month, around the new moon and full moon, tides reach their maximum height (spring tides). When the moon is at the first quarter or third quarter, the tide's range is at its minimum height (neap tides). Tides continually move salt water into and out of salt marsh-tidal creek systems. On flooding tides, the marshes and creeks are flooded with higher salinity water, as well as fine sediments and nutrients. During periods of heavy rainfall and ebbing tides, the creek and marsh can be inundated with freshwater, decreasing salinity. Salinity is a major factor determining which plant and animal species will successfully inhabit the salt marsh-tidal creek ecosystem.

Tidal creeks are a pathway for stormwater runoff to travel from the upland to the open estuaries. These creeks, some nearly dry at low tide, are particularly important nursery areas for many species of fish and invertebrates. These creeks provide an abundant food supply and give juveniles protection from predation as well as access to the marsh at high tide. The low marsh and tidal creek zones are the predominant areas where pluff mud occurs, particularly along the edges of creeks. Pluff mud gives off the characteristic "rotten egg" sulfuric smell many quickly associate with salt marsh-tidal creek systems. While the odor seems foul to some, it is actually a healthy indicator of a process called anaerobic (without oxygen) respiration. Anaerobic respiration uses sulfates from the water and releases hydrogen sulfide into the mud, creating that sulfuric odor. Certain bacteria and fungi in the mud thrive in low oxygen environments, as do clams, fiddler crabs, and small worms which have adapted to live in low oxygen environments. Mud flats are intertidal, non-vegetated, soft sediment habitats occurring in the areas of tidal creeks with weaker currents. Fine sediment particles tend to accumulate in these areas and form muddy intertidal habitat. Sand flats are intertidal, non-vegetated environments that occur in areas with stronger currents. Sand particles tend to accumulate in these areas and form sand bars. Sand and mud flats are inhabited by abundant populations of burrowing clams, crustaceans and worms, and are important feeding grounds for shore and wading birds, fish, crabs, and rays.

Animal tracks through pluff mud. Credit: SC DNR

One of the most recognized habitats in the salt marsh-tidal creek ecosystem is the oyster reef. Spawning peaks from April to October and is dependent upon temperature and food availability. Early life stages are free floating in the water as plankton, but the final larval stage must attach to a hard surface and transform into a small oyster, called spat, before it can continue to mature. Most often, the shells of other oysters, dead or alive, turn out to be the best solid surface for attachment.

The tides are also important in controlling the water quality of tidal creeks and salt marshes. South Carolina exhibits large tides with the constant movement of water in and out twice per day helping to flush the system. The salt marsh-tidal creek ecosystem, particularly vegetation along creek banks and oyster reefs, acts as a barrier that helps to reduce wave energy and current velocity. The natural buffering of the salt marsh helps protect upland areas and private property from flooding and erosion during storms. Without healthy salt marsh-tidal creek habitat, it is unlikely Southeastern fisheries would be as productive and as important to our economy as they are today.

Nutrients and Sediment

Salt marshes and tidal creeks provide us with a wealth of benefits, referred to as ecosystem services, including protecting us from flooding and erosion, providing nursery and essential habitat for commercial and recreational fisheries, and supporting recreational activities that have become part of the coastal lifestyle. One of the most important benefits the salt marsh-tidal creek ecosystem provides is maintaining healthy water quality. Poor water quality can be a result of excess nutrients, toxins, and/or suspended sediment. A healthy salt marsh has the ability to greatly reduce these pollutants. Excess nutrients and chemicals are filtered out and can be taken up by *Spartina* plants and stored in their roots as well as broken down by bacteria in sediments. Nutrients, such as nitrogen, phosphorus, silica, calcium, carbon, potassium, and magnesium are natural and needed for plant and algal growth and reproduction. For the purposes of this handbook, nutrients will refer to phosphorus and nitrogen due to their concern in the aquatic environment. Nutrients come from many sources, natural and unnatural. In the aquatic environment, nutrients can enter waterways as leachate from septic systems, fertilizer runoff (from agriculture, golf courses, and commercial and residential properties), and stormwater runoff, in general. Nutrients are only a pollutant when excessive amounts of nutrients result in a condition known as nutrient enrichment.

Sediments in the water are also an important component of the tidal creek-salt marsh system. In general, the estuarine waters of South Carolina, Georgia, and Northeast Florida have higher sediment levels (or turbidity) than North Carolina and Southeast Florida. The sediment can keep sunlight from penetrating through the water. This is likely why true sea grasses are not found in South Carolina and Georgia, but are found in North Carolina and Southeast Florida. Suspended sediments are also important in sustaining the surface elevation of the marsh and in their pollutant processing functions. Pollutants will often adhere to the sediments in water and settle on the marsh surface due to the drag of the plant stems. Some sediment is good to sustain the marsh elevation, but too much can limit sunlight penetration and decrease photosynthesis rates.

Temperature

Temperature is an important measure of the health of a river and its ability to serve as a functioning ecosystem. Water temperature has a significant impact on its inhabitants. Warmer temperatures may increase fish vulnerability to disease, toxins, and infection; play into the toxicity of ammonia in surface waters; and affect the rate of photosynthesis by aquatic plants. Reproductive stages of fish, spawning, and embryo development are highly sensitive to fluctuations in water temperature over the course of each day and over several days.

Parking lots that are directly connected to a storm drain. like this one here, can lead to heated runoff entering waterways.

Transparency (Clarity)

Transparency, or clearness of the water, is a measure of light penetration into the water column. This measurement is affected by both color and suspended materials. While clarity and transparency can be used interchangeably, *turbidity* is a different measure. Turbidity is the cloudiness of water, determined by measuring how suspended material in the water column affects light penetration (think of smoke in air). Turbidity may be described as murky or cloudy, for instance, and is measured in NTUs. Suspended materials may include soil, algae, phytoplankton, and more.

Together, these measurements are important determinations of the river's ability to thrive, regulate temperature, and provide suitable and sustained habitat.

Bacteria

The SC AAS tidal saltwater program does not include bacteria as there is no easy and inexpensive method for citizens to monitor for Enterococcus, the parameter that is used to establish bacteria regulations in saltwater systems. Enterococcus bacteria determine if the water is safe for recreational uses; fecal coliform bacteria are used to determine shellfish harvesting safety. SCDHEC has a shellfish monitoring program, as well as a beach monitoring program. To learn more about the shellfish program visit https://scdhec.gov/food-safety/shellfish-monitoring-program-overview. To learn about beach monitoring visit https://scdhec.gov/environment/pollution-types-advisories-monitoring/pollution-services-advisorie/beach-monitoring. For summer beach swim advisories, visit https://gis.dhec.sc.gov/beach-access/, as well as checkmybeach.com.

* The SC DNR *Guide to the Salt Marshes and Tidal Creeks of the Southeastern United States* serves as reference for content included in Section 2.2.

2.3 GETTING TO KNOW YOUR WATERSHED

Using the Watershed Atlas

You may have an idea of a saltwater body near you that you would like to adopt. Before you head out, you can learn more about it by using SC DHEC's Watershed Atlas available at https://gis.dhec.sc.gov/watersheds/. This web application brings the Agency's comprehensive watershed and water quality information into a user-friendly, statewide map application with more than 90 data layers. The searchable Atlas includes watershed descriptions, water quality assessments and trends, use support, monitoring sites, permitted facilities, permitted stormwater discharge by city, county, or other (known as MS4s, or multiple separate storm sewer systems), water intakes, discharges, base map options, and more. The Watershed Atlas is designed to provide enhanced access to timely information from DHEC's water programs in a user-friendly format, and it is regularly updated as new data becomes available. After customizing the map of your watershed, you can print it and bring it along on your driving tour.

Watershed Tour

With your watershed map in hand, you are ready to "hit the road." Taking the time to familiarize yourself with your watershed will be time well spent as you begin your monitoring program. Doing this at the onset of your project will give you a firm sense of what factors in your watershed may impact water quality. You should have at least two people in the car— one to drive safely and one to mark your map and take notes.
It is helpful to go during a time of day when there is not a lot of traffic. Take your tour in daylight, so you don't miss structures that may not be visible at night.

What should you be observing and recording? The answer is ANYTHING that may affect your waterbody. Some suggested questions and notes to take are included below, but not exhaustive. The information collected during your watershed tour is for your use only. Collecting this information is especially important at the beginning of your monitoring effort, but as construction or other major events occur in your watershed, revisiting this watershed tour may be helpful in better understanding your monitoring results and observations in stream. **See next page for further instruction.**

Exploring Your Monitoring Site

You have made a map, viewed your watershed and its characteristics in the Watershed Atlas, and conducted your tour of your approximate watershed. Now is the time to choose the legally accessible point to carry out your monthly monitoring activities. Note areas of litter and trash dumping and make a note to clean that up at your next visit (if you brought a bag, go ahead and clean it up now). If you find discarded tires, car parts, appliances, or other large trash items, contact your local government, and partner with the town or county (Adopt-a-Highway or Keep America Beautiful county office, for example) to schedule a larger clean-up.

Look for signs of animal activity in the stream and on the banks, areas of erosion, stormwater discharges, and sources of thermal impacts. Take pictures, and plan to do so continually to have a picture log of changes to your waterway.

FIELD NOTEBOOK

Stormwater Infrastructure – Is your watershed rural or urbanized? Are there storm drains along roads, ditches, or does stormwater sheetflow from roadways? Is the conveyance and its management effective, or leading to visible erosion?

Sewer Infrastructure – Do you see manholes and trunk lines indicative of sewer service? If not, the area may be served only by individual septic systems or a mix of both.

Reservoirs, ponds and dams – Are there large bodies of water that may serve as settling basins for sediment and associated pollutants? Are there dams? And, how are shorelines maintained?

Animals and bacteria – What are your likely sources of bacteria in the watershed, if animal-derived? These may include livestock, high waterfowl populations and dense populations of birds (rookeries), or large populations of cats and dogs.

Golf courses – Are there streams or drainage ditches within the course, and what is their management? Any ponds? Geese and other waterfowl should be noted.

Row crops - Is there evidence of good conservation practices such as grassed waterways, terraces, contour cropping, or others? Are streams lined with conservation buffers, or is the crop growing to the water's edge?

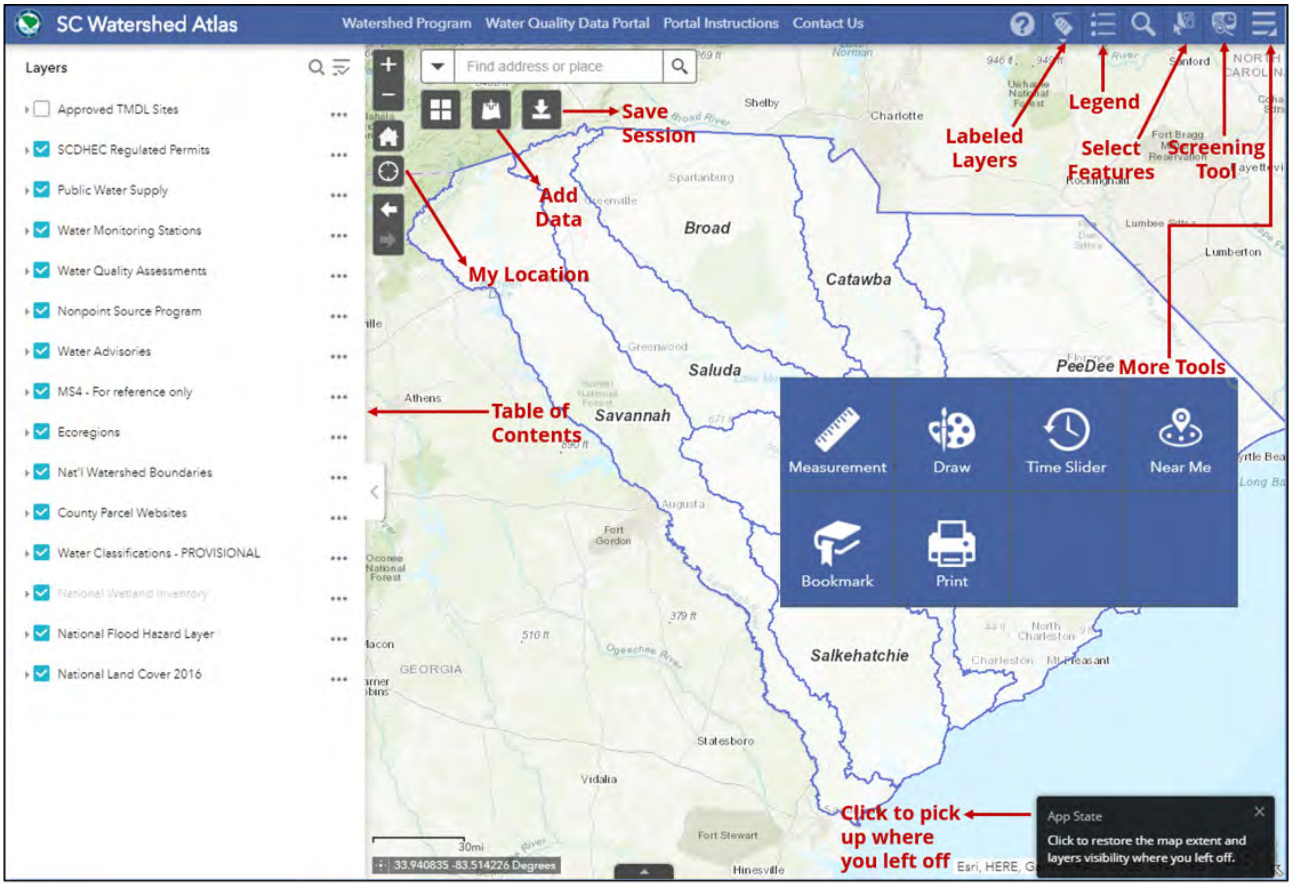
Residential areas - Can you pinpoint where storm sewers enter ditches or creeks? Is there evidence of failing stormwater infrastructure, such as roads or ditches caving towards the direction of stormwater flow?

Construction Areas – If these exist, depending on site size and proximity to waterway, there may be controls in place to keep sediment on site. Do you see silt fences, and if so, are they upright and intact? Is there very much sediment on the roadway at entrance and exit locations?

TRY FOR YOURSELF

WATERSHED ATLAS TOOLS

(https://gis.dhec.sc.gov/watersheds/)




About—gives information about each tool.


For more tools, click **more** in the upper right corner of the screen.


Zoom—zooms in or out in the map.


Default extent—zooms to the full extent of the state of South Carolina.


Extent Navigation—click the arrows to navigate the map to its previous or next extent.

The following three location tools are all different ways of seeing what's nearby.

My Location—zooms the map to an estimate of your current location. This tool works best on mobile devices, especially with GPS enabled. When the tool runs on desktops, it uses the browser on the network to detect the location. Turn on layers of interest in the Table of Contents to display nearby features. Remove marked location by clicking the My Location button again.

Near Me—finds all features within a buffer of a defined address or location and provides detailed information about those features. In the tool, define the buffer area by adjusting the slider to the desired number. Type an address in the search bar or click a location directly on the map to define the location to be buffered. A list of features found within the defined buffer for each layer is automatically populated, as well as a count of how many features belong to each layer. For detailed information about a feature, click a layer in the list of results, then the desired feature. The list of features disappears when the tool is closed. Use this tool to get detailed information about every layer in the map, relative to the defined location.

Screening Tool—defines an area of interest and analyzes specified layers for potential impacts. The area of interest can be defined through a place name or address search, by drawing on the map, by uploading a zipped shapefile, or by entering a traverse with coordinate and distance pairs. A defined buffer distance can be optionally set. Click **Report** to analyze the layers within the area of interest. Analysis results of features automatically display in the panel. Expand the result details by clicking a layer. Analysis results can be viewed in the tool and shared via a printed report or CSV file download.

The Screening Tool is the most advanced of the location tools because you can search an area of interest by drawing on the map (works for "upstream sites"), uploading a zipped shapefile, or entering coordinates, and it provides reports of analysis results. The report would be helpful in getting to know your watershed, learning what may affect your waterbody, and selecting your monitoring site.

Find address or place

Search—enter a number or place name to find the address location. As you type, suggestions appear in the drop-down list.

Search Layers—click the drop-down button to select a layer from the list in the search suggestion. Alternately, type a name, permit number, or ID in the search field for a list of suggested results.

Basemap Gallery—click the Basemap Gallery icon to display all basemaps. Click one of the basemaps to set it as the active basemap for the app.

Add Data—add data to the map by searching for layers in ArcGIS Online, entering URLs, or uploading local files. In this way, you can temporarily add layers to the map and remove them, only on your computer. On the **Search** tab, choose the scope you want to search and click **Add** on a specific item to add the layer to the map. The added layer will appear in the Layer List widget as well. Click **Remove** to remove the layer from the map and the Layer List widget. Click **Details** to get information about the layer. For additional information on this tool visit ESRI's Use the Add Data Widget.

Use this tool to import monitoring stations from Google Earth. KMZ files must be converted to KML files and zipped before adding the data to the Atlas.

Labeled Layers—shows/hides labels of regulated permits, water facilities, and monitoring stations. Some labels will not appear if the extent is too crowded. Zoom in to see all the labels.

Legend—shows how the features of the map are symbolized, typically displaying only what is visible in the map at the time.

Select Features—interactively select features on the map and take actions on the selected features. Choose the layer(s) of interest by checking the box(es). You can also make all layers selectable or de-selectable, or toggle layers select ability by clicking the button at the up-right corner of the panel, in line with **Layer.** The layers of interest must also be turned on in the Table of Contents. You can Select by Rectangle, Polygon, Circle, Line, or Lasso. The number of selected features display next to the layer. Click the ellipsis (...) to open the **Selection Actions** drop-down menu. Options include Statistics, Create Layer, Export to CSV file, View in Attribute Table, and more.

Use this tool to create layers that help you focus on a specific topic (like all Random Ambient Surface Monitoring Stations) or a specific area (like three 12-Digit Watersheds of interest within a 10-Digit Watershed). Once the layer is created, it cannot be removed in the same session. However, the layer cannot be saved for use in future sessions either. Click the ellipses to adjust layer transparency, disable/enable pop-up information windows, and view the layer in the attribute table.

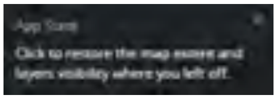
Time Slider—opens the panel when there is time-aware layer(s) in the map. The only time enabled layer is the Random Ambient Surface Stations. This tool shows all the random monitoring stations in an area from 1998 to 2018.

Measure—to make measurements on the map, select either the area or distance tool, select the measurement units, then sketch on the map (double-click to finish). The units selection may be changed after a result is shown, and the result will change to the new units.

Draw—to add graphics to a map, select properties such as color and style, then sketch on the map. For each graphic first choose a tool even if it is the same tool as just applied. The graphics and the ability to control visibility by component type will appear in the ellipses in the Table of Contents. Once graphics have been added, they can only be removed by clicking undo or clear.
Use this tool to identify your monitoring station by adding text, highlighting an area of concern by drawing a circle around it, or show the measurement length of a stream.

The following three "restore" tools are all ways to return to a map you were working on previously.

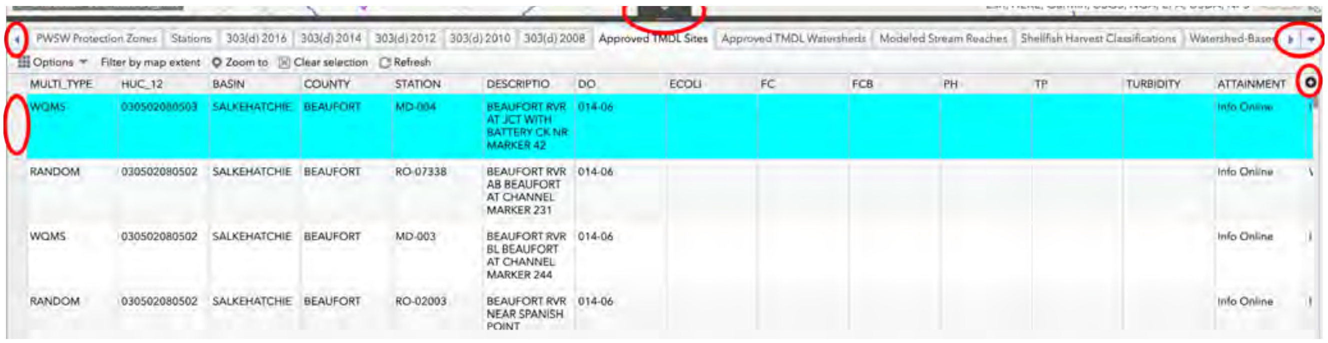
Bookmark—restores the map only to the spatial extent on the same computer you used previously. In the tool, click one of the bookmark thumbnails to set the map extent to the bookmark area. Click the blue text to add or edit the name. Add additional bookmarks by zooming to your desired location and clicking the **Add** button.



App State—restores the map to the spatial extent and visible layers on the same computer. Click on the box to return to where you left off.

Save Session—restores spatial extent, added data, visible layers, and graphics on the same computer. Once you have the map the way you want it, enter a name for the session and click the Save button. You can restore a session by double-clicking the title of the session to load the map. For more information on this tool visit ESRI's Save Session Widget.

Attribute Table Tools



Open and close the attribute table by clicking on the **Table** button. Alternately, click the ellipses beside the layer of interest in the **Table of Contents** and in the drop-down menu, select **View in Attribute Table**. A tabular view of the layers' attributes is displayed at the bottom of the map and can be opened, resized, or closed. Every layer has its own tab across the top of the panel, allowing you to switch among the different tables. Search for tabs not currently displayed by clicking the arrows on the top left and right corners of the panel. To show or hide columns, click the plus button on the top right corner of the panel to open the field visibility window. Check or uncheck the fields to set them to visible or invisible in the table.

Click a record in the table to select it and highlight the corresponding feature in the map. Press the Shift or Ctrl key to select multiple records. Zoom to the selected record in the map by clicking **Zoom** to reset the map extent to center around selected features, or by double-clicking a field in the selected record. Click **Clear Selection** to clear all selections. Display only the attributes for features within the current map extent by clicking **Filter by Map Extent**. Click on a column heading to sort the records in ascending or descending order. Click **Options** to open the drop-down menu for additional functions.

- Show selected records—Click to display only selected records. Click again to display all records.
- Show related records—Displays related records if a selected record has a related table.
- Filter—Filters records in the table.
- Show or Hide Columns—Equivalent to clicking the plus button on the right side of the panel to set visibility for individual fields.
- Export to CSV—Exports the attributes to a CSV file. The x,y coordinates are included for the point feature layer and maintain the same spatial reference as the data regardless of the map projection. If records are selected, only the selected records are exported. If no records are selected, all the records are exported.

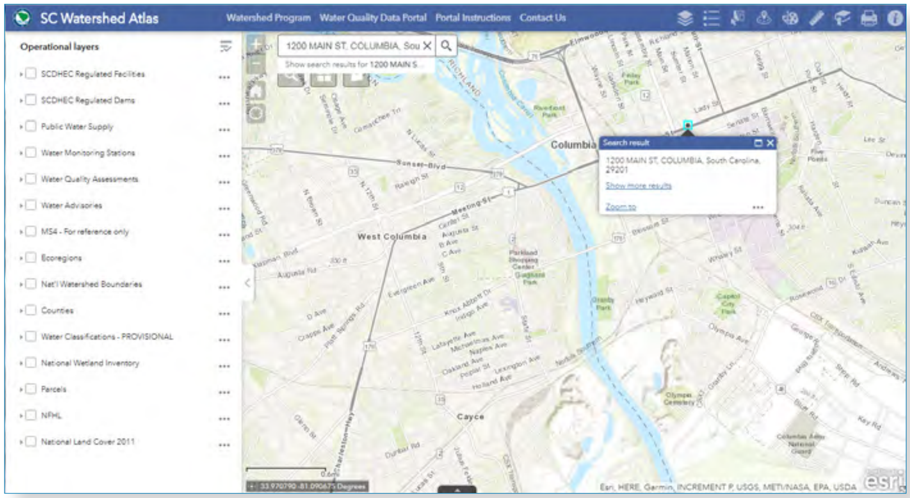
SC WATERSHED ATLAS EXERCISE

Here are exercises to try in the Watershed Atlas using "layers" that will help you find more information about your watershed, as it pertains to water quality monitoring and understanding results!

Find my home, watershed, and identify my HUC

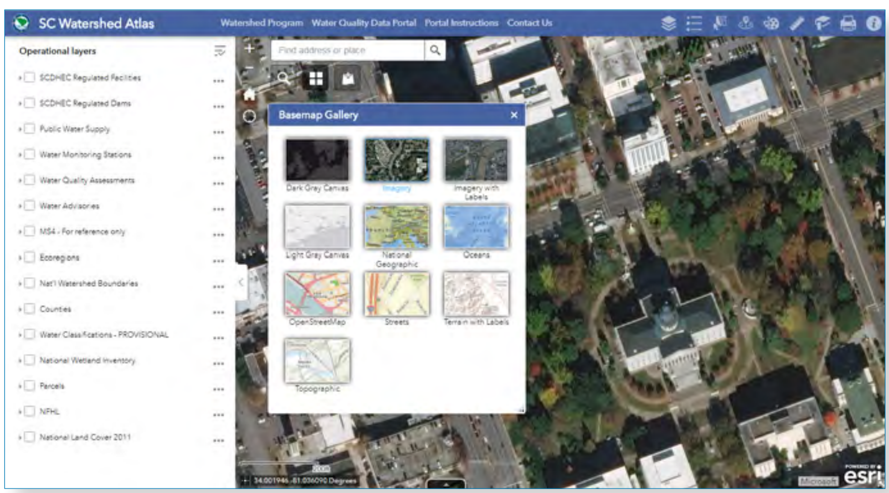
Point your browser to https://gis.dhec.sc.gov/watersheds/.

You will have to click OK to agree to the site's use policy. From there, you can see the layers on the left side of the screen, categorized as Operational Layers. In the top left, adjacent to the layer list, you can enter your address to search, and the map will zoom to your location.



The example is shown above. You can further zoom in using the +/- buttons or your mouse wheel.

You can alter the background map from the topographic basemap to aerial imagery (or other options) by clicking on the "basemaps" icon located under the address search. Now that you have located your address and verified it, let's identify your watershed. The SC AAS Database is organized by 8-digit HUCs and knowing how to find this number is essential if you are manually registering your monitoring site's location.

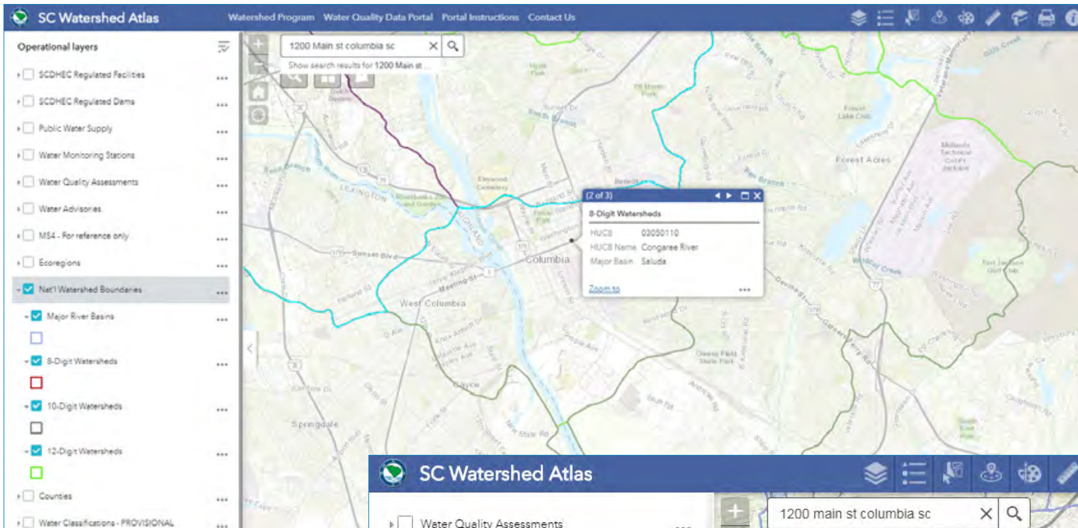


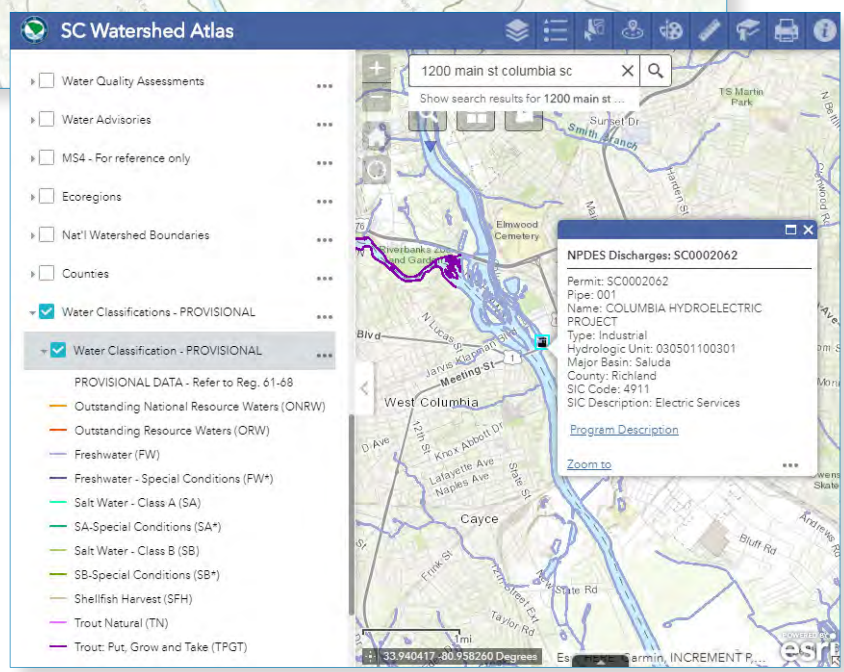
Therefore, turn on the 8-digit HUC layer by checking the box. When that layer loads, you can click on your site and a popup box will appear. That box will show you data for every layer that is "turned on" in the left panel. In this example, there are two: River Basin and 8-Digit Watershed; therefore, the example shows "2 of 2" windows of information that can be accessed and rotated by clicking the arrow backwards or forwards. Accessing these windows gives the major river basin name, watershed name, and needed watershed HUC-8.

All of these maps can be printed with data legends, title, scale, and more using the Print button at the top of the map.

What permits exist in my watershed?

Clicking on the layer names expands or contracts layers for easier viewing and scrolling. In the example, I have turned on and expanded "Water Classifications – PROVISIONAL" so I can more clearly see the stream network in my basin.

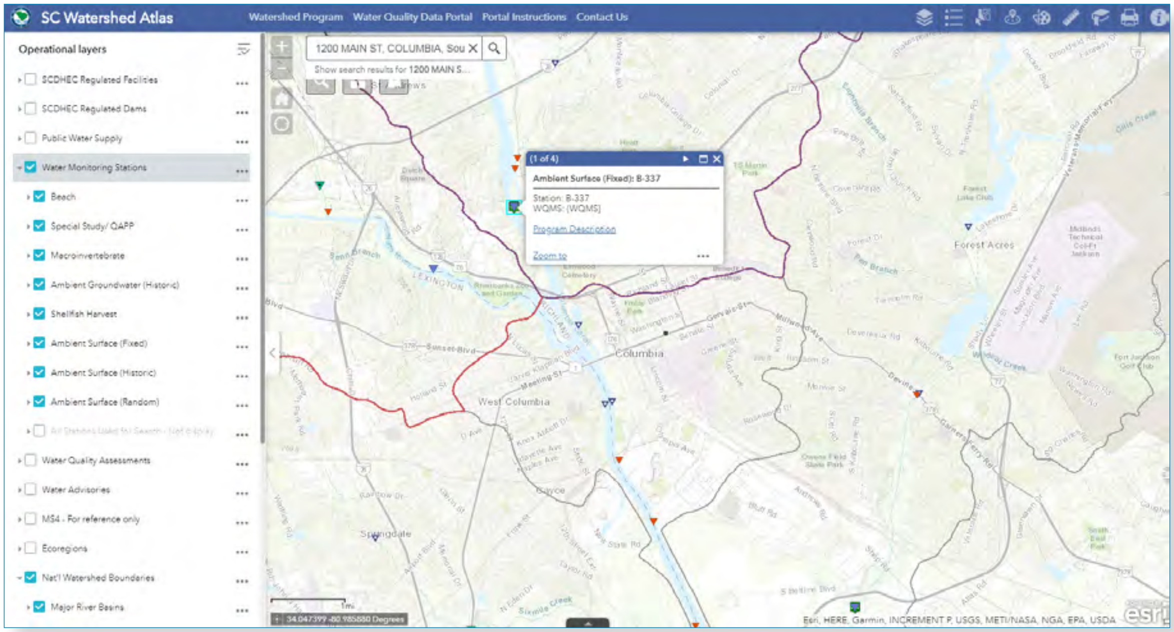




I have also selected a specific permit type under the Permits layer, and these are shown above. I have selected these specifically because they may provide me insights to my observations as an SC AAS volunteer monitor. Right clicking on some of the sub-layer names and then choosing "Program Description" will yield some background information on that sub-layer.

Where are the nearest monitoring stations to my home?

As a volunteer monitor, you may want to compare your collected data with that being collected by the state if one exists nearby. Your proximity to other stations may meet the objective of sharing headwater or upstream data and stream information with DHEC or others monitoring downstream. In this example, all Water Monitoring Stations have been turned on by checking all the monitoring layers and the 12-Digit Watershed layer to better ascertain monitoring stations per watershed. You can find information about a historic station in a tributary above you, and some historic stations below you. In the next receiving watershed, where your upper watershed flows, there is a macroinvertebrate station that may prove useful as well. Jotting down these Station numbers may prove useful if you want to find more information about the station from DHEC or USGS. When was it most recently monitored? How regularly was it monitored? For what parameters? Is there a flow gauge continually collecting data? Turning on the MS4 layer is important as well. MS4s are charged with monitoring waterways that receive stormwater runoff from pipes or ditches owned or maintained by the MS4 to identify if stormwater runoff is degrading waterway health. These stations are not mapped here in the SC Watershed Atlas; however, you can assume that in nearly all cases where a small MS4 exists, there are multiple monitoring stations collecting data to inform stormwater management decisions.



What regulatory documents can I find for my watershed?

Every two years, SC DHEC delivers to the US EPA its lists of waterways that are or are not meeting their designated use standards. Associated data can be located in the layer Water Quality Assessments, where 303(d) is the identification of waterways not meeting use standards by parameter. The layer also lists waterways as being able to fully, partially, or not meet use standards according to their most recent water quality monitoring data. If a waterway is listed on the 303(d) list for a parameter, then a Total Maximum Daily Load (TMDL) is required.

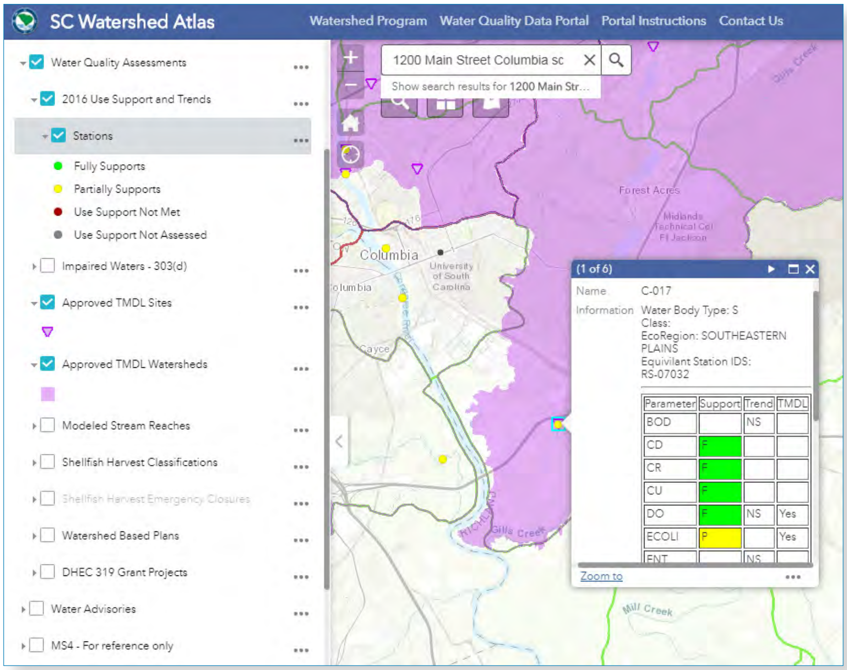
A TMDL is the amount of a single pollutant (such as bacteria, nutrients, metals) that can enter a waterbody on a daily basis and still meet water quality standards set forth by the State. “TMDL” refers to both a calculation of a pollutant entering a waterbody as well as a document which includes this calculation along with a source assessments, watershed and land use information, reductions and allocations information, and other relevant information, including maps, figures, and pictures. If you choose the layer “Approved TMDL Watersheds,” you can click on the purple areas of the map to access the TMDL document. This document provides substantial information about the pollutant, potential sources, potential link to rainfall events, and more, and can be very useful for the SC AAS Volunteer Monitor interpreting data.

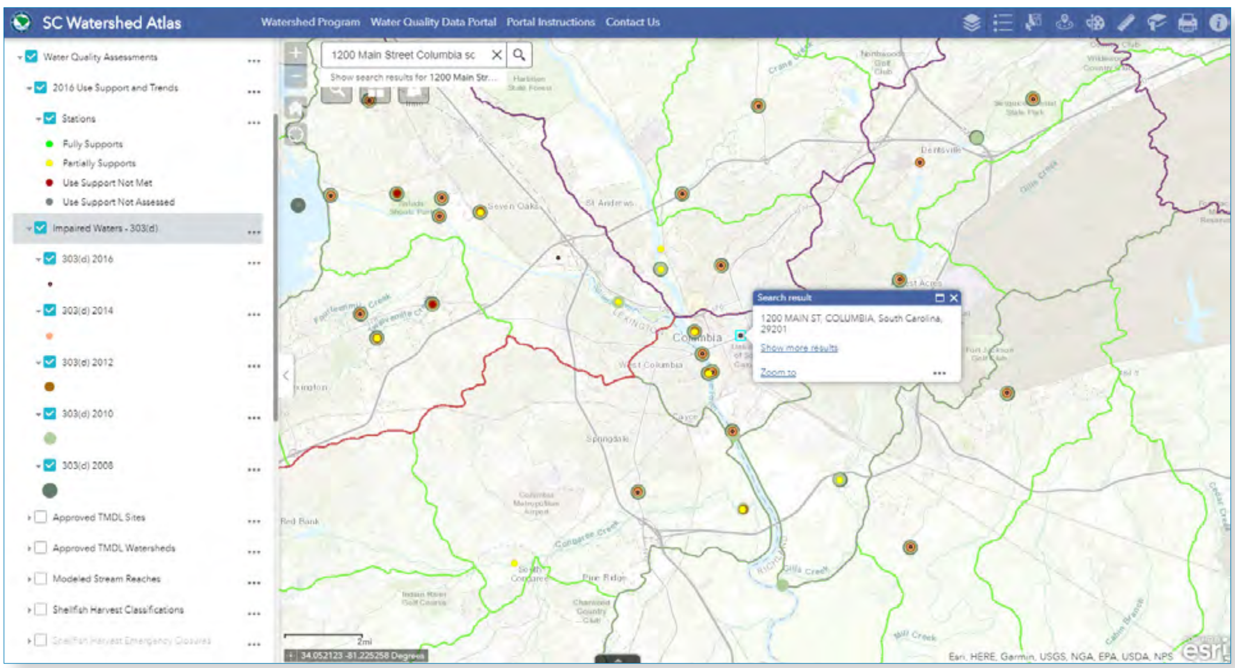
It is a regulatory document, approved by the US EPA. The Use Support Trends table may be the most easily interpreted data layer for water quality, with color coding that matches the data layer, and F, P, and NS for fully, partially, and not supporting use determinations, respectively.

Similarly, you can identify what projects have been funded and implemented to reach the TMDL reduction goal. This layer is named DHEC 319 Projects, and more information about their implementation can be found on SC DHEC Nonpoint Source Pollution website.

What is near me?

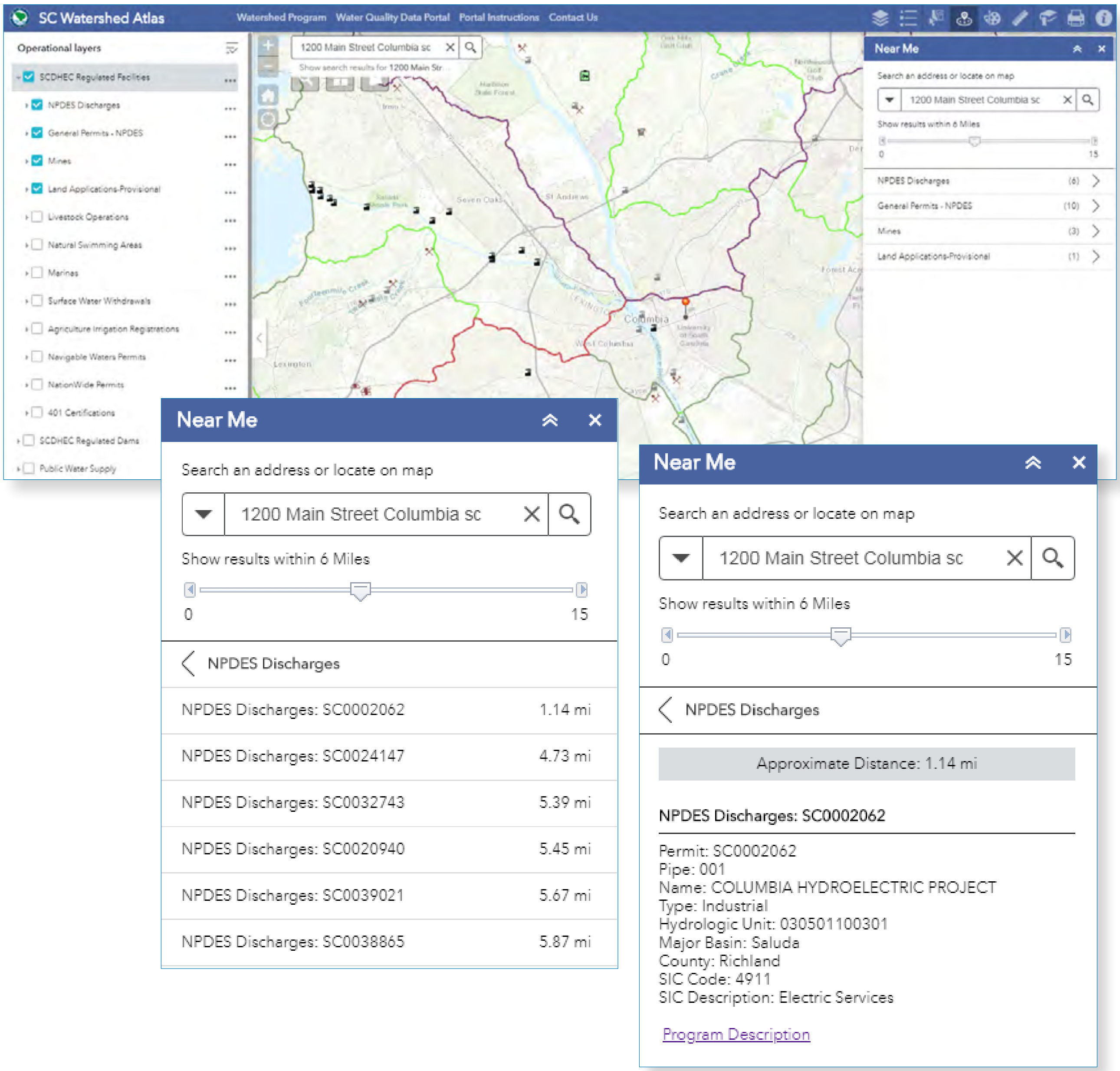
The Near Me button allows you to find features within a buffer of a defined address or location, view more detailed information about those features, and get directions to the selected feature, if desired. Click the Near Me button to open it. Define the area you want a buffer around by adjusting the slider to





the desired number. Search for an address in the search bar or click a location directly on the map to define the location to be buffered. You will see a list of the features found within the defined buffer for each layer as well as a count of how many features belong to each layer. Click a layer in the list of results and click the feature you are interested in to find detailed information.

There is so much more you can do in the Atlas ....
select and export features, save tables, draw, measure and book mark your extent. In addition, you can add data from outside sources or your own data to the application. Click on the "I" icon at the top right to learn how. The Atlas is also now mobile-friendly!



https://gis.dhec.sc.gov/watersheds/

CHAPTER END

CH.3: HABITAT ASSESSMENT & OBSERVATIONS

3.1 INTRODUCTION AND OBJECTIVES

Estuaries are critical habitat for thousands of birds, fish, mammals and other wildlife, as well as important nursery grounds. Healthy estuaries not only support wildlife, but also our state economy. In South Carolina, our major fisheries are shrimp, shellfish, crabs, and offshore fishing. Commercial fisheries contribute more than $42 million to the state economy annually, according to a study published in 2016 by Clemson University and sponsored by the SC Department of Natural Resources.

As a volunteer monitor, you must remember: *it's all connected!* Water quality data provides insights as to suitability of waterways for species maintenance and survival; assessing physical conditions of a waterway provides information on observed conditions that may otherwise be impacting wildlife. This might include accumulation of single use plastic debris or dumping of asphalt into a waterway. Finally, biological factors are used to document conditions in estuaries, such as presence or absence of plant or animal species. The Habitat Assessment combines physical and biological factors for an overall evaluation and snapshot in time of the conditions of the tidal saltwater system each time you monitor.

Visual monitoring allows for volunteers to use their eyes to identify problems or changes that may be impacting the valuable coastal wetlands. In order to document these changes, it is important that this habitat assessment be conducted **monthly.**

3.2 MONITORING PROTOCOL

The protocol uses the worksheet found in Appendix 1 to collect data involving this coastal ecosystem. Identify the presence or absence of the categories listed on the worksheet. This should be conducted before any other tests are conducted. **For your safety as well as for ecosystem protection, do not disturb the habitat.** The monitoring design of this protocol was created for the volunteer to collect from bank, dock, or boat. Volunteers are advised to collect their samples at the same time every month, as closely as possible, to see the full range of variability in this dynamic coastal system.

3.3 RECORDING SITE OBSERVATIONS

All monitoring protocols include the recording of essential, baseline data. These data set the stage for the monitoring results you will record. From time spent monitoring and miles traveled, to weather observations, completing these sections of your forms are equally important to the data you are recording for the stream. This portion of the data sheet requires the volunteer to observe conditions of the site and waterway. These include conditions of bank, presence of outfalls and observations of any discharge from these outfalls, presence of trash, hazards, and more. Additional resources are available at the Resources and Materials page of the SC AAS website, www.scadoptastream.org. Remember, the SC AAS Database is mobile friendly! So, your observations in the field, as well as monitoring results, can be directly recorded into the database using your smart phone or table with WiFi connection.

3.4 RECORDING WEATHER OBSERVATIONS

Weather strongly influences the physical characteristics of water. In tidal systems, wind strongly influences tide and turbulence. Long-term weather conditions can also greatly affect our watersheds. Floods, droughts, or other climatic extremes can change the estuary's physical and chemical characteristics quite dramatically (*e.g.*, creating sandbars, pools, widening a channel and more).

Weather can also impact water in other ways:

- Cloudy weather may result in lower DO levels because of less plant photosynthesis.
- Recent rains may dilute point source pollution.
- Rainfall may also dilute normal salinity levels.
- Recent rains may increase nonpoint source pollution by increasing surface water runoff and pollutant transport.
- Wind may raise DO levels by increasing turbulence.
- Temperature affects many parameters, as previously discussed, such as the saltwater's ability to retain DO.

Reporting Technique

Report weather conditions at the time of your Habitat Assessment. Use the thermometer to measure air temperature **before** you use it for water temperature. Take measurements in the shade. In the database, rainfall accumulation can be recorded in inches over past hours or days, using the dropdown. Make this selection based on the most local information and what you believe to be accurate data for the site. Use your own rain gauge, check local weather sites, or refer to the CoCoRaHs website, www.cocorahs.org, for the nearest volunteer weather data. You may consider becoming a CoCoRaHS volunteer yourself!

3.5 RECORDING WATER COLOR

The water color can provide you immediate clues to a waterway's condition. Although clear water may or may not be of high quality, other colors may indicate certain conditions:

- No Color—Clear water does not necessarily mean clean water, but it could indicate low levels of dissolved or suspended substances.
- Brown/Muddy—Brown water is usually due to heavy sediment loads.
- Green—Green water is usually the result of excessive algae growth or presence of phytoplankton
- Blackish—Blackish water is usually caused by natural processes of leaf decomposition (tannins begins released)
- Milky/White—a milky appearance may be caused by salts in the water. It can also be a sign of illegal disposal by contractors or dischargers.
- Oily sheen—Oily sheens can be caused by petroleum or chemical pollution, or they may be natural by-products of decomposition. To tell the difference between petroleum spills and natural oil sheens, poke the sheen with a stick. If the sheen swirls back together immediately, it is more likely petroleum; if the sheen breaks apart and does not flow back together, it is from bacteria or plant or animal decomposition.
- Reddish—Reddish or orange colors are usually due to iron oxides, but may also be due to presence of certain types of algae and dinoflagellates.
- Gray—Gray water may be a result of natural or human-induced activities. Surface foam is common and can be naturally occurring. Vegetation can produce surface-acting agents, or "surfactants," which can cause surface foam. Human-induced surface foam may be an unnatural color (red, pink, blue, yellow, or orange) and have a fragrant smell. This foam is most likely generated by household detergents and may be a sign of a failing septic drain field or illegal discharge.

Reporting Technique

Fill a clean, clear container with a water sample from the site. Hold the container up towards the sun to determine color. Color of water in tidal saltwaters is always best determined using a container rather than looking at the water.

In the SC AAS Database, any entry for "Other" will trigger an email alert to the SC AAS State Team, SC DHEC, and the local municipality or county, if they have agreed to receive such alerts.

3.6 RECORDING WATER ODOR

Water odor, like water color, can provide immediate clues about potential problems in a stream:

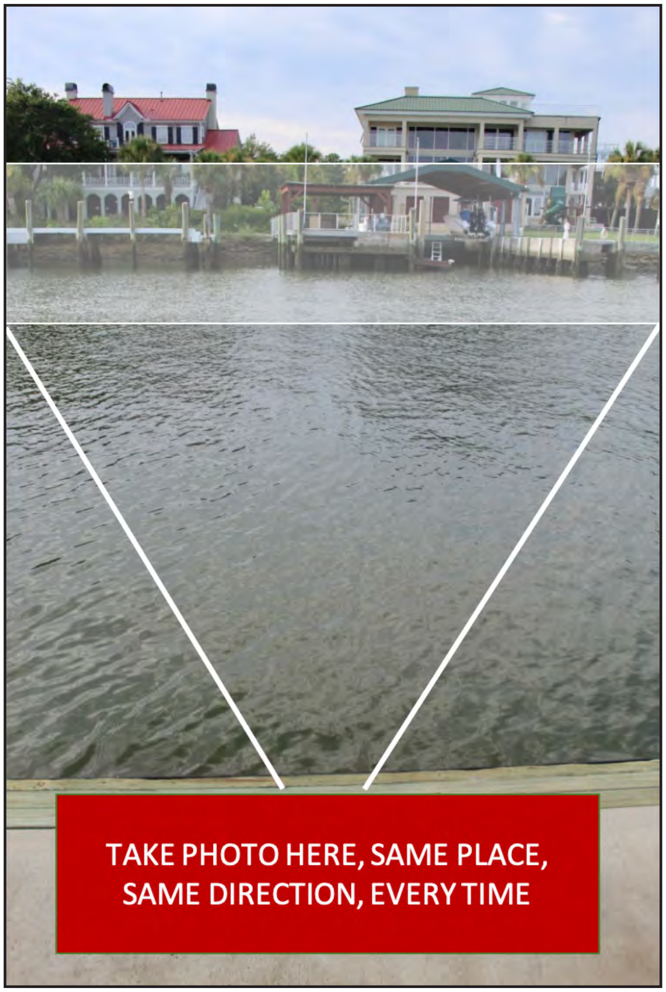
- Gasoline—any petroleum or chemical smells may indicate serious pollution problems from a direct source, such as a factory, parking lot, or storm sewer runoff.
- Sewage/Manure—these smells can be common in the air, but should not be what our water smells like. It is important to differentiate whether the odor is coming from the water or the air.
- Rotten egg—this odor may be caused by hydrogen sulfide gas, a by-product of anaerobic decomposition (rotting without oxygen). This is a natural process that occurs in areas that have large quantities of organic matter and low levels of DO, such as a marsh. This odor is heightened as the tide recedes.
- Fishy—this smell may be a sign of dead and decomposing fish in the stream.
- Chlorine—this smell may be a sign of pollution and will smell like a swimming pool.

Reporting Technique

Using the same sample collected to determine water color, smell the water, and record odor on the form.

3.7 RECORDING SURFACE WATER HEIGHT

If the situation allows and the volunteer and property owner are willing, a staff gauge can be installed at the site to quantitatively record surface water height. The type of gauge is dependent on the depth of the



waterway, and therefore, is not included in the monitoring kit. The gauge is best secured to a dock or bridge, but can be driven into the riverbed, if stable. High flow events and floods may easily sweep away your gauge. As best possible, the zero measure on the staff gauge board should be at the river bed.

More likely, the volunteer will be able to use a photo to show the surface water height. This image should be taken from the same location each time (use tape to mark your line and stand on it each time) and should include some other stable element, such as a piling across the river. It is helpful to always have the camera all the way zoomed out or zoomed in, whichever works best for your setting, so that the range of the photo is the same every time. Tide stage will be different every month. Expect wide variations in water height.

A note on photos: the SC AAS Database allows for three photos per monitoring event. Plan to take photos in the ebb direction (towards the ocean) and the flow direction (inland). As best possible, these photos should be taken at the same location each time to denote changes. The third picture should be of the water height.

There are several useful apps that record latitude, longitude, elevation, date and more on the photo. This can be very useful to share with others exactly where you are monitoring and what you are observing. The example shown here utilizes the Sololocator app, which stores a copy of the photo in your photo library on your cell phone, with the GPS, date, and time information added. This photo can be uploaded into the database, even directly from the field.

3.9 RECORDING WETLAND CONDITIONS/ APPEARANCE

Notice the health of specific plants that grow in the marsh. Like other plants, marsh grass naturally goes through seasonal changes. Generally, marsh grass is green with new growth in the spring and fall, but browns in the winter months. Therefore, some browning in the winter months is expected. However, colors should continue to fluctuate, and grasses should not be brown all year long. Also, pay attention if the marsh surface has an increase in mud composition differing from salt pannes.

Spring

Summer

Fall

Winter

A salt panne, shown below occurs when a thin layer of water over the high marsh evaporates, which quickly results in high levels of salt in the sediment.

Phragmites australis, or common reed, is thought to be one of the most widespread plants on earth, inhabiting marshes and coastal rivers nearly worldwide. Introduced in the 1700 or 1800s, European subspecies have become highly invasive across the US, with the exception of the majority of the southeast. This aggressive, towering *Phragmites* has a number of negative impacts including outcompeting other native species and the native common reed (creating a monoculture), loss of ecological integrity due to its thick bunching growth pattern, altered wetland hydrology, and increased potential for fire.

Very recently, *Phragmites australis subsp. australis*, the invasive subspecies, has been identified in South Carolina. *Phragmites* typically establishes in disturbed soils and in areas of high nutrient inputs, such as alongside agricultural fields, residential neighborhoods, and construction sites. Volunteers are asked to indicate in the SC AAS data form if *Phragmites* are present at their monitoring location as an indication of disturbed conditions and so that resource managers can implement controls and track the spread of this highly aggressive non-native plant.

Stand of nonnative Phragmites. Credit: Michigan State University

A native Phragmites stand on left, compared to the invasive Phragmites on right. The non-native Phragmites on right is more dense and tall, preventing any other plant growth. Credit: Janice Gilbert, Minnesota Natural Resources

HABITAT SUITABILITY INDICATORS

From illegal dumping to stormwater runoff, human activities can and do adversely impact wetlands. The data form to be completed each month asks the volunteer to record presence or absence of conditions at your site. With all of these elements, the volunteer is asked to document significant changes since the last monitoring event and take notes to document conditions. These assessment elements include the following:

- Erosion - evidence of active erosion and bank loss,
- Mud in marsh - mud accumulates in the marsh and can be seen as mud flats or fresh deposition of wet mud,
- Sediment plumes - obvious turbidity in the water column that is atypical of the site,
- Dredging - note evidence of any dredging activity that has deepened or widened the channel,
- Submerged aquatic vegetation - grasses and plants that are visible along the bottom and shelf (or sides) of the waterway,
- Jetties/groins - manmade structures for access and water management,
- Debris - this may include vegetative debris, signs of illegal dumping, trash in general, and plastic pollution.

Areas adjacent to a tidal creek (riparian zones) are important in that they "buffer" waterways from manmade impacts. Within the riparian zone, vegetation slows stormwater runoff and increases infiltration, plants use nutrients in stormwater for growth, heated runoff can cool, and sediment is trapped as stormwater slows. Riparian buffers also provide shade for waterways, habitat for wildlife, and help to stabilize banks and shorelines, protecting them from erosion and slumping. Buffers of 100 feet or more have been proven to be effective in removal of nutrients; therefore, the protocol asks the volunteer to document non-natural land uses (industrial, commercial, agricultural, and residential) that exist **within 100 feet of the waterway or marsh.**

South Carolina's fisheries are fortunate to include oysters. Oysters grow in "beds" and provide significant value to estuary health. Oyster beds provide habitat, breeding grounds, and refuge from predation for some species.

Oyster beds also stabilize sediments and protect our shorelines. As bivalves, oysters are filter feeders, removing pollution from the water column as they feed.

Volunteers should record observations of oyster beds. Oyster beds are easily impacted by coastal development, disease, nutrient-rich runoff, stagnation, and even oyster harvesting techniques. When thriving, oysters attract significant biodiversity to the estuary.

COMMONLY SPOTTED ORGANISMS OF OUR SOUTH CAROLINA ESTUARIES

Eastern oyster, *Crassostrea virginica*

Acorn barnacle, *Balanus spp.*

Marsh periwinkle, *Littoraria irrorata*

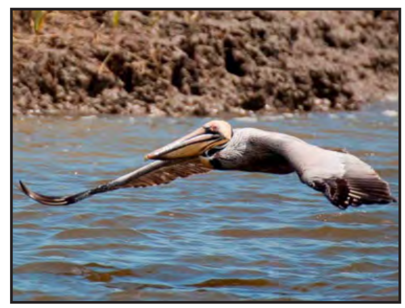
Eastern mud snail, *Ilyanassa obsoleta*

Blue crab, *Callinectes sapidus*

Mud fiddler crab, *Uca pugnax*

Horseshoe crab, *Limulus polyphemus*

Red-winged blackbird, *Agelaius phoeniceus*



Brown pelican, *Pelacanus occidentalis*

Laughing gull, *Leucophaeus atricilla*

Diamondback terrapin, *Malaclemys terrapin*

Bottlenose dolphin, *Tursiops truncatus*

Refer to the *Guide to the Salt Marshes and Tidal Creeks of the Southeastern United States* for more identification tools and information. Photo credit: SC DNR
www.saltmarshguide.org

CHAPTER END

CH.4: PHYSICAL & CHEMICAL MONITORING PROTOCOL

4.1 INTRODUCTION

Physical and chemical monitoring allows information to be gathered about specific water quality characteristics. In addition to basic visual observations, SC AAS recommends monitoring these core parameters monthly:

- Air temperature,
- Water temperature,
- pH,
- DO,
- Salinity, and
- Transparency.

If you choose to conduct physical and chemical monitoring, plan on sampling regularly – once per month, at the same time of day, and at the same location. Regular monitoring enables your chemical data to be compared over time. Water quality and environmental conditions can change throughout the day, especially in tidal creeks, so monitoring at approximately the same time of day is important. Always record the tidal conditions during monitoring. Also, chemical testing during or immediately after a rain may produce very different results than during dry conditions, so always record weather conditions.

As you explore your tidal creek's saltwater chemistry, it is important to understand that water chemistry is very complex and that natural variation in some parameters is not unusual, but actually the norm. The following are some examples of how environmental conditions can influence water chemistry:

- Time of Day – DO levels rise during sunlight hours due to increased photosynthesis in aquatic plants and algae, and decrease overnight when synthesis is not occurring.
- Weather – Runoff from heavy rains can transport pollutants, especially visible sediment to estuaries. As discussed previously, freshwater runoff will lower salinity concentrations.
- Physical Influences – Tides, wind, and storms affect salinity, temperature, transparency, and more.

4.2 FIELD EQUIPMENT

- Chemical monitoring kit for appropriate parameters with instructions,
- Thermometer,
- Secchi tube (or Secchi disk),
- Salinity refractometer and distilled water,
- Waste jug (old milk jug labeled as 'Waste' will work),
- Rubber gloves,
- SC AAS Tidal Saltwater Data Form (see Appendix 1 and Helpful Resources page at www.scadoptastream.org),
- Bucket with rope (if sampling from a bridge or in deeper water) or sampling pole to sample from bank (see below),
- Clear container for the visual observations,
- *Pen/pencil,
- *Clipboard,
- *Trash bag to pick up litter,
- The 'Who to Call List',
- *First Aid Kit.

*Items that the volunteer should bring to each monitoring event that may not be in the kit.

QUICK NOTE

DO NOT SAMPLE
When conditions are unsafe for any reason, including high water or threat of dangerous storms.

Chemicals, or reagents, used in measuring pH and DO have expiration dates. Please be sure that your chemicals are not expired before monitoring. Results found using expired chemicals are not trustworthy for reporting and sharing, and therefore, are blocked from being entered into the database. If you need to replenish your chemicals in your SC AAS monitoring kit, please contact your Trainer for guidance. Return any expired chemicals to your trainer for disposal.

After your sampling event, rinse your sample bucket, cup, bottles, tubes, and caps with tap water three times and let dry. Dismantle the titration syringe and rinse with water. Let dry. Make sure the caps on all bottles are closed tightly. Store equipment and chemicals in a cool, dry place.

4.3 COLLECTING YOUR SAMPLE

Volunteers are discouraged from entering the marsh to collect samples to best protect the marsh ecosystem. Instead, samples can be collected by a bucket or sampling pole from bank, dock, or boat.

Collecting with a Bucket

From a bridge or dock, lower your bucket on a rope gently into the creek. Be careful not to stir up the bottom sediments. Pour water out downflow of where you are collecting. Rinse the bucket out and pour the water out in as previously described. Repeat two more times. This ensures that your sample fully represents the waterway you are monitoring. Once you have rinsed your equipment three times, throw the bucket out as far into the main channel as possible, trying not to disturb the bottom sediments. As much as possible, you are looking to collect your sampling in active, flowing water. Take your readings (and any additional sample containers) from this bucket.

Collecting with a Sampling Pole

Many official monitoring agencies and organizations invest in a sampling pole. This allows the monitor to collect a sample easily from shoreline or dock without disturbing the water or bottom sediment. For your rinse procedure, simply dip and dump the sampling container on the pole three times to ensure your collected sample represents the waterway. Following this rinse procedure, dip the sampling container or cup into the main flow of the channel. Record results directly from your collected sample.

4.4 RECORDING AIR AND WATER TEMPERATURE

Air temperature is taken first, as a reference point for the water temperature. Water temperature is one factor in determining which species may or may not be present in the system. Temperature affects feeding, reproduction, and the metabolism of aquatic animals. A week or two of high temperatures may make the tidal saltwater unsuitable for sensitive aquatic organisms, even though temperatures are within tolerable levels throughout the rest of the year. Not only do different species have different requirements, optimum habitat temperatures may change for each stage of life. Fish larvae and eggs usually have narrower temperature requirements than adult fish.

The SC AAS program can serve to establish a baseline of current conditions for each site monitored regularly. The temperature standards in state regulations are primarily intended for the control of potential impacts to water temperature from permitted discharges.

General Points to remember:

- Take air temperature before water temperature.
- Keep your water samples out of direct sunlight (use your body to cast a shadow).
- Let the thermometer stabilize (or settle) before recording temperature.
- Use a thermometer protected by a plastic or metal case.

Monitoring Technique

1. Record air temperature <u>in degrees Celsius</u> once temperature stabilizes.

CELSIUS TEMPERATURE (ºC)	FAHRENHEIT TEMPERATURE (ºF)
0	32.0
1	33.8
2	35.6
3	37.4
4	39.2
5	41.0
6	42.8
7	44.6
8	46.4
9	48.2
10	50.0
11	51.8
12	53.6
13	55.4
14	57.2
15	59.0
16	60.8
17	62.6
18	64.4
19	66.2
20	68.0
21	69.8
22	71.6
23	73.4
24	75.2
25	77.0
26	78.8
27	80.6
28	82.4
29	84.2
30	86.0
31	87.8
32	89.6
33	91.4
34	93.2
35	95.0

2. For water temperature, submerge the thermometer in the bucket or monitoring cup as soon as you obtain the sample (before it heats up). Record temperature in degrees Celsius once stabilized.

4.5 PH MONITORING

pH is a measure of how acidic or basic water is and is measured in pH units on a scale of 0 to 14. A pH of 7 is neutral (distilled water), while a pH greater than 7 is basic/alkaline, and a pH less than 7 is acidic. The pH scale is logarithmic, so every one unit of change in pH actually represents a tenfold change in acidity. A pH of 6 is ten times more acidic than a pH of 7; a pH of 5 is 100 times more acidic than a pH of 7.

The pH of saltwater is influenced by the concentration of acids in rain and the types of soils in the watershed. The typical rainfall in the US is slightly acidic, with a pH ranging from 5.0 to 5.6. As rainwater falls, carbon dioxide from the atmosphere dissolves into it, forming a weak carbonic acid and thereby lowering the pH of the precipitation.

Low pH levels (acidic water) can have a harmful impact on the health of aquatic communities. Very acidic water or acid rain can allow toxic substances such as ammonia and heavy metals to leach from our soils and possibly be taken up by aquatic plants and animals in a process called bioaccumulation.

Most aquatic organisms require habitats with a pH range of 6.5 to 8.5. Extremely high or low pH values are quite rare in South Carolina. Most values that exceed 9.0 (basic) are caused by excessive algal growth, a sign of nutrient enrichment. Very low (acidic) pH readings are generally near point sources of pollution, however, there are surface waters in South Carolina's coastal plain where pH may be very low, which is the natural condition of these waterways.

pH is measured by adding a to a sample of water which reacts with the pH of the sample to produce a color. The color of the water sample is then matched to a color comparator to determine the pH level.

State Standards

In saltwater habitats in South Carolina, pH levels should fall between 6.5 and 8.5 to meet South Carolina state standards. Specially designated areas of the coastal plain, e.g. swamps and blackwater systems may have lower pH levels due to natural conditions.

Instructions for the LaMotte pH Monitor:

1. Rinse the two plastic tubes two times with sample water.
2. Fill each tube to the 10 mL line with sample water.
3. Add 10 drops of the pH wide range indicator (holding indicator bottle vertical). Cap and gently invert the sample several times to ensure mixing.
4. Insert the wide range pH Octa-Slide Bar 2 into the Octa-Slide 2 viewer.
5. Insert pH test tube into Octa-Slide 2 viewer.
6. Match sample color to a color standard and record pH to 0.25 standard units.

Duplicate precision rule for pH: The two samples must be within 0.25 standard units.
If your two sample results differ by more than 0.25, resample until another sample results in a pH value within this acceptable range. Both final results must be recorded in the SC AAS Database.

Remember to always discharge the analyzed sample into the waste bottle and not into the waterway or on the ground. The waste bottle can later be dumped in the sink to be processed by a wastewater treatment plant.

4.6 DO MONITORING

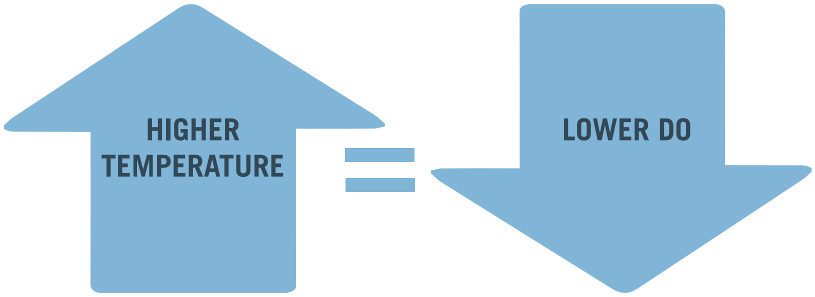
Like land organisms, aquatic animals need oxygen to live. Fish, invertebrates, plants, and aerobic bacteria all require oxygen for respiration.

Sources of DO

Oxygen dissolves readily into water from the atmosphere at the surface until the water is full, or saturated. Once dissolved in water, the oxygen diffuses very slowly, and distribution depends on the movement of aerated water by turbulence and currents caused by wind, water flow, and thermal upwelling. Aquatic plants, algae, and phytoplankton produce oxygen during photosynthesis.

DO Capacity of Water

The solubility of oxygen decreases as temperature increases.
DO decreases exponentially as salt levels increase.
DO will increase as pressure increases.



The temperature affect is compounded by the fact that living organisms increase their activity in warm water, requiring more oxygen to support their metabolism. Critically low oxygen levels often occur during the warmer summer months when solubility decreases and oxygen demand increases. This is often increased by the respiration of algae or by decaying of organic material.

Significant Levels

The amount of oxygen required by an aquatic organism varies according to species and stage of life.

- DO levels below 3 ppm are stressful to most aquatic organisms.
- DO levels below 2 or 1 ppm will not support fish; levels of 5 to 6 ppm are usually required for growth and activity.
- Fish and invertebrates that can move will leave areas with low DO and move to higher level areas.

Interpreting Your DO Results

There is always demand on oxygen in a system. Pollutants, including inadequately treated sewage or decaying natural organic material, can cause an increase in demand. Organic materials accumulate in bottom sediments and support microorganisms (including bacteria), which consume oxygen as they break down the materials. Some wastes and pollutants produce direct chemical demands on oxygen in the water. In areas of dense algae, DO levels may drop at night or during cloudy weather due to the net consumption of DO by aquatic plant respiration. Please note that there are marshes and tidal creeks where DO may be very low, which is the natural condition of these waterways. On sunny days, high DO levels occur in areas of dense algae or submerged aquatic vegetation (SAV) due to photosynthesis. In these areas, the lowest DO levels occur just before sunrise each morning, with the highest levels just after noon.

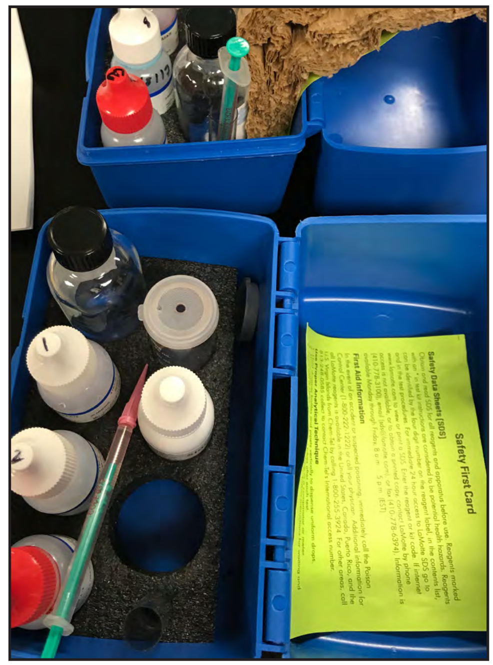
State Standards

For the majority of South Carolina’s saltwater, DO levels must average of 5.0 mg/L and not less than 4.0 mg/L to meet South Carolina state standards.

DO Monitoring Technique

For this program's purposes, DO is measured using the Winkler Titration Method. A sample bottle is rinsed twice with stream water and then filled completely. Cap the bottle under water so that no air is present in the sample. Chemicals are added to produce a 'fixed' solution – the DO content cannot be influenced by external sources or changes. This fixed solution is then titrated until it reaches the 'endpoint' where the color of the solution changes to clear. The level of the remaining liquid in the direct-read titrator corresponds to the DO level in the sample.

Duplicate precision rule for DO: The two samples must be within ±0.6 ppm or mg/L. Make two measurements from the sample for duplicate precision and repeat the steps below for a second result. If the tests are not within duplicate precision of each other, run additional tests until two are within that range.



Labeling the bottles in your DO titration kit by which solution to use first and expiration date will expedite the duplicate test required.

Before you begin,

- Wear safety goggles and gloves.
- Empty the wastewater container down the sink, if needed. If your location is served by a septic system, dispose of waste container fluids at a location served by sewer.
- Make sure you completely fill your DO bottle with water. Air bubbles will cause erroneously high results. Please follow the steps in the order they are written.
- Rinse your sample bottle twice with tidal saltwater.
- Wear safety goggles and gloves while completing the procedure outlined below. Keep a supply of paper towels on hand to mop up any spills right away.
- Always discharge analyzed tidal saltwater to the wastewater container and not on the ground or in the waterway.

Step 1: Do not have the cap off the sample for any longer than necessary!

a. Holding the chemical bottle completely upside down, add 8 drops of Manganous Sulfate solution (labeled "1" on bottle).
b. Holding the chemical bottle completely upside down, add 8 drops of Alkaline Potassium Iodide Azide (labeled "2" on bottle).
c. Cap and shake the bottle for 30 seconds. A white to brownish orange floc will cloud the sample bottle.
d. Let the floc settle until the top half of the bottle is clear. Shake again. Allow to settle again.

Step 2: Add 8 drops of Sulfuric Acid 1:1 (red cap on bottle) and shake for 30 seconds. The solution will turn from cloudy to translucent and a burnt orange color. (If you still see some dark solids in the solution, add 1 more drop.) Your sample is now "fixed."

Step 3: Rinse the graduated cyclinder twice with your fixed solution, then pour your fixed sample into the graduated cylinder to the 20 ml mark and pour into titration vial.

Step 4: Fill the titrator (plastic syringe or glass syringe) by putting the tip of the titrator into the hole in the top of the titrating solution Sodium Thiosulfate 0.025N (labeled "4" on bottle). Turn bottle upside down and slowly pull back on the syringe plunger to draw some of the solution into the titrator. Then push in the plunger to expel any air. Draw back the plunger again until the tip on the bottom of the plunger is well past the zero mark on the scale on the titrator. Once all air bubbles are expelled, push the titrator so that the solution is exactly at the zero mark.

Step 5: Turn everything right side up. Slowly push the plunger until the large ring on the plunger of the plastic titrator or the black tip of the plunger of the glass titrator is right at the zero mark. Remove the titrator from the sodium thiosulfate bottle.

Step 6: Put the tip of the titrator into the opening on the plastic cap of the titration vial (code 0299 or 0608) that contains your fixed sample.

Step 7: Titrate the sample. Add the titrating solution one drop at a time by gently pushing the plunger. Swirl the solution between drops until the sample has turned pale yellow. If your solution is already pale yellow skip this step. If your solution is colorless you have zero mg/L DO. (If this is the case you can proceed to step 8 for confirmation.)

Step 8: Pop off the plastic cap from the titration vial with the titrator still in the hole without moving the plunger. Add 8 drops of Starch Indicator solution to the titration vial. The sample should now turn purple, brown, or black.

Step 9: Continue titration. Put the cap and titrator back on the titration bottle and continue to add one drop at a time, swirling the solution between each drop. Stop right when the solution turns from purple to colorless. If the color change is not complete by the time the plunger tip reaches the bottom of the scale on the titrator, refill the titrator by filling with titrant to the zero mark and continue the titration. (Add both titration amounts together for the final test results.)

Step 10: Read the test result directly from where the scale intersects the ring of the plunger for plastic titrator or the tip of the plunger for the glass titrator. The titrator is marked at 0.2 ppm increments. So if the titrator ring or tip is touching the third line below the line marked “7” the result would be 7.6 mg/L DO. (If the titrator has been refilled once before, the result would be 17.6 mg/L DO.)

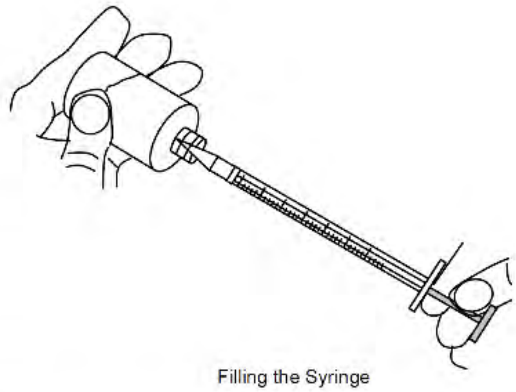
Step 11: Repeat steps 1 through 9 for a duplicate test. If the results are more than 0.6 mg/L apart between the two tests, repeat the test again and record all three results on your monitoring sheet.

Step 12: Empty anything left in the pipette into the waste container. Empty the wastewater container down the sink. If your location is served by a septic system, dispose of waste container fluids at a location served by sewer.

General Information on Syringes (Titrators)

Exactly how do I fill the glass syringe with the sodium thiosulfate?

1. Before you fill your syringe with sodium thiosulfate push the plunger to the bottom to expel air.
2. Insert the syringe into the little hole in the inside top in the sodium thiosulfate bottle.
3. Hold the sodium thiosulfate bottle upside down and slowly pull back on the plunger.



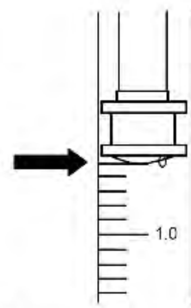
Filling the Syringe

What happens if I see air bubbles in the barrel of the syringe?

Push the plunger all the way in and then pull back. You may have to do this several times to rid of any air bubbles.

How far back should I pull the barrel of the syringe?

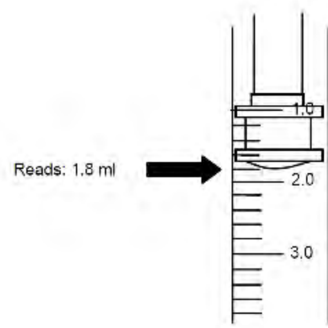
Pull back on the plunger until the black point of the barrel is right at the "0".



Fill Syringe to Zero Mark (as Showr

Exactly how should I read the syringe?

Hold the syringe vertically with the top of the syringe pointing up (and the tip down). The zero mark should be facing up. Read the syringe where the tip of the plunger meets the scale. The scale is measured in units (bigger lines 0 to 10) and in two-tenths (0.2, 0.4, etc.)



Reading the Syringe

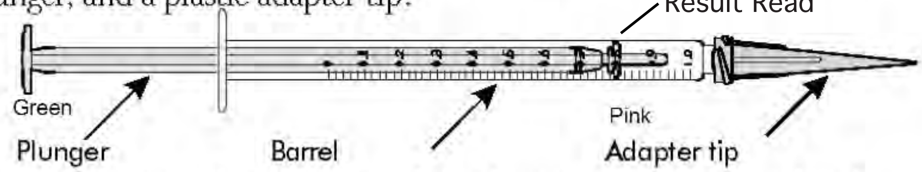
LaMotte

Product Upgrade Notice

Direct Reading Titrator General Instructions

Code 1649

The new Direct Reading Titrator consists of a plastic barrel, a plastic plunger, and a plastic adapter tip.



The adapter tip reducesthe size of the drops that are dispensed and increases the precision of the test results. DO NOT REMOVE THE ADAPTER TIP.

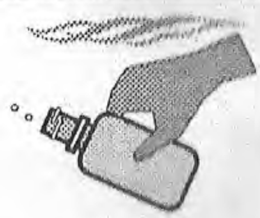
TEST PROCEDURE

PART 1 - COLLECTING THE WATER SAMPLE

1. 
Rinse the Water Sampling Bottle (0688-DO) with the sample water.

2. 
Tightly cap the bottle, and submerge it to the desired depth.

3. 
Remove the cap and allow the bottle to fill.

4. 
Tap the sides of the bottle to dislodge any air bubbles.

5. 
Replace the cap while the bottle is still submerged.

6. 
Retrieve the bottle and make sure that no air bubbles are trapped inside.

TEST PROCEDURE

PART 2 - ADDING THE REAGENTS

NOTE: Be careful not to introduce air into the sample while adding the reagents.

1. Remove the cap from the bottle.

2. Immediately add 8 drops of *Manganous Sulfate Solution (4167). AND Add 8 drops of *Alkaline Potassium Iodide Azide (7166).

3.

Cap the bottle and mix by inverting several times. A precipitate will form.

4.

Allow the precipitate to settle below the shoulder of the bottle.

5.

For Kit Code 7414.
Immediately use the 1.0 g spoon (0697) to add one level measure of *Sulfamic Acid Powder (6286).

OR

For Kit Code 5860
Add 8 drops of *Sulfuric Acid, 1:1 (6141WT).

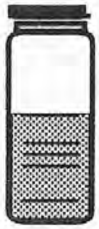
6. Cap and gently invert the bottle to mix the contents until the precipitate and the reagent have totally dissolved. The solution will be clear yellow to orange if the sample contains dissolved oxygen.

NOTE: At this point the sample has been "fixed" and contact between the sample and the atmosphere will not affect the test result. Samples may be held at this point and titrated later.

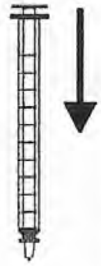
TEST PROCEDURE

PART 3 - THE TITRATION

1. Fill the titration tube (0299) to the 20 mL line with the fixed sample. Cap the tube.

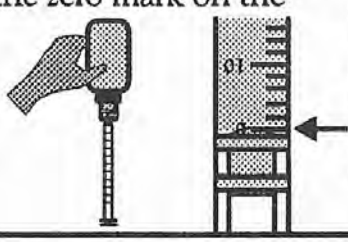


2. Depress plunger of the Titrator.



3. Insert the Titrator into the plug in the top of the *Sodium Thiosulfate, 0.025N (4169) titrating solution.

4. Invert the bottle and slowly withdraw the plunger until the bottom of the plunger is opposite the zero mark on the scale.



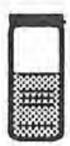
NOTE:

If small air bubbles appear in the Titrator barrel, expel them by partially filling the barrel and pumping the titration solution back into the reagent container. Repeat until bubble disappears.

5. Turn the bottle upright and remove the Titrator.

NOTE:

If the sample is a very pale yellow, go to Step 9.



TEST PROCEDURE

6. Insert the tip of the Titrator into the opening of the titration tube cap.

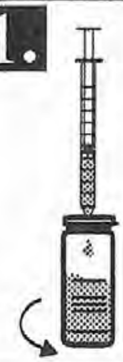
7. Slowly depress the plunger to dispense the titrating solution until the yellow-brown color changes to a very pale yellow. Gently swirl the tube during the tiration to mix the contents.

8. Carefully remove the Titrator and cap. Do not to disturb the Titrator plunger.

9. Add 8 drops of Starch Indicator Solution (4170WT). The sample should turn blue.

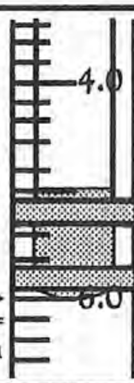
10. Cap the titration tube. Insert the tip of the Titrator into the opening of the titration tube cap.

11. Continue titrating until the blue color disappears and the solution becomes colorless.



12. Record the test result where the titrator tip meets the scale. Record as ppm Dissolved Oxygen. Each minor division on the Titrator scale equals 0.2 ppm.

Result = 6.0 ppm



4.7 COMMON QUESTIONS ABOUT ANALYZING OXYGEN

Should I pour off any of the water in my sample bottle before I add the chemicals?
NO! If you pour off some water you are introducing air (and oxygen). When you cap the bottle and shake it, this oxygen can cause erroneously high results. Put the bottle on a paper towel if necessary to catch any water that spills over when you add the chemicals. The reagents are more dense than the water and will sink to the bottom. Any overspill liquid is just water from your sample.

How should I hold the dropper bottles to dispense each chemical?
Hold the dropper bottles completely upside down. This ensures a uniform drop size. The liquid chemicals will not come out until you squeeze the bottle.

Why must I shake the bottle and let the floc settle twice?
Doing this twice ensures that the chemical reactions are complete and that all of the oxygen molecules have reacted with the chemical reagents.

Sometimes after I add the eight drops of sulfuric acid some brown particles remain. Is this OK?
The brown particles should be dissolved before you continue with your test. First, try shaking the sample bottle quite hard to see if they dissolve. If this doesn't work add one more drop of sulfuric acid (red capped bottle). Occasionally in water with an algae bloom there may be some organic matter present in your sample. This won't dissolve. You should be able to tell the difference between this and the chemical particles.

What does it mean by saying that the sample is "fixed?"
In a practical sense it means that contact with atmospheric oxygen will not affect your test results. Fixed samples may be stored up to eight hours, if kept refrigerated and in the dark. The chemical reactions that occur in this analysis are explained after these questions.

What is the best way to measure the amount of fixed sample that I should titrate?
If you have a plastic graduated cylinder, measure 20 ml of fixed sample. If you don't have a plastic graduated cylinder pour the fixed sample directly into the titration vial to the white 20 ml line.

Okay, now I've got my syringe filled and through the hole in the cap on the titration vial. Sometimes the drops don't seem to fall right into the water sample. Why?
Each cap should have a tiny vent hole in it so that, as the sodium thiosulfate is added to the water sample, the displaced air can escape. If you don't have this tiny hole, when you add the sodium thiosulfate instead of it dropping into the liquid it will run down the side of the bottle.
This will also happen if a drop of liquid on top of the cap covers the vent hole. So, make sure that 1) your cap has a vent hole, and 2) that is remains unobstructed during the titration. If you cap doesn't have a vent hole, you can easily make one or enlarge an existing one by heating a pin and pushing it through the plastic.

My water sample is pale yellow right after it is fixed. Do I still have to see it get lighter before I add the starch indicator?
If your water sample is already a pale yellow after it is fixed, add the starch indicator before you begin your titration. If your sample is completely colorless after it is fixed and remains that way after you add the indicator this means that there is no DO in your sample.

How many times should I run the test on my water sample?
You should run the DO test at least twice on each of your water samples. If the results are more than 0.6 ppm apart, collect new water samples and follow the protocol from the beginning.

What should I do with any leftover sodium thiosulfate in the syringe?
Discard any remaining sodium thiosulfate in your waste container. Do not put it back into the bottle it came from. Then take apart your syringe and rinse it with tap water. Store it with the plunger backed off from the bottom of the syringe. Waste containers can be dumped into the sink.

4.8 SALINITY

Salinity is a measure of the amount of dissolved salts in a given unit of water. The salinity of full-strength ocean water is normally around 28-35 parts per thousand (ppt). There is a salinity gradient from the ocean to freshwater. Salinity recordings taken closer to the ocean will be much higher than the salinity recordings taken near freshwater inflows.

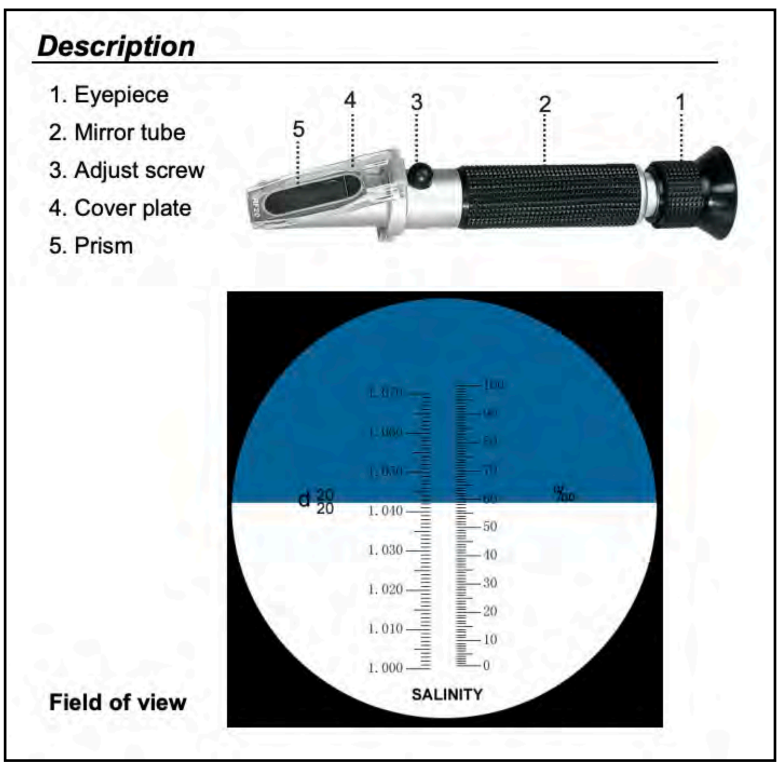
Human activities, such as using water for irrigation or stormwater discharges of rain water, can alter these salinity gradients significantly. Taking regular salinity readings gives you an indication of what kind of salinity gradient occurs in your saltwater monitoring locations.

The change in the way light bends, or refracts, through salty water is the basis for measuring salinity using a refractometer. *The greater the amount of salts in water, the more resistance the light will meet, and thus, the more it bends or changes direction*. Refractometers are relatively fragile, so volunteers should take great care when using these instruments. Salinity in freshwater is less than 0.5 parts per thousand (ppt); the salinity of seawater is approximately 35 ppt.

Salinity Monitoring Technique

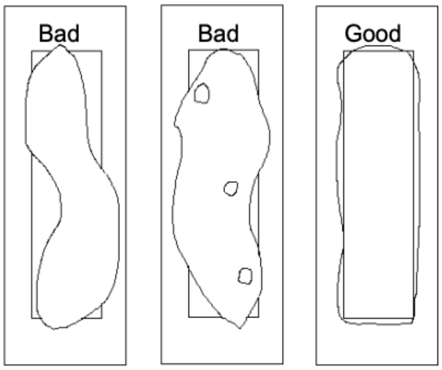
1. First, check the refractometer. Cover the prism with a few drops of distilled water from the included vial. Close the cover plate and rotate the adjusting screw clockwise or counter clockwise as needed so that the light/dark boundary line (known as the shadow line) evens up with the zero line. If the reading is not a “0,” turn the calibration screw with the included screwdriver while looking through the eyepiece, until the boundary line falls on “0.”

After the zero adjustment, clean the prism with a soft cloth.



Working parts of the Extech RF20 Refractometer. Credit: Extech Instruments

2. To take a reading, place a few drops of sample on the measurement prism. Ensure that enough solution is added to the prism in order to cover the entire surface. Close the prism so that the liquid spreads across the surface without air bubbles or dry spots (see diagram). Allow the sample to remain on the prism for approximately 30 seconds.



3. While holding the instrument in a bright area, look through the eyepiece. The salinity concentration is determined by the intersection of the boundary of the light and dark fields on the printed scale. The left side of the scale indicates the specific gravity and the right side parts per thousand (o/oo). If the scale appears out of focus, the eyepiece may be adjusted by rotating the knurled portion. The instrument also features an eye guard to prevent any stray light from entering the eyepiece and causing reflections. Record your result as parts per thousand (o/oo or ppt) in the database or on your form.

Note: If your screen is all blue, two conditions may be at play. There may be too small an amount of sample water on the prism. Or, you may be seeing results of freshwater dilution, perhaps from a large storm.

It may be necessary to adjust the position of the light source to maximize the contrast of the shadow line. Under normal conditions, optimal contrast is obtained by holding the instrument underneath and perpendicular to a light source. Once a reading has been taken, wipe dry with a clean, soft cloth (do not wash or rinse) and place the instrument in its case. Store your refractometer in a safe, dry environment. Saltwater is highly corrosive, so care should be taken to store the instrument after it is fully dry.

Also, temperature is the largest source of error in readings from refractometers. Always check that your refractometer model autocorrects for temperatures normal to your monitoring site.

4.9 TRANSPARENCY

The Secchi depth is a measurement of water transparency. Water transparency directly affects the amount of light penetration into a waterbody, which as we know, sets into action plant and algae growth, affecting DO as well as other chemical parameters. Algae and suspended particles can make the water cloudy decreasing transparency. Also, Secchi depth can vary seasonally.

For our protocol, there are two Secchi equipment options to measure transparency in water - Secchi disk and transparency tube. It is recommended that Secchi disks be used at docks, if the current does not move your rope, and that all other locations use the transparency tube (creek, river bank, boat). Both pieces of equipment utilize the same principle. A disk divided into quadrants, alternating two black and two white, is lowered into the water or a volume of water. The recorded depth is taken at the point where black and white quadrants can just barely be discerned from each other and the disk is visible.

Transparency Monitoring Technique - Transparency Tube

Remember to remove hats and sunglasses and perform this test in a shady spot.

1. The Secchi disk within the tube may be stationary or may be pulled out with a string. If on a string, pull the Secchi disk out.
2. Using your bucket or sampling pole, lower the bucket to collect a representative sample of water at your site. Be careful not to stir up the bottom, as this will increase the turbidity of your sample.
3. Fill the tube with your sample water. Your sample water should be well-mixed. Stir it if you have let it sit.
4. If your disk is stationary, work with a partner to slowly discharge sample from the bottom release valve until a member of your group tells you to stop, stopping at the point that the quadrants can just begin to be discerned. If your disk is on a string, begin to lower the disk slowly, adjusting up and down, until the disk and its quadrants are just visible. Firmly hold the string in place, pinching it along the top of the

tube, as you raise the tube to take your reading.

5. **IMPORTANT: Take readings in the shade or indirect sunlight to eliminate glare.** Using the ruler on the tube, measure the depth in centimeters to record in the database. Your tube may also have a measure for turbidity (measured in NTUs). The SC AAS Database will automatically convert your transparency measurements (in cm) to turbidity results. Remember that transparency and turbidity are inversely proportional, meaning the greater the depth of visual clarity, the lower amount of turbidity is present.

After sampling, rinse any mud or debris from the transparency tube and allow to dry completely before storing.

Stationary disk transparency tube as sample water is lowered and disk begins to be visible. Ruler in centimeters for measurement.

Dock Transparency Monitoring Technique - Secchi disk

The Secchi disk may be your preferred instrument if you are sampling from a dock and can look straight down at the disk (or a boat if the rope is not moved by the current). Remove hats and sunglasses to perform this test, choosing the more shady side of the dock or boat. The Secchi disk should be hanging vertical into the water. If the current is changing the angle of the rope and moving the disk, the line should be weighted OR transparency tube should be used instead.

10 cm, 50 cm, and 100 cm markings on SC AAS Kit Secchi disks.

1. Slowly lower the Secchi disk until it is no longer visible. Be careful not to touch and disturb the bottom sediments. Record this depth (at the water surface).
2. Slowly raise the disk until it just reappears. Record depth (at the water surface).
3. Average these two readings for your Secchi depth and measure of transparency. Record on your data sheet or in the database.

After sampling, rinse any mud or debris from the line and allow to dry completely before storing.

CHAPTER END

CH.5: NOAA PHYTOPLANKTON MONITORING PROTOCOL OVERVIEW

5.1 INTRODUCTION

Phytoplankton, also known as microalgae, are similar to terrestrial plants in that they contain chlorophyll and require sunlight in order to live and grow. Most phytoplankton are buoyant and float in the upper part of the ocean, where sunlight penetrates the water. Phytoplankton also require inorganic nutrients such as nitrates, phosphates, and sulfur which they convert into proteins, fats, and carbohydrates.

In a balanced ecosystem, phytoplankton provide food for a wide range of sea creatures including whales, shrimp, snails, and jellyfish. When too many nutrients are available, some phytoplankton may grow out of control and form HABs. These blooms can potentially produce extremely toxic compounds that have harmful effects on fish, shellfish, mammals, birds, and even people. It is important to remember that algae and cyanobacteria (cyanos) are a natural part of the waterway; not all are "bad". Some species, however, can be harmful, and these are the organisms that are actively monitored.

Harmful algal blooms impact the coastal economy on average $82 million a year. Every coastal state suffers HABs and the problem is too large for any one agency. The Phytoplankton Monitoring Network (PMN) is a national volunteer organization started in 2001 that monitors for potential Harmful Algal Blooms (HABs) and promotes a better understanding of HABs by way of volunteer monitoring. PMN's coastal monitoring program collects ecological data at low taxpayer expense in nearly every coastal US state, including Hawaii and Alaska.

This is a true citizen science program that combines expertise from NOAA, state and federal agencies, and industry with the energy of volunteers from schools, universities and civic groups. The organization aims to educate the public on HABS while expanding the knowledge of phytoplankton that exist in the coastal waters through research-based monitoring.

Participating citizen scientists are trained to:
- Collect samples from coastal or freshwater environments,
- Identify potential harmful algal/cyanobacterial species,
- Enter information into a NOAA Database.

With participants' contributions, NOAA scientists can then:
- Analyze water samples for HAB toxins,
- Alert state/local agencies to the presence of blooms,
- Identify temporal and geographic HAB trends.

Linglodinium polyedrum bloom off California coast (Credit: NOAA)

WHAT IS A HARMFUL ALGAL BLOOM?

SOME species of phytoplankton (or algae) are potentially harmful and can produce toxins that can impact drinking and recreational waters. This can affect wildlife, pets and humans. They can:
- Cause physical damage (*i.e.*, clog or irritate fish gills that can lead to fish kills),
- Lead to hypoxic or anoxic conditions through the removal of oxygen from the water (which can lead to fish kills),
- Produce marine toxins (which can lead to marine animal mortalities and human health syndromes).

Mounting evidence indicates global climate changes support increased frequency and geographic extent of HABs, which can then put more people and animals at risk for exposure to HABs and the toxins that they can produce.

WHY THE PHYTOPLANKTON MONITORING NETWORK?

Very few government agencies or private institutions have the capacity or capability to monitor the vast amount of coastline that is annually impacted by HABs. The PMN engages local citizens in environmental monitoring of potentially harmful algae to aid NOAA scientists and others in their research.

Participants in the program include school groups, civic groups, tribal communities, interested individuals, and government entities on the national, state and local level.

Fish kill related to HABs (Credit: Texas Parks and Wildlife)

5.2 TRAINING INFORMATION

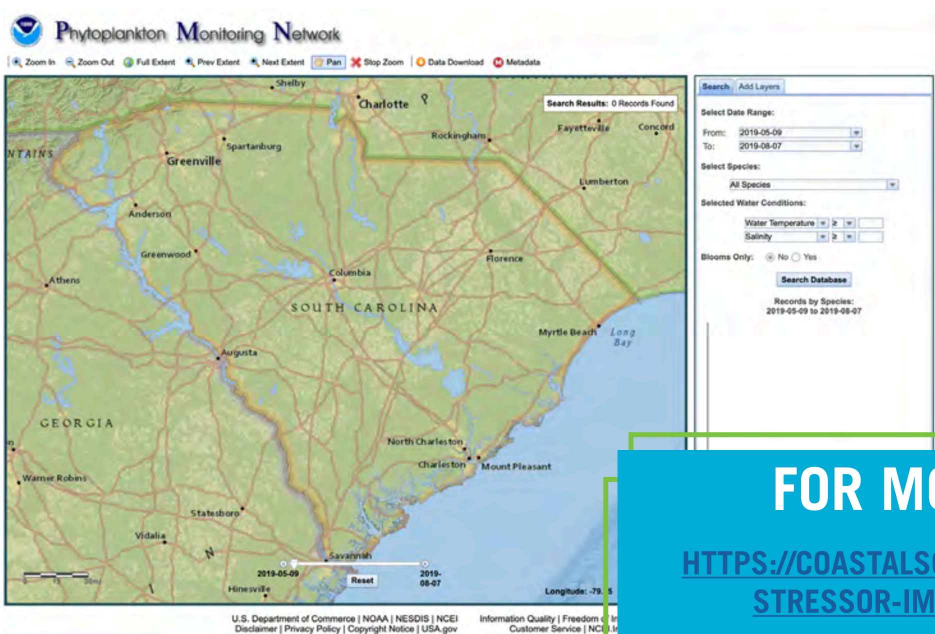
Training sessions on protocols and identification of target algae and cyanobacteria can be done via webinar or on-site. Identification guides are available to be used as a resource for volunteers; the “Phyto” App available on iTunes is updated to assist with and improve volunteers’ identification skills of marine algae and cyanos. Volunteers must participate in practice sampling sessions. The identifications are confirmed by PMN staff via photos and/or mailed-in samples to ensure accuracy.

Volunteers will:

1. Collect the sample at least once every two weeks during the sampling season
2. Analyze the sample by identifying target algae/cyanobacteria via a prepared slide
3. Take digital pictures to send in to the PMN
4. Input data into a PMN database
5. Ship the sample to PMN as required

BENEFITS OF OUR WORK

Since 2001 PMN volunteers discovered over 225 blooms throughout the coastal United States and have generated over 300,000 observations of environmental conditions. Volunteer data is directly incorporated into the state HAB monitoring plans of Texas, Mississippi, Alabama, Georgia, and South Carolina. HAB managers of other states are notified of potential blooms by PMN staff directly.



FOR MORE INFORMATION

[HTTPS://COASTALSCIENCE.NOAA.GOV/RESEARCH/STRESSOR-IMPACTS-MITIGATION/PMN](https://coastalscience.noaa.gov/research/stressor-impacts-mitigation/pmn)

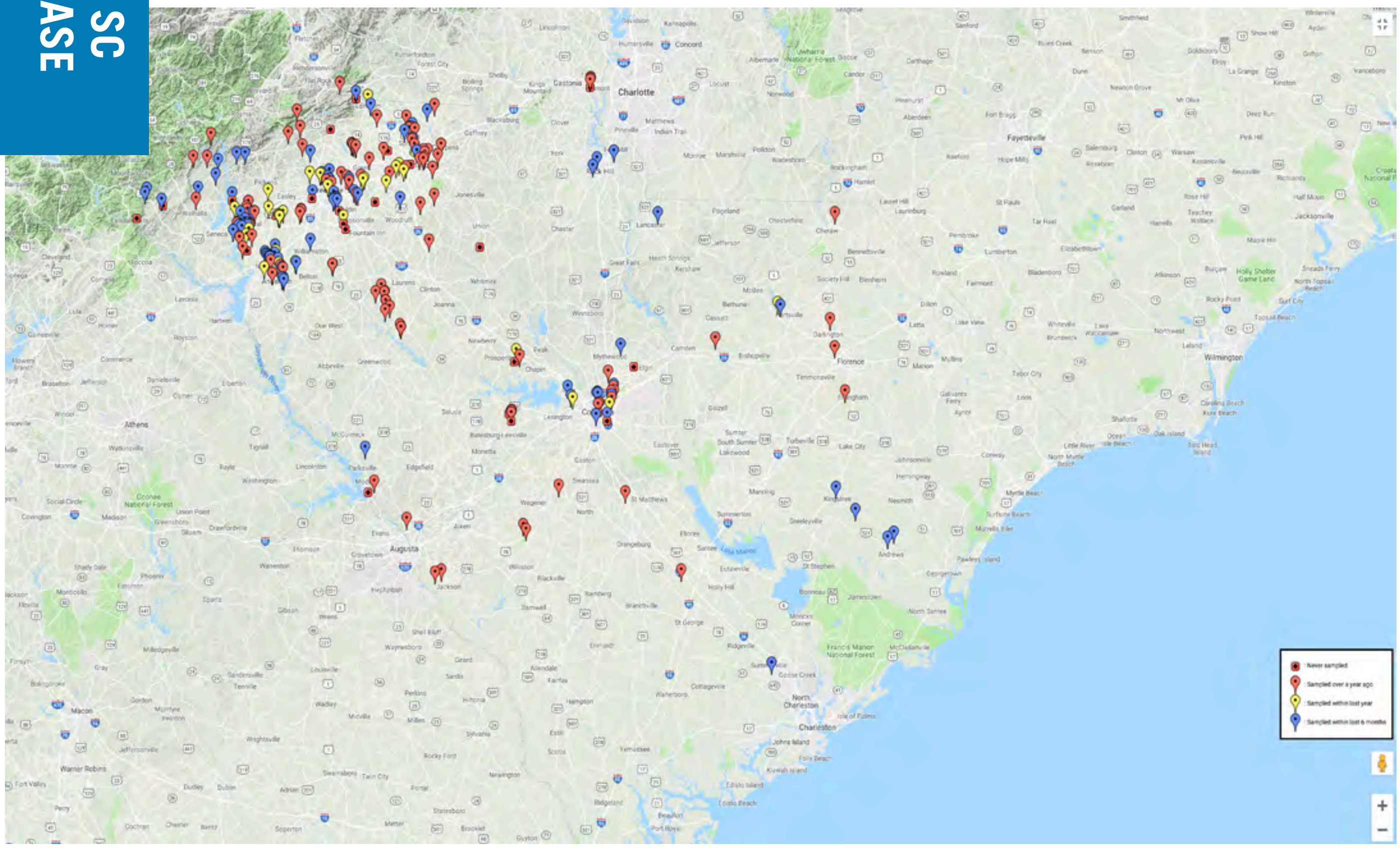
EMAIL: pmn@noaa.gov

Steve Morton, Principal Investigator
Steve.morton@noaa.gov

Jennifer Maucher Fuquay, Program Coordinator
Jennifer.maucher@noaa.gov

CHAPTER END

CH.6: USING THE SC AAS DATABASE



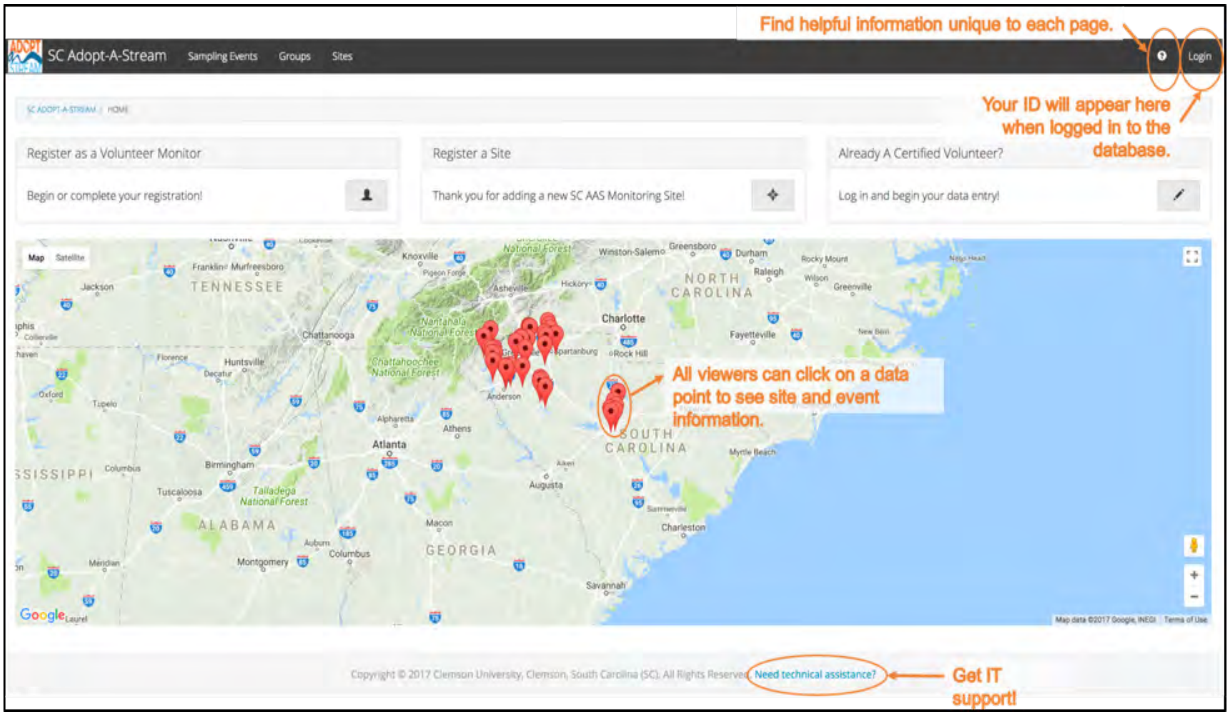
Getting Started

Once certified, SC AAS Trainers add participants to the SC AAS Database. The database will generate an email to the newly certified volunteer with a prompt to complete their registration. This step is critical to authorizing your involvement in this program and should be completed within 24 hours of receiving the email! Registration includes entering your name, address, affiliation, email, and overall contact information. The newly certified volunteer can also add themselves to an existing monitoring group or create a monitoring group. Groups are important and will be discussed further in this document.

Trainers enter certification date and protocol(s) in which participants were certified or recertified (annually).

The home screen of the database is shown below and accessible from **www.scadoptastream.org**.

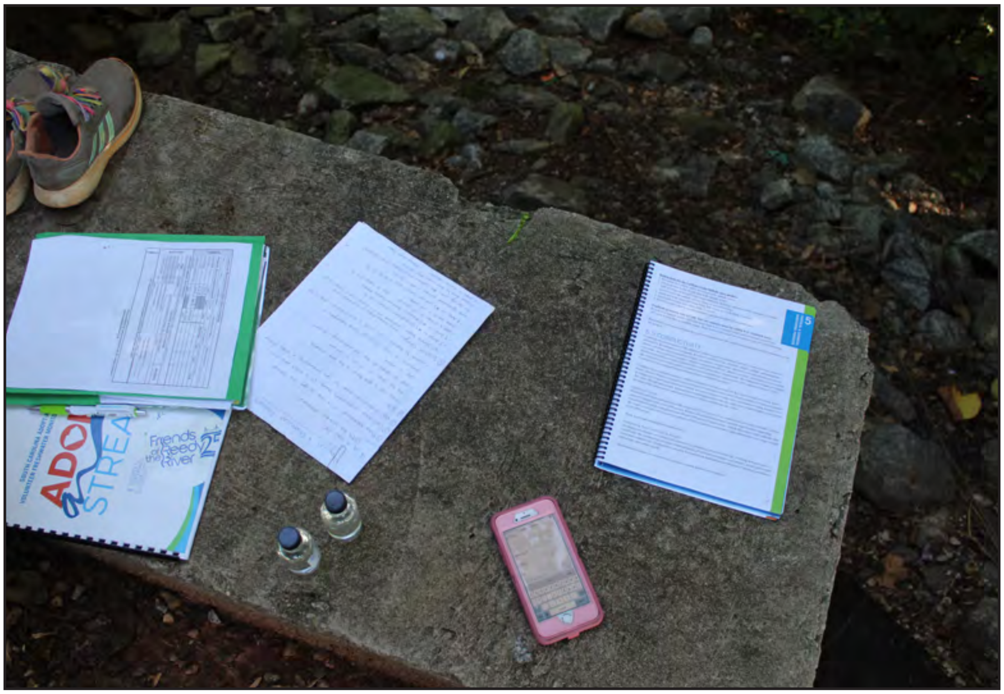
Icons and drop down menus, and the use of tabs, streamline data entry. On a mobile device, drop down menus are scroll wheels.



Mobile-Friendly and Secure

The SC AAS Database operates through an online application, accessible anytime you are online with your computer, smartphone, or tablet. With a built-in "Save as Draft" button, the Volunteer Monitor with cellular service or Wi-Fi can begin data entry in the field, geo-locating the site, entering observations and results, and recording conditions. After temporarily saving the data with this feature, the Volunteer Monitor can then complete the data development process and finalize the data entry.

The SC AAS Database is restricted through the registration process; users should be certified as a Volunteer Monitor or Trainer with a case-sensitive password protecting their user profile and access rights.



Restrictions

User restrictions built into the database allow different actions according to certification status. There are four statuses built into the database – Public Viewer, Volunteer Monitor, SC AAS Trainer, and SC AAS State Team. The following are some of the access rights and restrictions by each user.

- Public Viewer – The SC AAS Program is built with the objective that local data can more quickly lead to local solutions to water quality concerns and threats. Therefore, data collected under SC AAS can be viewed by the public without any log in or registration process. Information is available only for the site's observations and results, which can also be exported as a .csv file.
- Volunteer Monitor – Volunteer Monitors can register sampling sites, add data, add and edit group membership, and modify their password or contact information. They can only edit data for a sampling site if they are an individual within the group associated with the sampling site. Editing data can occur by an associated volunteer monitor even after the site data is saved and submitted.
- SC AAS Trainers – Trainers play a crucial role in the certification and recertification process. In addition to entering monitoring data for sites in which they are a member of the group, Trainers upload the initial contact information (Name, Email, Training Event Date, Protocols) for newly certified Volunteer Monitors. Trainers also update the certification/recertification status of Vounteer Monitors associated with their Training Events.
- SC AAS State Team – There are many more functions of the database, currently and in development, and the SC AAS State Team keeps up with these evolutions. Some useful functions include deleting a monitoring site (if entered incorrectly), deleting duplicate monitoring results, and alerting users of all changes in the database.

Alerts

The SC AAS Database includes alerts sent to a city or county government that would like to expediently know that there may be a threat to local water quality in their jurisdiction. An automated email is distributed when the following results are recorded and saved in the database:

- Sewage is selected for Water Odor in Observations.
- Other is selected for Water Color in Observations.

SIGN UP!
Notifications of updates to the database are distributed through the SC AAS E-News. Please be sure to sign up on the SC AAS website to receive program updates!

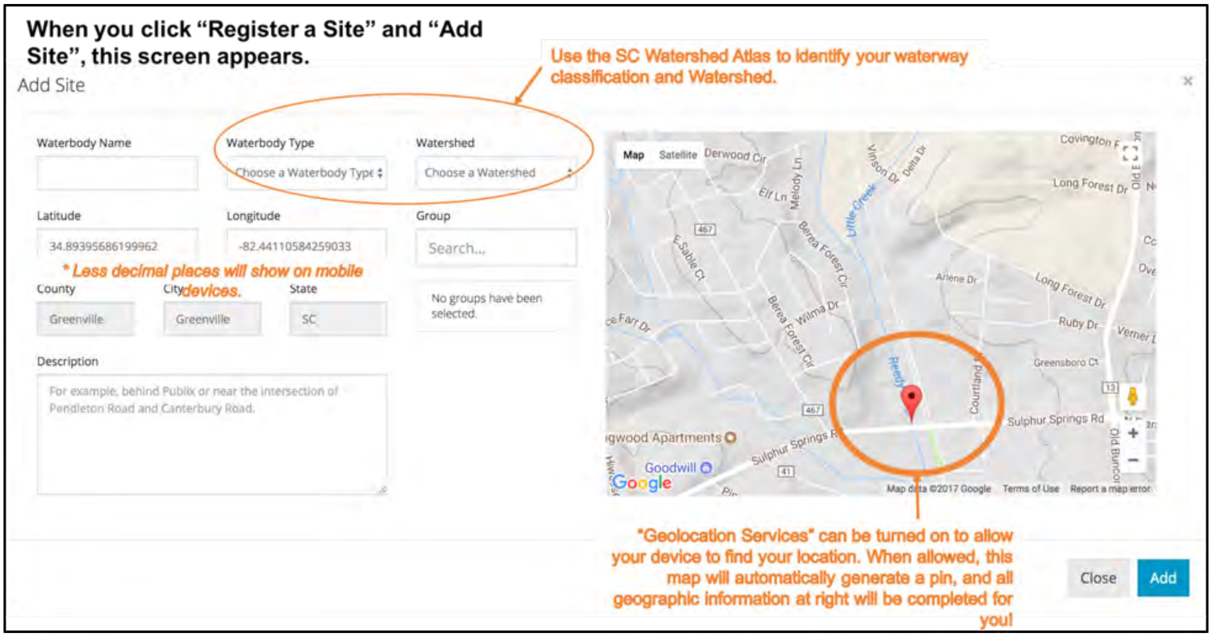
These alerts are also issued to the SC AAS State Team (found on page 3) and communicated to the SC DHEC Bureau of Water Watershed Manager for the watershed of concern. If you are a city or county interested in receiving these alerts, please contact the SC AAS State Team, and we can quickly add you to the alert system.

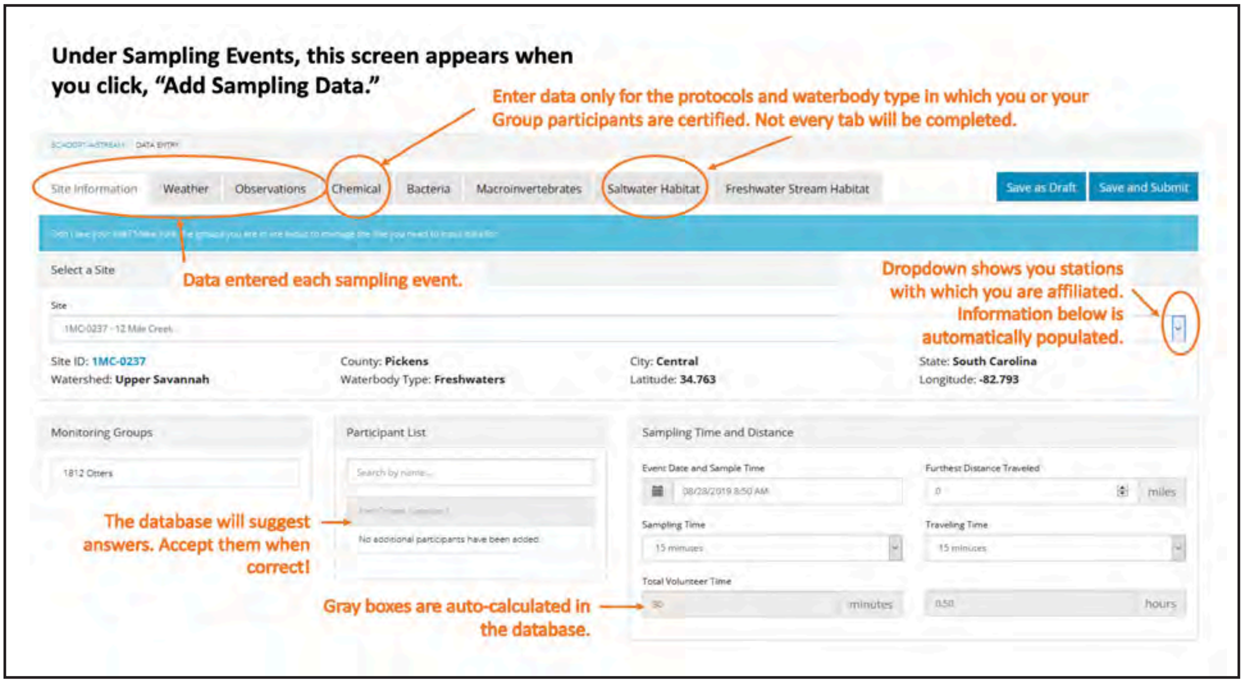
Additional Resources

There are a number of resources available to help you navigate the SC AAS Database and use it responsibly and easily.

1. Webinars – recorded and regularly offered, live webinars will be held throughout the year to walk participants through the database. Webinars will be announced in the SC AAS E-News and included in the Events Calendar.
2. Online – As the SC AAS website, Resources & Materials webpage hosts videos and information to support the SC AAS Volunteer Monitor, including previously recorded database how-to webinars.
3. Video – Though the program and database continue to evolve, videos are available to walk Volunteer Monitors through the data entry process. Just check the website!

https://scaas.app.clemson.edu/home.php

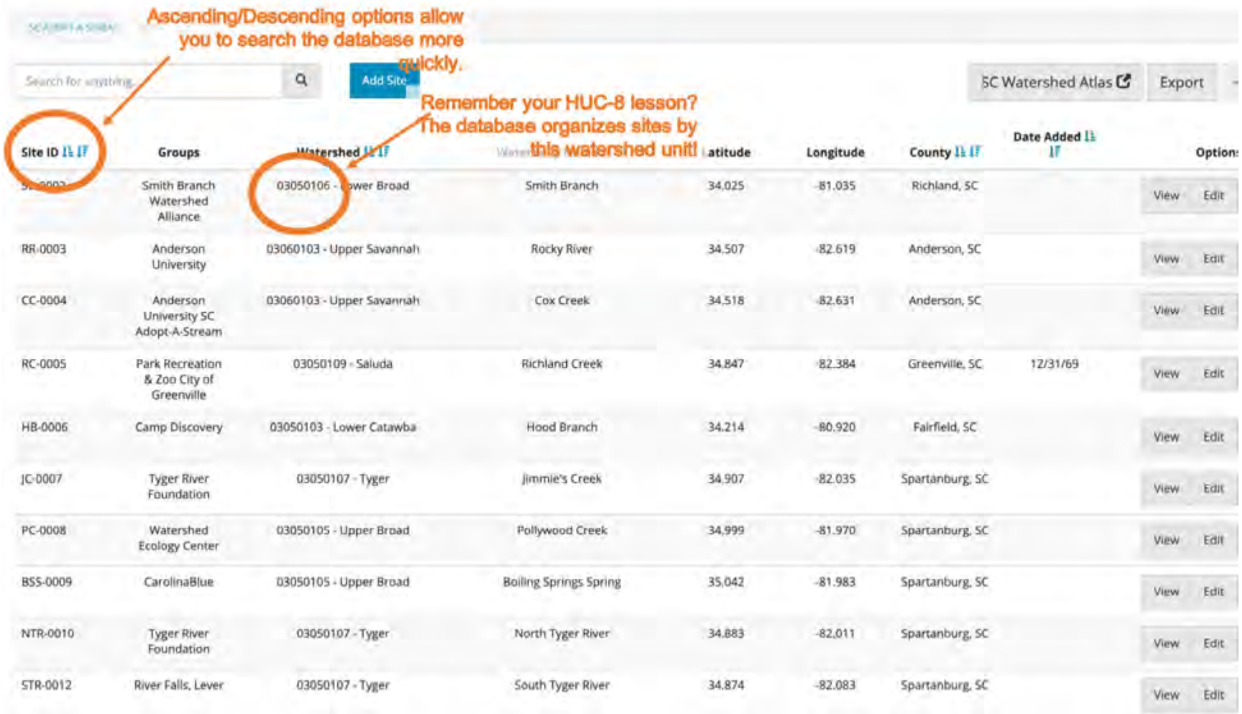




Groups are important as every group member can edit, add data, or add photos to a monitoring site with which they are associated. Be sure to recognize those in your monitoring group when creating the group, as well as assigning a group to a site. In the "Site" dropdown menu shown above, you will only see sites monitored by your group(s). No more than two groups can monitor any one site.

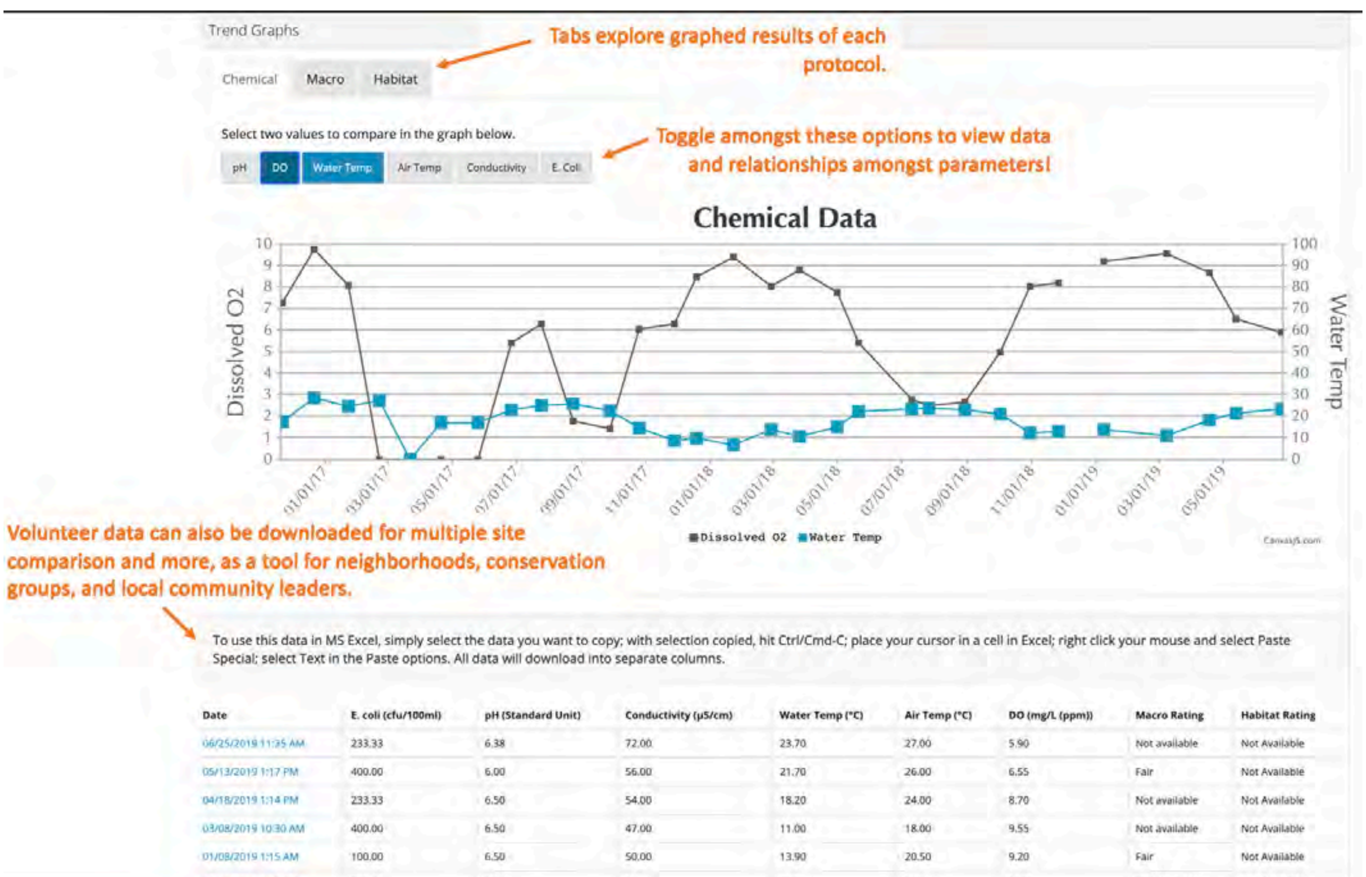
The database is also "smart!" When a person's name or other information is suggested, *select it if correct*! This feature helps reduce potential error and maintain consistency, for example, a spelling of someone's name.

All viewers can see what sites exist, as shown on the next page, the site's monitoring data, photos, and data trends. No personal information can be viewed by someone not logged in to the system and is restricted based on user type. In this way, your collected data and observations can be used by local resource managers, stormwater departments, conservation groups, and more, expanding the science of what we know about our waterways.



Site ID	Groups	Watershed	Waterbody	Latitude	Longitude	County	Date Added	Options
[illegible]0002	Smith Branch Watershed Alliance	03050106 - [illegible]wer Broad	Smith Branch	34.025	-81.035	Richland, SC		View Edit
RR-0003	Anderson University	03060103 - Upper Savannah	Rocky River	34.507	-82.619	Anderson, SC		View Edit
CC-0004	Anderson University SC Adopt-A-Stream	03060103 - Upper Savannah	Cox Creek	34.518	-82.631	Anderson, SC		View Edit
RC-0005	Park Recreation & Zoo City of Greenville	03050109 - Saluda	Richland Creek	34.847	-82.384	Greenville, SC	12/31/69	View Edit
HB-0006	Camp Discovery	03050103 - Lower Catawba	Hood Branch	34.214	-80.920	Fairfield, SC		View Edit
JC-0007	Tyger River Foundation	03050107 - Tyger	Jimmie's Creek	34.907	-82.035	Spartanburg, SC		View Edit
PC-0008	Watershed Ecology Center	03050105 - Upper Broad	Pollywood Creek	34.999	-81.970	Spartanburg, SC		View Edit
BSS-0009	CarolinaBlue	03050105 - Upper Broad	Boiling Springs Spring	35.042	-81.983	Spartanburg, SC		View Edit
NTR-0010	Tyger River Foundation	03050107 - Tyger	North Tyger River	34.883	-82.011	Spartanburg, SC		View Edit
STR-0012	River Falls, Lever	03050107 - Tyger	South Tyger River	34.874	-82.083	Spartanburg, SC		View Edit

Data summaries and graphs are provided at the Site Profile Page for each site in the database. Parameters can be toggled to view different relationships and tabs can be explored to see graphed results for each protocol.



To use this data in MS Excel, simply select the data you want to copy; with selection copied, hit Ctrl/Cmd-C; place your cursor in a cell in Excel; right click your mouse and select Paste Special; select Text in the Paste options. All data will download into separate columns.

Date	E. coli (cfu/100ml)	pH (Standard Unit)	Conductivity (µS/cm)	Water Temp (°C)	Air Temp (°C)	DO (mg/L (ppm))	Macro Rating	Habitat Rating
06/25/2019 11:35 AM	233.33	6.38	72.00	23.70	27.00	5.90	Not available	Not Available
05/13/2019 1:17 PM	400.00	6.00	56.00	21.70	26.00	6.55	Fair	Not Available
04/18/2019 1:14 PM	233.33	6.50	54.00	18.20	24.00	8.70	Not available	Not Available
03/08/2019 10:30 AM	400.00	6.50	47.00	11.00	18.00	9.55	Not available	Not Available
01/08/2019 1:15 AM	100.00	6.50	50.00	13.90	20.50	9.20	Fair	Not Available
11/29/2018 3:55 PM	133.33	N/A	N/A	N/A	N/A	N/A	Not available	Not Available

CHAPTER END

APPENDIX 1:

SC AAS DATA FORMS

South Carolina Adopt-a-Stream: Tidal Saltwater Assessment

SITE INFORMATIO

Group Name: ____________________________ Event Date: ____________________________ (MMDDYYYY)
Group ID: ____________________ Site ID: _____ Time Sample Collected: _____________ (HHMM am/pm)
Waterbody Name: ______________________ Time Spent Sampling: _________________________ (Min)
Monitor(s): ____________________________ Total Time Spent Traveling (*optional*): ___________ (Min)
Number of Participants: ________________ Furthest Distance Traveled (*optional*): __________ (Miles)
(in addition to you)

WEATHER

Present conditions (check all that apply)

☐ Heavy Rain ☐ Steady Rain ☐ Intermittent Rain
☐ Overcast ☐ Clear/Sunny ☐ Partly Cloudy

Amount of rain, if known?

Amount in Inches: ________________
In Last Hours/Days: ____________
*Go to *cocorahs.org for rainfall data*

OBSERVATIONS

Tide is: ☐ flow tide (incoming) ☐ ebb tide (outgoing)

Water Conditions ☐ Calm ☐ Ripples ☐ Waves

Water Surface: ☐ Algae ☐ Oil ☐ Foam ☐ Other

Water Color: ☐ No color ☐ Brown/ Muddy ☐ Green ☐ Milky White ☐ Tannic ☐ Other:________

Water Odor: ☐ Gas ☐ Chlorine ☐ Sewage/Manure ☐ Fishy ☐ Other: ___________

Water Clarity: ☐ Transparent ☐ Somewhat Turbid ☐ Turbid

HAZARDS, RISKS, BARRIERS

Hazards	***Security***	***Sources of Bacteria*** (signs of fecal matter)	***Barriers to Fish Movement***
☐ Steep Bank	☐ Drug Use	☐ Dog	☐ Incised Culvert *(pipe caving in or filled)*
☐ Trash	☐ Vagrancy	☐ Goose	☐ Perched Culvert *(pipe set too high above water line)*
☐ Fast Current	☐ Animals	☐ Livestock	☐ Low Flow
☐ Other	☐ Other	☐ Human	☐ Dam
☐ None	☐ None	☐ Other	☐ Other
		☐ None	☐ None

OUTFALLS

Presence of Outfalls

☐ Pipe
☐ Other ☐ None

Presence of Outfall Flow after 3 Days of Dry Weather?

☐ Yes ☐ No

in.
Diameter

Condition of Outfalls

☐ Eroded/Undercut
☐ Trash/Debris
☐ Damaged
☐ Clogged
☐ Vegetation
☐ Other
☐ Clear

Please enter all data promptly into the SC Adopt-a-Stream Database
www.scadoptastream.org

Marsh Condition/Appearance

Photo(s):

Please take 2 pictures to document observations and changes that may impact water quality. Take 1 picture to document water height. Images can be uploaded online. Refer to Handbook for more info.

Marsh Condition/Appearance:

☐ Marsh Grass Green ☐ Marsh Grass Brown ☐ Marsh Surface Mostly Muddy
☐ Unseasonable Change in Color

Is the marsh area? ☐ Increasing ☐ Decreasing ☐ Same as last event
☐ Presence of Phragmites

Comments:

Located within 100 feet of Waterway:
(check all that apply)

☐ Industrial ☐ Commercial ☐ Agriculture ☐ Dock
☐ Residential development ☐ Groin ☐ Jetty

Comments:

Observed Impacts on Marsh:

☐ Trash ☐ Dumping ☐ Dredging ☐ Erosion ☐ Large vegetative debris ☐ Algae

Comments:

Biological Survey:

☐ Snails	☐ Other: ___________________
☐ Oysters	☐ Other: ___________________
☐ Blue Crabs	☐ Other: ___________________
☐ Fiddler Crabs	☐ Other: ___________________
☐ Fish	☐ Other: ___________________
☐ Barnacles	☐ Other: ___________________
☐ Submerged aquatic vegetation	☐ Other: ___________________

Comments:

Surface Water Height:

☐ Photo ☐ Staff Gauge Use Gauge Reading: _______

Additional Comments/Observations:
(Include significant changes since last monitoring event)

Chemicals*: Are any chemicals expired?* ☐ Yes ☐ No List any expired: _________

Core Tests	**Test 1**	**Test 2**	**Units**
Air Temp			°C
Water Temp			°C
pH (+/- 0.25)			Standard unit
Dissovled Oxygen (+/- 0.6)			mg/L or ppm
Salinity		(Deionized water)	o/00
Transparency	☐ Trans. Tube ____ cm ☐ Greater than 120 cm ☐ Turbidity _____ NTU	☐ Secchi Disk ___ m **Disappearance** depth Average______ ___ m **Reappearance** depth ☐ Hit bottom before disappearing	
Other Test			

APPENDIX 2:
GLOSSARY

GLOSSARY OF WATER QUALITY TERMS

Acid rain. Rain with a pH of 4.5 or less.

Aerobic. Life or processes that depend on the presence of oxygen.

Algae. Green plants that occur as microscopic forms suspended in water (phytoplankton) and as unicellular or filamentous forms attached to rocks and other substrates. These plants lack roots, stems, flowers, and leaves, live mainly in water, and use the sun as an energy source.

Algal bloom. A sudden increase in the abundance of suspended (planktonic) algae, especially at or near the water surface, producing a green appearance to the water. Excess nutrient can cause an algal bloom.

Alkalinity. A measure of water's ability to neutralize acid.

Anaerobic. Refers to life or processes that occur in the absence of oxygen.

Anaerobic decomposition. The breakdown of organic material without oxygen.

Anoxia. A condition of no oxygen in the water. Often occurs near the bottom of eutrophic, stratified lakes in summer and under ice in winter.

Aquatic community. All the groups of plants and animals occupying a common body of water.

Bank. The portion of the stream channel that restricts the movement of water out of the channel during times of normal water depth. This area is characterized as being the exposed areas on either side of the stream above water level.

Baseline. A level or concentration that is the norm.

Baseflow. That portion of stream flow originating from groundwater discharging into the stream.

Basin. Another word for a watershed.

Benthic. Describes all things associated with the bottom, or sediments, of a stream.

Benthic macroinvertebrates. Bottom-dwelling organisms that lack a backbone, inhabit streams or lakes, and can be seen with the naked eye.

Benthic zone. The zone on the bottom of moving or standing waters.

Bioaccumulation. The build-up of toxic substances in animal flesh.

Biodiversity. Biological diversity in an environment as indicated by the numbers of different species of plants and animals.

Biomass. Living things and their by-products.

Canopy cover. Overhanging vegetation that provides shade to a stream or waterway.

Chemical weathering. Erosion caused by chemical reactions (e.g., rainwater dissolving limestone).

Chlorophyll. Green plant pigments that are necessary for photosynthesis; may be used as an indicator of algal population levels in a stream or lake.

Clarity. A measure of light penetration in a water column. May also be referred to as transparency (see definition).

Creek. A natural, fresh-water stream that is smaller than a river. This term is sometimes used specifically for small streams in coastal areas.

Cultural eutrophication. Accelerated enrichment of waters due to human activities. Excess nutrients from agricultural runoff, sewage, or other sources allow waters to support a higher amount of plant and animal matter than they would naturally.

Decomposer. An organism that feeds on and breaks down dead plant or animal matter, thus making organic nutrients available to the ecosystem.

Dead zone. An area of estuary or ocean where oxygen conditions are depleted, usually due to pollution.

Denitrification. The process of converting nitrate nitrogen into nitrite nitrogen, which can convert to nitrogen gas and escape into the atmosphere.

Deposition. A natural process in which sediment (sand, clay, gravel) falls out of the water, wind, or ice that carries it. In a stream, this process builds up stream banks – the opposite of erosion. Also called sedimentation.

Discharge permits. The maximum amount of a pollutant that an entity is permitted to release into a waterbody.

Dissolved oxygen. The amount of oxygen dissolved in water. Higher amounts of oxygen can be dissolved in colder waters than in warmer waters. Dissolved oxygen is necessary to support fish and other aquatic organisms.

Diversity. A large variety of organisms.

Dystrophic. Low in nutrients; highly colored with dissolved humic organic matter.

Ecology. The study of relationships among living and nonliving things.

Ecoregion. Large area within which local ecosystems reoccur in a more or less predictable pattern. Ecoregions provide a spatial framework for ecosystem assessment, research, inventory, monitoring, and management.

Ecosystem. A community of animals, plants, and microorganisms interacting within the physical and chemical environment.

Ecotone. The transition area between two ecosystems. These regions are typically rich in diversity and can be wide or narrow. The transition may be sharp, such as forest to cleared land, or transitional, such as forest to marsh, where there is a gradual change in species and more.

Emergent vegetation. Plants living along the edges (or banks) of a stream that are rooted in sediment but grow above the water's surface.

Enterococcus bacteria. A type of bacteria that lives in the intestinal tracts of warm-blooded animals, including humans, pets, and wildlife. Enterococci are typically not considered harmful to humans, but their presence in the environment may indicate that other disease-causing organisms may be present. **Elevated levels of these bacteria in water can indicate possible contamination by fecal waste.**

Ephemeral stream. A stream that flows during the wet season and is dry in the dry season; see Intermittent stream.

Erosion. The wearing down and removal of soil, rock fragments, and bedrock through the action of running water, wind, moving ice, and gravitational creep (or mass movement).

E. coli (*Escherichia coli*). A bacterium of the intestines of warm-blooded organisms, including humans, that is used as an indicator of water pollution for disease-causing organisms.

Estuary. A semi-enclosed coastal body of water which has free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage

Eutrophic. A term used to describe very productive or enriched lakes. These lakes tend to exhibit some or all of the following characteristics: an abundance of rooted plants, elevated turbidity levels due to high algal populations, loss of oxygen in bottom waters during the summer months, rapid accumulation of soft bottom sediments, and abundant fish, which may include stunted and/or rough species in the most fertile lakes.

Eutrophication. A gradual increase in the productivity of a lake ecosystem due to enrichment with plant nutrients, leading to changes in the biological community as well as physical and chemical changes. This is a natural process, but can be greatly accelerated by humans (see Cultural eutrophication).

Fecal coliform bacteria. The portion of the coliform group that is present in the gut or feces of warmblooded organisms. The presence of fecal coliform bacteria in water is an indication of pollution and potential human health problems.

Floodplain. An area on both sides of a stream where flood waters spread out during high flow. The surface may appear dry for most of the year, but it is generally occupied by plants adapted to wet soils. Plants and trees in floodplains also filter pollutants and sediment.

Flow, Discharge. A measure of how much water passes a given point in a given time (m3/s).

Geographic Information System. A mapping application that uses different overlaid layers of information to represent the earth's surface.

Geology. The study of the earth's history, the materials that make up the earth, and the processes that act on the earth.

Groin. A long, narrow structure built out into the water from a beach in order to prevent beach erosion or to trap and accumulate sand that would otherwise drift along the beach face. Groins are usually smaller than jetties. The effect depletes sand deposition immediately down drift of the groin, which often leads to repeated groins for sand capture.

Groundwater. Water found beneath the earth's surface.

Habitat. The place where a plant or animal lives that has all of the conditions necessary to support its life and reproduction.

Habitat diversity. The range of habitats within a region.

Hydrogeology. The effect geology has on water quality and stream morphology.

Hydrologic unit code (HUC). A description of watersheds that indicates size and location of particular watersheds; a watershed address.

Hydrologic cycle. The continuous movement of water among the oceans, air, and the earth in the form of precipitation, percolation, evapotranspiration, and stream discharge.

Hydrology. The science of how water flows on top of, and below, the earth's surface.

Hypereutrophic. Refers to murky, highly productive waters, closest to the wetlands status. Many aquatic species cannot survive in them.

Hypoxia. A condition of low dissolved oxygen levels in a waterbody that can result from the decay of plants and algae.

Impervious. Water cannot pass through; waterproof.

Indicator species. Groups or types of organisms used to assess the environmental health of a waterbody.

Infiltration rate. The rate at which water soaks into the soil.

Inorganic. Any compound not containing carbon.

Intermittent stream. A stream that flows when there is adequate precipitation and is dry when there's not. The stream does not flow continuously.

Invasive Species. A species of plant or animal that is not native to a given ecosystem but whose presence might cause environmental harm to the system or harm to human health. Invasive species often thrive in new habitats because they have no natural predators in the new ecosystem to keep them in check.

Invertebrate. An organism without a backbone.

Jetty. A long, narrow structure that stretches from shore into the water, to protect a coastline from the currents and tides and keep a channel open for navigation. Jetties are usually larger than groins. Minimizes sand deposition within the inlet.

Left bank. When facing downstream, the bank to your left.

Lentic water. Standing water, such as lakes, ponds, and wetlands.

Limiting resource. A resource that limits the abundance of an organism.

Loamy soil. Material composed primarily of sand and silt particles with some clay present.

Lotic water. Flowing water, such as rivers and streams.

MPN – is the acronym used for Most Probable Number, and represents a method for estimating quantitative results of organism growth in sample medium.

Macroinvertebrates. A spineless animal visible without the use of a magnifying glass. Benthic macroinvertebrates, which live in the bottom of streams and wetlands, are good indicators of water quality because they live in the same area most of their lives and differ in their sensitivity to pollution. Which macroinvertebrates you find – or don't find – in a stream indicates the pollution level of the water. Benthic macroinvertebrates include aquatic insects (such as dragonfly and damselfly larvae) and crustaceans (such as crayfish, snails, and clams).

Meander. A bend in a stream.

Microhabitat. Local conditions that immediately surround an organism. Microhabitats include algae mats, leaf packs, logjams, rock piles, root wads, undercut banks, and weed beds.

Mineralization. The process of decomposition and transformation of organic nitrogen found in plant parts and animal manure into available forms of inorganic nitrogen.

Niche. The function or position of an organism or population within an ecological community, or the particular area within a habitat occupied by an organism.

Nitrate. A form of nitrogen. Nitrate is water soluble and is the most common form of nitrogen found in streams and lakes.

Nitrogen. An element necessary for the growth of aquatic plants. It may be found in several forms, including nitrate, nitrite, and ammonia. Nitrogen is considered to be limiting because it is needed by plants and animals in the stream in moderate amounts. When present in higher amounts, such as from large amounts of fertilizer runoff from local farm fields or urban lawns, large algal blooms occur, which can result in a depletion of dissolved oxygen.

Nitrogen cycle. The uptake of inorganic nitrogen by plants that convert it to organic forms, which are used by animals and transformed back into inorganic nitrogen by bacteria.

Nitrification. The process of converting ammonium nitrogen into nitrate nitrogen.

Nonpoint source pollution. A type of pollution whose source is not readily identifiable as any one particular point, such as pollution caused by runoff from streets, agricultural land, construction sites, and parking lots. Polluted runoff and pollution sources not discharged from a single point.

Nutrient. Any of a group of elements necessary for the growth of living organisms, such as nitrogen and phosphorus. Excessive supplies of phosphorus or nitrogen, however, may overstimulate plant growth in surface waters.

Nutrient enrichment. Elevated levels of nitrogen and/or phosphorus in a waterbody that result in nuisance growths of algae or other aquatic plants.

Organic matter. Plant and animal material.

Organic phosphate. Phosphates that are found in plant and animal tissue, waste solids, or other organic matter.

Orthophosphate. Inorganic form of phosphorus.

Pathogen. An organism capable of causing disease.

Pathogenic. Capable of causing disease.

Perennial stream. Stream that flows nearly all year long.

Pervious. Allows water to pass through.

Pesticides. Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Though often misunderstood to refer only to insecticides, the term also applies to herbicides, fungicides, and various other substances used to control pests.

pH. A measure of acidity or alkalinity on a scale of 0 to 14. A pH of 7 is neutral, less than 7 is acidic, and greater than 7 is alkaline (basic).

Phosphorus. An element necessary for the growth of aquatic plants. Elevated levels of phosphorus can affect water quality by increasing the production of algae and rooted plants. This can lead to eutrophication of waterbodies.

Phosphorus cycle. The process of orthophosphate being converted to organic phosphate by plants and animals and converted back to inorganic phosphate and recycled when they die and decay.

Photosynthesis. The process by which green plants produce oxygen from sunlight, water, and carbon dioxide.

Physical weathering. Erosion caused by mechanical forces (e.g., water expanding as it freezes and breaking apart rocks).

Phytoplankton. Algae that are microscopic and suspended in water.

Plankton. The community of microorganisms consisting of plants (phytoplankton) and animals (zooplanton) inhabiting open-water regions of lakes and rivers.

Point sampling. Sampling from a specific depth, or point, in the lake water column.

Point source pollution. Pollutants originating from a "point" source, such as a pipe, vent, or culvert.

Point source contamination. Contamination stemming from a single, isolated source, such as a drainpipe or an underground storage tank.

Pollution. An undesirable change in the environment, usually the introduction of abnormally high concentrations of hazardous or detrimental substances, such as nutrients or sediment. The presence of any substance that harms the environment.

Pollution-sensitive organisms. Organisms that cannot withstand the addition of pollution to their aquatic environment.

Pollution-tolerant organisms. Organisms that can withstand polluted environments.

Pond. Body of water that has water in it year-round but that is smaller than a lake.

Pool. That portion of a stream that is deep and slow moving, often following a riffle.

Predators. Benthic macroinvertebrates that eat other animals.

Producers. Organisms that produce their own food through photosynthesis.

Reagent. A substance or compound added to a system to cause a chemical reaction, or added to test if a reaction occurs.

Recharge areas. Areas that allow surface water to infiltrate and recharge groundwater.

Respiration. Oxygen consumption in living organisms.

Riffle. That portion of a stream that is shallow and fast moving. An area of the stream where shallow water flows swiftly over completely or partially submerged rocks or other debris.

Right bank. When facing downstream, the bank to your right.

Riparian zone. An area adjacent to and along a watercourse that is often vegetated and constitutes a buffer zone between nearby lands and the watercourse. The natural plant community adjacent to a waterway.

Riprap. Any material (such as concrete blocks, rocks, car tires, or log pilings) that may have been used to stabilize a stream from erosion.

Run. A stream habitat type characterized as having a moderate current, medium depth, and smooth water surface.

Runoff. Water from rain, snowmelt, or irrigation that flows over the ground surface and runs into a waterbody.

Salinity. A measure of dissolved salts in water, typically stated as grams of measured salt ions in one kilogram of seawater.

Salinity gradient. The profile formed where freshwater from a river mixes with saltwater from the ocean.

Sanitary sewer. A pipe that carries food and human wastewater to a municipal sewer system or a septic system.

Secchi disc. A device used to measure the depth of light penetration in water. The instrument consists of a black and white disc that is lowered by rope into water. The point where white and black are just visible is the depth at which clarity is documented.

Secchi tube. A tube that receives water sample. A small Secchi disc is either stationary at the bottom or lowered into the tube. Similar to a disc, depth is recorded at the point where black and white quadrants appear out of the sample. A ruler is marked on the side of the tube for measurement.

Sediment. Eroded soil particles (soil, sand, and minerals) transported by water.

Sedimentation. The process by which soil particles (sediment) enter a water body, settle to the bottom, and accumulate. The addition of soils to lakes or streams.

Semi-diurnal tides. Tidal cycle with two nearly equal high tides and low tides every lunar day.

Silt. Fine particles of soil and minerals formed from erosion of rock fragments.

Siltation. The process of silt settling out of water and being deposited as sediment.

Soil. Soil is a mixture of solids (minerals and organic matter), liquid, and gases that occurs on a land surface Slope. Change in elevation over a given distance.

Stormwater sewer. A pipe that transports stormwater and meltwater runoff from roads and parking lots to streams and lakes. Stormwater sewers rarely lead to any type of treatment facility; the water is piped directly to streams and lakes.

Stratification. Term used to describe the layering of water created by differences in salinity and temperature, for coastal waterways.

Stream. This term is used to describe any natural body of running water that moves over the Earth's surface in a channel or bed. Rivers, creeks, and brooks are all considered "streams."

Streambank. The sides of the stream that contain the flow, except during floods.

Streambed. The bottom of a stream where the substrate and sediments lie.

Stream depth. A measurement of the depth of a stream from the water's surface to the streambed.

Stream energy. Erosion potential of a stream.

Stream flow. The amount of water moving in a stream in a given amount of time.

Stream morphology. The shape of a stream. Stream order. Stream classification system. Stream reach. A specified length of stream.

Stream transect. An imaginary line drawn from water's edge to water's edge perpendicular to the flow of the stream.

Submerged Aquatic Vegetation (SAV). Rooted vascular plants found in the waters of estuaries where the water is shallow and clear enough for sunlight to penetrate the water column so that photosynthesis can occur.

Substrate. The surface upon which an organism lives or is attached. The material making up the bottom of the streambed.

Suspended load. Sediment that is transported in suspension.

Thalweg. Area of concentrated flow in a stream channel.

Thermal pollution. The raising of water temperatures by artificial means that interferes with the functioning of aquatic ecosystems. Sources of thermal pollution include removal of trees along streams, introduction of cooling water from power plants or other industrial facilities, and runoff from hot paved surfaces.

Tidal saltwater. Those waters whose elevation is subject to changes due to oceanic tides and which have chloride ion content in excess of 250 milligrams per liter (mg/l) (salinity = 0.48 parts per thousand).

Tile lines. Drainage pipes used to remove water from an area.

Topographic map. A map representing the surface features of a particular area. Features illustrated include streams, lakes, roads, cities, and elevation.

Topography. What the surface of the earth looks like.

Total coliform bacteria. A group of bacteria that is used as an indicator of drinking water quality. The presence of total coliform bacteria indicates the possible presence of disease-causing bacteria.

Transparency. The measure of water clarity. Transparency is affected by the amount of material suspended in water (i.e., sediment, algae, and plankton). This is typically reported as a measure of length, determined with a secchi disk.

Trophic status. The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration.

Turbidity. The presence of sediment in water, making it unclear, murky, or opaque.

Velocity. The speed at which water moves.

Vertebrates. Animals with backbones.

Vertical stratification. Incomplete mixing of water in a water body.

Water cycle. The continuous circulation of water in systems throughout the earth involving condensation, precipitation, runoff, evaporation, and transpiration.

Water ecology. The study of aquatic environments and the relationships among the living and nonliving things associated with those environments.

Water quality. The condition of the water with regard to the presence or absence of pollution.

Water Table. The top of the underground area that is filled with groundwater.

Watershed. A region or area of land that drains into a body of water such as a lake, river, or stream.

Wetland. Shallow body of water that may not have water in it year round.

Zooplankton. Microscopic aquatic organisms.

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